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DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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Daniel Allison Meneley
1935 – 2018

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DGR: Dismantling Good Regulation or Deflecting Government Responsibility?

At the recent 2018 Canadian Nuclear Association Conference, the President of our nuclear regulator conveyed disappointment in the lack of progress of the regulatory and environmental assessment of the proposed Deep Geologic Repository (DGR), now in its 18th year, with no resolution in sight. Dr. Michael Binder said "If the DGR doesn't go, then low and intermediate level radioactive waste will have to remain on site." He also noted that revisions to Canada's environmental assessment procedures were expected from the federal government in 2018.

The DGR is a proposal from Ontario Power Generation, the utility that operates and leases nuclear reactors in Ontario. The proposed location is on the OPG's existing and secure reactor site near Kincardine, Ontario. The waste content for the DGR is NOT high-level used reactor fuel - that is the responsibility of the Nuclear Waste Management Organization (NWMO). The OPG proposal is strictly for low- and intermediate-level waste that is mildly radioactive, and includes scrap metal, rags and mops, and the sort of garbage that accumulates in any industrial facility.

To those who are scientifically informed and capable of rational thinking, OPG's DGR is a no-brainer; humans have been disposing its refuse by burial since forever, and the fact that the waste in question can be detected by a Geiger counter, if it gets close enough, is immaterial. Unfortunately, there are blusterers who are incapable of rational thinking, people who believe that one atom of tritium or cobalt will go on irradiating people for centuries, inflicting cancer to the entire human race! (They seem to think that electricity just happens and need not be generated.)

As for approval of the DGR, the ridiculously indeterminate time to make a decision is similar to the legal proceedings described by Charles Dickens in his novel *Bleak House*; the story has the law firm of "Jarndyce and Jarndyce" arguing a disputed will for a large estate, for decades, until the decision is finally rendered, that is, when all of the value of said estate has been completely consumed by legal procedure. In the case of the DGR, approval might come about after the entire radioactivity has decayed to oblivion. Reasonable argument be damned!

But what of Dr. Binder's hope for reasonable revisions to Canada's environmental assessment procedures? They're here, though not necessarily reasonable (except for politicians and other unreasonable people).

The Liberal Government has been hampered (or assisted?) by protestors opposing oil pipelines, most recently the Trans Mountain Pipeline Expansion that will parallel the existing pipeline through BC. The alternative is to transport oil via rail. (I wonder if any residents of Lac Mégantic are among the protestors ...) The Liberal political response to media-echoed shouts from special interest groups is to further remove science from decision making. Hence, the Liberal Government will replace the Canadian Environmental Assessment Agency (CEAA, enacted by the Conservative Government in 2012) with the new Impact Assessment Agency of Canada, which will have sole responsibility for projects like pipelines and, unfortunately in my opinion, the DGR. Experts from the CNSC, who are knowledgeable on matters of nuclear safety and radioactive waste and experienced in separating gimcrack from reasonable argument and had responsibility under the former CEAA, need not apply. Instead, reviews conducted by the new agency (or a panel appointed by the government) would look at factors including environmental, social and health aspects; the effect on Indigenous peoples; gender issues; and jobs and the economy. But haven't these issues already been submitted to the present DGR assessment? And no mention of science? Perhaps the firm of Jarndyce and Jarndyce will be appointed to the panel.

The indeterminate DGR assessment, ongoing with no end in sight, is a travesty of social justice but few people realize it as such. Some would even call the delay tactics a victory - but a victory for what, social injustice? Scientific assessments judge the risk of harm to society, and aim to keep that risk to a minimum. Non-scientific bodies, including the self-appointed "Great Lakes Waterkeeper", despite their social justice claims, seem intent on ignoring science and maximizing the risk to the public.

In This Issue

We are again saddened by losses of our pioneering nuclear engineers and scientists. In December 2017, Bill Penn passed away; he was an excellent manager for the Nuclear Studies and Safety Department (NSSD) of the former Ontario Hydro. In February 2018, J.A.L. (Archie) Robertson passed away; he did pioneering research and development in reactor fuel and materials at Chalk River Nuclear Laboratories. Also in February 2018, Dan Meneley passed away; his life spanned several careers in nuclear research, reactor safety and education. He is a former manager of NSSD and Chief Engineer of AECL. Dan was so remembered by friends and colleagues that a special memoriam has been prepared for this issue of the *CNS Bulletin*.

February 2018 also marked the largest attended conference and trade show of the Canadian Nuclear Association which is featured in this *CNS Bulletin*. We also include a number of papers, news and other events.

I know the calendar says its Spring, but my observations are in gross conflict!

From The Publisher

They arrived in hundreds: delegates, exhibitors, students, speakers, policymakers. They were there at the recent Canadian Nuclear Association (CNA) annual conference in Ottawa.

There was a lot to discuss. Canada's nuclear industry had just had one of its most active and successful years in all areas of research, innovation, operation and construction. Parliamentary Secretary Kim Rudd expressed it well, noting the hundreds of students and young people entering employment in the nuclear industry. This was clear evidence that nuclear technology was once again an industry of growth in Canada.

During the two days of the conference, which was standing-room only, delegates shared experiences in ongoing construction in Canada with the refurbishment of Darlington and the upcoming plans for the same for Bruce. They heard about new nuclear prototypes planned in Canada for small reactors and under review by the CNSC. They observed demonstrations of new products and services developed in Canada to meet nuclear power needs in Canada and around the world.

They also heard about Canadian nuclear technology developments happening around the world, in science, in waste management, in communications opportunities and activities.

With approximately 850 in attendance, this was the largest nuclear conference ever held in Canada. In attendance figures alone, it serves as a measure of just how active and vigorous the Canadian nuclear industry has become over the past decade. Gone now are the days of the seven-reactor shutdown of 1998. On the contrary, Ontario Power Generation (OPG) has applied for permission to extend the operation of the Pickering nuclear power station to 2024 with the full support and encouragement of the Ontario government.

Ontario Energy Minister Glenn Thibeault was emphatic about the province's desire that Pickering continue its safe, effective and cost-efficient supply of electricity for Ontario's citizens. He noted that Pickering had had some of its best performance in both safety and electricity production ever during 2017. For him, this was evidence that old reactors could have better safety and economic performance than when they were new.

It should also be noted that there was considerable discussion of the prospects of operating Pickering beyond 2024.

The largest surprise at the conference came from the President of NB Power Gaetan Thomas. He indicated that he had recommended to the New Brunswick government that it give serious consideration to the construction of a second reactor at Point Lepreau. There is a need in New Brunswick to decide soon on new electricity generation. The province has four large generating stations other than the CANDU at Lepreau: the Mactaquac hydro dam on the Saint John River, and the two fossil-fired stations at Coleson Cove and Belledune. One or both of the fossil stations may well have to be retired over the next decade, and that means New Brunswick needs at least one new generating station. It's the preference of NB Power that it be nuclear.

There was also extensive news at the conference about the revitalization of the Chalk River Laboratories. Canadian Nuclear Laboratories (CNL) President Mark Lesinski had much to say about the $1.2 billion project to redevelop the laboratories to permit an expanded research and development program for nuclear science. Ms. Rudd confirmed that the expansion and improvement of the labs is a result of federal government commitment to the future of nuclear in Canada.

But there's a dark cloud hanging over all this. In February, the federal government introduced two new pieces of legislation. Taken together, these bills propose to replace the National Energy Board (NEB) with a new tribunal, the Canadian Energy Regulator, and to replace the Canadian Environmental Assessment Agency (CEAA) with a new Impact Assessment Agency. The NEB and the Canadian Nuclear Safety Commission would no longer have powers to conduct environmental reviews.

The new agencies would have sole responsibility to conduct environmental assessments not referred to a review panel, and they would have an expanded mandate to include social, gender and aboriginal matters.

It doesn't matter that all of this was brought on by the federal government's political troubles over pipeline projects in Canada. The nuclear industry is getting side-swiped by it anyway. And given the fact that there are no mandatory hearing timelines, these new processes will have the strong potential for indefinite delay of any proposal that the federal government doesn't much like.

Stated simply, if they go through, these bills could be nicknamed, "Why Canada will never build anything, anywhere, ever again."

CGH

Contents

~ Cover Photo ~

DANIEL ALLISON MENELEY, PhD, P Eng., FEIC, FCAE, FCNS, FANS. Engineer, Professor, Mentor and Friend. CNS President 2006-2007.

Photo Source: Clip sourced from the TVO Public Archives, March 17, 2011, https://www.youtube.com/watch?v=rn0jhNKLrZA

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The Canadian Nuclear Society
998 Bloor St W., #501
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Editor / Rédacteur
Ric Fluke — Tel. (416) 592-4110
e-mail: richard.fluke@amecfw.com

Publisher
Colin Hunt — Tel./Fax (613) 742-8476
e-mail: colin.hunt@rogers.com

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IN-MEMORIAM

Daniel Allison Meneley, PhD, P Eng., FEIC, FCAE, FCNS, FANS

(1935 – 2018)

Dan was born and raised in Maple Creek, Saskatchewan and in 1958, graduated with a B.E. in Civil Engineering (with Great Distinction) from the University of Saskatchewan College of Engineering in Saskatoon. He was employed during the summers of 1954 to 1957, and from May 1958 to September 1959 by Legal Surveys and Land Plan Registration in Saskatchewan - roads, oilfields, and urban subdivisions. He was commissioned as a Saskatchewan Land Surveyor in 1959. His graduate studies were undertaken in London, England, where he earned a DIC (Diploma of the Imperial College London) in 1960 and a PhD (1963) in Reactor Physics specialty in the Department of Mechanical Engineering at Imperial College. His PhD thesis was entitled "Experimental Studies of Neutron Diffusion in the Presence of Absorbers and Voids".

Dan became a Post-Doctoral Fellow at the Applied Physics Division, Argonne National Laboratory from April 1963 to April 1964, where he worked on Physics analysis of FARET and RAPSODIE critical assemblies on ZPR3 facility. He also supervised the design and construction of experimental apparatus for measuring U^{238} and Pu^{239} Doppler effect in fast spectra, supervised experiments and analyzed the results. This work lead to his appointment as Associate Physicist, fast reactor physics research, from 1964 to 1970. He became Head of the Reactor Analysis Section from 1970 to 1972 where he was responsible for the development of kinetics and fuel management methods for fast breeder reactors, and for analysis of FFTF reactor safety for regulatory review.

It was at Argonne where Dan and a colleague, Karl Ott, published their seminal journal paper entitled *Accuracy of the Quasistatic Treatment of Spatial Reactor Kinetics* which has received 225 citations to date. This is an outstanding number of citations, considering that the number of persons specializing in the esoteric field of nuclear reactor space-time kinetics in those years could likely be counted on the fingers of one hand.

In 1972, Dan decided to return to Canada and joined Ontario Hydro's Generation Concepts Department. After a short period in Power Projects he returned to the Generation Concepts Department at Head Office as Supervising Design Engineer, Nuclear Analysis Unit in the Nuclear Studies and Development Section. The Nuclear Analysis Unit had 4 staff at that time. This was an exciting but extremely busy time for Ontario Hydro in the operating, design, and construction organizations. The Pickering NGSA units were being commissioned for operation, the design and construction of Bruce NGSA was well underway and planning for Pickering NGSB, Bruce NGSB, and Darlington NGSA had started. AECL was responsible for the reactor design and for the preparation of the Safety Report for submission to the AECB of the Pickering and Bruce 'A' stations. Part of Nuclear Analysis Unit's role at that time was to provide review of the licensing submissions and provide technical support to operations when required. The projections for nuclear growth at that time, both domestically and overseas, were such that Design and Development Division management realized that it needed to expand its capabilities in these areas. In 1975, a new department was formed: the Nuclear Studies and Safety Department (NSSD), part of the Design and Development Division. Dan was appointed Head of the Nuclear Analysis and Development Section in NSSD where he took the leading role in expanding its analytical capability. He supervised 25 professional staff through 5 unit leaders. They were responsible for reactor physics, thermal-hydraulics, shielding, conceptual design, economic evaluation, and advanced concept evaluation. A key assignment included setting preliminary specifications for safety systems, liaising with the AECB, and undertaking safety analysis for Darlington NGSA.

Dan was promoted to Manager, NSSD in September 1978 and remained in that position until November 1980. Under his management the department had grown to about 70 professional staff through 3 section heads and 13 group leaders. His expertise successfully guided the early safety analyses for Darlington, and for another vitally important element to the success of those analyses – the Common Development Program. This was a program established by Ontario Hydro, AECL, New Brunswick Power, and Hydro Quebec that undertook experimental programs to provide the technical basis to substantiate claims made in the safety analysis. Dan was a very strong supporter of this program and provided

much input, guidance, and support relevant to the performance of these experiments. He encouraged his staff to attend meetings and conferences, including international ones, to keep abreast of results from international experiments and code developments.

In recognition of his extensive experience, Dan was promoted to Manager, Nuclear Group in December 1980, a position he held until July 1984 when he left Ontario Hydro. He was responsible for three Departments (about 300 professionals) engaged in reactor safety design, plant licensing, nuclear systems design, radioactive waste management, heavy water, chemical systems, and nuclear waste management for Ontario Hydro's nuclear stations.

In August 1984 Dan became Professor of Nuclear Engineering, Department of Chemical Engineering at the University of New Brunswick (UNB). He was granted tenure in August 1985 with the rank of Professor. He was responsible for development of programs for the undergraduate option and for post-graduate studies in Nuclear Engineering. Throughout his stay at UNB he took on administrative duties as well, becoming Chairman of the Energy Conversion Engineering, Department of Chem. Eng., UNB - May 1986 to December 1987 and Chairman, Department of Chemical Engineering - July 1987 to June 1988. Throughout this period Dan took special delight in supervising and mentoring many post graduate students at the Masters and Ph.D. level, at UNB. He continued to foster his interests in the CANDU reactor, and reactor safety in general, through many interactions with New Brunswick Power. After leaving UNB in 1991, he remained an Adjunct Professor, until August 1996.

In 1991 Dan left the academic world to become a Vice President and Chief Engineer at AECL. Dan and his group had the role of overseeing AECL's participation in the development of new reactors and new methodologies, and of supporting the company's activities in the construction of overseas CANDU plants. In this regard he was very active in the support of the CANDU reactors in South Korea and China. In support of the Korean reactors, Dan took a leave of absence from AECL to spend 17 months at the Institute for Advanced Engineering, Seoul, Korea. "As a tireless advocate of CANDU, Dan established valuable ties with China's technical and academic communities during his time there as AECL's Chief Engineer in the late '90s. His enthusiasm for education was well received by the Chinese and his initiatives to establish training programs and Chinese language training materials helped overcome the perception held by many Chinese that CANDU technology was outside of the mainstream".

After his time as Chief Engineer, Dan served as Senior Advisor, Marketing and Sales, and in 2001 became Engineer Emeritus at AECL. His never-ending efforts to promote the CANDU and reactor safety in general, led to a five year stint as Director of the CANTEACH program for the CANDU Owners Group. CANTEACH is a knowledge repository that provides high quality technical documentation relating to the CANDU nuclear energy system. This information is public and is intended for use in various aspects of education, training, design, and operation.

In 2007 he joined the University of Ontario Institute of Technology (UOIT) as an Adjunct Professor, Faculty of Energy Systems & Nuclear Science. His association with UOIT, however, began much earlier when he helped to recruit and select the first cohort of deans in 2001, and he became a member of the Advisory Committee for the nuclear programs. At the senior (fourth year) undergraduate level, Dan taught courses on Risk Analysis Methods and Nuclear Plant Safety Design. He also taught a graduate course on Advances in Nuclear Power Plant Systems. Dan served as an external examiner for defense and candidacy exams and also a co-supervisor on capstone projects related to Small Modular Reactors. Everyone loved his courses and materials. He made it fun and engaging.

With a career involving so many different areas of engineering and science, it is not surprising that

CNS Outgoing President Dan Meneley passes the gavel to Incoming President John Luxat.

he was a member of several distinguished professional organizations: International Nuclear Energy Academy, Chairman 1998-2000; Canadian Nuclear Society, President 2006-2007; Professional Engineers of Ontario; Sigma Xi: The Scientific Research Society; American Nuclear Society, Vice Chair, Environmental Sciences Division. Nor is it surprising that he has been the recipient of many awards: Fellow, Canadian Nuclear Society, 1998; W.B. Lewis Medal, for "Competence and accomplishment in the field of nuclear science and engineering", June 1990; Fellow, American Nuclear Society, 1988; Argonne National

Laboratory Postdoctoral Fellowship, April 1963 to April 1964; NRC (Canada) Postgraduate Fellowship, September 1961 to February 1963; Athlone Fellowship, September 1959 to September 1961.

His list of publications in Journals, Topical Conferences, CNS and CNA conferences and in reports, is in excess of 120 papers and range from detailed Reactor Physics Modelling to "CANDU Co-Generation Opportunities" to "Nuclear Fission Energy is Inexhaustible" and "Nuclear Energy: The Path Forward in Canada: becoming a sustainable energy powerhouse".

The years at Ontario Hydro with Dan were extremely interesting and exciting. It was the dawn of the nuclear power age in Ontario. The prototypes had been built and tested and now the big machines were being designed and built. They were Canadian designed reactors; something that Dan was extremely proud of, and he wanted to make sure everybody knew they were safe. This he intended to do with rigorous analyses, well documented and supported by experimental data. With the support of Dan, Hugh Irvine, and Bill Morison, NSSD staff expanded the scope and capability of codes in the areas of reactor physics, thermal-hydraulics, fuel behavior, source term calculations, containment capability, and atmospheric dispersion and integrated them into a suite of accident analysis tools. Jointly with AECL and other nuclear utilities, an experimental program was developed to support the analytical codes. Dan never wavered in his support of these activities and the staff always appreciated the freedom they were given to undertake this work.

As noted below in the "memories" section, Dan's style of management was best described as "management by wandering around". Staff would never know when he might pop in to see what and how they were doing. This he did with everybody in the department, not just his supervisors. The questions he asked were detailed and showed the extent of his wide knowledge base and he didn't hesitate to give you his opinion on tricky issues. There were many occasions, however, when Dan would expound on a topic, and after his departure, those present would quizzically look at each other and say "now, what the heck did he just tell us?" Eventually we would figure it out and, of course, Dan was right. He was just that much brighter than the rest of us. He respected his staff members and was respected by all in return.

Dan was a strong proponent of nuclear safety and often participated in the International Atomic Energy Agency's (IAEA) activities. The International Nuclear Safety Group (INSAG), established by the IAEA, is a group of experts with high professional competence in the field of safety working in regulatory organizations, technical support organizations, research and academic institutions, and the nuclear industry, to provide authoritative advice and guidance on nuclear safety approaches, policies and principles. This group was established just after the Chernobyl accident in 1986 and produced its first publication INSAG 1 "Summary Report on the Post-accident Review Meeting on the Chernobyl Accident", in 1986. Dan was a strong supporter of the IAEA's efforts to promote reactor safety and was the Canadian representative on that committee for the first three INSAG reports.

Following in the wake of the Chernobyl accident, the Ontario Government appointed Professor F. Kenneth Hare in late 1986 as Commissioner of a review of the safety of Ontario Hydro's Nuclear Power reactors. This Ontario Nuclear Safety Review lasted a year. Ontario Hydro made several submissions to the review and Dan played a significant part in the preparation of those reports, being the author of a report titled "Ontario Hydro's CANDU Nuclear Stations: An Outline of Safety-related Design Aspects". He also provided advice and assistance to NSSD staff preparing submissions and presentations to the committee. The results of these efforts were successful with the Commissioner's major conclusion that *"The Ontario Hydro reactors are being operated safely and at high standards of technical performance. No significant adverse impact has been detected in either the workforce or the public. The risk of accidents serious enough to affect the public adversely can never be zero, but is very remote."*

Following the March 2011 accident at the Fukushima Daiichi nuclear power plant in Japan, Dan was invited to appear on TV Ontario (TVO) to explain what had happened. His calm explanation of what facts were known at the time, his ability to clearly identify what was speculation rather than fact, his ability to clearly explain what was important and what was not among the dramatic headlines that were appearing daily, demonstrated his keen understanding of the subject and his ability to explain highly technical issues to members of the public.

Dan's interests were much broader than just the CANDU and its safety issues. His vision included ways to reduce greenhouse gas emissions. He was very knowledgeable in LWR reactors, molten salt reactors, fast neutron reactors and for many years had championed the idea of a nuclear complex with both FNRs and CANDUs working in conjunction. In a paper published in this Bulletin in 2015 he once again pointed out that a combination of FNR and CANDU fission systems could deliver energy to the world, at essentially any production level, forever. In a further paper in 2017, he presented a more detailed discussion of how we could transition away from fossil fuels by introducing large-scale energy production from uranium and thorium supporting a wide range of end products in nuclear energy parks.

His interest in nuclear power was not restricted to civilian enterprises. His earlier work in the United States had introduced him to military reactors as well. As a result, Dan established contact with the Department of National Defence in Canada and became a lifetime member of the Defence Science Advisory Board, serving as Chairman 1997-2003. This independent Board responds to tasks assigned by the Deputy Minister and the Chief of Staff, Department of National Defence (DND). He also served (part time) for a short period as Director General Nuclear Safety (DGNS) responsible for evaluation of safety performance of two nuclear-powered submarine bids, and for making a recommendation to DND regarding the acquisition.

In November 2007, the CNSC ordered the NRU reactor at Chalk River be shut down because two of eight cooling pumps had not yet been connected to the seismically qualified backup power supply. This shutdown caused a world-wide medical crisis because of the disruption in the production of Mo-99 medical isotopes. Dan and David Torgerson from AECL were asked to make a presentation to members of the House of Commons on the safety aspects of this shutdown. Based on their authoritative presentation, Parliament passed emergency legislation reversing the CNSC decision.

In the early 1990s there were several programs established by Western countries to review the safety of RBMK reactors built by the former Soviet Union. Dan was instrumental in ensuring that Canada, with its knowledge of channel reactors, played a significant role. Dan's initiative ensured that AECL led the Canadian contribution through the Western Consortium, a group of western countries having bi-lateral agreements with Russia. The European Bank for Reconstruction and Development, through the Nuclear Safety Account, provided funds for a safety review of the Ignalina NPP in Lithuania. Through Dan's international contacts, AECL and Vattenfall from Sweden undertook this review. These projects were successful in identifying several weaknesses in the design and recommending solutions to enhance the plants' safety. While Dan did not oversee the actual projects (Ken Petrunik did), it was clearly Dan's initiative that led to Canadian participation.

Dan was also a person who was fun to be with. He had a great sense of humour and many readers of this document will remember fun times with him at various conferences and other social events. As Allan Brown recalls, everywhere we went, domestically and internationally, he always seemed to have many friends. Some of these adventures, in retrospect were funny, but didn't seem so at the time. In 1995 Dan, Milli, and I were in Turkey at a conference and were invited out for a meeting and dinner with AECL's representative. On leaving his apartment after the meeting, the elevator came to rest a few inches below the ground floor door level. We were stuck and it took a couple of hours to get out. We then drove to a restaurant just north of Istanbul on the edge of the Black Sea. After an excellent dinner, we were informed that the representative's son would drive us back to the hotel. Little did we know that this kid's driver's education took place on the Monaco Grand Prix circuit. It was "thrilling" to ride through the streets of Istanbul at 11PM, doing 50, 60 and 70 mph, occasionally slowing for corners. On the final approach to our hotel, a car passed us going the other way and the driver's side wing mirrors clipped each other. When the car stopped, Dan dove out, knelt down and kissed the ground. Never was he so happy to be out of a car.

Dan was a humble, fun-loving man who just happened to be one of the most respected and widely known men in the nuclear business. His technical expertise was astounding, and over the years he developed the ability to communicate highly technical and difficult issues to members of the general public amazingly well. His style of management was always appreciated by his staff for their freedom to explore new methods and techniques with the knowledge that they could count on his support and guidance in convincing others of its veracity. Not limited to just technical issues, he had visions of how today's existing nuclear technology could be better utilized to reduce greenhouse gas emissions and improve the quality of life. He devoted his later years to passing on this wealth of knowledge to the next generation of nuclear engineers and scientists. The nuclear industry has lost a great champion. He will be fondly remembered by all who knew him.

The thoughts expressed above are reflected in the following quotations from some of those who knew and have worked with Dan.

Remembering Dan

"I was saddened to hear of Dan's passing. He was a good friend and close associate whom I admired very much. He was an exceptional nuclear engineer who helped me a lot at Ontario Hydro. I will miss him a lot. He was admired and respected by those that worked for him and by all of his associates in Hydro, AECL, AECB, and in the worldwide nuclear industry. Morag and I were happy to enjoy his friendship and company. Dan had a fine sense of humor. I will always remember his rendition of the 'Old Carnalachy'

song that he sang at several parties in Ajax."

"It was my privilege to meet Dan shortly after I joined the staff of the Atomic Energy Control Board in 1962. We had many "interactions" as we sat on opposite sides of the table during the licensing of Ontario's CANDU nuclear-electric stations and the Point Lepreau G.S. Each and every meeting with Dan was a learning experience for me, and my associates, not only in an engineering sense but also about how to conduct one's-self in serving corporate and more importantly, the public interest."

"Extremely sad news. Dan was a good friend and colleague who will be greatly missed."

"Dan was an outstandingly knowledgeable engineer and a superbly gifted professor at UNB and more recently UOIT. Dan was admired for a multitude of reasons as he demonstrated his dedication to his family, his friends, to Canada and to the World Community. Like you and your family and hundreds, more likely thousands of others, I shall never forget Dan."

"Dan shouldered a great deal of responsibility and he carried it well. He was an excellent representative of Ontario Hydro. I respected him because he was a very bright man, always knew his subject and did not tolerate obfuscation."

"Very sad news, too soon for a great man and friend to us all. "

"Dan had the friendship and respect of all who worked with him."

"As Manager of NSSD, Dan instilled a strong staff culture characterized by hard work, dedication, motivation, and excellence including thinking outside the box. Dan made it a point to know what each staff member was working on as well as showing genuine interest in each person's work. He was very approachable and supportive and was well known for his 'stop and chat' sessions with staff, either in passing or by just dropping in their offices. Dan possessed not only a keen intellect, but also a curious one. In many ways, Dan was a renaissance man. During his last year or so, Dan got involved with a group of diverse individuals interested in climate change issues and invited me to join the group. Alas, I will miss Dan's input and contributions. Dan was also a dedicated family man. His genuine pride of and joy for family clearly came through in the annual Christmas letters that he and his wife Milli sent."

"Dan was an icon in our industry, but more than that he was a great boss who always had time to talk to you. A sad day."

"A sad loss of an enlightened gentleman with a great sense of humour. He will be missed."

"He practiced "management by wandering around" before any of the management gurus had coined the term. You'd always see him walking the floor and engaging even the most junior analyst, taking a genuine interest, and no matter how unfamiliar he initially was with what you were working on, he'd ask some very tough technical questions that really got you thinking. After he walked away you'd think to yourself "How did he know that?" He was famous for making a statement and leaving you wondering exactly what it was he was saying. But you didn't ask a question because you felt like you were the only one who didn't understand him. I found out years later that many people couldn't understand what he was saying. I suspect he was just that much smarter than the rest of us. I feel a huge sense of loss."

"I worked for Dan for several years in the Office of Chief Engineer and appreciated his insight, management, and character. He had worked on both the civilian and military sides of nuclear power, which gave him a rather unique perspective. As my boss, I appreciated his "long-leash" approach - although he was always available when I needed advice or direction. Much later on, he was a thorough and very helpful reviewer of a chapter I wrote for The CANDU Textbook. A remarkable man."

"Dan was a good friend and a great boss. He had a great mind and a tremendously wide range of knowledge. He led us through interesting times, always encouraging us to be creative and rigorous in our design and safety studies, and always supportive of the results our staff produced. He was well respected by throughout the industry and held in high regard by the CNSC, with whom he had many interesting "discussions". His sense of humour was unique. He will be sorely missed."

"I always had great respect for Dan and enjoyed those "discussions" we had. He was a calm debater who never seemed to lose his cool, despite our best efforts. It is a sad day."

"I would like to point out how much I (we all) learned from Dan in our interactions with him at AECL, later at UOIT (where we were both teaching), and also at the CNS. Dan was always ready to generously share his deep wisdom in nuclear engineering, nuclear safety, and general human communication. Dan was a great mentor to so many people. He was a great defender of CANDU and always touted CANDU's tremendous potential for synergism with other reactor types. On the less scientific side, Dan was kindly able, during his years in China, to order silk ties for the CNS – 100% silk ties with the CNS logo, that many of us continue to wear proudly. I often met Dan at ANS meetings, which he regularly attended. It was very pleasant for my wife Denise and me to meet Dan and his charming wife, Milli, at these events."

"I enjoyed working with Dan during his time in Asia and occasionally in Canada. As a tireless advo-

cate of CANDU, Dan established valuable ties with China's technical and academic communities during his time there as AECL's Chief Engineer in the late '90s. His enthusiasm for education was well received by the Chinese and his initiatives to establish training programs and Chinese language training materials helped overcome the perception held by many Chinese that CANDU technology was outside of the mainstream. This concern was reinforced by the difficulties then being experienced at Ontario Hydro and the feeder issues at Lepreau and Dan's work was instrumental in addressing it."

"One of Dan's strengths was in patiently articulating the CANDU safety case to non-technical audiences, using a variety of analogies to relate reactor events to those within the experience of his audiences. These were highly effective in establishing comfort with CANDU technology."

"I knew Dan since the 1970s, especially after he became Chief Engineer at AECL, 1991-1999. Yes, he was exceptionally knowledgeable about reactors and nuclear safety, but what really surprised me was the first time that I showed him some evidence of beneficial health effects of low doses of radiation. He promptly pulled out a thick folder of the articles that he had collected on this subject, and we talked!

Dan was active in trying to revive the International Nuclear Energy Academy (INEA). He arranged a new INEA website that is hosted by the CNS and managed by the CNS webmaster. He tried to encourage more membership nominations from countries other than the USA, and he nominated new members to the INEA from Canada. Dan organized an informal session on health effects of radiation at the 2014 PBNC Meeting in Vancouver, and arranged for position papers to be uploaded to the INEA website on this subject. Dan is unforgettable. We all will miss him. He spoke with authority and style. I corresponded with him quite often in later years. I am honoured to know him."

"Dan had strong connections with the IAEA and he served on the first INSAG meetings when INSAG was established after Chernobyl. He may have played a role in creating INSAG and he played a key role in the first documents produced by INSAG. He worked hard to demonstrate that the CANDU positive void co-efficient did not result in a "poorer safety" case when dealing with a loss of coolant accident and was able to convince the IAEA safety people of this, as well as the CNSC. He had extensive experience in support of CANDU in universities, e.g., UNB, in Korea, in China, and UOIT. He was a leader on an advisory committee to NRCan on the Canadian contribution to the Gen 4 reactor program. (He may have been the first chairman of that committee.) He was also a strong supporter of molten salt fast reactor."

"Almost exactly 22 years ago, Daniel led the Canadian delegation to India, to an IAEA Technical Meeting on heavy-water reactors, held at the Trombay Nuclear Establishment in Mumbai. He was highly regarded by our Indian hosts, and being in his wake, we were treated exceptionally well. Among others, he knew the CEO of the Indian Nuclear Safety Authority from the days when both were at the Argonne National Laboratory. As a result, the CEO invited Daniel (and us) to a private dinner at an exclusive restaurant. It was easy for us to be in Daniel's entourage."

"Dan had the gift of metaphors to relay his technical response to a good technical outcome; I recall his input at the end of some design assist analyses when all safety criteria were met (not the least of which was the CVR). Dan responded with the following phrase "this is the holy grail for CANDU." He had a pleasant disposition whether he was delivering a stern or a positive message. His influence will live with us forever."

"I always remembered Dan from my fist day at Ontario Hydro as a warm, caring and supportive leader. He will be missed."

"Dan was a real gentleman and a real professional."

"I'll miss Dan, and always be grateful to him for introducing the knowledge of the impact of primordial fear to me."

"I am so sorry to hear about Dan, he was a leader that fostered competition among his staff in pursuit of excellence in engineering. His contribution to nuclear generation will be remembered fondly."

"Dan was my mentor through life. In fact, he was largely the reason for my emigration to Canada from England in the mid-1970s. My first contact with Dan was as a graduate student at Imperial College. I was fortunate enough to be referred to him by a faculty member for some guidance on my thesis. What followed was my first introduction to the CANDU reactor, and a few months later, the beginning of a new life in Toronto. Dan and Milli were always ready to help my wife and I adapt to our new surroundings. They treated us as family, getting to know our two daughters as they progressed through their early years through to adulthood. In my work career, he encouraged me in so many different areas that I cannot do them justice in this short paragraph. Dan made you think with a simple cryptic comment or a prod in what was usually the right direction. He actively encouraged revolutionary (some might say crazy) ideas, and did not always go through line management to discuss these with whoever originated them. He once told me that you bring out the best in people when you make them feel like they are experts in their own area. This did not necessarily make us experts, but it sure felt good to come to work every day! As many will know, Dan was much more than just a nuclear guru. A very strong memory for me is that he loved music and encouraged live performances at every opportunity. Once at a

party, he asked me if I could play "Wild Colonial Boy". I said I only know the first two lines, whereupon he disappeared for twenty minutes and returned with the entire eight or nine verses freshly (and very neatly) hand-written, and we sang it together! I still have the original sheet of paper! Dan taught us much and he will be greatly missed."

"I owe Dan a deep debt of gratitude for guiding me into nuclear safety and nuclear engineering. A few years out of university, I was working at a consulting company in 1976 when the American Nuclear Society held their annual summer meeting in Toronto. At one conference lunch I was sitting at a table with Dan, Walter Lee and the late Prof. Doug Andrews when Dan slid a note to me across the table, asking whether I would like to continue developing a reactor space-time kinetics code at Ontario Hydro. I replied, certainly, as a consultant should. Walter interviewed me later that day in a hotel room and subsequently I received a six month contract. At the end of the contract Dan offered me a position in NSSD – an offer I could not refuse. And thus, ended my consulting career and began my nuclear safety career."

"It was my great pleasure to have worked with Dan Meneley. His lucidity and foresight to engineer very complex devices and yet make them feasible has added immense contributions in the nuclear field."

"Dan was always a sincere and kind mentor for me since I began my career as a very junior GIT. Over the years he nurtured that relationship with caring advice and encouragement, including writing papers and presenting at international meetings. He was never lost in his vision for a world class nuclear science and technology based electric utility. As much of my worked involved working with R&D organizations, including the AECL Research Labs, he once confided to me his views of maintaining excellence in R&D facilities. Concerned with the bureaucratization that evolves in any large organization, and its negative impacts on fundamental learning, he stated his opinion (tongue in cheek of course) that an R&D organization should be bulldozed to the ground when it reaches the age of 20 years. It was a sad day for me when Dan left me behind at Ontario Hydro to pursue his calling, first teaching at UNB, and many years later as Chief Engineer at AECL. That's when I met him again at a conference in Saskatoon and I asked him, now that he was in charge of AECL's R&D labs, if he still felt that an R&D organization should be bulldozed to the ground after 20 years. He said yes, and that, well, after 40 years, it should be done much more violently! Dan always was the ultimate master of the metaphor, but I will always remember him as the wise and caring mentor that he was."

"I first met Dan Meneley in 1974. I had recently joined AECL at the Whiteshell Laboratory where I was involved with developing the CANDU safety research program. One goal of the research program was to check the accuracy of the models against data gathered from heavily instrumented physical models of the CANDU heat transport system at progressively larger scales (RD-4, RD-12 and RD-14). Dan was a key advocate for the research program within OH and secured funding to support a cost sharing arrangement. The OH funding allowed the program to advance much more rapidly than if AECL was to proceed on its own.

The data from these tests showed two important points; (1) a high pressure injection system was necessary to prevent fuel failures from small pipe breaks, and (2) for low probability large breaks the existing codes could not replicate the experimental results for some limiting conditions. Thus new codes encompassing phase separation had to be developed, and other processes like iodine release and retention had to be incorporated into the safety case. This was a bold and risky move by Dan which went against the prevailing licensing approach and placed him under considerable pressure but he prevailed. In my experience, this was typical of Dan who valued his integrity and credibility with the people he dealt with above everything. He had set a new standard for licensing submissions.

I had an extremely productive collaboration with Dan from 1974 through 1984. We wrote several papers together on CANDU safety and had many late-night sessions over a bottle of single malt scotch. Some of our most creative thinking came out of these sessions. I look back on this period with great fondness and value highly the interactions I had with Dan."

The following three longer memorials come from three of his international colleagues, Jan van Erp from Argonne National Laboratory, USA, and Agustín Alonso, Profesor Emérito, Universidad Politécnica de Madrid, Spain and Bob Henry from Fauske and Associates. They serve to demonstrate how much Dan was respected, and will be missed, internationally.

"It was my great fortune to meet Dan Meneley at Argonne National Laboratory (ANL) where I started working in August 1969, coming from Westinghouse' PWR division in Pittsburgh, PA. Though I did not work directly with him, we met regularly at the Argonne Staff Club where we had lengthy discussions on a range of topics, not always of a technical nature. I recognized Dan as being a clear thinker of superior intellect from whom I could learn much.

It was therefore a great disappointment for me, and many others at Argonne, to hear in the early 1970s that Dan had been persuaded by Bill Morison to return to Canada. I remember, as if it were yesterday, Dan's farewell party at the Argonne Staff Club which was

attended by many. In his farewell words Dan stated in his usual jocular way that he looked forward to meeting his Argonne colleagues often at future meetings of the American Nuclear Society (ANS), "swaying your little red books" (making reference to the customary printed red ANS Meeting Proceedings and Mao's then-obligatory little red book in China).

Not long after he had left, Dan confided to me that in his new job "I have to be careful 'not to oversteer' because the Staff will actually do what I say". This was the difference between his new position at a power utility with his old one at a research organization (where 'thinking aloud' is often common practice). I also remember Dan telling me that Bill Morison had instructed him "never to be confident that all safety aspects are under control; be on your guard at all times because something completely unexpected is bound to happen".

Over the many decades that followed, I stayed in contact with Dan. We worked together on many projects, several of them in connection with the ANS. One of them was the establishment of the ANS '*W. Bennett Lewis Award'* for lifetime contributions towards the development of sustainable energy. Our last joint project was to organize (jointly with Yoon Chang of ANL) a session on "*Optimal Energy Strategies Aimed at Sustainable Reduction of Greenhouse Gas Emissions*" at the Annual Meeting in San Francisco, CA (June 2017). Dan and Yoon co-chaired the session.

Whenever I needed advice or an unbiased and clear opinion, my first thought was often to turn to Dan who was always willing to help. Dan was also very good company to be with. He had a great sense of humor and always knew how to lighten up a difficult situation with a light-hearted remark followed by his contagious smile. I remember fondly the many luncheons and dinners I shared with Dan and his dear and charming wife, Milli, at past meetings.

It was with great sadness that I received recently Dan's last message to me, stating that regretfully he was forced to curtail his professional activities because of health reasons. Dan stayed active and was clear-of-mind to the very end. I, and with me many others, will miss this dear friend and most generous colleague."

"Dr. Daniel Meneley was one of the founding members of the International Nuclear Safety Group (INSAG), which was established by the International Atomic Energy Agency (IAEA) after the accident at Chernobyl in 1989. The concept of *nuclear safety culture* was introduced for the first time in the first report published by the Group. Dan preceded me at INSAG where I served from 1996 to 2010. While we never interacted directly at INSAG, I was well aware of his valuable contributions which derived from his experience at Ontario Hydro.

It was my pleasure to cooperate with Dan during many decades on various projects, including on the book *Infrastructure and Methodologies for the Justification of Nuclear Power Programmes*, where he was a valuable contributor on the subject *Nuclear Safety in Nuclear Power Plants*, and for which I undertook to serve in the capacity of coordinator / editor. Under the enthusiasm and experience of Jan van Erp, we further co-authored a number of peer-reviewed articles and contributed to statements to stress the importance of nuclear energy in combating climate change at COP meetings of the United Nations Framework Convention on Climate Change (UN-FCCC).

Dan was a clear thinker with a very fertile mind. He was always generous in sharing his ideas and insights. I consider it a great privilege to have been able to exchange ideas with Dan over many years. Because of distance, our personal meetings have regrettably been few but include the ANS meeting in 2008 where I received the ANS Tommy Thompson Award, in large part because of Dan's kind sponsorship of me.

Dan Meneley was a dear friend and a wonderful colleague, who will be sorely missed by me and many others."

"I first met Dan Meneley at Argonne National Laboratory when he was a staff member of the Reactor Analysis Division and I was a new (green) addition to the Reactor Analysis and Safety Division. Shortly thereafter he left Argonne to join Bill Morison and the Ontario Hydro staff. A few years later he called to ask my advice on a Bruce preheater licensing analysis. The issue involved the potential loads that could be generated by an impinging steam-water jet if a reactor coolant pipe were to rupture. Only limited experimental data were available and these were all scale tests compared to the reactor case. His first question was "What do we need to do to get essentially full scale test data sufficient to address the issue in a timely manner?" This led to forming an international group that sponsored the Marviken large scale Jet Impingement Tests that remain as the gold standard for these important licensing evaluations for all water-cooled reactors, even today. Dan Meneley and Ontario Hydro were the driving forces that brought this to fruition.

I always appreciated Dan's direct approach to solving technical issues/problems: what do we know and what do we need to know to have a sufficient technical basis to address the issue at hand. He loved experiments but he also had a critical eye for determining whether a given experiment got to the heart of the issue/problem. As is always the case with difficult issues/problems everyone wants to do the right thing but there are honest differences of opinion. He had

a good sense of humor and he used it in those somewhat tense times to help find the common ground and develop a consensus approach for the solution.

He was a good and kind man, a loving husband, father, grandfather and great-grandfather. To those of who worked with him, he was also a bright, energetic and dynamic leader in a complex, difficult and developing technology. We are all better for having Dan in our lives and he most certainly will be missed."

NOTE from the EDITOR

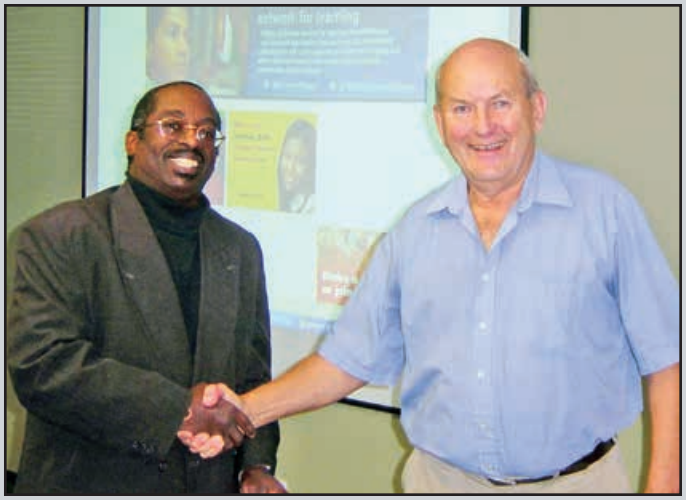
We are indebted to Allan Brown for leading the preparation of this memoriam with the assistance of Hugh Irvine, Walter Lee and John Luxat, who worked closely with Dan during the important years at the

former Ontario Hydro making pioneering contributions to nuclear safety worldwide.

Several of Dan's many friends and colleagues contributed their memories for this memoriam:

Colin Allan (AECL); Glenn Archinoff (OH); Vern Austman (OH); Allan Brown (OH); George Bereznai (UOIT); Keith Bradley (AECL); Jerry Cutler (AECL); Zig Domaratski (AECB); Ric Fluke (OH); Arnold Eyre; Keith Garel (OH); Bill Hancox (AECL); Hugh Irvine (OH); Jon Jennekens (AECB); John Luxat (OH); Walter Lee (OH); Ed Moeck (AECL); Ajit Muzumdar (OH); Ken Petrunik (AECL); Ben Rouben AECL/CNS); Basma Shalaby (AECL); Nick Sion (OH); John Skears (OH); Victor Snell (AECL); Ken Talbot (OH); Mike Taylor (AECB); Peter Wigfull (AECB); Nabila Yousef (OH).

Scenes of Dan, at home and at various CNS events. Dan is remembered by his many friends and colleagues, and by CNS members for his significant contributions to the Canadian Nuclear Society as President, Chair of the Past President's Committee and numerous other contributions, including the recruitment of the present Editor-in-Chief of the CNS Bulletin.



2018 CNA Annual Conference and Trade Show

"Canada's Nuclear Advantage: The Next Generation"

by COLIN HUNT

Kim Rudd, Parliamentary Secretary to the Minister of Natural Resources.

The plenary hall was packed, the halls were jammed, the exhibitors' booths were crowded. For three days, the Canadian Nuclear Association's (CNA) 2018 Annual Conference, February 21-23, was the scene of the largest ever nuclear industry conference in Ottawa this year.

The keynote and opening speaker for the conference was Kim Rudd, Parliamentary Secretary to the Minister of Natural Resources. In line with the conference theme, Ms. Rudd focused her remarks on both renewal and growth over the past year within Canada's nuclear industry.

"We see the influx of such large numbers of young people into the industry," Ms. Rudd said. "We see this as a strong vote of confidence in the future of Canadian nuclear science and technology."

Ms. Rudd had a large number of positive federal government policy items, both national and international, to outline for the audience. And she described the Canadian nuclear industry as rarely before by federal politicians:

"We see your industry as a strategic national asset."

Of great importance in Canada is the revitalization of the Chalk River National Laboratories.

"We have committed $1.2 billion to investment in Chalk River," Ms. Rudd noted. She added that the government was firmly committed to the decade-long project that would see Chalk River labs as fully modernized with an enhanced research and technology development mission.

With respect to the international role of Canada, Ms. Rudd discussed in considerable depth our country's role in the Clean Energy Ministerial. This annual meeting among leading countries around the world is for the express purpose of developing policy transitions to new systems of producing energy. And nuclear is now taking a strong role in these discussions, in large part to the advocacy of the Canadian government. Ms. Rudd noted that Canada was the chair of the meeting in 2017 and provided strong leadership and support for nuclear technology.

This international government meeting was originally founded by Canada, Japan and the United States. But its agenda, according to Ms. Rudd, is increasingly focused on nuclear energy. She noted that five nations are now in agreement on the strong role of nuclear, and seven more countries have expressed strong interest.

But the best is still to come. Canada will be the host nation of the 10th Clean Energy Ministerial in 2019.

Of great importance to the government is new technology. Two areas in particular were noted. The first is the strong attraction to Canada of companies interested in developing small modular reactors. The second was the development of the Advanced Fuel CANDU project in China, which will use used fuel from light water reactors as its fuel. The importance of this project for Ms. Rudd was enormous, as it will enable a re-use of nuclear fuel without reprocessing.

But it was not just nuclear power generation.

"We have innovation happening in all areas of nuclear science and technology, not just power generation," Ms. Rudd said.

Ms. Rudd paid a strong tribute to the regulatory leadership of Dr. Michael Binder of the Canadian Nuclear Safety Commission (CNSC). She noted that the regulatory leadership and stability of the CNSC has been a large part of the foundation of new science and development over the past decade.

Glenn Thibeault, Ontario Minister of Energy.

Ms. Rudd's optimism on Canada's nuclear future was echoed by Ontario Energy Minister Glenn Thibeault. Speaking at the closing of the conference, Mr. Thibeault expressed strong satisfaction with the progress of the refurbishment of Darlington Unit 2. After nearly one and a half years into the project, it was on time and on budget. This was why Mr. Thibeault was happy to announce that the government gave permission on February 15 to proceed with Unit 3.

Mr. Thibeault noted that nuclear has been and will

continue to be the main provider of electricity in Ontario. For 2017, nuclear generation provided about 63 per cent of the province's electricity supply. He also stated that the provincial government supported strongly Ontario Power Generation's proposal to extend the operation of the Pickering nuclear power station to 2024. He also congratulated the federal government for its strong policy and regulatory support for Canada's nuclear industry.

Dr. Michael Binder, President of the CNSC, provided a series of observations on developments at the CNSC during his decade as leader. Dr. Binder outlined three priorities for the CNSC during his time in office.

"We spent a lot of time on establishing clarity in nuclear operating licences," Dr. Binder said. "We wanted that there be no dispute about what requirements were in the licences."

The second key priority of the CNSC has been to examine internal procedures within the CNSC on a regular five-year cycle and to implement efficiencies. The third priority was to enhance the visibility, both public and within government, of the role of the CNSC.

One of the results of these measures has been the advent of new nuclear technology. Dr. Binder observed that today, ten developers of small modular reactors had applications before the CNSC.

"These are all private companies," Dr. Binder said, "There's no government capital behind these proposals."

Dr. Binder described them as concepts in which the physics had been established in the past and were now looking at materials research and development and reactor design.

There was one area of dissatisfaction for him and the CNSC however.

"The Deep Geologic Repository (DGR) is now in its 18th year of regulatory and environmental assessment approval," Dr. Binder said. "If the DGR doesn't go, then low and intermediate level radioactive waste will have to remain on site."

Canada needs clearly defined project approval timelines, Dr. Binder stated. He noted that revisions to Canada's environmental assessment procedures were expected from the federal government in 2018. He also observed that Canada's nuclear industry needs to pay careful attention to the Designated Project List of federal environmental assessment rules.

One of the most important industry presentations at the conference was a panel of the three nuclear utility CEOs: Jeffrey Lyash of OPG, Mike Renchek of Bruce Power and Gaetan Thomas of NB Power. Mr. Lyash discussed the Darlington refurbishment progress. He also outlined the steps OPG was taking toward the extended operation of Pickering to 2024.

Mike Renchek of Bruce Power discussed the upcoming Major Component Replacement Program of Bruce Power, to start in 2020 with Bruce Unit 6. He noted that Bruce Power had been doing considerable work in advance to prepare for the decade-long project.

Left to right: Jeffrey Lyash Gaetan Thomas, Mike Renchek.

But the most surprising development came from Gaetan Thomas. He stated that he was in strong support of new nuclear in New Brunswick, and that he was proposing to the provincial government that it consider and approve a plan to build a second nuclear power reactor at Point Lepreau. In view of the age of New Brunswick's existing fossil generation at Belledune and Coleson Cove, the province would need new electric generation in the future.

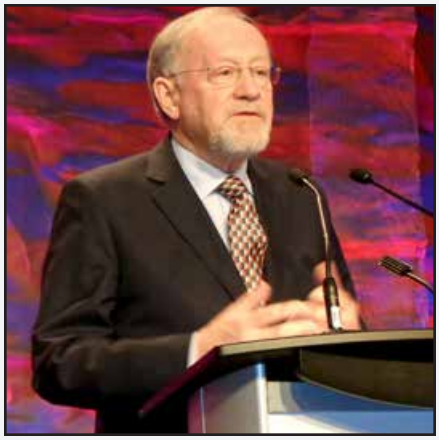
Sandy Taylor, President, Nuclear, SNC Lavalin.

Sandy Taylor, President, Nuclear, SNC Lavalin, outlined the commercial prospects immediately before the Canadian nuclear industry. Of immediate interest were new projects in China and Argentina. He noted that China and Canada are proceeding with the Advanced Fuels CANDU Reactor. He also observed that a partnership of Canada and China would be proceeding with the Argentinian project to build a new Atucha 3 reactor.

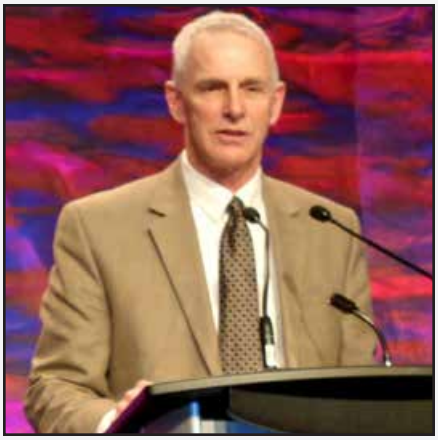
Mr. Taylor noted that the prospects for two more reactors at Cernavoda were still good but had been delayed by changes in the Romanian government.

It should be noted that this year's CNA conference is the largest nuclear industry conference ever held in Canada. About 850 delegates attended the event, including approximately 90 students. Typically the plenary hall was standing room only with audience members standing three-deep at the rear and sides.

Scenes from the Conference



Dr. John Barrett, CNA President, opens the conference.



Glen Jager, OPG Chief Nuclear Officer.

Michael Shellenberger announces his candidacy for California governor.

Michael Binder, President CNSC.

Conference exhibitors.

Conference exhibitors.

The CNS booth at the conference.

Kim Rudd visits the exhibitors.

To the Editor:

Some years ago, responding to a perceived industrial need, we found ourselves studying neutron activation analysis for nitrogen. (John van Berlo, Honours B.Sc. Research, 1975). More specifically, we were studying the analytical determination of protein in the large shipments of grains to be sent from Canada.

This was seen to be very easy and fast. The reaction was straightforward:

^{15}N (n,γ) ^{16}N

A problem was that the ^{15}N concentration was very low (0.36%) in normal nitrogen. On the other hand, the half life of ^{16}N is very short – 7.13 sec – so the total analysis time could be short. The most prominent gamma ray from ^{16}N is very high energy – 6.1 MeV – so there should be no other interference with the measurements. In fact, we were able to do two parallel determinations per minute, as organized by Pat Kennedy of AECL Commercial Products Division using the AECL Slowpoke Reactor. The timing was easy: shoot a sample into the reactor, wait 10 seconds, shoot it out again, measure for 10 seconds and prepare a next sample – all in one minute, while a second determination was proceeding in a parallel channel.

The results determined on standard amines were excellent, showing gratifying agreement with the expected values.

However when we tried measuring real proteins, the data were all over the place, with no apparent sense. We soon realized that we were seeing the results of a second reaction:

^{16}O (n, p) ^{16}N.

This reaction, fortunately, required higher energy neutrons, so we should be able to work in the thermal column of the reactor. But no – there are apparently enough high-energy neutrons in the thermal column of most reactors to spoil our results and, of course, ^{16}O is nearly 100% of normal oxygen.

At the same time, we developed (with AECL's support) a photo-neutron source, using ^{124}Sb in which the neutrons were produced at about 25 KeV. Unfortunately, although 10 kCi this was likely the largest Sb-Be neutron source in the world, it didn't give enough neutrons to do our job with useful sensitivity.

So here is the problem: can one develop a thermal column with no higher-energy neutrons? If so, here is a significant source of revenue to be gained from protein analyses.

If not ... ?

Don Wiles

Ed. Note: The following letter was first published in Dose Response: an International Journal, February 14, 2018, http://journals.sagepub.com/doi/full/10.1177/1559325818756461. It was submitted to the CNS Bulletin by the author as a follow-up to a letter in the March 2017 edition of the CNS Bulletin (Vol.38, No.1).

Letter to the Editor

Second Update on a Patient With Alzheimer Disease Treated by CT Scans

This is the second update on an 81-year-old female patient who in April 2015 was in the final stages of advanced Alzheimer disease (AD) in hospice care. Her husband searched to find a remedy for her illness. After reviewing evidence of upregulation of biological protection systems by low doses of ionizing radiation, he arranged for his wife to receive a series of standard computed tomography (CT) scans to image her brain. A case report described the procedure and the patient's partial recovery from AD symptoms.[1] It covered the period from April to December 2015. A subsequent letter to the editor summarized the patient's ongoing condition, from January until December 2016, during which she received additional "booster" CT scans.[2] These were intended to prolong her recovery and delay the inexorable progression of AD. The letter also mentioned that her husband, with Parkinson disease (PD), requested a series of CT scans to remedy the symptoms. These scans began on October 6, 2015. This second letter to the editor outlines the experiences during 2017 of the patient with AD, who is now 83, and the patient with PD.

Back on December 13, 2016, the patient with AD received a CT scan. On 16th, she fed herself with a spoon and opened her mouth to accept food. She gave smiles, drank glasses of juice by herself, and gave 1-word answers. A physical therapist reported some improvement in her functioning shortly after this scan.

In 2017, the patient received 2 booster CT scans, a double scan (80 mGy) on January 24 and a single scan (40

mGy) on July 25. On February 4, a major improvement was noted in her attempts to put words together. She gave many appropriate 1-word responses, some 2-word responses, and some 3-word statements. However, this speaking ability gradually declined. She was still wheelchair bound but moved her feet to help propel it.

On March 6, 2017, the physician and the patient's husband decided to return the patient to hospice care. Over several months, she gradually lost her ability to swallow solid food and later could not swallow liquids, such as nutritional drinks. The patient would hold the liquid in her mouth, wanting to swallow, but unable to because her brain could not control those muscles. During this period of reduced food intake, her weight declined from 185 to 160 lbs.

The caregiver began to feed the patient ice chips and found that it would trigger the swallow reflex. She was given frozen drinks, such as cola, and then blended mixtures of ice, fruit, and yogurt. On August 3, after the July 25 scan, no immediate physical improvement was noted, but the patient began to flash many smiles, repeatedly.

On October 28, 2017, her 83rd birthday, the patient was able to chew and swallow chopped peaches at noon time. In the evening, she swallowed potato salad, watermelon, and pieces of cupcake. Through November, she continued to swallow solid food and appeared relatively happy, giving many smiles and laughter.

Update on the Patient With PD

The husband of patient with AD has PD and, as reported in the first letter to the editor, began receiving CT scans on October 6, 2015, to treat the symptoms. On the night after the first scan, he observed a complete absence of tremor while sleeping and on waking at about 4 AM. Soon afterward, he cut his medication from 6 to 2 or 3 pills per day. By mid-December 2016, the patient noted that his tremor was reduced and his stools were softer (constipation is a symptom of PD).

During 2017, he received a normal CT scan on the following days: January 9, February 28, March 16, May 12, August 3, September 14, November 14, and December 23. On February 1, he stopped taking pills because the tremor almost stopped. By February 6, his tremor was not noticeable. Again, on September 15, the tremor was diminished. The patient consistently observed a decrease in tremor shortly after each low dose of ionizing radiation. It appears that each exposure upregulates biological protection systems, which delay the progression of PD.

The patient's vision improved during the course of his CT scans. He can now read at a distance of about 18 inches without his glasses, which is a clear improvement. After the eye examination on May 26, the ophthalmologist noted: "Dr XXX has presented to our clinic today with improved Fuch's endothelial cornea dystrophy including corneal edema which improved his vision in his left eye from 20/30 to 20/20. His last visit was 03/22/16 and his present visit today is 05/26/2017. He is not taking any regular treatment for this condition at this time. His dry eye and symptoms have also greatly improved."

The patient received a hearing test on August 21, 2017. When the results were compared to an earlier test on June 28, 2016, small improvements in the high frequency range were seen. At a frequency of 4000 Hz, the improvement was 5 dB; at 6000 Hz, the improvement was 18 dB.

Further neuropsychological examinations will be carried out. Improvement in both vision and hearing appears to be correlated with ongoing scans. Proper clinical studies should be carried to provide more evidence that low doses of ionizing radiation upregulate neuroprotection systems.

Declaration of Conflicting Interests

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Thyroid Cancer Following Childhood Low Dose Radiation Exposure: Fallacies in a Pooled Analysis

by JERRY M. CUTTLER, D.SC.[1], S.M. JAVAD MORTAZAVI, PH.D.[2], JAMES S. WELSH, M.D.[3], MOHAN DOSS, PH.D.[4]

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According to the linear no-threshold (LNT) hypothesis, there is no safe dose of ionizing radiation. Predictions of cancer in a small proportion of the persons exposed to low doses are the rationale for opposing nuclear energy and for mass evacuations in the event of a radioactive release, as at Fukushima. Such predictions also restrict the use of beneficial nuclear technology in medicine. Evidence of actual excess cancers attributed to low doses is generally restricted to thyroid cancer.

A recent article by Lubin et al.,[1] which analyzes nine cohorts, illustrates common pitfalls.

The authors report that for doses <0.2 gray (Gy) and <0.1 Gy, relative risk (RR) increased with thyroid dose (P<0.01), without significant departure from linearity (P=0.77 and P=0.66, respectively). They conclude: "These analyses reinforced the existence of an excess thyroid cancer risk at doses <0.2 Gy and <0.1 Gy, and perhaps at even lower doses" and "reaffirm that the direct application of a linear relationship remains the most plausible approach for the extrapolation of radiation-associated thyroid cancer risk and adds support to the use of a linear model for ALARA [as low as reasonably achievable] assessments." Cohorts included two of childhood cancer survivors; six of children treated for benign diseases; and one of children who survived the atomic bombings in Japan.

There is no indication that this study controlled for the myriad of confounding factors that affect cancer incidence. These include genetics, which affects susceptibility, and the significant incidence of occult thyroid cancer that depends on geographic location.

Screening for thyroid cancer has been shown to result in enormous overdiagnosis. A population-based trend study in Switzerland from 1998 to 2012[2] showed that the age-standardized annual incidence of thyroid cancer increased from 5.9 to 11.7 cases/100,000 among women (annual mean absolute increase: +0.43/100,000/year) and from 2.7 to 3.9 cases/100,000 among men (+0.11/100,000/year). The increase was limited to the papillary subtype, the most indolent form of thyroid cancer. There was no concomitant rise in mortality, and the screening may have resulted in unnecessary thyroidectomies. South Korea's thyroid cancer "epidemic"[3,4] was the result of screening and overdiagnosis. Hoang and Nguyen[5] concluded that indiscriminate workup of incidental thyroid nodules is not cost-effective and is potentially harmful.

While Lubin et al. model radiation-induced cancer using a linear relationship, the 1956 National Academy of Sciences (NAS) recommendation to use the LNT model to assess the risk of radiation-induced mutations (cancer) has been progressively discredited for the past 8 years.[6]

It is well known that DNA mutations overwhelmingly result from attack by reactive oxygen species, which are produced abundantly and constantly by aerobic metabolism. All organisms have powerful protection systems, which prevent, repair, and remove damaged cells. The rate of mutation induction by low-level radiation is negligible when compared with the rate of endogenously-induced mutations.[7] Low dose radiation stimulates the protection systems, resulting in a reduction in mutations.[8] The immune system destroys cancer cells, and therefore cancer generally appears when the immune system has been weakened or damaged.[9] Low-dose radiation stimulates immunity,[10] so the idea that increased thyroid cancer follows an exposure to low-dose radiation simply contradicts biology.

In 1957 the UK had its most serious nuclear accident when there was a fire at the Windscale reactor No. 1 and plutonium production plant in Northwestern England. Emergency measures "started with the knowledge that cancer of the thyroid in children had been known to occur following X-ray doses greater than 200 rad (2 Gy). No cases were known to have occurred following exposures to smaller doses."[11] A recent study of the leukemia incidence of 97,000 Hiroshima survivors identified a threshold at about 500 mSv.[12] Since the blood-forming cells are more sensitive to radiation than the thyroid gland, it is reasonable to expect the threshold for radiation-induced thyroid cancer to be higher than 500 mSv.

1. Jerry M. Cuttler, D.Sc., is a nuclear scientist.
2. S.M. Javid Mortazavi, Ph.D., is a visiting scientist, Department of Diagnostic Imaging, Fox Chase Cancer Center.
3. James S. Welsh, M.S., M.D., F.A.C.R.O., is a radiation oncologist, Department of Radiation Oncology, Stritch School of Medicine, Loyola University-Chicago.
4. Mohan Doss, Ph.D., M.C.C.P.M., is a medical physicist, Department of Diagnostic Imaging, Fox Chase Cancer Center.

Radioiodine has been employed to treat hyperthyroidism for more than 70 years. The Franklyn et al.[13] study of many cancer rates following this treatment showed there was a significant increase in rare thyroid cancer mortality; however, "the decrease in overall cancer incidence and mortality... is reassuring." Continuing concerns about the risk of cancer have led to many other studies. The review by Cuttler and Pollycove in 2009 did not identify a conclusive link between low doses of radiation and thyroid cancer.[14]

The natural history of thyroid cancer strongly suggests the existence of self-limiting cancers, which are truly malignant but do not progress to lethal cancers, a first-time observation in the history of medicine. Early detection of self-limiting cancers results in overdiagnosis. Ultrasonographic screening of the thyroid in the young should be avoided. Lethal thyroid cancers, whose origin is still unknown, appear suddenly after middle age, writes Dr. Toru Takano.[15]

In conclusion, the Lubin et al. study on thyroid cancer following low-dose exposure lacks credibility. The radiation level needed to induce thyroid cancer is far above environmental levels, even after a hypothetical severe accident. Applying ALARA is not necessary for protection; it is very detrimental. The ALARA standard sustains the unwarranted cancer scare and impairs important applications of low-dose radiation in the diagnosis and treatment of serious illnesses, as well as in industry.

Mass screening for thyroid cancer after low-dose radiation exposure has led to unnecessary treatment with its inherent risks and has not been shown to save lives.

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HITL-Monitor: Towards Real-Time Monitoring of Operator Situational Awareness

by HARSH V.P. SINGH[1,2] and QUSAY H. MAHMOUD[2]

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Abstract

The Human-in-the-Loop (HITL)-Monitor offers a non-intrusive means of monitoring operator situational awareness by detecting human errors introduced via interactions between the operator and the Human Machine Interfaces (HMIs). Motivation for this application is partly in response to develop a system using computer vision to acquire data from legacy HMI devices common to industrial I&C systems in control rooms, field mounted control panels, etc. in nuclear power plants, aviation and locomotive industry. Visual data acquisition for real-time monitoring of legacy HMI devices does not require the target indicator device to be digitized incurring expensive retrofits, nor causes any process or production downtime. Secondly, automatic validation of equipment status during maintenance and/or prior to returning to service, is also explored through this application. Moreover, severity of accidents caused due to operator errors can be reduced, if HITL errors can be promptly discovered, trended and intervened upon.

1. Introduction

Severe industrial accidents in the nuclear power (NPP) industry have brought about significant improvements in reducing human performance errors, effective equipment status monitoring and identification of human factors engineering (HFE) deficiencies with legacy HMI designs.

Review of the NPP industry accidents that are rated high on the severity scale (ranging between 5 to 7) of the IAEA International Nuclear Event Scale (INES) [1], indicates a common theme of confounding operator performance issues combined with inherent HFE design flaws in legacy control room HMIs and poor equipment status monitoring practices leading to catastrophic failure of stand-by safety critical systems essential to remove reactor decay heat post SCRAM (emergency reactor trip).

The case of NRX Chalk River Canada (INES-5) - where multiple failures involving incorrect control rod status indicator lights in the control room, mechanical failures and miscommunication between control room personnel led to accidental withdrawal of the safeguard bank of shut-off rods. As a result it caused an uncontrolled reactor power excursion over 4 times its design limit in matter of 5 seconds resulting in a severe core damage on December 12, 1952; Three Mile Island, USA (INES-5) - where poorly designed ambiguous control room indicators introduced operator error to override the emergency cooling water supply, causing a partial meltdown of the TMI-2 reactor core containment on March 28, 1979; Chernobyl disaster, USSR (INES-7) - where confounding human factors and inherent design flaws led to a catastrophic reactor Unit 4 explosion and release of radioactivity on April 26, 1986.

Key accident precursors, as evident from the post accident reports [2], [3], [4] include: (1) reduction in situational awareness owing to human factors related deficiencies in legacy HMI design; (2) normalization to deviance to lax nuclear safety culture; (3) information overload (looking-but-not-seeing effects [5]) owing to rapid rate at which information was presented to operators via the control room HMIs (panel indications, annunciations, etc.); and (4) incorrect mental model of highly dynamic unit evolutions resulting in cognitive errors, owing to conflicting plant information supplied by failed or faulty sensors and incorrect field equipment status monitoring.

Beyond the advances in control theory, real-time process control and the like, industrial processes are lagging to utilize the potential advantage of advancement in high performance computing platforms, Cyber-physical system and pattern recognition using machine learning data analysis techniques. Taking advantage of these few similar technological advancements, this paper focuses on the application of computer vision and machine learning data analytics to build an Expert supervisory system framework (EYE-on-HMI [6]) that can be used to detect above identified accident precursors.

In this paper, the above conceptual framework and its potential application scenarios are further explored.

1 Ontario Power Generation, Computers, Controls and Design Dept., Nuclear Engineering Pickering, ON, Canada.

2 University of Ontario Institute of Technology, Dept. of Electrical, Computer and Software Engineering, Oshawa, ON, Canada.

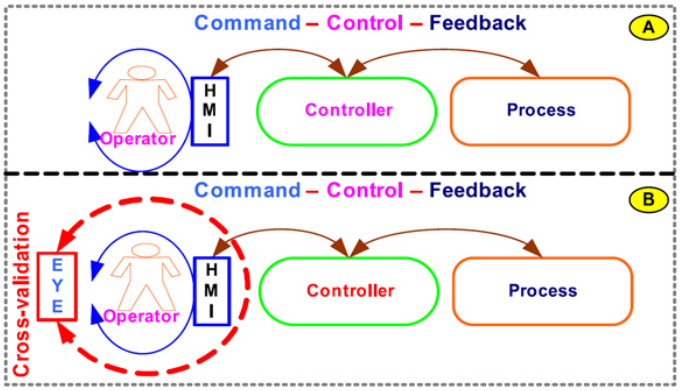


Figure 1 Architecture of: (A) Conventional Operator based Command-Control-Feedback process systems (B) EYE-on-HMI adds cross-validation to operator Command-Control- Feedback process systems.

1.1 Concept of Situational Awareness Monitoring

NPP control room operators must rely on manual effort and acquired cognitive skills to overcome the fundamental limitation inherent in the conventional operator based command - control - feedback architecture (Fig. 1-A), vis-´a-vis errors injected through human command inputs via HMIs. While rigorous operator training does minimize human command input errors, in reality unit transients do continue to fatigue the human brain owing to sensory overload thus, increasing chances of human-in-the-loop cognitive errors.

In contrast, the proposed Visual Data Acquisition (ViDAQ) [7] based EYE-on-HMI framework [6] (using computer vision) incorporates a closed-loop independent cross-validation over the conventional operator based command - control - feedback architecture (Fig. 1-B). Cross- validation, firstly, can be achieved by verifying what the operator is visualizing from the HMI, does truly match the plant process state. Semantically, this is coined as *inverse oculism,* as the operator performance is be being tracked indirectly by their interaction with the HMI, rather directly monitoring operator gestures and actions using a camera. Secondly, logging and verifying operator command input patterns in response to the current HMI state are in fact safe and in alignment with the approved procedure(s) can aid in monitoring operator situational awareness in real-time. The proposed solution is to realize data acquisition that leverages computer vision and machine learning techniques to independently capture and detect sequence of events from control room physical HMI devices such as indication lights, displays, meters, alarm windows, etc. via visual data acquisition. Lastly, monitoring situational awareness of a field operator can take advantage of computer vision in validating the equipment status during and post maintenance, to overcome looking-but-not-seeing effects [5].

1.2 Feasibility of Visual Data Acquisition (ViDAQ)

Although, NPPs have a plant information (PI) system [8], [9] that collects selected field transmitter sensory data for trending of plant process data, however the information that is actually displayed to operators via control room HMI is seldom captured fully nor analyzed for any anomalous patterns currently. Moreover, ViDAQ [7] offers a non-intrusive and relatively cost effective means of digitally capturing data from legacy HMI devices in control rooms and remote monitoring of field mounted control panels.

Computer vision based data gathering, though a unique application, is not far-fetched in terms of implementation using available real-time video and image processing technologies. Nevertheless, the key challenges and marked distinctions of this technique when compared to passive recording of control room HMIs are: (1) it involves video or image content or scene analysis; (2) it must offer an expert system that assists in validation routines that CROs continually exercise in control rooms; (3) must accurately, via computer vision, capture panel indication data.

The benefits of the ViDAQ [7] and EYE-on-HMI frameworks [6] include: (1) improved monitoring of operator situational awareness using non-intrusive means; (2) it can provide supervisory oversight on any missed procedural step for post event analysis and lastly; (3) it can hold a longer term contextual memory of all actual or spurious HMI indication events which can help to quickly correlate and diagnose problems that persist over long duration. These events otherwise can be missed by CROs over time or subside lower on priority list of issues.

The rest of the paper is organized as follows: Section 2 is a review of key enabling current state- of-the-art relevant to proposed framework. Section 3 outlines EYE-on-HMI [6] and ViDAQ [7] framework. Section 4 discusses an evaluation platform for HITL-Monitor, experiment results and application case scenarios using HITL-Monitor.

2. Related Work

In this section, we outline relevant concepts and review state-of-the-art of key enabling technologies envisioned to be at the core of EYE-on-HMI framework.

2.1 Computer Vision

As stated previously, Computer Vision (CV) is at the core of EYE-on-HMI framework to visually acquire HMI

state in real-time and perform video content analysis (VCA) [10]. VCA generally [11], [12] involves following computational steps image pre-processing or filtering to remove optical noise, segmentation for image dimensionality reduction for simplifying the image into a format that's more relevant and compact for computation, feature extraction [13] and classification based on machine learning techniques (E.g. convolutional neural networks [14]) to detect target changes in panel indication states and to accurately interpret temporal events. Notably, Machine Vision (MV) is a subset of several technologies under computer vision that has seen applications in robotics [15], intelligent transportation systems [16], industrial manufacturing etc. Therefore, MV is a specific application domain of the much boarder research topic that is computer vision.

Application of CV in EYE-on-HMI framework stands to extend the next generation of plant monitoring systems to use visual data acquisition for reading instruments mounted in control rooms or even remote field mounted gauges. The feasibility and reliability of this use case is evident from the current research trend in applying CV for traffic light, road sign, pedestrian recognition [17], [18] and driver fatigue detection [19]. Moreover, use of CV based devices across the automotive industry, for example Toyota's lane departure warning system (LDA) [20] and Volvo, Nissan's driver fatigue alert systems [21] etc. is also an indication of CV's feasibility and reliability in public safety domain by making vehicles safer on roads.

2.2 Expert Systems

Expert systems, synonymous with recommender, advisory or decision support systems, are rule based computer systems that may employ data analytics, machine learning (neural networks), optimization (fuzzy, genetic algorithms), pattern matching (inference) techniques etc. to emulate expert human judgement. Previous expert systems with target applications in NPP industry for fault diagnosis, operator support, alarm processing, etc. include: REACTOR [22] and RiTSE [23] as the earliest examples of rule based designs. LISP interpreter was used to process upwards of thousands of rules in real-time to predict nuclear accidents. The TPDES (Thermal Performance Diagnostic Expert System) [24] was earliest attempts to combine per component fault tree rules for each steam feed train equipment (Heat exchangers, boiler, pumps etc.) in conjunction with real-time sensor data to diagnose thermal losses, which is critical performance parameter to NPPs. Similarly, APACS (Advanced Process Analysis and Control System) [25] was a working prototype of a real-time monitoring and diagnosis system for feed water system in CANDU® NPP. It relied on several numerical reference models to reduce processing of large rule sets by constantly comparing simulation results.

3. Eye-On-HMI and VIDAQ Framework

3.1 EYE-on-HMI Framework

The proposed EYE-on-HMI framework [6] (Fig. 2a) is poised to provide an independent closed- loop validation of human-in-the-loop CPS by visually gathering data from HMIs. Validation of plant process state will aid CROs to improve early detection of unit upsets and transients to avoid expensive unit trip.

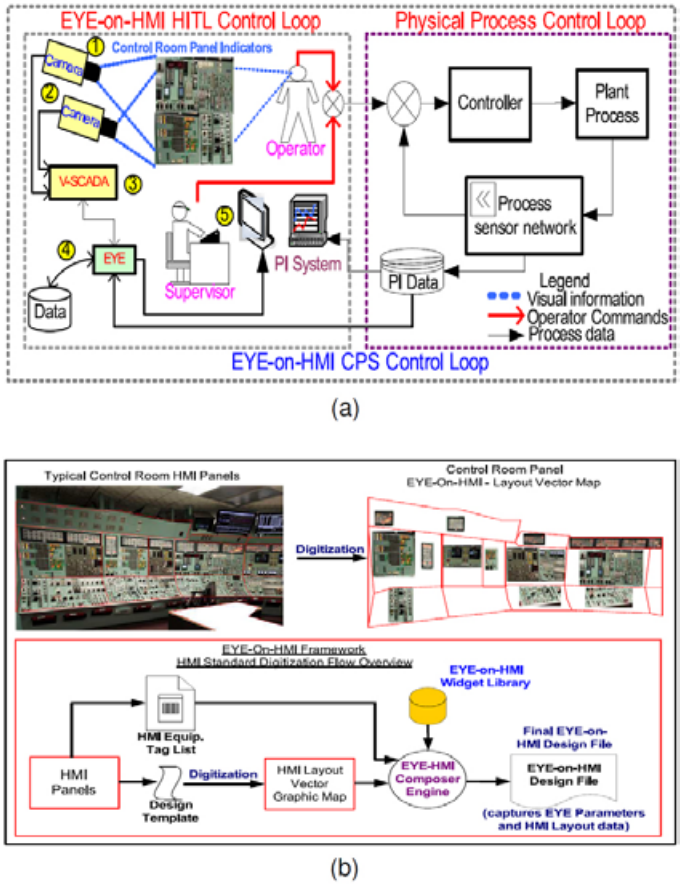


Figure 2 . (a) Expert Supervisory System (EYE) on HMI for Cyber Physical System (CPS) in control room environment (b) EYE-on-HMI Framework - HMI Layout to Final Design file generation flow.

3.1.1 Design Overview

The framework is conceptually realized as a stepwise data flow as presented in Fig. 2a. Operator view (Fig. 2a step- 1) of the control room panel HMIs can be captured using an array of cameras pointed from multiple angles to ensure an unobstructed stereoscopic view at all times. Camera video stream feeds (Fig. 2a step- 2) can be captured by specialised data gathering hardware platforms synonymous with industrial automation such as DCS and SCADA.

VCA [10] based solutions, commonly referred to here as V-SCADA (VCA enabled SCADA)(Fig. 2a step- 3),

can inspire further development of specialized intelligent VCA platforms for industrial control room surveillance to do visual data acquisition for typical industrial HMI devices (E.g. analogue meters, digital bar displays, indicator lights, process controller display, etc.). Successful data logging of temporal HMI events can be used by the EYE (expert supervisory system) [6] (Fig. 2a step- 4) to correlate real-time plant process data obtained from the plant information (PI) system. Finally, EYE [6] can generate cross-validation overview displays and reports for human supervisor to monitor both Operator command response in relation to live control room HMI state (Fig. 2a step- 5).

3.1.2 Control Panel Digitization Flow

The intent of EYE-on-HMI framework [6] (Fig. 2b) is towards realizing an extensible architecture that exploits computer vision and machine learning techniques to independently capture sequence of events from any physical control panel consisting of HMI devices such as indication lights, displays, meters, alarm windows, etc. via visual data acquisition (ViDAQ). One of many possible custom software flows to digitize any arbitrary control panel, to be interpreted by the EYE-on-HMI system [6], is described below.

An overview of the custom software tool chain employed by the EYE-on-HMI framework [6] to digitize any HMI design that the ViDAQ can recognize is shown in Fig. 2b. The digitization process involves converting the HMI design template information into a vector image format using a custom tool. Lastly, another custom tool, EYE-on-HMI [6] composer engine combines the input HMI vector template image and equipment type (HMI Equip. Tag list) with various parameters obtained from the custom EYE-on-HMI [6] widget library, to output the final EYE- on-HMI [6] design file. The latter output governs loading of appropriate ViDAQ library routines to successfully recognize a given HMI and extract data from various types of instruments present in the HMI.

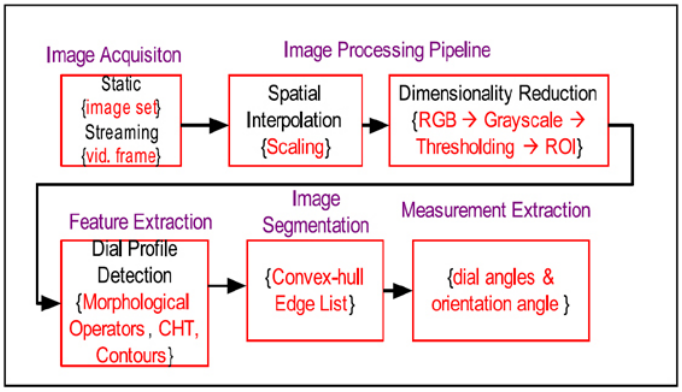
3.2 ViDAQ Framework

ViDAQ [7] framework currently addresses detection and data acquisition from two types of HMI devices: rotary multi-dial gauges (Fig. 3a) and indicator lamps (Fig. 3b).

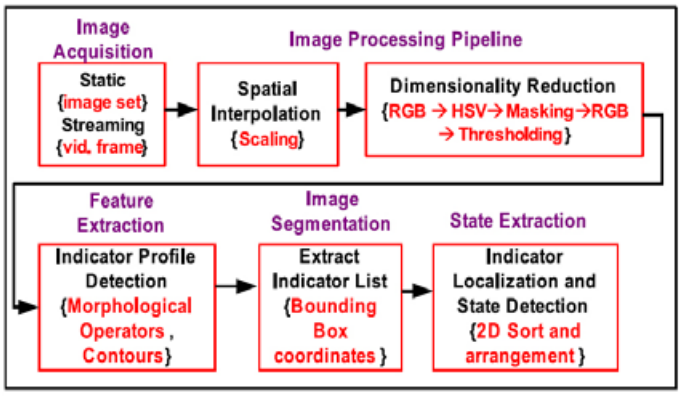
While an in depth technical evaluation of each processing stage as required for reading dial gauges, shown in Fig. 3a, has been published in previous work on ViDAQ [7], this paper limits the technical description of the framework and design to a high level for brevity.

3.2.1 Multi-Dial Gauge Reading

Motivation behind development of ViDAQ [7] framework is to include the ability to accurately and precisely acquire information from typical multi-dial meters,



(a)



(b)

Figure 3 . ViDAQ Framework (Processing Stages) (a) Dial Gauge Reading (b) Alarm Indicator Detection.

such as a clock with at least two (hours and minutes) dial arms (needles). Since, numerous industrial instruments are of rotary dial gauge indicators, using clock dials for prototype testing was a closest analogy. Initially, rotary dials with circular bezel was addressed which is now relaxed to recognize variety of dial shapes (E.g. box, semi-circle, etc.).

The processing stages required for reading dials as show in Fig. 3a begins with Image Acquisition. Image source for ViDAQ [7] is selectable between a fixed source (E.g. an image archive) or a streaming source (E.g. live camera video stream). Next, Spatial Interpolation (Fig. 3a), which is done to scale the input raster images to a required specific resolution *(width x height),* prior to processing, is done to bound both the run-time and error rate of the feature and measurement extraction algorithms. Either *Bicubic or Lanczos* [26] based scaling for image down sampling has been utilized in ViDAQ [7].

Image Dimensionality (Fig. 3a) Reduction is required to retain just the target shape features (edges and contours) in the image to aid in faster image processing with lower memory requirements. The target features in case of gauges, are the dial arms or needle shapes (Fig. 4a). This is achieved by converting a stan-

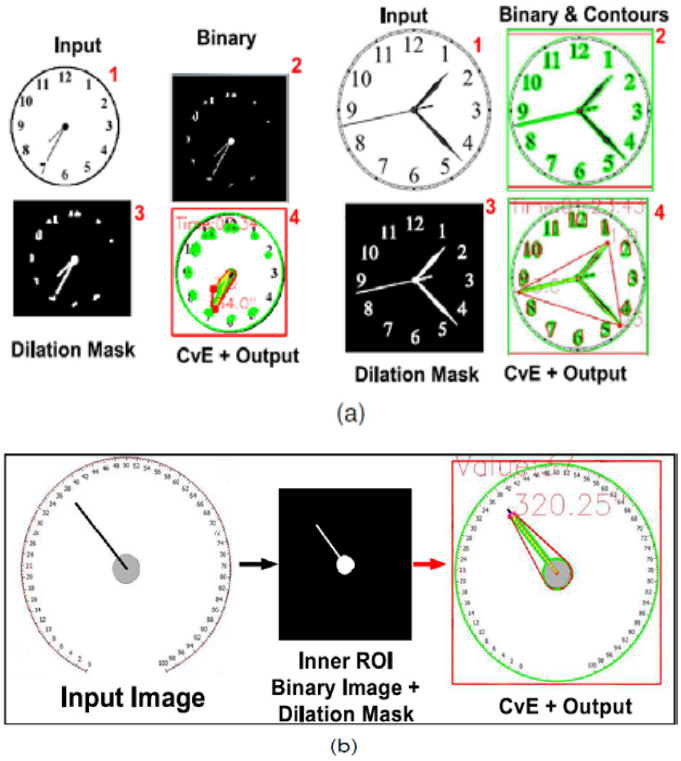


Figure 4 . ViDAQ processing stage outputs: Input image is converted to binary image, followed by application of Dilation mask to remove noise. Green outline identifies output of feature extracted shape contour and Red outline identifies output of segmentation step convex-hull envelope edge (CvE) as the dial arm; Actual ViDAQ processing example(s):
(Fig 4a) 2-Dial gauge (on left): Input: 07:35, ViDAQ Output: 07:34; 3-Dial (right): Input: 01:23:44, ViDAQ Output: 01:23:43.
(Fig 4b) ViDAQ single dial gauge reading. Input Image (left), Final image (right) shows convex-hull edges (CvE) (red outline) identifying the dial needle. ViDAQ Output acquired angle 320.25° and gauge value: 37

dard 3 channel (Red, Green, Blue) 24-bit pixel image (*Width x Height x 3*), into a single channel 8-bit per pixel grayscale image (*Width x Height*). The latter is further converted to binary *(black/white*) image format by thresholding - which replaces all grayscale pixel values greater than a pre-selected threshold constant, to value *1* (*white*) and others to *0* (*black*).

Thresholding is a critical step and sufficiently preserves the required visual features (edges and contours) of only the selected Region of Interest (ROI) areas required for processing. A standard adaptive thresholding algorithm, Otsu's thresholding [27] for generating binary images is adopted in ViDAQ [7] processing framework.

Feature Extraction step (Fig. 3a) is used to emphasize features of the target shape which aids segmenting the image to suppress any noise introduced by shadows and image vibration during image acquisition. ViDAQ's terminal Feature Extraction step is based on contour generation [28], that produces a set of points representing the edges of the dial needles in dial area ROI (Fig. 3a). A standard implementation of Canny edge detector based contours generator [29] has been utilized in ViDAQ [7] framework, which provides excellent signal to noise ratio (Gaussian smoothing removes high-frequency noise) with hysteresis thresholding to reduce false positive edges. In, Fig. 4a and Fig. 4b contour is shown by green outline around each shape in ROI. The dial outline or bezel can be detected using the standard Circle Hough-Transform (CHT) [30].

Image Segmentation (Fig. 3a) is used to retain only the extremities of the contour polygon bounding the dial arms, which is also known as the Convex-Hull of the target shape. In ViDAQ [7] the convex-hull edge (CvE) list facilitates resolving the dial needle end points (tips). In Fig. 4a and Fig. 4b, convex-hull edges (CvE) are shown as red outline edges enveloping the shape subtended by dial needles.

Measurement extraction (Fig. 3a), entails three steps: (1) identify the dial arm tips (end points) accurately; (2) determine the clockwise angle each dial needle makes with a reference segment (such as the 12 o'clock diameter segment) (3) convert the measured angle to required measurement quantity - for example in case of clocks, the longest dial arm represents seconds dial and shortest dial as hour.

3.2.2 Indicator Lamp Detection

In addition to acquiring data from rotary dial gauges, ViDAQ [7] is also designed to detect alarm status displayed by multi-colour indicator lamp lights (Fig. 3b). The processing pipeline steps: Image Acquisition, Spatial Interpolation and Feature Extraction are common to those in dial gauge reading (Image Segmentation and State Extraction technical details are skipped here for brevity).

Indicator lamps usually indicate binary states using two colours (E.g. Red and Green). Therefore, input images are first converted to *Hue, Saturation and Value* (HSV) colour space (Fig. 3b). Transformation of input RGB image to HSV entails converting to a 3-dimensional cylindrical coordinate space that allows intuitive selection of Hue and Saturation ranges for detecting only the desired colour captured at various luminance Value levels. That, otherwise is practically not feasible to achieve in RGB space owing to a non-linear combination of *Red, Green, Blue* values required for filtering similar shades (gamut) of a colour.

HSV further assists in creating a binary colour mask by using *Hue and Saturation* thresholding constants. This HSV binary image mask is equivalent in dimension

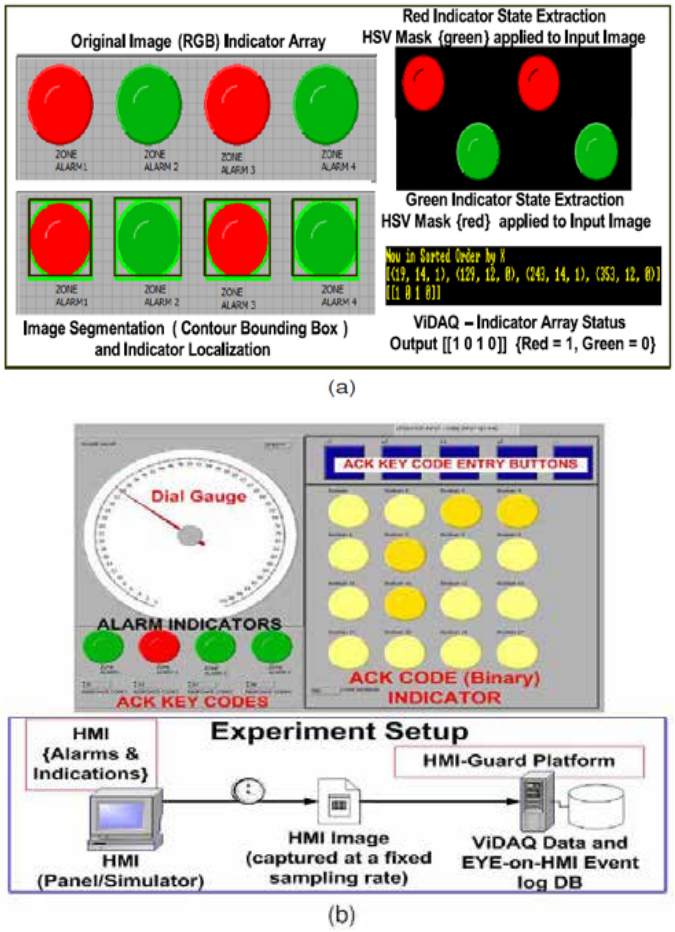


Figure 5 (a) ViDAQ Indicator Status Detection using HSV mask for each colour alarm indicator **(b)** HITL-Monitor Experiment Setup. Soft-HMI control panel (top); Experiment flow (bottom) - HMI states as images are captured at regular intervals and fed to HITL- Guard (or monitor) evaluation platform for processing.

to the original 3Ðchannel RGB image but only contains either 0, where the colour to be masked is detected and 1 otherwise, for each pixel location. Once the mask is applied (using bit-wise AND) to the original RGB image, it sets all R, G,B channels to zero value (black) for those pixels where the HSV mask contains 0, effectively suppressing pixels at locations where RGB values are for colour shades that are required to be masked.

In Fig. 5a, a green and a red mask is computed by thresholding the original HSV image using pre-determined upper and lower *Hue, Saturation and luminance* Value as thresholds for suppressing each red and green coloured indicators. For example, the green HSV mask is applied to original input RBG image to only detect indicators that are illuminated red and vice-versa.

4. Applications

Industrial application case scenarios, where monitoring of operator situational awareness using ViDAQ [7] and EYE-on-HMI framework [6] may potentially be noteworthy are discussed below.

4.1 Control Room - HITL-Monitor

In order to non-intrusively monitor operator situation awareness and Human-in-the-Loop (HITL) errors in a control room environment, the HITL-Monitor [31] (an application of EYE-On-HMI framework) is envisioned to acquire change in control panel indication states caused either due to dynamic plant process states and/or due to direct operator action. The data captured visually is then used to indirectly measure operator reaction metrics in response to control panel indication states - *inverse oculism* (looking inwards).

4.1.1 Experiment Setup

The evaluation experiment setup incudes using a *soft*-HMI (Fig. 5b) (software graphics generated) control panel that is used to emulate a typical industrial control panel with legacy indicator devices (E.g. a dial gauge and indicator lamps). In addition, the *soft*-HMI panel includes a basic operational rule to engage the user/operator to do a timed response in order to acknowledge active alarms. Experimental data is gathered by capturing screen-shots of the soft- HMI panel that shows the HMI state at (an adjustable) *900mS* sampling interval. The images are then streamed as input to the HITL-Monitor application for HMI event logging and evaluation (the images may as well be captured live using a camera). The HITL-Monitor uses the ViDAQ to extract the dial gauge values and indicator lamp states from each input image.

The soft-HMI panel (Fig. 5b) (developed using NI Labview 8) includes: (1) one constantly moving rotary dial gauge (scale: 0 to 100 with 50 ticks); (2) 4 multi-state Red (active)/Green (inactive) alarm state indicators; (3) a 4 x 4 grid to display a 16-bit binary word using Orange (1)/Yellow (0) lamps; (4) 5 code entry push buttons for user. The soft HMI panel activates a corresponding zone alarm (Red) once the gauge reading is within the zone (high/low) alarm limits window.

Associated with each Zone alarm, is a pre-set alarm acknowledgement (Ack) code. The user must input the Ack code by using keypad push buttons. The user input Ack code (16-bit value) is displayed on the 4 x 4 indicator grid. The required operational logic is to acknowledge the zone alarm as soon a zone alarm activates and prior to the next zone alarm activation, by inputting the correct pre-set Ack key code.

In Fig. 6 (top plot) ViDAQ [7] captured dial gauge value, indicator alarm states and operator input Ack code are plotted over each input sample image index (or time). The captured gauge dial value reading is validated as a monotonically ramping linear curve, 0 to 100 labelled Gauge Reading (Ð symbol), in top row of plot in Fig. 6.

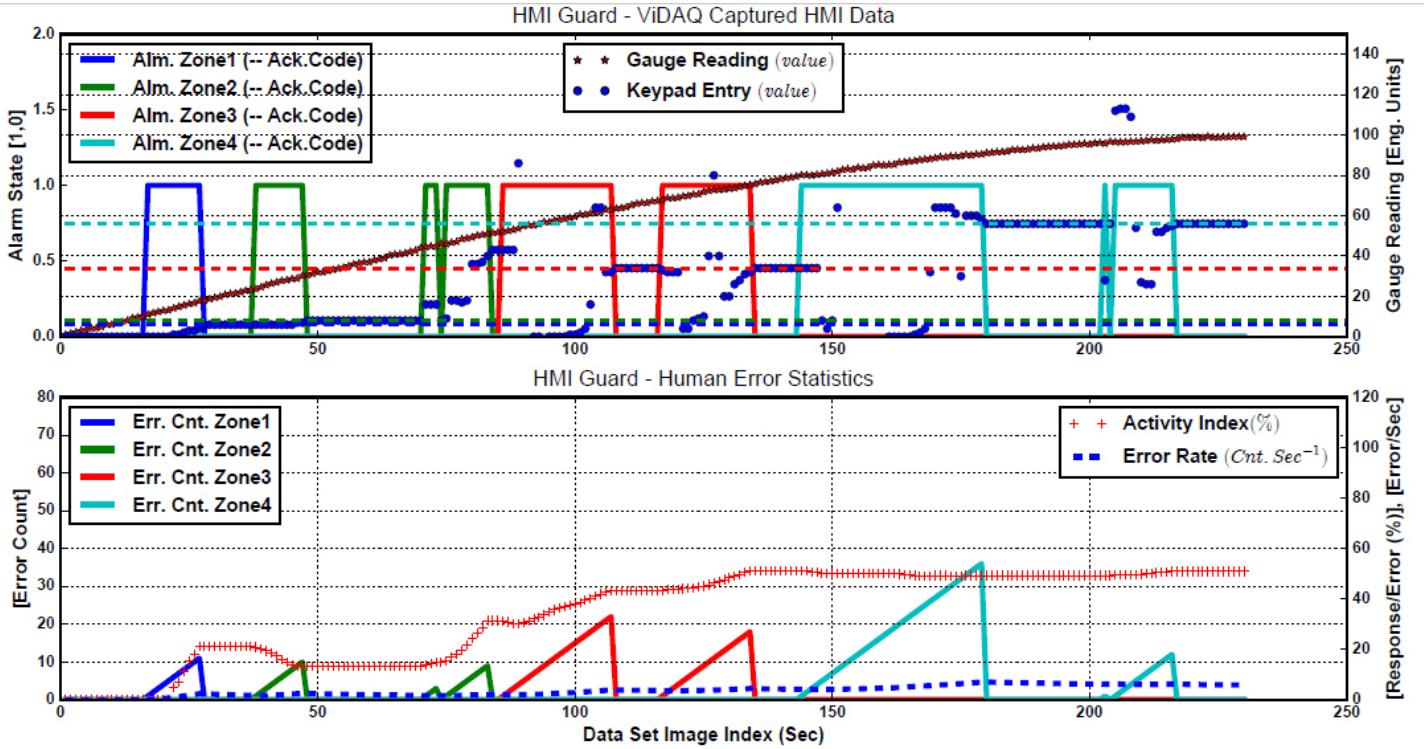


Figure 6 HITL-Guard (or Monitor) Evaluation result: Top graph indicates ViDAQ visually captured data from soft-HMI - Dial gauge value, indicator alarm states, and operator Keypad Entry values. Bottom graph indicates human performance metrics: Activity Index (%) and Error Rate (ErrCnt/Sec).

When the gauge dial value is within the window of a particular Zone alarm (*Low-Hi* limits; E.g. *Zone1:10-22, Zone2: 23-50, Zone3: 51-78, Zone4:79-100*), corresponding Zone alarm (*Alm:Zone*) gets activated (*ON*). It is deactivated (*OFF*) once the dial exceeds the Zone's Hi limit. This behaviour is accurately captured by HMI-Monitor platform output, as seen in top row of plot in Fig. 6 as 4 non-overlapping step functions for each *Alm: Zone1; 2; 3; 4* that activate and deactivate in sequence with respect to the *Gauge Reading* value.

The *Ack*: code values input by user via the key code entry buttons in response to Zone alarms are seen as scattered values (• symbol) in top row plot of Fig. 6. Evidently, each *Alm:Zone* deactivates when user input Ack: code value matches the pre-set *Ack*: *key* code (shown as dashed horizontal lines having same colour as *Alm:Zone*), thus validating the intended operational requirement for operator action.

Bottom row of plot in Fig. 6 shows computed human operator performance metrics updated every sample interval (t_{sample}). Two error counters are utilized, firstly, a Zone Error Count

(*Err.Cnt.Zone*), associated with each zone alarm event (Note: *Zone Error* in this context refers to sampled HMI states, where the HMI is in trouble or alarm state). It keeps count of number of sample intervals elapsed since a Zone alarm was triggered and only resets to 0 once the associated zone alarm is successfully acknowledged by user - this behaviour emerges as a sawtooth pattern in Fig. 6.

Secondly, a Cumulative error count (*Cuml.ErrorCount* Eq. 1) is a running tally of individual *Err.Cnt.Zone* values and only resets at end of experiment. This value is used to calculate subsequent metric values. This value is used to calculate subsequent metric values.

$$Cuml.ErrorCount = +\Sigma_{i=0}^{MaxAlm} Err.Cnt.Zone_i \quad (1)$$

$$ActivityIndex(\%) = \frac{\Sigma_0^{t_{sample}} \Sigma_{i=0}^{MaxAlm} \alpha_i}{Cuml.ErrorCount} \times 100 \quad (2)$$

$$ErrorRate = \frac{Cuml.ErrorCount}{t_{sample}} \quad (3)$$

Activity Index (%) (Eq. 2) is the ratio of t number of operator initiated updates (activity) on the HMI with respect to the current value of Cuml.Error Count. This metric captures the operator responsiveness (i) with respect to existing alarms events on HMI. Whereas, Error Rate (Eq. 3) (▪ symbol) in bottom row Fig. 6, tracks in real-time, overall error in operator response to correctly address HMI alarms. This metric effectively aids in capturing operator situational awareness (Note: t_{sample} is the elapsed time obtained from current sample index x ViDAQ sampling interval or *900mS*).

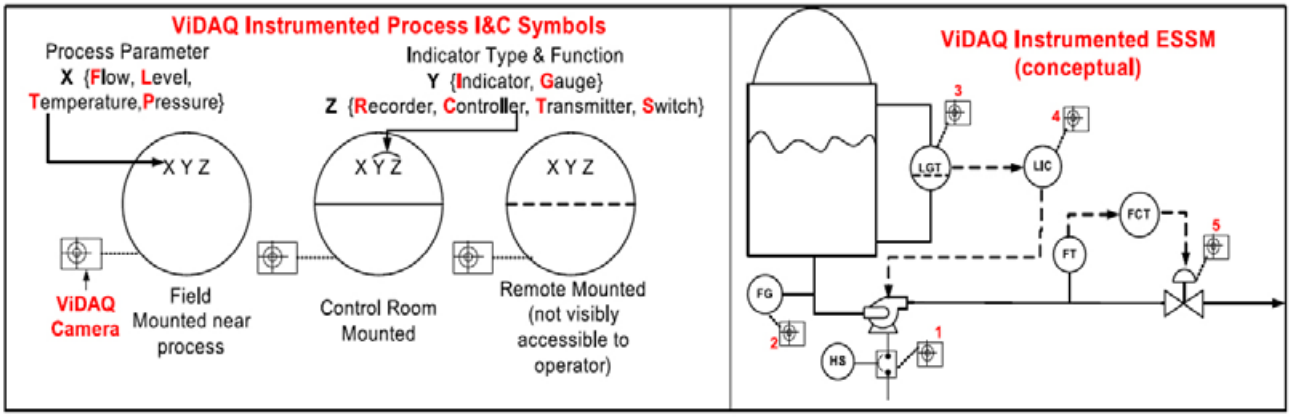


Figure 7 ViDAQ Instrumented ESSM. (left) Standard IC symbols instrumented by ViDAQ cameras; (right) Field deployment of ViDAQ cameras for ESSM: 1. circuit. breaker hand switch position, 2. field mount. flow gauge, 3. , 4. Field & control. room mount. level gauge, Valve positioner.

4.2 Equipment Status Monitoring - HITL Monitor

Industrial operation relies on regular system outages. During outages, maintenance requires equipment to be taken out of service and placed in non-standard states. Moreover, it is crucial that post maintenance activities ensure system equipment is returned to its final required state to ensure worker and overall plant operation safety. Therefore, equipment status monitoring is usually tightly controlled by procedural work authorization processes and involves equipment tagging to visually identify field equipment states in a given work area. Moreover, a station wide electronic equipment status monitoring (EESM) system is used to check for logical inter-ties such as energy isolation points, de-energization and back-feed prevention guarantees.

Despite above measures the ultimate interface to the field equipment is the field operators. Who apply, record and manually convey the equipment state to the EESM. If a human-in-the-loop error were to be introduced in performing concurrent verification in ensuring end equipment state, is actually, as indicated on the work authorization forms, then it can introduce significant cascading error into the station wide EESM.

Alternatively, a distributed network of either permanently or temporary installed wireless camera's can be deployed in the field safe work areas to capture equipment states where possible (Fig. 7) E.g. valve stem/ actuator position, indicator gauges readings, circuit breaker states, etc. ViDAQ in conjunction with EESM can then perform final equipment state validation automatically pre and post-maintenance.

Conclusion

This paper presents the HITL-Monitor [31] platform built on ViDAQ [7] and EYE-On-HMI [6] frameworks, which is targeted for visually monitoring Human Machine Interfaces [31]. The proposed approach provides a non-intrusive (using computer vision) means of monitoring and detecting human-in-the-loop (HITL) errors in real-time both in control room environment and in field by monitoring equipment status. Future work entails extending the HMI-Monitor platform to include pattern recognition to predict HMI HITL errors.

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Nomenclature

CV	Computer Vision.
DCS	Distributed Control System is a non-centralized computer based control system usually targeted for monitoring and controlling several processes in a plant.
EYE-on- HMI	Expert SupervisorY SystEm-on-HMI. – Term used to refer to the proposed system framework to monitor control room HMIs.
SCADA	Supervisory Control and Data Acquisition - control system involving network of dedicated programmable controller(s) for controlling or monitoring few plant processes.
HMI	Human Machine Interface generally refers to software interface. In this paper it refers to any generic man-machine interface implemented either in hardware and/or software.
HITL	Human-in-the-Loop are associated with operator performance due to cognitive errors.
HFE	Human Factors Engineering.
ViDAQ	Visual Data Acquisition is the proposed methodology to visually acquire data from HMIs that are normally used by human operators.

Reactor Fast Acting Platform

by EDWARD VECKIE[1], EMILY FERREIRA[2], JIM HANNA[2]

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Abstract

In this highly regulated industry, developing and introducing the best tools to perform a function can pose a challenge. An innovative culture to develop safer more efficient systems can make existing products obsolete. This can be termed 'Proactive Obsolescence' and was incorporated by Bruce Power for maintenance access to the reactor area bridge in the reactor vault. Reactor maintenance requires a dedicated team of professionals to ensure safe, efficient work execution. Scaffolding has long provided a necessary function yet it introduces risks such as: foreign material entering the systems, working at heights on a temporary structure and radiation exposure for the workers installing and removing the scaffolding. Bruce Power personnel saw the need to minimize these risks and partnered with Unified Engineering to design and manufacture a mobile platform to eliminate the need for scaffolding. Bruce Power's Human Factors and Operations / Engineering departments supported the design to ensure the best possible platform system. The scope was to design a platform with the following considerations:

- In its compacted state must be able to pass through the airlock
- Be deployed without any tooling, hardware or electrical powered motors/drives
- Be able to be lifted in place by an overhead crane
- Be deployed with 4 person crew in 1 ½ hour time frame
- Have a coverage area of 16 feet by 10 feet (filling in the recesses in the bridge pit where accessibility is required)
- Design based on Human Factors and Foreign Material Exclusion considerations

The result was a folding platform system that reduced 90 man hours of radiation exposure, ensured that FME was achieved, eliminated the issue of working at height, and achieved substantial reduction in reactor maintenance and deployment time. This project is an example of 'Proactive Obsolescence' and an example of how innovative thinking and partnering resulted in the elimination of several problems.

Keywords: Bridge Crane Maintenance, Foreign Material Exclusion, Working at Heights, Human Factors, Proactive Obsolescence, Critical Path.

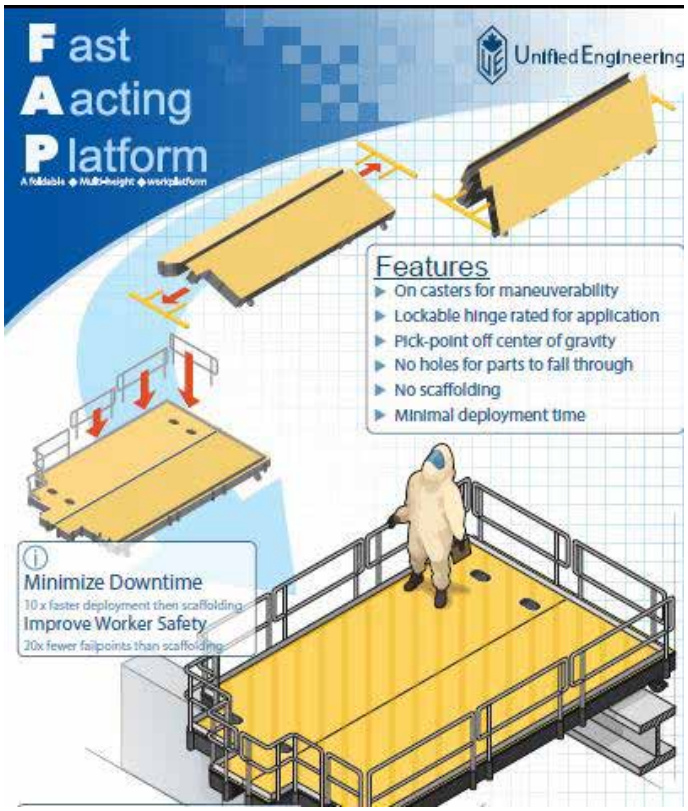

Figure 1: Fast Acting Platform Conceptual Graphic

1. Introduction

Reactor maintenance is a necessary process for the smooth and efficient operation of any nuclear power plant. Safety is of paramount concern, which is why Bruce Power and Unified Engineering teamed up to address and resolve some major concerns associated with reactor maintenance at the Bruce Nuclear Generation Station. The concerns in this case were radiation exposure to employees, working at heights, foreign material entering the fueling machine duct and outage duration. A solution needed to be developed as the conventional system of scaffolding contributed to these safety and schedule concerns. Aside from these concerns, Bruce Power wanted to shorten the outage critical path. Bruce Power worked with Unified Engineering to conceive a system to make scaffolding obsolete. The result was a foldable, multi-height

1 Unified Engineering, Hamilton, Ontario
2 Bruce Power, Kincardine, Ontario

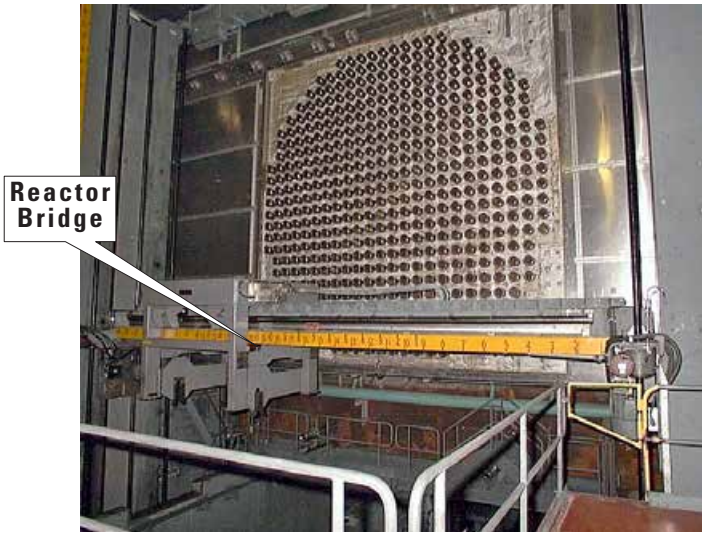

Figure 2: Reactor Area Bridge & Reactor Face

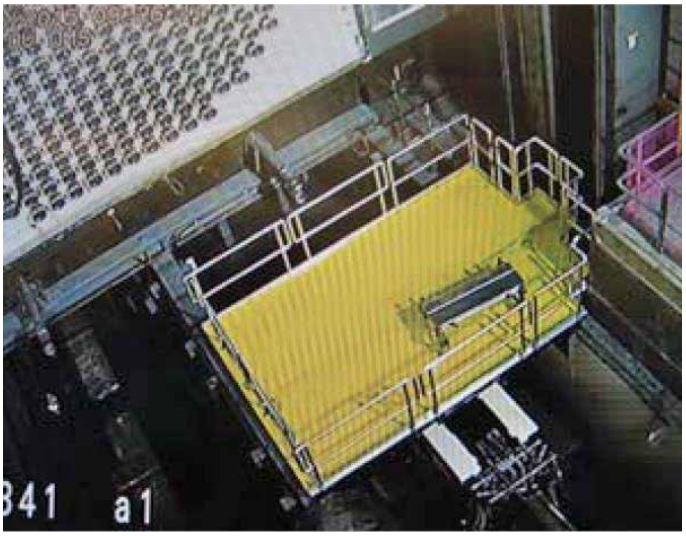

Figure 3: Platform in use (1/2 deployed)

platform that was designed to meet Human Factors and the first platform was delivered in 2 month time frame. This paper discusses the evolution of the platform from initial concept, design through to testing and turnkey commissioning.

2. The Reactor Area & Design Considerations

2.1 Background

Figure 2 shows the reactor face. The floor opening in front of the face is called the Fueling Machine Duct (FMD). The FMD runs under each reactor and is connected to the fuel handling system in the control service area. The Fueling Machine Trolley carries the Fueling Machine to each unit to deliver new fuel and extract spent fuel.

As shown in Figure 2, the Reactor Area Bridge (RAB) spans the space between two large vertical columns on the north (left) and south (right) side. Below the reactor face, the fuel duct runs east-west and has steel walls on the north and south side of the opening (both called Structure B), plus a large beam/frame structure in the center of the duct (called Support Structure A). The platform is lowered down below the Reactor Face and then travels under the RAB and lands on the support structures. Since the platform is lowered directly under the RAB, it had to be designed to be picked up from one side. Figure 3 below shows the platform being deployed.

2.2 Platform Features

The Bruce Power Human Factors team partnered with Unified Engineering and the result was a system that can be rolled, rigged, assembled and installed without the use of any hand tools and fully met maintenance operations requirements.

The unique features of the Fast Acting Platform include:

- Folds up to fit into the air lock.
- Is easily moved by hand, despite its size and weight.
- In the vault, it folds down and locks into position, without the use of any tools.
- All handrail and filler plates are mounted on a rolling cart for transport into the vault.
- All the necessary handrails can be installed (no tools) prior to hoisting over the FMD.
- All the rigging is fixed and covered on the deck.
- The platform is counterbalanced to allow hoisting from one side, so it can be maneuvered under the RAB.
- The platforms can be placed on the north, south or both sides of the RAB if a full deck across the FMD is required.

2.3 Safety & Financial Justifications

The great motivator for this case of proactive obsolescence was the working at heights issue, one of Bruce Power's seven categories of high risk jobs. An additional safety & financial benefit was the reduction in man hours associated with installing and removing scaffolding. Figure 4 shows their "Take Two (For Your Safety)" cards that workers use to notify management of job site hazards and potential


TAKE TWO
FOR YOUR SAFETY
NAME: _____ DATE: _____
JOB/TASK: _____
LOCATION(S): _____
COMPLETE AT THE JOB SITE
AM I PERFORMING A HIGH RISK JOB TODAY?
CHECK ALL THAT APPLY.
☐ ELECTRICAL
☐ CONFINED SPACE
☐ WORKING AT HEIGHTS
☐ ROTATING EQUIPMENT/ MOVING PARTS
☐ RIGGING AND LIFTING
☐ RADIATION
☐ PRESSURIZED FLUIDS/ COMPRESSED GAS
OBSERVE THE WORK SCENE AND LIST HAZARDS
ARE THE CONTROLS GOING TO KEEP ME SAFE?
YES - What are they? NO - I need to back out
POST-JOB BRIEF
DID THE JOB GO AS PLANNED? YES NO
Any lessons learned to make it safer?
You can count on me. EVERY STEP. EVERY TIME. EVERY DAY
Bruce Power

Figure 4: Bruce Power's Take Two (For Your Safety) Card

methods of mitigation. There are costs associated for the install and removal for the worker resources and even more costs associated with each revolution for dose. Traditional scaffolds are installed in the vault during outages and if the Critical Path schedule is affected by their installation and removal, the lost production costs can drive costs even further. Aside from worker safety and FME issues that have been addressed with the Fast Acting Platform, the system essentially pays for itself in its first deployment.

3. Human Factors

3.1 Highlights of usability

Human Factors (HF) involvement at the beginning and throughout design was essential in the design of the platform with safety and ease of use as their key focus. By design, the workers are able to deploy the platform and execute work in the reactor vault with full Personal Protective Equipment (PPE). They don't require hand tools and cannot lose any parts since all pieces on the platform are attached, thus eliminating FME risk. Additionally, HF identification of critical task steps aided in producing an event free first time installation.

3.2 Learning from OPEX

Review of the current platform systems in use for reactor maintenance at Bruce Power yielded important information for design to address and improve on issues and challenges such as:

- Platform maneuverability
- Handling for transportation in the station
- Human error in mixing up and misplacing loose pieces
- Orientation and configuration issues of components for assembly
- Identification of critical task steps

3.3 HF Influence on Elements in Component design

HF analysis and use of Bruce Power HF design guidance, significantly influenced the design and selection of elements for prevention of human error and promotion of usability in the platform design.

3.3.1 Castor Size Selection

Castor size selection was a key element in transportation and maneuverability of the platform in the station and in the reactor vault. HF specified a castor wheel size of 12 inch diameter that could swivel in all directions and be locked in place. This addressed the 2% slope in the vault floor towards FMD and OPEX from previous reactor maintenance systems where smaller wheels became caught in the 1-1/2 inch floor expansion joints and floor drains. The locking status of the castors is made visually apparent to the workers with the lock tab positioning. The castors are removable by pulling an easily manipulated detent pin once the platform is in the lowered and locked position.

3.3.2 Platform Weight and Shape

Human Factors focused on the ability to handle the platform during transportation due to its' weight and size. Therefore, in order to optimize locations for maximum worker push forces, the locking bar/grab bar was placed at a specific worker height for pushing/pulling in transport configuration. With consideration of weight and ergonomics, the platform was designed to be able to be moved manually by 2 workers with space on the grab bars for a third if necessary for maneuvering in tight space locations such as an airlock or in the reactor vault walkways.

When changing configurations from transportation to unfolding for use, the platform was designed to prevent human error. The design ensures that the platform cannot be folded or unfolded accidentally, as workers are physically unable to remove the grab bar until the weight is taken by the crane hook.

3.3.3 Grab Bar and Transportation Handle Design

Human Factors used design guidance and industry standards to determine the size and height for optimal pushing forces for the workers in determining where to locate the bars on the platform. Additionally, the grab bars serve as the restraining element to hold the platform in the upright configuration, eliminating the need for additional components. It is visually apparent to the workers if the handles are not installed and locked correctly.

3.3.4 Lifting Lugs and Pocket Doors

The lifting lugs by design are easily accessible. At all times the lugs remain attached (no loose parts) and sliding pocket doors "fill in" the platform deck and enhance platform use once the platform is installed (preventing FME). The lifting lugs are dual purpose and serve as a fall arrest anchor point once the first platform section is installed.

3.3.5 Hinge Pin

HF impacted design selection for detent pin, requesting due consideration of worker dexterity with 3 layers of gloves. Insertion of the pin and confirmation of pin engagement whether it is locked or unlocked is visually evident for verification. If the locking pin button is flush with the pin surface it is unlocked. If the locking

pin button is proud of the surface then it is locked.

3.3.6 Handrail and Plate Design

This system was designed with usability as a focus to save time and prevent incorrect handrail selection. OPEX from previous platforms had an influence on handrail design and labeling. Human errors on previous platforms included having multiple handrails in several different sizes being brought up or installed in incorrect locations while the platform was deployed on the reactor face. The design of the platform ensures that all handrails are attached while the platform is in the unfolded configuration on the vault floor. The handrails and plates have labels that match the mounting locations on the platform, and are easy to use and align so there is no lost time due to confusion as to where the rails go.

Additionally, fastening of handrails/plates with locking pull pins was selected to eliminate the need for hand tools and to reduce the possibility of human error in correct attachment of handrails/plates. This was achieved by having a visually apparent space between the barrel and the handle if the fastener was not fully engaged.

3.3.7 Center of Gravity (COG) Markings

Center of Gravity markings and platform weights are labeled on the platform for quick reference in the field to avoid having to refer to drawings every time this information is required.

3.3.8 Transportation Cart Design

The transportation cart that accompanies the platform has two functions that promote usability. First it is the only other piece of equipment required to transport all accompanying equipment (handrails, castors, rigging and lifting equipment) and therefore helps minimize the footprint in the reactor vault where space is an issue. Secondly, it helps manage inventory and parts by allowing a quick visual check for all parts prior to vault exit. This helps the worker teams know that all parts are present and not missing prior to the next outage without having to open radiation protection wrapping in a contamination control area between outages. This is achieved by having all components in specific locations with labeled slots, with the handrail outlines painted on the carts for ease of user identification.

3.3.9 Aids in Rigging and Craning

The method to rig and crane the platform, to fold it out and deploy it, and to rig it for lifting into place on the reactor face designed out the possibility of human error in attaching rigging to incorrect locations on the platform. When unfolding the platform, there is only 1 pick point that the hook can be attached to at a height that is accessible by all workers. For rigging, to lift the platform in place there are only 4 locations on the platform that can be connected (swivel hoist rings/lifting lugs in the recessed sliding doors). These also serve a dual purpose as being designated fall arrest tie off locations once the first half of the platform is deployed. Additionally, the platform cannot be installed backwards on the reactor face as the halves only fit one way.

3.4 Designing to Prevent Human Error

Engineering barriers are the best line of defense against human error. Through designing out the possibility of an error or placing an engineered barrier that physically prevents the error, it improves the robustness of the design in the reduction of the probability for human error. This results in less reliance on procedural or administrative barriers which are less effective than engineered barriers. Examples of engineered barriers on the platform include: the inability to remove the locking bar on the platform until the crane has the full weight to eliminate the risk of the platform collapsing, easy visual checks for correct installation and engagement of components (platform locking pin, castor locks, handrail pins), the platform can only be installed in one correct orientation, and specific rigging location are constrained to the lifting lugs only and therefore it cannot be incorrectly rigged.

In addition to the engineered barriers designed into the platform, deployment of the platform was reviewed and human performance checks were incorporated into the execution procedures. This resulted in Human Factors identification of critical steps requiring human performance tools such as independent verification in the work order task instructions and a full procedure review for first time deployment in the Unit 1 outage. Also, human factors reviewed training and mock-up deployment prior to vault entry and attended the first deployment in vault during the unit 1 outage.

4. Conclusion

Proactive approach is sometimes required to improve on existing systems. ‘Proactive Obsolescence’ can be used to replace an existing system to make significant gains in worker safety, operations and schedule. In this case, scaffolding was replaced by the ‘Fast Acting Platform’ which is safer, easier to use and faster to deploy. Engagement with human factors early in conceptual design and continual involvement through the design and implementation stages of a project was key in ensuring usability and engineered barriers to prevent human error in the use of the equipment. The platform was designed with usability in mind which resulted in:

- Ability to deploy equipment in triple gloves (vault PPE) without any hand tools
- Ease and simplicity of assembly on the vault floor
- Simple inventory management of parts

This is evident in the reduction of time, dose and human error. After the first successful deployment in the Unit 1 outage, the platforms are now implemented for use at both Bruce Power stations for a continual savings of time and dose.

Unified Engineering designs and manufactures structures, components and engineered systems with a global customer reach. From an initial RFQ scope document, Unified provided an integrated design/manufacture fixed price quote with an expedited delivery deadline. Bruce Power worked closely with Unified Engineering at the concept stage to achieve a product that met the initial scope requirements, 2-month delivery schedule (for the first platform) and original fixed price quote.

Faculty Position in Nuclear Engineering Royal Military College of Canada

The Department of Chemistry and Chemical Engineering at the Royal Military College of Canada in Kingston, Ontario, invites applications for a bilingual position at the level of Assistant Professor. The Department desires applicants with a recent PhD, or one nearing completion, in nuclear engineering or a closely related field.

Full details located at:
https://engineering.AcademicKeys.com/job/fsrt9xw3

Closing Date: 4 May 2018

News from Branches

Sheridan Park Branch/Rajendra Jain

For very sad reasons, a planned presentation by Dan Meneley in January, was cancelled. The branch executive committee meeting was held on March 08 to discuss the 2018 business plan and upcoming branch activities.

Uoit Branch/Mohamed Saleh

Executive members were elected by the students at UOIT, and roles were assigned at the first council meeting. Mohamad Saleh is the chair of the UOIT branch, along with Eyad Tamimi as the vice chair.

The Branch is organizing an event due for March 22nd, to bring in a panel consisting of senior engineers working at OPG. This panel will educate and answer questions regarding the career pathway for engineers. We have confirmed 4 former graduates from UOIT that now work at OPG to be a part of this panel. We have forecasted a high student turnout for this event, thus, we attained the biggest lecture hall available on campus.

The list of the executive members of the UOIT Branch is as follows:

Branch Chair:
Name: Mohamad Saleh
Status: Second year
Email: mohamad.saleh@uoit.net
Vice Chair
Name: Eyad Tamimi
Status: Third year
Email: eyad.tamimi@uoit.net
Treasurer
Name: Peter Schwanke
Status: Graduate studies
Email: Peter.Schwanke@uoit.ca
Secretary
Name: Rami Nessim
Status: Fourth year
Email: rami.nessim@uoit.net
Communications and Marketing
Name: Sidhartha Bhardwaj
Status: Third year
Email: sidhartha.bhardwaj@uoit.net
Event Coordinator
Name: Tyra Gordon
Status: Management year
Email: tyra.gordon@uoit.net
Event Coordinator
Name: Roman Popov
Status: Fourth year
Email: roman.popov@uoit.net

New Brunswick Branch/Derek Mullin

The NBB Executive Committee members are:

Chair:	Derek Mullin
Past Chair:	Mark McIntyre
Secretary:	Rick Sancton
Treasurer:	Elif Can Usalp
Outreach & Education:	Kathleen Duguay
Member-at-Large:	Paul D. Thompson
Member-at-Large:	Michael Hare

Branch Events
Mike Bourque

On January 23, following a social mixer Mr. Michael Bourque delivered a lecture regarding NB Power's 2017 Integrated Resource Plan to approximately 18 interested attendees. The presentation was followed by an informative question and answer period, and the branch chair presented Mr. Bourque with a small token of appreciation.

Mr. Bourque is a professional engineer and is currently the Director of Energy Projects with NB Power. He has worked for NB Power for more than 37 years with most of this time spent within the strategic planning area and directing the Integrated Resource Plan. Michael's work has contributed to the development of major supply and transmission projects as well NB Power's long term strategic plan. Currently Michael is leading the development of new and innovative projects such as Micro-Grid Demonstration projects which combines solar and battery storage as well as other utility scale energy storage opportunities.

On February 9, Mr. Bourque again delivered the lecture at the Point Lepreau Nuclear Generating Station site as part of a CNS Lunch and Learn for those who could not attend the evening lecture on January 23.

Manitoba Branch/Jason Martino

The last event the Branch hosted was an evening talk by Dr. Kathy McCarthy, V.P. of Research and Development on October 11, 2017 in Pinawa at the W.B. Lewis Centre. The talk was open to the public and attracted a small but very interested group of CNS members and other people. The talk focussed on the 10-Year plan for science and technology research, the path to realizing it, and highlighting recent accomplishments.

Durham Region Branch/ Jacques Plourde and Nick Preston

No events were held during the reporting period. Planning is taking place for activities during the 2nd quarter of the year.

Toronto Branch/Mo Fadaee

CNS Toronto branch held 2 events during February and beginning of March.

1. On Feb 27, CNS TB with the collaboration of the Mechanical Engineering department of UOIT the Branch took students (see below) to visit the mock-up CANDU reactor at Darlington Energy Complex. It was a half-day tour. We had speakers from OPG that talked about the refurbishment projects and the future of nuclear energy and SMRs. We also had guest speakers from the Human Resources department to talk about how students can get more involve with OPG and apply for positions.
2. On March 1st we held a seminar titled "The Fast Neutron – A horse of a Different Colour" by Dr. Peter Ottensmeyer on Physics department of UOfT. We had about 20 registrants. At the end we had a nice discussion sessions and people were suggesting to hold this kind of event on a monthly basis.

The Branch plans to do 2 more events in March (a visit to the McMaster reactor and the Darlington Energy Complex).

Western Branch/Matt Dalzell and David Malcolm

General

The Western Branch now has a Facebook page! Like us at Facebook.com Canadian Nuclear Society – Western Branch. Members of the Saskatoon Chapter also met December 15 to talk about providing local support to this year's annual conference.

Outreach Activities

- **Jason Donev** participated in a panel on the next generation of the nuclear workforce at the Canadian Nuclear Association's annual conference in February.
- Branch education coordinator **Aaron Hinman** will be representing the CNS at the Earth Science for Society Exhibition in Calgary March 18 to 20.
- Branch co-chair **David Malcolm** is working with Canadian Nuclear Laboratories to develop collaborative projects within Natural Resources Canada SMR Roadmap initiative.

Branch co-chair **Matthew Dalzell** was a guest lecturer in December at the Johnson Shoyama Graduate School of Public Policy on risk communications. He was also an invited speaker at the Spectrum conference put on by the University of Saskatchewan's student chapter of the IEEE, speaking on innovation and opportunities in small nuclear plants.

Golden Horseshoe Branch/Kendall Boniface

This month (March) the Branch has arranged for a talk to be given by Jason Wight, Director of Engineering at Pickering NGS. Taking place at the end of the month, Jason will share his experiences in the nuclear industry, and his views on the current innovation and technology climate, and the future of nuclear energy both in Canada and round the world.

The Branch has also made arrangements for the CNS to be present at the Bay Area Science and Engineering Fair. Several CNS-sponsored awards will be given to students presenting outstanding work on energy-related issues.

Chalk River Branch/Andrew Morreale

The Branch had to reschedule the CNS President's Dinner due to some logistics issues. The new date will be in late March or April and is yet to be exactly determined.

Besides that the next upcoming event is the Renfrew County Science Fair which will be held on April 7th. CNS-CRB will be assisting in judging the fair and will be contributing some awards for the contestants.

GENERATION IV & SMALL REACTORS

G4SR-1

INTERNATIONAL CONFERENCE

G4SR.ORG | NOV 6 - 8, 2018 | OTTAWA, ONTARIO, CANADA

Canadian Nuclear Society (CNS), and Canadian Nuclear Laboratories (CNL) as the Host Sponsor, are hosting the 1st International Conference on Generation IV and Small Reactors.

Building on the momentum of increasing interest in partnership in SMR development in Canada, in both governments and the private sector, this International Conference's theme is about "Meeting the Challenges to Deploy Next Generation Advanced Reactors and SMRs" in fostering low-carbon energy innovation for Canada and the world. As such, this conference is an international forum for the industry and stakeholders to work together to identify obstacles and opportunities, and seek solutions through dialogue, engagement and collaboration. It will cover the topics of interest to designers, operators, researchers, analysts, policy makers involved in the design, development and deployment of Generation IV and small reactors for research and power generation purposes

NOV. 6 - 8, 2018 OTTAWA MARRIOTT HOTEL, ONTARIO, CANADA

WORKSHOPS ON INTEGRATED SAFETY ASSESSMENT METHODOLOGY, AND CANADIAN REGULATORY CHALLENGES OF GENERATION IV AND SMRS.

CALL FOR PAPERS
12 TECHNICAL PROGRAM TRACKS

PLENARY SESSIONS:

1. CANADA'S NUCLEAR ADVANTAGE IN DEPLOYING GEN IV & SMR AND INTERNATIONAL COLLABORATIONS

2. PROMINENT SHOWCASES IN GEN IV ADVANCED REACTORS & SMR DEVELOPMENT

3. INTERNATIONAL LANDSCAPE IN ADVANCED REACTORS DEPLOYMENT – CHALLENGES, MARKET AND EXPORT STRATEGIES

4. POLICY LEVERS TO ENABLE SMR DEPLOYMENT IN CANADA

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens | CHALK RIVER

CANADIAN NUCLEAR SOCIETY ® SOCIÉTÉ NUCLÉAIRE CANADIENNE

www.G4SR.org

G4SR-1

MESSAGE FROM THE CO-CHAIRS

Canadian Nuclear Society (CNS) and Canadian Nuclear Laboratories (CNL) are hosting the 1st International Conference on Generation IV and Small Reactors. It is our privilege as the Conference Co-Chairs to present to you our exciting Preliminary Conference Program.

The six advanced reactor designs selected for development by the International Generation IV Forum (GIF) are: Gas-cooled Fast Reactor (GFR); Lead-cooled Fast Reactor (LFR); Molten Salt Reactor (MSR); Supercritical Water-cooled Reactor (SCWR); Sodium-cooled Fast Reactor (SFR); and Very High Temperature Reactor (VHTR).

Several Small Modular Reactor technology developers (whose designs belong to some of the above Generation IV design categories) have recently established themselves in Canada and initiated dialogue with the regulator, suppliers, utilities, governments and potential customers, for potential development and deployment in Canada. Currently, seven SMR technology developers have applied for pre-licensing vendor design review (VDR) process with the regulator, to gain an early assessment of their SMR design.

Building on the momentum of increasing interest in partnership in SMR development in Canada, in both governments and the private sector, the theme of this International Conference is "Meeting the Challenges to Deploy Next Generation Advanced Reactors and SMRs" in fostering low-carbon energy innovation for Canada and the world. As such, it will cover the topics of interest to designers, operators, researchers, analysts, policy makers involved in the design, development and deployment of Generation IV and small reactors for research and power generation purposes.

To start off on Nov. 6, 2018, there will be two timely workshops on hot topics: Integrated Safety Assessment Methodology for SMRs, and Canadian Regulatory Challenges of Gen IV and SMRs, delivered by domain experts. The conference (Nov. 7 – 8, 2018) will have four important plenary sessions delivered in sequence by distinguished Canadian and international speakers, plus 12 Technical Program Tracks conducted in parallel over the two days, covering wide spectrum of advanced SMR research and policy topics.

A technical tour of the Chalk River Laboratories, hosted by CNL, will be offered to interested attendees on Friday November 9, 2018.

Advanced SMRs are potential game changing technological innovations which can meet the goals for Generation IV nuclear energy systems on sustainability, economics, safety and reliability, proliferation resistant and physical protection. For the benefits of the society at large, the SMR innovations can lead to potential large-scale production of hydrogen, a potential future low-carbon energy source that can provide energy sustainability for the world in replacing gasoline for transportation or natural gas for heating or industrial processes. Just as importantly, Generation IV advanced reactors can potentially lead to technological innovations on reprocessing or recycling of used nuclear fuel or the use of thorium to power nuclear reactors.

As SMR vendors and the industry stakeholders work to advance the SMR technologies from the design concept to laboratory testing, licensing and on through to deployment, there will be challenges; G4SR-1 is an international forum for the industry and stakeholders to work together to identify obstacles and opportunities, and seek solutions through dialogue, engagement and collaboration.

The exciting moment to explore the SMR technological innovations has come. We invite you to submit your research papers, join the important discussion with your peers at the conference, and explore the international collaborations in meeting the challenges for future SMR deployments.

Wilson Lam, P.Eng. (Ont), Charter Eng. (UK)
CNS Division Chair – Generation IV and Small Reactor Technology
Senior Advisor, Nuclear Technology, Ontario Ministry of Energy

Dr. Bronwyn Hyland
Program Manager, Small Modular Reactors
Canadian Nuclear Laboratories

Project: Savannah River Site – Salt Waste Processing Facility (SWPF) – Aiken, South Carolina
Atkins is the subcontractor leading SRS SWPF Commissioning and Operations.

One team.
Combined strength.
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We are SNC-Lavalin and Atkins, working for you as one team. Together, we deliver exceptional safety and project execution for our clients in the nuclear, clean power, mining and metallurgy, oil and gas, and infrastructure markets. We help optimize your project costs and schedules through our enhanced combined service offering and wealth of experience.

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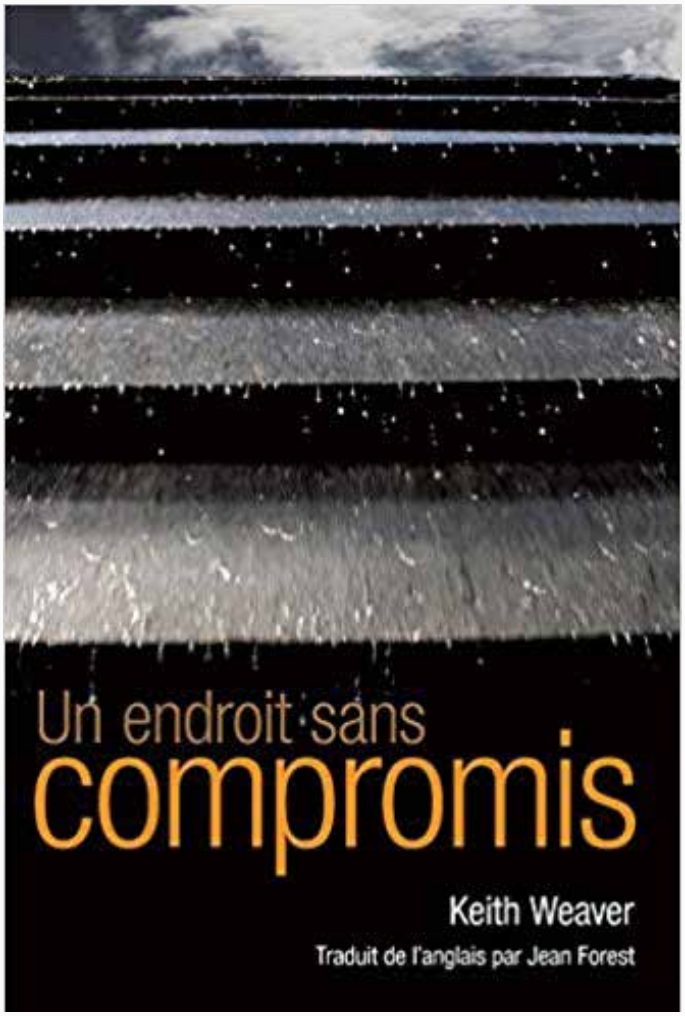
‘Un endroit sans compromis’: Pensées d’un traducteur



Pas même dans mes rêves les plus fous ai-je pensé qu’un jour je serais un traducteur.

Mais c’est exactement ce qui s’est passé.

Il y a quelques années, j’ai lu le premier chapitre du livre “An Uncompromising Place” de mon ami et collègue Keith Weaver. À cet époque, le livre n’était pas encore publié. Keith a finalisé le texte en anglais et a commencé à chercher un éditeur. L’idée d’un livre, même en anglais, restait un projet.

Rapidement, j’ai produit une traduction du premier chapitre. Et on pourrait dire que dès ce moment là, des rouages se sont inexorablement mis en marche.

En mars 2018, on a publié le livre “Un endroit sans compromis”. Pour moi, comme traducteur, et vu que c’était ma première tentative pour une traduction de cette envergure (plus de trois cent pages), avoir ce livre enfin entre mes mains est une sensation extraordinairement agréable.

Naturellement, je ne peux pas présenter une critique objective d’un texte que j’ai élaboré moi-même. Mais je peux indiquer aux lecteurs du Bulletin ce qui m’a attiré dans l’histoire que raconte ce roman.

Il s’agit d’un ingénieur qui vient de prendre sa retraite. (C’est un livre que n’importe qui peut lire, mais un ingénieur trouvera dans ses pages pas mal de situations, commentaires et démarches qui vont entrer en résonnance avec le quotidien de sa profession…)

Notre ingénieur, Richard Gould, a des intérêts variés, comme ceux de Keith et moi, vu que nous sommes depuis longtemps deux étudiants passionnés de l’histoire, de la littérature, de la philosophie. Au commencement du roman, Gould a déménagé de son condo à Toronto vers une maison ancienne qu’il a rénovée dans un village ontarien, le village paisible et imaginaire de Greenvale. Et il a une idée pour un projet beaucoup plus audacieux, celui de rénover le moulin dans le village, maintenant réduit à l’état de structure en ruine. Le travail débute. Tout va bien, au commencement. Puis Gould trouve des choses qui clochent. Un homme est tué. Il y a quelque chose de sinistre en jeu.

“Un endroit sans compromis” est un mystère complexe qui s’échelonnent sur six siècles et dans trois pays. Je l’ai décrit dans ma Préface du Traducteur comme “une petite perle canadienne”. J’espère, chers lecteurs éventuels, qu’Un endroit sans compromis vous procurera autant plaisir que j’y ai trouvé moi-même d’abord à sa lecture en anglais et ensuite pendant plus d’une année au cours de mon travail de traduction en français.

Un endroit sans compromis” sera disponible par Amazon.ca ou Indigo.ca à partir du 15 mars.

Jean Forest

GENERAL news

(Compiled by Colin Hunt from open sources)

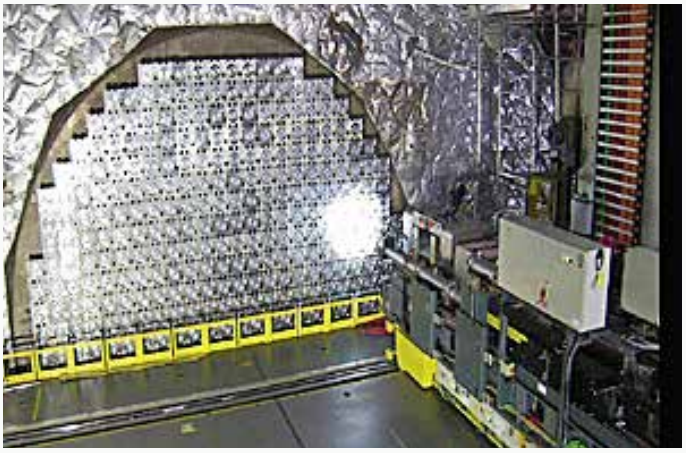
Final Calandria Tube Insert Removed from Darlington Nuclear's Unit 2

The final calandria tube insert (CTI) was removed on March 28, completing yet another step in the disassembly phase of Darlington Nuclear Generating Station's Unit 2 reactor.

A new production planning tool used during CTI removal is credited for building efficiency and allowing for early completion of this important work series in the Darlington Refurbishment project.

"We developed a process map showing the work step-by-step, including all processes involved," said Perrik Le Dreff of the Darlington Refurbishment team.

The process included durations for each step, down to the second, for: reactor component removal; placement of the removed items into protective flasks; transport to the Re-tube Waste Processing Building; storage preparation and placement into waste containers; and the flasks' return trip to Unit 2.



Inside the Darlington Unit 2 reactor vault during calandria tube insert removal.

Green Light to Proceed with Unit 3 Refurbishment

On Feb. 15, the Ontario government confirmed its commitment to begin the refurbishment of Unit 3 at Darlington Nuclear. Durham MPP Granville Anderson made the announcement at an event at the Darlington Energy Complex to celebrate the halfway mark of refurbishing Unit 2.

OPG President & CEO Jeft Lyash (right) at a press conference for Unit 3 green light.

"The Darlington refurbishment will ensure that reliable, nuclear energy continues to be the backbone of our generation fleet," the Minister of Energy said in a news release. "This multi-phase project will continue to boost economic activity across Ontario, create jobs and secure a clean supply of affordable electricity for the future."

"The government took a phased approach to Darlington refurbishment, with each unit requiring individual approval to proceed," said OPG President and CEO Jeff Lyash. "The go-ahead to move forward with the next unit is a testament to the hard work and dedication of the Darlington Refurbishment team.

Chalk River Laboratory Request for Proposals Issued

Canadian Nuclear Laboratories (CNL) has issued a request for proposals (RFP) for the design and construction of a CAD370 million (USD283 million) laboratory research complex that will be the largest single capital investment in the CAD1.2 billion revitalisation of its Chalk River site.

The ANMRC is central to CNL's vision for Chalk River. (Image: CNL)

The Advanced Nuclear Materials Research Centre (ANMRC) will consolidate key capabilities from a number of ageing facilities that are scheduled for decommissioning and will provide services critical to the life extension and long-term reliability of existing reactors, CNL said. It will include new shielded facilities for post-irradiation examination of small modular reactor (SMR) and next-generation nuclear fuels; glovebox facilities to support the development of advanced fuel fabrication concepts; and materials storage bays that will simplify the on-site transportation of radioactive materials, improving work efficiency at the Ontario campus.

With construction scheduled to start in 2019, the ANMRC will be one of the largest active research facilities ever to be constructed in Canada and, according to CNL president and CEO Mark Lesinski, will be at the centre of the transformation of Chalk River.

NB Power Reaches Settlement with Nuclear Insurers and Seeks Permission for Lower Rate Increase

NB Power announced on March 26 that it has reached a settlement with several insurers who underwrote a construction all risk insurance policy during the refurbishment project at the Point Lepreau Nuclear Generating Station.

"This is a great day for NB Power and the people of New Brunswick," said Gaëtan Thomas, NB Power President & CEO. "While the specific details of this insurance settlement are subject to a confidentiality agreement at this time, we do know that the settlement allows us to seek a lower rate increase for all New Brunswickers in the current hearing."

As a result of this settlement, NB Power's Board of Directors has asked management to seek permission from the Energy & Utilities Board (EUB) to temporarily adjourn the current EUB proceeding in order to assess the implications of this settlement on the 2018/19 General Rate Application. At this time, it is expected that the overall rate increase will be adjusted down from the original overall request of 2.0 per cent.

Community support for Bruce Power's Life-Extension Program remains high

An aerial view of the Bruce Power site.

Nine of 10 residents in Bruce, Grey and Huron counties believe Bruce Power operates a safe facility, is a good community citizen, and contributes to the community in a positive way.

During recent independent telephone polling conducted across the region, Ipsos found health care, jobs and infrastructure remain the top issues for residents, while their support for Bruce Power's Life-Extension Program remains very high (84 per cent).

"Bruce Power continues to receive strong public support to accompany the government policy that is allowing us to continue operating safely and reliably," said James Scongack, Vice President, Corporate Affairs & Environment. "Though the support of Bruce, Grey and Huron county residents is not something we will ever take for granted, we are pleased to see such a strong belief in nuclear energy and Bruce Power's future in our region."

Over 80 per cent of respondents also believe Bruce Power keeps people updated through regular communications, while 84 per cent of people familiar with Bruce Power feel 'excellent,' 'very good,' or 'good' about the organization.

Terrestrial Signs IMSR Fuel Testing Contract

Terrestrial Energy of Canada has signed a contract for technical services with the European Commission's Joint Research Centre (JRC) in Karlsruhe, Germany. Under the contract, JRC will perform confirmatory studies of the fuel and primary coolant salt mixture for Terrestrial's Integrated Molten Salt Reactor (IMSR).

Rendering of the IMSR core unit. (Image: Terrestrial)

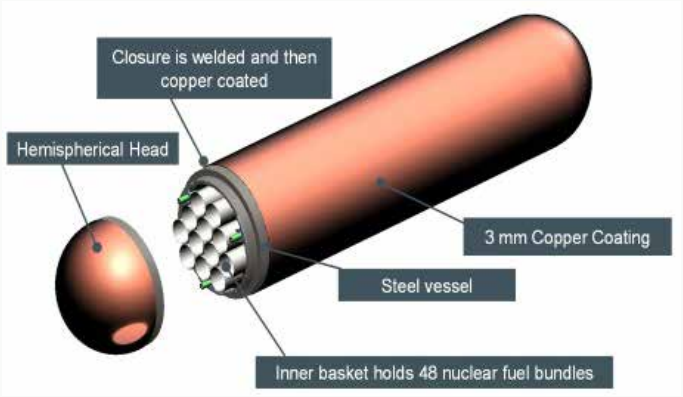
Molten salt reactors use fuel dissolved in a molten fluoride or chloride salt which functions as both the reactor's fuel and its coolant. This means that such a reactor could not suffer from a loss of coolant leading to a meltdown. Terrestrial's IMSR integrates the primary reactor components, including primary heat exchangers, to a secondary clean salt circuit, in a sealed and replaceable core vessel. It is designed as a modular reactor for factory fabrication, and could be used for electricity production and industrial process heat generation.

Terrestrial announced today it has signed the fuel testing contract with the JRC as part of its "validation and verification programme for the IMSR power plant design now under way".

Uk Nuclear Laboratory to Review Canadian Research

The UK's National Nuclear Laboratory (NNL) is to carry out an expert peer review of a Canadian research programme on microbiologically influenced corrosion of canisters that will be used to dispose of used nuclear fuel. The NNL has been contracted by Canada's National Waste Management Organisation (NWMO) to review its work on the potential for corrosion of the copper-clad canisters.

The NWMO is responsible for designing and implementing the safe, long-term management of Canada's used nuclear fuel under a plan known as Adaptive Phased Management. This requires used fuel to be



The Canadian canister design. (Image: NNL/NWMO)

contained and isolated in a deep geological repository, with a comprehensive process to select an informed and willing host for the project.

The used fuel will be isolated from the environment using a series of engineered barriers. Fuel elements comprise ceramic fuel pellets, which are themselves highly durable, contained inside corrosion-resistant zircaloy tubes to make fuel elements. Bundles of fuel elements are placed into large, durable copper-coated steel containers which are designed to contain and isolate used nuclear fuel in a deep geological repository, essentially indefinitely. The canisters will be placed in so-called "buffer boxes" containing by bentonite clay, providing a fourth barrier.

Barakah 1 construction formally complete

Celebrations mark Barakah unit 1 completion. (Image: Cheong Wa Dae)

President Moon Jae-in of South Korea and Crown Prince of Abu Dhabi Sheikh Mohamed bin Zayed Al Nahyan attended a ceremony to celebrate the completion of construction at the United Arab Emirates' first nuclear power reactor.

Initial construction of the South Korean-designed APR-1400 pressurised water reactor, built for Emirates Nuclear Energy Corporation (Enec) by a consortium led by the Korea Electric Power Corporation (Kepco), was completed last year. Today's ceremony, held at

the reactor site, marked the official completion of the construction phase. The focus for Barakah 1 now shifts to completing the preparations for operation needed to receive an operating licence from the UAE's nuclear regulator, the Federal Authority for Nuclear Regulation (FANR).

Court approves Westinghouse reorganisation plan

On 4 January, it was announced that Brookfield Business Partners, together with institutional partners - collectively known as Brookfield - had agreed to acquire 100% of Westinghouse from Japanese parent company Toshiba for about $4.6 billion.

Westinghouse filed for Chapter 11 bankruptcy protection with US courts in March 2017 to enable it to undergo strategic restructuring. The company's bankruptcy filing affected only its US operations, including projects to construct a total of four AP1000 reactors at two projects, Vogtle in Georgia, and VC Summer in South Carolina.

Obituaries

John Archibald ("Archie") Law Robertson

July 4, 1925 - February 18, 2018

Archie, a Fellow of the Royal Society of Canada, has been a proud Deep River resident since 1957. He died comfortably at the North Renfrew Long Term Care Centre on February 18, 2018. Predeceased by his wife of 52 years, Betty Jean ("BJ") nee Moffatt in 2007. He is mourned by: his son Ean Stuart (Linda Margaret (nee Heppes)) and their children Jennifer Catherine (Jamie Tyler Dennis) and their children Faith Angela and Caiden Alexander, and Jeffrey Christopher; daughters Clare Deborah (Ken Coleman Kortner) and their children Kevin Coleman and Laurene Catherine; and Fiona Heather (Robert Gerald Hogan) and son Conor Everet. Missed by all including Pamela Wyatt, a friend to Archie both early and later on in his life.

Archie was born in Dundee, Scotland on July 4, 1925 to John and Ellen (nee Law) Robertson. Archie was commissioned in the Royal Engineers then seconded to the Indian Army, serving in United Kingdom, India, Sumatra, and Singapore achieving the rank of Captain. He attended Epsom College, England, then continued, receiving his B.A. in Natural Sciences / Physics in 1950 and then his M.A. in 1953, both from Clare College, Cambridge, England. He began his professional career at the U.K.A.E.A. in Harwell, U.K. In 1953 and with business in Washington, D.C. he met B.J. beginning their journey in life. In 1957 he joined A.E.C.L. where he filled many roles before retiring as Assistant to the Vice President. During parts of that time he served as the editor of the Journal of Nuclear Materials. He has authored many papers, articles, and several books.

Archie participated in a number of activities in Deep River but found his true enjoyment with cross-country skiing through the Silver Spoon trails and was proud of his achievements in the annual race.

Cremation has occurred in Ottawa. A memorial will be celebrated in the spring.

Archie's family greatly appreciates the tremendous care provided by Dr. Terry McVey, along with all the other doctors, nurses, and support staff at the Deep River and District Hospital, the benevolent assistance of the staff and nurses (his Guardian Angels) of the Community Care Access Centre, the superb care by the staff of the North Renfrew Long Term Care Centre and those in the community who assisted him. In recognition, memoriam donations may be made to the North Renfrew Long Term Care Centre.

William (Bill) John Penn

August 18, 1933 – December 10, 2017

Bill Penn died peacefully Sunday, December 10, 2017 at Ross Memorial Hospital Lindsay. He was 84 years old. His wife Mollie, daughters Andrea and Wendy and their families will sorely miss such a loving and supportive man. He is predeceased by his son Nicholas Penn.

Bill is a former manager of the Nuclear Studies and Safety Department of Ontario Hydro, where his son Nicholas also worked. He was a very dedicated and talented engineer and manager as well as being a good friend and gentleman to all his associates. His farm in Pontypool, Ontario was a frequent venue for his department summer picnics.

He will be missed.

The IAEA is pleased to announce the publication of:

Knowledge Loss Risk Management in Nuclear Organizations

IAEA Nuclear Energy Series No. NG-T-6.11

This publication provides a methodology to enable knowledge loss risk management to ensure safe, reliable and efficient operation of nuclear facilities. It focuses on aspects of knowledge loss risks associated with employee attrition and provides guidance to mitigate them. The described methodology has proved itself in nuclear power plants and can be adopted by any other nuclear related organization. The publication also provides examples of best practices (case studies) of effective knowledge loss risk management gathered from the nuclear power plants and nuclear related organizations as outlined in annexes I-V.

STI/PUB/1734, 77 pp.; 31 figs.; 2017; ISBN: 978-92-0-101816-8, English, 30.00 Euro

Electronic version can be found: http://www-pub.iaea.org/books/iaeabooks/10921/Knowledge-Loss-Risk-Management-in- Nuclear-Organizations

Status and Trends in Spent Fuel and Radioactive Waste Management

IAEA Nuclear Energy Series No. NW-T-1.14

Based on the outcome of a collaborative project undertaken by the IAEA, OECD-NEA and the European Commission, this publication provides a global overview of the status of radioactive waste and spent fuel management concerning inventories, programmes, current practices, technologies and trends. It includes an analysis of national arrangements and programmes for radioactive waste and spent fuel management, an overview of current waste and spent fuel inventories and estimates of future amounts. International and national trends in these areas are also addressed.

STI/PUB/1799, 57 pp.; 25 figs.; 2018; ISBN: 978-92-0-108417-0, English, 39.00 Euro

Electronic version can be found: http://www-pub.iaea.org/books/iaeabooks/11173/Status-and-Trends-in-Spent-Fuel-and-Radioactive- Waste-Management

Leadership, Human Performance and Internal Communication in Nuclear Emergencies

IAEA Nuclear Energy Series No. NG-T-1.5

This publication focuses on the challenges and their possible solutions in the areas of leadership, human performance and internal communication in a severe nuclear emergency. It presents a brief overview of some of the key concepts, especially how they relate to an organization's ability to successfully manage an emergency event. The target audience for this publication are those officials and senior managers dealing with emergency response in the operating organization, government, local authorities and the regulatory body. Those who have an influence on the style of leadership and personnel development and training that is applied in their organizations and who are involved in emergency preparedness and response will also benefit from this publication.

STI/PUB/1789, 36 pp.; 2 figs.; 2018; ISBN: 978-92-0-103317-8, English, 30.00 Euro

Electronic version can be found: http://www-pub.iaea.org/books/IAEABooks/11100/Leadership-Human-Performance-and-Internal- Communication-in-Nuclear-Emergencies

Safety Aspects of Nuclear Power Plants in Human Induced External Events: Assessment of Structures

Safety Reports Series No. 87

This publication provides detailed guidelines for the safety assessment of nuclear power structures against mechanical impact, explosion and fire caused by human induced external events. It covers the characterization of loading, the assessment of structural integrity using both simplified methods and more elaborated methodologies, and the assessment of induced vibration. The acceptance criteria provided in the publication are for different failure modes: overall stability, overall bending and shear, local failure modes and induced vibrations. The process of analysing fire consequences is also included.

STI/PUB/1769, 204 pp.; 71 figs.; 2018; ISBN: 978-92-0-101117-6, English, 65.00 Euro

Electronic version can be found: http://www-pubiaea.org/books/iaeabooks/10953/Safety-Aspects-of-Nuclear-Power-Plants-in-Human- Induced-External-Events-Assessment-of-Structures

Country Nuclear Power Profiles - 2017 Edition

The Country Nuclear Power Profiles (CNPP) publication compiles background information on the status and development of nuclear power programmes across participating International Atomic Energy Agency (IAEA) Member States. The publication summarizes organizational and industrial aspects of nuclear power programmes and provides information about the relevant legislative, regulatory and international framework in each State. The descriptive and statistical overview of the economic, energy and electricity situation in each State and its nuclear power framework is intended to serve as an integrated source of key background information about nuclear power programmes throughout the world. This 2017 edition, issued on CD-ROM, contains updated country information for 50 States.

IAEA-CNPP/2017/CD, ISBN: 978-92-0-150818-8, English, 95.00 Euro

Electronic version can be found: https://www-pub.iaea.org/books/IAEABooks/12350/Country-Nuclear-Power-Profiles

Arrangements for the Termination of a Nuclear or Radiological Emergency

IAEA Safety Standards Series No. GSG-11

This publication provides guidance and recommendations on arrangements to be made at the preparedness stage, as part of overall emergency preparedness, for the termination of a nuclear or radiological emergency and the subsequent transition from the emergency exposure situation to either a planned exposure situation or an existing exposure situation. It elaborates the prerequisites that need to be fulfilled so that responsible authorities can declare the nuclear or radiological emergency ended and it gives detailed guidance on adapting and lifting protective actions. This publication, jointly sponsored by 10 international organizations (FAO, IAEA, ICAO, ILO, IMO, INTERPOL, OECD/NEA, UN OCHA, WHO and WMO) is intended to assist Member States in the application of IAEA Safety Standards Series Nos GSR Part 3 and GSR Part 7.

STI/PUB/1796, 189 pp.; 20 figs.; 2018; ISBN: 978-92-0-108017-2, English, 53.00 Euro

Electronic version can be found: https://www-pub.iaea.org/books/iaeabooks/12269/Arrangements-for-the-Termination-of-a-Nuclear-or- Radiological-Emergency

Self-assessment of Nuclear Security Culture in Facilities and Activities

IAEA Nuclear Security Series No. 28-T

The IAEA has developed a comprehensive methodology for evaluating nuclear security culture. When implemented by a State, this methodology will help to make nuclear security culture sustainable. It will also promote cooperation and the sharing of good practices related to nuclear security culture. This publication is the first guidance for assessing nuclear security culture and analysing its strengths and weaknesses within a facility or activity, or an organization. It reflects, within the context of assessment, the nuclear security culture model, principles and criteria set out in the Implementing Guide, IAEA Nuclear Security Series No. 7. This guidance will be useful for organizations and operating facilities in conducting the self-assessment of nuclear security culture by providing practical methods and tools. It will also help regulatory bodies and other competent authorities to understand the self-assessment methodology used by operators, encourage operators to start the self-assessment process or, if appropriate, conduct independent assessments of nuclear security culture.

STI/PUB/1761, 107 pp.; 8 figs.; 2017; ISBN: 978-92-0-111616-1, English, 55.00 Euro

Electronic version can be found: http://www-pub.iaea.org/books/IAEABooks/10983/Self-assessment-of-Nuclear-Security-Culture-in-Facilities-and-Activities

Cyclotron Based Production of Technetium-99m

IAEA Radioisotopes and Radiopharmaceuticals Reports 2

This publication presents a comprehensive overview of the technologies involved in the production of cyclotron based 99mTc. These would include techniques relevant to preparation of targets, irradiation of targets under high beam currents, target processing, target

Calendar

2018

April 22-26 — **PHYSOR 2018**
Cancun, Mexico
physor2018.mx

May 2018 — **Nuclear 101**
cns-snc.ca

June 3-6 — **38th Annual CNS Conference & 42nd Annual CNS/CNA Student Conference**
Sheraton Cavalier Hotel
Saskatoon, SK
cns2018conference.org

June 17-21 — **ANS Annual Meeting**
Philadelphia, PA
ans.org/meetings

Sept. 30-Oct. 3 — **PBNC 2018**
San Francisco, CA, USA
pacificnuclear.net/pnc/pbnc
ans.org/meetings/c_2

Fall — **Waste Management, Decommissioning and Environment Restoration for Canada's Nuclear Activities**
cns.snc.ca

Fall — **International Conference on Simulation Methods in Nuclear Engineering**
cns-snc.ca

Fall — **International Technical Meeting on Small Reactors**
cns-snc.ca

Nov. 11-15 — **2018 ANS Winter Meeting**
Orlando, FL, USA

2019

February — **CNA Nuclear Industry Conference and Tradeshow**
Westin Hotel
Ottawa, Ontario
cna.ca/2019-conference

March — **CANDU Technology & Safety Course**
cns-snc.ca

May — **Nuclear 101**
cns-snc.ca

June — **39th Annual CNS Conference & 43rd Annual CNS/CNA Student Conference**
cns2019conference.org

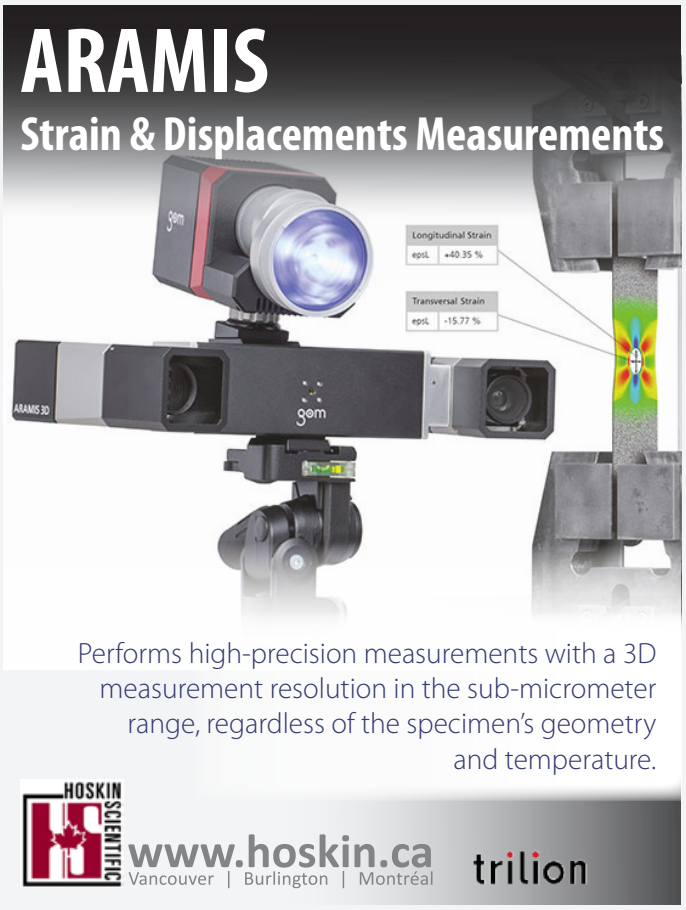
Publications

continued from page 45

recovery and quality control of the final product. The publication provides broad information, well supported with references, on improved production routes and improved separation and purification of cyclotron based 99mTc. These approaches achieve high specific activity and chemical purity of 99mTc suitable for labelling molecules of medical interest and also enable spare capacity to be available at medical cyclotron centres. The readership of this publication is scientists interested in translating this technology to practice, technologists already working with cyclotrons wanting to enhance the utility of the existing machines and managers who are in the process of setting up facilities in their countries. Students working towards higher level degrees in related fields may also benefit from this publication.

STI/PUB/1743, 59 pp.; 48 figs.; 2017; ISBN: 978-92-0-102916-4, English, 33.00 Euro

Electronic version can be found: http://www-pub.iaea.org/books/iaeabooks/10990/Cyclotron-Based-Production-of-Technetium-99 m



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Branch Affairs / Chapitres locaux
Ron Thomas . . . . . 613-236-3297 rthomas@storm.ca

Education and Communications / Éducation et communications
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CNA Liaison / *Agent de liaison avec l'ANC*
John Barrett 613-237-4262 barrettj@cna.ca

CNS Bulletin Publisher / Éditeur du Bulletin SNC
Colin Hunt 613-220-7607 colin.hunt@rogers.com

CNS Bulletin Editor / Rédacteur du Bulletin SNC
Ric Fluke 416-592-4110 rfluke@sympatico.ca

CNS Office Manager / Bureau de la SNC
Bob O'Sullivan 416-977-7620 cns-snc@on.aibn.com

Branches / Chapitres locaux

Bruce	John Krane	519-361-4286 jck@bmts.com
Chalk River	Andrew Morreale	613-584-8811 x 42543 morreaac@mcmaster.ca
Durham Region	Jacques Plourde	905-441-2776 jap-performance@rogers.com
Golden Horseshoe	Jason Sharpe	905-975-5122 jason.r.sharpe@gmail.com
Manitoba	Jason Martino	204-753-2311 x62229 martinoj@cnl.ca
New Brunswick	Derek Mullin	506-650-3374 dmullin@nbpower.com
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Québec	Michel Saint-Denis	514-875-3452 michelstdenis@videotron.qc.ca
Sheridan Park	Raj Jain	raj.jain@candu.com
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UOIT	Mohamed Saleh	289-221-0739 mohamad.saleh@uoit.net
Western	David Malcolm	867-446-7017 david.malcolm@mcri.ca

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http://www.cns-snc.ca

Word Power

by NEIL ALEXANDER

Words have both denotative (literal) meanings and connotative meanings, that are based on associations or emotional responses. They can also have different meanings to different people.

In the nuclear power industry, contamination occurs when something escapes. In the pharmaceutical industry its the opposite. This different understanding is the cause of endless misunderstandings in radiopharmacy.

Call a group of people a club. Positive response. Call them a clique. Negative. It is the hidden, connotative meanings, that make words more powerful than swords.

Critical decision making relies on using words that convey both a clear denotative meaning and an appropriate connotative meaning. In the power industry the recent disruption (a word that used to connotate bad but now seems to connotate good) is forcing development of our lexicon and it is not being done in a very helpful way.

Prior to the disruption things were quite simple. A community would need power, at times a lot, at times a little. There would always be a level below which it never fell, the "baseload". Power demand would then rise above that baseload and fall back to it forming a series of "peaks".

Based on the expected shape of the graph the community would invest in a range of plant that would suit their needs. Some would be designed to operate all the time. Typically, these had high capital and low operating costs. Other plant was designed to operate just during the peaks. These typically had lower capital costs but higher fuel costs. We used the terms "baseload" and "peaker" to describe the plant denoting their role in the system.

Connotatively baseload meant cheap and peaker more expensive. Connotatively a baseload plant meant 24/7, reliable operation.

The grid operator acted like the conductor of an orchestra using all the plants at their disposal to most effectively follow the demands of the music. Large slow moving double basses underpin the music, violins weave in and out to create the dynamic and the tympani intermittently ("not continuous") crash in for the crescendos.

The orchestra has now been disrupted by wind and solar, and for the first time the conductor has to deal with instruments that play when they want to, not when they are told to.

These new renewables were described as "intermittent" because they came and went much like the tympanists.

And because the historic "intermittents" were also our peak providers this connotatively aligned wind and solar with peak power and its high value.

But intermittent has two meanings and their intermittency wasn't the "not continuous" sort it was the "occurring at irregular intervals" kind. Expect them to be there when you need a crescendo and you may be sorely disappointed by a resounding silence. The connotative association with peaking and valuable power was never justified.

So, does this mean they are baseload? They certainly come on during the quiet pieces. And given that they have zero variable costs they also fit the economic profile.

But the conductor wants his underlying sound to be constant so that he or she can focus on ensuring the dynamics are effectively rendered. And so, while they are operated as baseload plant, they certainly don't deserve the connotative association.

Interestingly, the connotative meaning for "intermittent" has morphed as a result of them using the word and the new meaning is unhelpful to them. Those industries are now trying to use the word "variable". It's a clever ploy. Variable has two meanings as well, "not consistent" and "able to be changed or adapted". They are using the former to inappropriately associate with the latter and gain a connotative association with a helpful feature. An association that is again not justified.

Perhaps we should establish an appropriate word with the right denotative and connotative meaning to describe these technologies that cannot be depended on. Any ideas?

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What is your vision for SMR technology in Canada. What role will you play in making this vision a reality?

www.CNL.ca/SMR

Canadian Nuclear Laboratories (CNL) has begun a process to explore the possibilities for Small Modular Reactor (SMR) deployment in Canada. As part of this effort we are gathering input from researchers, technology developers, nuclear supply chain members and interested community stakeholders.

Your participation through a short survey will help us identify the challenges and opportunities faced in bringing an SMR to successful deployment. We would like to have your input and invite you join the discussion at www.CNL.ca/SMR.

Submission deadline: July 31.