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JANUARY/FEBRUARY 2021

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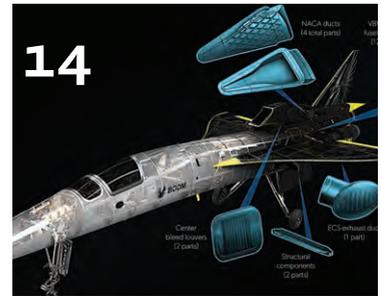
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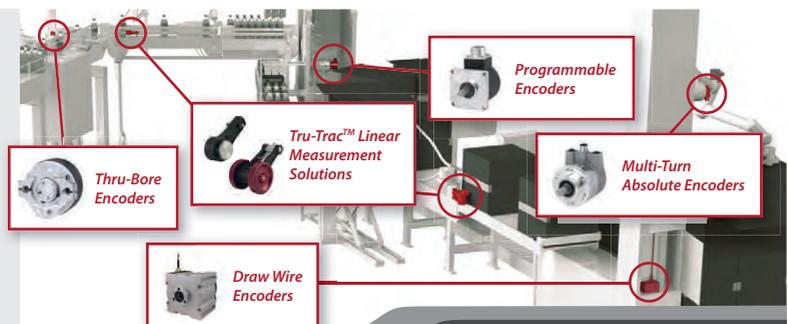
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## Access Denied

When Bitcoin rocketed to the low \$30,000s early in 2021, Stefan Thomas thought he'd hit the jackpot. The 7,002 Bitcoin he had collected a decade ago are now suddenly valued at roughly US\$220 million. Problem is, he forgot the password to his digital wallet. He only gets 10 wrong guesses before it irrevocably locks, and so far, he's guessed incorrectly eight times.

Listening to the rhetoric of Alberta's premier, Jason Kenney, you'd think the province has a lot in common with Mr. Thomas. Canada sits on the third largest oil reserve in the world, but has struggled, off and on, to profitably withdraw its value and transfer it to the U.S. gulf coast refineries that can process it. So, when President Biden nixed the Keystone XL pipeline permit on day one of his presidency, Kenney reacted – calling the decision a “gut punch,” and that PM Trudeau should “go to war” – like Alberta's fortunes had been permanently locked away.

It's not hard to see why. In addition to losing the iffy \$1.5 billion bet Alberta put on KXL, the cancellation also sends a chilling signal to would-be investors. Added to that, the oil sands' economics have been souring for a decade. The U.S., once a massive oil importer, has become a net exporter of oil in recent years, due to the dramatic rise in U.S. shale oil production since 2010.

At the same time, the world's largest auto markets, including California and several U.S. states, the EU and the UK, as well as auto makers, including VW and, most recently GM, have all committed to transition away from gas burning vehicles over the next 15 – 20 years. Couple that with the rapid growth and declining cost of renewable energy and the western hemisphere's demand for oil is poised to contract significantly.

In the meantime, things aren't quite so dire for Alberta or the oil sands. U.S. gulf coast refineries will continue to gobble up Alberta's heavy sour for the time being. And expansions to Enbridge's Line 3, the Transmountain and TC Energy's existing Keystone pipelines will add 950,000 barrels per day of export capacity by 2025, more than the 830,000 bpd KXL would have provided.

Even so, Canada's oil reserve was staring down an end to business-as-usual well before KXL was canceled and will need to shift gears rapidly. That may require making India/China Canada's new best consumer or locally processing higher value petro-chemical feedstocks for making fertilizer, plastics and synthetic materials. Whatever the case, Western Canada hasn't had its assets frozen just yet but it may have only a couple more attempts left at getting the password right.

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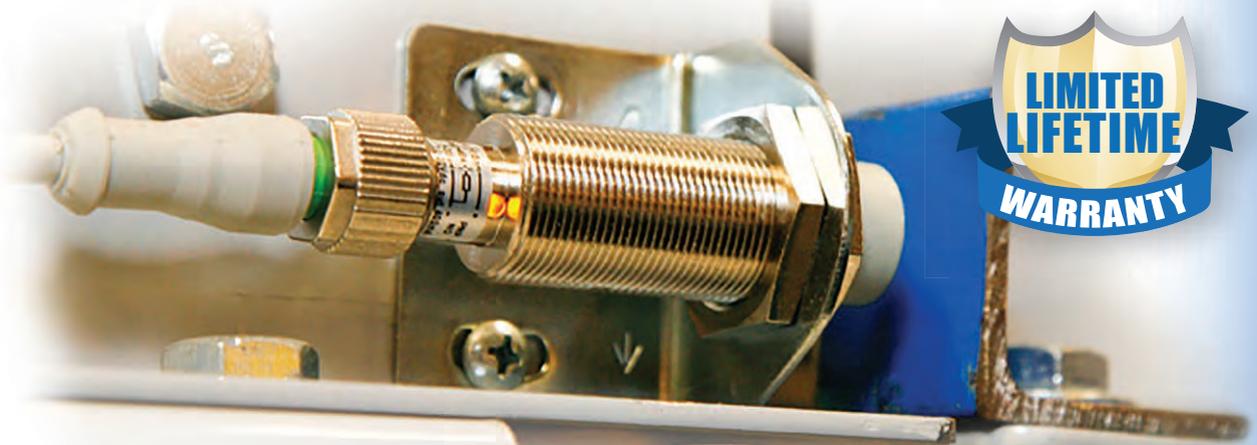
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ENERGY

**MCGILL, GENERAL FUSION AWARDED GRANT TO HELP DEVELOP FUSION REACTOR**

McGill University and General Fusion announced they have received a \$240,000 NSERC Alliance Grant for the study and mitigation of hydrodynamic instabilities in magnetized target fusion. General Fusion will contribute an additional \$120,000 over three years.

To create a net energy fusion reactor, Vancouver-based General Fusion is pursuing Magnetized Target Fusion technology. In place of superconducting magnets or high powered lasers used in other fusion approaches, General Fusion’s reactor employs pistons surrounding a spherical compression chamber. Swirling liquid metal inside the chamber creates a vortex into which hydrogen plasma is injected. At the right moment, pistons hammer the chamber and collapse the vortices, which compresses and heats the plasma to fusion conditions.

For the past 10 years, the company has partnered with McGill University to advance fusion energy. Currently, General Fusion is tapping the expertise of McGill Faculty of Engineering professor, Jovan Nedić, who specializes in hydrodynamics and the flow of liquids under extreme pressure.

His study will examine the appearance of fluid instabilities, such as jets or droplets, that could enter the plasma at various stages of compression. Using laboratory experiments and mathematical models that derive from the equations of fluid dynamics, the motion of the liquid surface will be investigated and approaches to prevent jets from forming or growing will be explored.

“The expertise of Professor Nedić and his team will support the integration of the



*A prototype of General Fusion’s piston-laden compression chamber.*

**5M**

The temperature in Celsius of the plasma that General Fusion’s injectors generate.

compression and plasma systems in our planned Fusion Demonstration Plant,” said Michael Delage, General Fusion’s CTO. “This prototype facility is our next major step in bringing fusion energy to the world.”

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**U OF T AI PLATFORM ACCELERATES MATERIALS DISCOVERY**

Researchers at the University of Toronto and Northwestern University announced the development of a machine learning platform that can quickly hone in on the optimal molecular building blocks from which to craft materials for use in targeted industrial applications.

The platform, developed with Harvard and the University of Ottawa researchers, is designed

to identify optimal web-like frameworks. These frameworks self-assemble from molecular building blocks to form crystalline porous materials that function as molecular “sponges”.

The problem, however, is that developing these materials often requires extensive trial-and-error since these molecular building blocks can be assembled in infinite ways.

“Designing reticular materials is particularly challenging, as they bring the hard aspects of modeling crystals together with those of modeling molecules in a single problem,” said senior co-author Alán Aspuru-Guzik, Canada 150 Research Chair in Theoretical Chemistry in the Departments of Chemistry and Computer Science at U of T and Canada CIFAR AI Chair at the Vector Institute. “By using an AI model that can ‘dream’ or suggest novel materials, we can go beyond the traditional library-based screening approach.”

To test their AI platform, the researchers focused on developing metal-organic frameworks (MOFs), which are considered an ideal material for absorbing and removing CO2 from flue gas and other combustion processes.

“We began with the construction of a large number of MOF structures on the computer, simulated their performance using molecular-level modeling and built a training pool applicable

*A computer model of a nanoporous material autonomously designed by an artificial intelligence system developed by U of T and Northwestern University.*



Photo credit: University of Toronto

to the chosen application of CO2 separation,” said study co-author Randall Snurr, the John G. Searle Professor and chair of the Department of Chemical & Biological Engineering in the McCormick School of Engineering at Northwestern University.

“In the past, we would have screened through the pool of candidates computationally and reported the top candidates,” he adds. “What’s new here is that the automated materials discovery platform developed in this collaborative effort is more efficient than such a ‘brute force’ screening of every material in a database. Perhaps more importantly, the approach uses machine learning algorithms to learn from the data as it explores the space of materials and actually suggests new materials that were not originally imagined.”

According to the research

team, whose work was recently published in the journal, *Nature Machine Intelligence*, their AI system shows significant prediction and optimization capability and is fully customizable to address many technology challenges.

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[www.northwestern.edu](http://www.northwestern.edu)

### UWINDSOR ENGINEERING PROFESSOR NAMED TO ORDER OF CANADA

University of Windsor engineering professor Dr. Hoda ElMaraghy has been named a member of the Order of Canada for her contributions to the field of mechanical engineering. Serving as director of the UW’s Intelligent Manufacturing Systems Centre, she was recognized for her work in advancing manufacturing systems in Canada and abroad.



*University of Windsor engineering professor Dr. Hoda ElMaraghy*

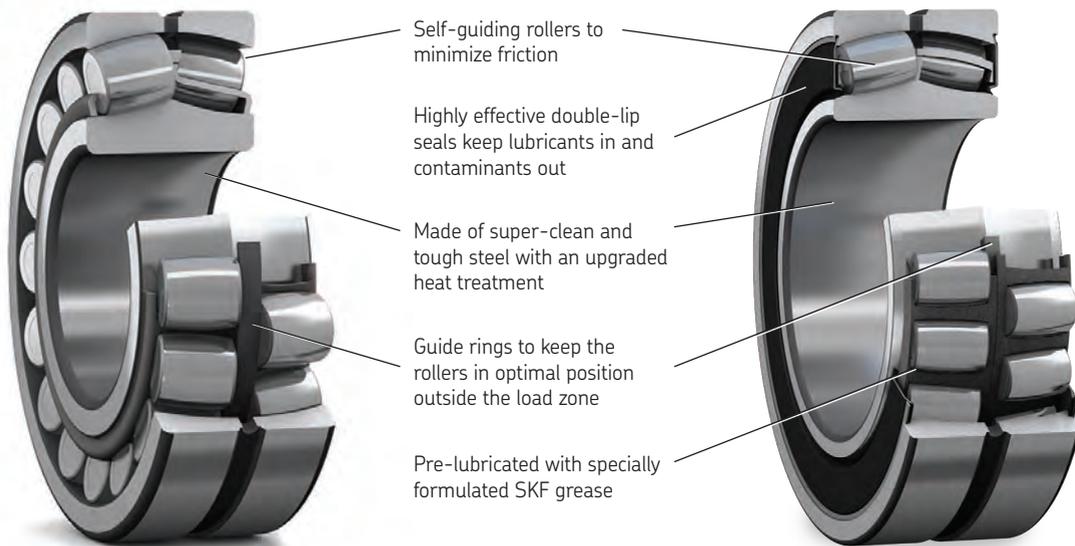
As a 2016 appointee to the Order of Ontario and Canadian Academy of Engineering, Dr. ElMaraghy has been hailed for her pioneer-

ing research in manufacturing systems engineering. Her research on flexible manufacturing has helped companies around the world adapt and respond to market changes by allowing them to produce different products with the same flexible manufacturing system.

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**TRANSPORTATION**

**BALLARD MODULES TO POWER SCOTLAND'S FIRST FUEL CELL-POWERED TRAIN**

Ballard Power Systems announced a contract to supply Arcola Energy, a U.K.-based firm specializing in zero-emission solutions for heavy-duty vehicles and transport applications, with the company's FCmove-HD fuel cell modules. The fuel cells will power a passenger train planned for demonstration during COP26 – the 2021 United Nations Climate Change Conference – to be hosted by Glasgow City in November 2021.

Scottish Enterprise, Transport Scotland and the Hydrogen Accelerator, based at the University of St. Andrews, have appointed Arcola and a hydrogen fuel cell integration consortium to deliver Scotland's first hydrogen-powered train. The consortium will convert a Class 314 car passenger train, made available by ScotRail, into a deployment-ready and certified platform for hydrogen-powered train development.

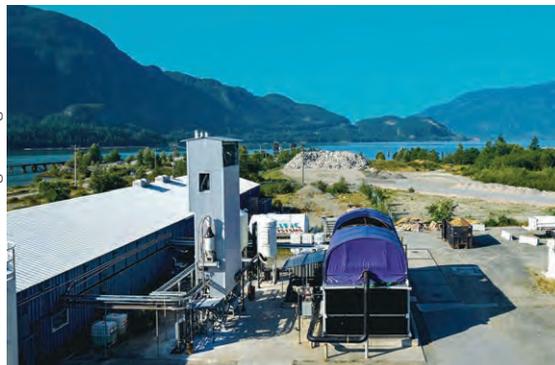
"Hydrogen traction power offers a safe, reliable and zero-carbon alternative for Scotland's rail network," Dr. Ben Todd, CEO of Arcola Energy said. "The hydrogen train project is an excellent opportunity for industry leaders in hydrogen, rail engineering and safety to collaborate with Scottish and other technology providers to develop a deployment ready solution."

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*A Class 314 car passenger train, like this one, will be converted to Scotland's first fuel cell powered train using Ballard Power System's fuel cell modules*

*Carbon Engineering's direct air CO2 capture demonstrator facility in Squamish, B.C.*

Photo credit: Carbon Engineering



**CARBON ENGINEERING SCORES INTERNATIONAL CLEAN TECH AWARD**

Cleantech Group announced that Squamish, British Columbia's Carbon Engineering (CE) has been named as the 2021 North American Company of the Year on the research and consulting firm's Global Cleantech 100 list. The annual list highlights international companies with solutions that have the greatest potential to make a significant market impact, in terms of digitization, de-carbonization and resource efficiency, within five to ten years.

This year's list is the 12th edition with cohorts that include innovators from 15 countries – half located in the US and the rest from Asia, Australia, Canada, Europe and the Middle East.

This is the second time Carbon Engineering's direct air CO2 capture technology has scored a place on the Cleantech 100 list but the first time it has won a regional category.

Other regional award winners this year include TWAICE (Europe & Israel) – a predictive analytics software developer for batteries – and the Asia Pacific region's Dishangtie, a provider of charging and management solutions for new energy vehicle fleets. Past Cleantech 100 list recipients include Tesla, Airbnb, Beyond Meat and Uber.

"This year's Global Cleantech 100 list was striking for how many carbon-related companies there

were in it, a far cry from even 3-4 years ago," said Richard Youngman, CEO, Cleantech Group. "I hope we will look back at 2020 as the year in which the foundation stones for Direct Air Capture enabling major new industrial markets in carbon management were laid."

[carbonengineering.com](http://carbonengineering.com)

**ONTARIO UNIVERSITIES CREATE ENGINEERING FELLOWSHIP TO FOSTER INCLUSION**

Six Ontario universities announced they have partnered to create the Indigenous and Black Engineering and Technology (IBET) Momentum Fellowships to encourage and support the pursuit of graduate studies by under-represented groups.

Led by the University of Waterloo, the partnership also includes the engineering faculties at McMaster University, the University of Ottawa, the University of Toronto, Queen's University and Western University.

Fellowship recipients will receive \$25,000 per year for four years as they pursue doctorate degrees and specialized engineering research.

The Momentum Fellowships are part of the IBET PhD Project, which aims to increase the number of Indigenous and Black engineering professors teaching and researching in universities across Ontario within the next five to 10 years.

"The partner universities share an understanding that greater diversity is needed among academic leaders in engineering and technology to reflect all populations and to ensure a full range of thought and problem-solving approaches," said Tizazu Mekonnen, Inaugural Director of the IBET PhD Project.

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# Kill the File

Autodesk lays out vision for design data storage and workflows plus its plans for design software at Autodesk 2020. **BY RALPH GRABOWSKI**



Autodesk CEO Andrew Anagnost is adamant: “I think there is something we need to acknowledge right now:

That a file is a dead thing working,” he said in an interview last fall with Archintosh magazine.

Here, Anagnost is referring to an issue that has been the company’s Achilles heel for some time: The cornucopia of file formats that have proliferated while Autodesk went about inventing or acquiring its 80 software programs. As a result, Revit has a hard time talking to Inventor, which has a hard time talking to Alias, etc, etc.

The company has tried several times to develop universal translators and file systems, such as Navisworks, A360, Project Quantum and Plasma, but those efforts fell short or else never shipped.

At Autodesk University 2020, held online last November, Autodesk presented its latest solution to its file format-related woes. Passing files through translators will be replaced by web service APIs (application programming

*In place of translators, Autodesk envisions its Forge web services API functioning as the lingua franca that facilitates seamless workflows between its numerous design software titles.*

interfaces) written with Forge. Forge is Autodesk’s all-encompassing programming system that Autodesk is encouraging customers to adopt. The proprietary programming system handles, among other tasks, automated workflows through projects. As Anagnost explained, “APIs can enable tools to talk to each other, passing data around without the need for files.”

For Autodesk, the future is made of apps and thick clients. Apps, like BIM Layout, are small, task-specific programs that usually run on phones. Thick clients is a new name for desktop programs that run with significant assistance from the Internet, such as doing generative design, of which Autodesk Fusion is the best example.

The plan is for each program to have an API that allows Autodesk, third-party developers and programming-savvy customers to access data of the type and format needed. Between 3D models

and the API will sit the product information model containing the data that define models. Forge’s own Model Derivative API already extracts geometry and properties from sixty file formats.

It’s a big job to define APIs that access data from each its 80 apps and thick clients, and Autodesk so far has not released any hard details. This is why CAD writer Anthony Frausto-Robledo mused that, “The death of the file is not going to be a quick death, and it may not happen in any of our lifetimes.”

In his Archintosh article from October 2020, Anthony describes an API-based data-exchange scenario of the future: “It is possible to imagine bespoke workflows where colleagues and teammates use a variety of different workflows customized to their exact needs. One can imagine Slack, for example, advancing its snooze feature so tasks automatically happen during certain hours of the day.”

Autodesk is not the only one working on the problem. It's most acute on the architectural side of design, and so in one case, the AEC Delta Mobility project, proposes exchanging small changes ("delta") between design programs at the object level, regardless of data format. Other CAD vendors are also looking at exchanging just the data chunks needed by ancillary software.

As Autodesk University was online this year, a remarkable 100,000 attendees took in 550 sessions. Here are some of the other highlights from the CAD software firm's yearly user conference.

**AutoCAD:** Autodesk, in its very early years, boasted that AutoCAD could run on any viable engineering platform, and so we saw it on hardware ranging from low-cost CP/M-based Zilog Z80s to uber-expensive Unix-based Silicon Graphics workstations; even on Macs. Then, following the big rewrite (i.e. Release 14 in 1997), it went Microsoft Windows-only.

At the time, this move made sense. Windows had secured its domination.



*At Autodesk University 2020, company CEO Andrew Anagnost spelled out the CAD software giant's vision of its future, including Autodesk's plans to deal with the multiple incompatible file formats that hamper exchanging CAD data between design applications.*

But that also was right about the time that the Internet burst into the consumer space, and the Web browser was anointed as the new platform, followed a decade or so later by the explosion of apps running on connected phones.

Autodesk was caught off-guard, and so its Web and mobile apps were lacking compared to smaller competitors. It has spent the last decade rewriting AutoCAD's core code to make it multi-platform again.

This is why AutoCAD has suffered

over the last few years from an impoverishment of new functions, as well as why the DWG file format stayed frozen longer than usual. The new AutoCAD Core Engine (ACE) runs on Windows, MacOS, Android, iOS, and Web browsers; Linux is not on the list. We don't know, however, when the Web, mobile and desktop versions of AutoCAD will be deployed with the new ACE engine.

**Inventor:** The CEO of Autodesk comes from the mechanical side of design, so it was no surprise that many

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new functions mentioned at AU were in MCAD. Some years ago, Autodesk had to reassure Inventor users that Fusion wouldn't soon displace their favorite MCAD program. The best proof of support is to show new functions, and here Inventor got pride of place during the AU keynote.

Autodesk is working on storing every manufacturing stage in Inventor

models, which sounds like a precursor to digital twinning. Lightweight versions of Inventor models can be placed in Revit models, and then the mechanical parts scheduled in Revit. To make documentation easier, users will be able to pick a template to generate drawings in Inventor automatically. No delivery date for these features was given.

**Fusion:** This cloud-based 3D

modeler represents Autodesk's future in MCAD, and so it boasted the largest number of announcements. Concurrent design will allow multiple users to work on the same project at the same time, such as on designs involving sheet metal and electrical. SPICE analysis has been integrated for auto-routing of PCBs [printed circuit boards] and other electrical tasks.

Moldflow solver is being included in Fusion 360 for testing the best way to manufacture plastic mold designs. A new management extension starts up in three seconds, as compared to "weeks" for similar software in Solidworks, according to Autodesk. ANSYS Workbench analysis software now works with Fusion 360 and is round-trip.

Other new extensions, such as Fabrication, Nesting and Machining, can be turned on for just the durations needed. Among them is a new feature-based machining system that applies strategies automatically for different areas of parts being made. Cooling analysis is being added through a new fluid solver.

**Digital Twins:** The hot marketing word in CAD these days is "digital twins," which are 3D models that accurately mimic physical products, even after manufacturing. (To me, it sounds like what PLM already is.) At AU, Autodesk announced it had joined the Digital Twins Consortium and was beta-testing Tandem digital twin software for architecture. It made no mention of digital twins for MCAD, lagging competitors in this area.

Autodesk and other software vendors are also supporting new Omniverse coordination software from nVidia, once it ships. Omniverse merges 3D models from Revit, ArchiCAD and other design software to Pixar's USD format, and then does photorealistic simulations in real-time. It requires computers with RTX-level graphics boards.

Autodesk used AU to announce bold steps for its future with Forge's API data exchange and its multi-platform AutoCAD Core Engine (ACE), neither of which have delivery dates. Many other new features likewise had no availability dates, but I expect to see them in the March time-frame when Autodesk usually sends out new releases. **IDE**  
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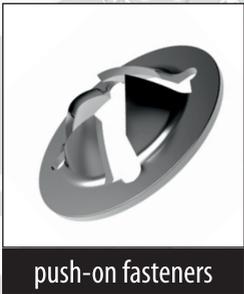
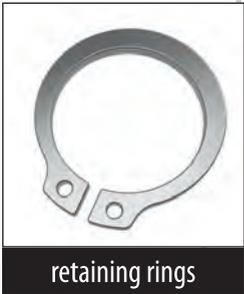


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# READY FOR FLIGHT

*Boom Supersonic's XB-1 demonstrator aircraft leverages metal 3D printing for challenging titanium parts.*



The unveiling of Boom Supersonic's XB-1 supersonic demonstrator aircraft last fall at the company's Denver hangar has brought the return of supersonic air travel closer to reality. Slated to begin flight testing in 2021, the jet prototype is a one-third scale demonstrator for the full-sized Overture, a commercial supersonic jet scheduled to debut in 2025, with passenger flights to commence before the end of the decade. According to the company, two major airlines – Virgin Group and Japan Airlines – have already pre-ordered 30 airliners.

While XB-1 and future Overture resemble the earlier Concorde, XB-1 presented its creators with an opportunity to explore more advanced designs and manufacturing technologies than were available to Concorde engineers.

For example, Boom's Overture airliner will include a carbon-composite airframe, and the company is exploring the use of quiet and efficient Rolls-Royce jet engines that don't use afterburners during supersonic cruise.

Early on, Boom Supersonic's design and engineering team also started thinking about employing additive manufacturing (AM) to produce some of their most complex part designs.

"There are many reasons for choosing that technology over others," says Boom Engineer Byron Young. "There's a great deal of design flexibility in using 3D-printed materials. You might be able to achieve similar results by making

multiple parts and welding or bolting them together, or by using complex carbon-fiber tools. But that requires a lot of engineering time and often more manufacturing time as well."

"Engineers are always trying to implement time-savings into a job," he adds. "Much of the time and effort in aircraft design goes into joints, the interfaces between components. By designing directly for AM, we can reduce the number of parts and joints, which also reduces time and net effort. And part consolidation cuts out significant amounts of weight, something that's a major priority in aircraft design."

## **Lightweighting**

Many of the XB-1's 3D-printed parts are related to channeling air, including complex vanes, ducts and louvers. Some of the air being routed through these parts exceeds 500 degrees Fahrenheit. The geometric complexity of these parts required a surface-based design approach.

"If fast moving air is touching it, we care about that surface from an efficiency and performance standpoint," says Young. "So when designing these parts, you generally start with aerodynamic profiles and then trim, fillet and thicken surfaces to create the solid part itself. The resulting parts are very complex – which means they definitely needed to be fabricated through AM."

VELO3D applications engineer, Gene Miller, agrees with the sentiment and worked closely with both



*Rolled out last year, Boom Supersonic's XB-1 supersonic demonstrator aircraft incorporates 21 components manufactured by 3D metal printer.*

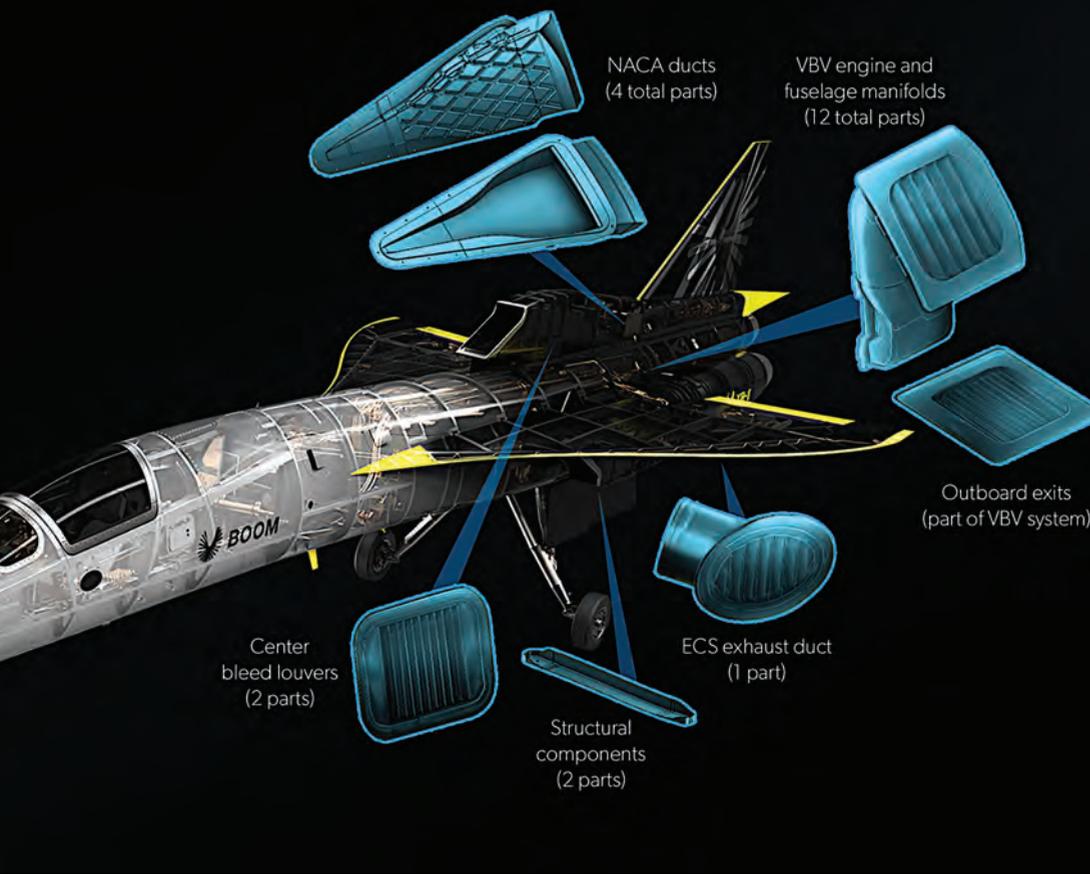
Boom Supersonic design engineers and Oklahoma-based Duncan Machine Products (DMP), the precision machine shop that handled both printing and post-processing.

"Boom designed all these parts specifically for their novel aircraft," Miller says. "The unique types of geometries they created for directing flow, with a focus on weight savings, couldn't be done with sheet metal or casting or any other way. To reap the benefits of complex design and weight reduction together, the only option was to do it with metal AM."

Having established a relationship with VELO3D on some trial parts in 2019, the Boom Supersonic team chose the company's latest laser powder-bed fusion (LPBF) technology to produce a number of printed titanium components (a right and a left version for many of them) located in critical areas of the plane.

These included manifolds for the Variable Bypass Valve (VBV) system that routes air released by the engine compressor to the aircraft's outer mold line (OML); exit louvers for the environmental control system (ECS)

**Many of the XB-1's 3D-printed parts are related to channeling air.**



on the center inlet's bleed louvers were printed hollow, and the parts were designed with high aspect ratios (very thin walls along long spans).

"Because our technology provides the ability to print that very high aspect ratio in this kind of design, we didn't need excess material for strength inside the structures and we could grow those duct vanes up very high without any interference from the recoater," says Miller.

### The Bane of Machinists

All parties involved agree that one of the biggest challenges of the project was working with the titanium material Boom chose for the 3D-printed parts.

"One of the positive aspects of using titanium is the material allowables at temperature," says DMP additive manufacturing engineer Aaron Miller (no relation to Gene). "There's less loss of strength at high temperatures compared to aluminum or carbon fiber, and it has a higher strength-to-weight ratio."

But lightweight, extremely heat-resistant titanium—widely used throughout the aerospace industry for critical components—also has a reputation for being delicate and difficult to work with no matter how it is manufactured. If titanium is cooled too rapidly, it becomes brittle and is prone to cracking. Jokes Aaron, "Titanium is on that list of things that machinists don't like, right behind engineers and Inconel [a superalloy]."

Titanium parts can be manufactured conventionally via casting, which has a slower cooling rate to prevent cracking, notes Gene. But the extremely thin walls in the aircraft hardware

Photo credit: VELO3D

Photo credit: Duncan Machine Products



**The dual 1kW lasers of VELO3D's Sapphire metal 3D printer tracing the geometry and melting titanium powder into a near-net shape part, in this case, for XB-1's VBV fuselage manifolds**

that cools the cockpit and systems bay; louvers that direct the center inlet's secondary bleed flow to the OML; and NACA ducts and two diverter flange parts. NACA ducts are frequently used in high-speed aircraft to capture exterior air and channel it into the aircraft to cool the engine bays. All parts were printed on the VELO3D Sapphire system.

In almost every case, the Sapphire machine was able to print parts directly from

Boom's CAD data, preserving original design intent. "We did use our system's Flow pre-print software to add some structural ribbing on the thinner walls of the NACA ducts that had to be constrained," says Miller. "But, for the most part, the other components all printed as-is, with no compromise to the design."

Boom's Young was impressed with the ability of the Sapphire to accurately produce the extremely thin-walled designs of the parts.

"The Sapphire system allowed us to print walls as thin as 20 thou (0.02 inch, or 750 $\mu$ ), with a surface finish that didn't require additional machining in most cases," he says.

The high aspect ratio (height to width) made possible by the VELO3D machine's non-contact recoater system (which distributes each new layer of powdered metal to be fused by dual lasers) was another plus. For example, to remove mass, the vanes

designs would have been nearly impossible to cast.

“That’s really one of the driving forces behind using 3D printing for these parts because we can print large, thin-walled titanium sections without the high scrap rate of cracked cast parts,” he says.

“This was a learning process on all sides,” Gene adds. “Boom designed a part family that was new to us, really pushing the envelopes for weight reduction and thin-wall geometries. We had a lot to learn as far as printing these components out of titanium and what to expect from the physics of printing. How is it going to move? How is it going to shift? What can be printed without supports and what areas needed to be supported so the result is nominal?”

This is where process control is critical. VELO3D’s semiconductor heritage provides an intense focus on quality control. The team has developed a unique, proprietary AM process that optimizes the print parameters and sequences to produce robust titanium parts. “This reduces the amount of internal stress in the substrate as the material is being built up in the Z build-direction,” Gene explains. “It diminishes the possibility of cracking by mitigation of internal stresses formed during cooling.”

**Part Finishing**

Once Boom’s titanium parts were 3D printed, they were easily sliced off the build plate with sawing or wire-cutting EDM. The DMP machinists say they found post-processing to be relatively straightforward, compared to parts made in other AM systems they’ve worked with, remembers Aaron.

“After cutting off the build plate, we had very little to do in the way of post-machining, apart from minimal support removal,” he says. “You don’t have any tiny supports in small crevices or hard-to-reach places because the SupportFree technology eliminates the need for those. The parts come out of the Sapphire system almost finished, just needing a little handwork with a screwdriver or grinder. We also ream out pilot holes (on larger parts to be joined together) with a mill to ensure they’re the correct size. It’s part-dependent, but probably just a half-hour of machining per part, which is not a big deal.”

Part finish right out of the machine was tested with a profilometer, registering about 250 RA on average.

“If the customer wanted to go to 125 RA, it would take just a few minutes with a vapor hone to achieve that,” says Aaron. “So far, Boom hasn’t asked us

to dial-up the surface finish on their parts; they’re concentrating on geometry and part strength at this point, but if a smoother surface is needed, that’s easy to accomplish.”

Finished parts were heat treated and/or HIP (hot isostatic press) processed to enhance fatigue life.

“Doing this is always a good idea, especially when you have flight components that may be cyclically loaded during take-off and landing,” says Gene. “Supersonic flight introduces a number of different phenomena and stresses you generally don’t see with conventional air travel.”

“The main forces being applied aren’t generally pressure loads from, say, breaking the sound barrier,” adds Young. “In many cases, it’s induced strain caused by the overall structure of the aircraft flexing around your part. When parts with dissimilar thermal expansion coefficients are mounted to each other, significant stresses can also result (this includes carbon composites and aluminum in addition to titanium). Designing these 3D printed parts to be very thin and flexible can actually mitigate some of these issues.”

The three companies that put their heads together to successfully produce the 3D printed parts for Boom Supersonic’s XB-1 supersonic demonstrator say they’ve learned a lot from their collaboration. The Boom team found that AM was more complex than they had envisioned—but could also deliver on their original design intent. And Duncan Machine Products expanded their 3D printing expertise significantly, going on to purchase a third Sapphire machine. Says Aaron, “We’re getting a lot of new business because of our capabilities in additive manufacturing.” **IDE**

**boomsupersonic.com**  
**www.velo3d.com**

*This article contributed by VELO3D*

*The three 3D-printed parts of the XB-1’s Variable Bleed Valve (VBV) system (right) mirror the VBV’s CAD data (left), shown here in VELO3D’s Flow pre-print software.*



Photo credit: VELO3D

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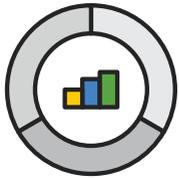


# CANADIAN ENGINEERING EMPLOYMENT TRENDS IN 2021

Randstad Engineering report reveals salary and labour trends for mechanical engineers in Canada.



According to Randstad Engineering's 2021 report on engineering labor and salary trends, engineering, across disciplines, continues to experience significant shortages, especially for experienced engineers. And, as the bulk of this labor segment moves into retirement in the next 5 to 10 years, shortages of skilled engineers with industry specific expertise will only intensify.



Even so, the majority of companies surveyed for the report have resisted making any significant changes to compensation, despite the effects of COVID-19. Based on the salary and survey data supplied by the Economic Research Institute (ERI), 45% of business surveyed indicated they haven't committed to any compensation course change. Beyond that, another 35 percent of employers said they have halted, slowed or otherwise kept compensation stable. About 19%, however, have increased paychecks for employees willing to hazard the pandemic.



Given the above, Canadian engineers' median salaries (\$75,200), across all disciplines, is unchanged from 2020. Also unchanged from last year are median salaries for those in the bottom 10% of the salary range, who make \$45,900 or less. Those in the top 10%, however, did see their median salaries increase to \$104,500+, most likely due to the shortage of experienced engineers.

## Top Jobs 2020

The list of the most in demand engineering titles shifted considerably from last year, with manufacturing and electrical engineer falling out of the top spots. Replacing them is the leader and new comer to the list, Civil Engineering Technician, as well as Director of Engineering. Others retained their leadership but swapped positions. Project Coordinator and Engineer moved out of the top three while Quality Assurance Technician and Industrial Engineer moved up in reported demand.

1. Autodesk AutoCAD
2. Quality assurance
3. Instrumentation
4. Solidworks
5. Autodesk REVIT
6. French bilingualism

## Top Skills 2020

As in past years, being adept with CAD software remains the top general skill sought by Canadian engineering employers. Despite its age and limited capabilities, AutoCAD retained its top spot this year followed by Solidworks and REVIT. Engineers stick with the tool they learned early, and since most active Canadian engineers are over 50, it's not surprising the 2D drafting software hangs on. Rounding out the list are QA and metrology, as well as the always handy bilingualism.

1. Civil Engineering Technician
2. Quality Assurance Technician
3. Engineering Manager
4. Industrial Engineer
5. Project Manager
6. Project Coordinator
7. Project Engineer
8. Director of Engineering

## Top Certifications 2020

The certifications that carry the most weight with engineering employers is unchanged from last year. Randstad's report points out that, COVID or no, buildings and infrastructure remain essential projects, hence the continued demand for structural engineers. Below the top spot are the Professional Engineer designation followed by the pre-req for full engineer status, Engineer in Training (EIT), and the trade-oriented cert, Certified Engineering Technologist.

1. Structural Engineer (SE)
2. Professional Engineer (P.Eng / PE)
3. Engineer In Training (EIT)
4. Certified Engineering Technologist (C.Tech / CET)
5. Computer Aided Design And Drafting (CADD)
6. Electronic Systems Technician (EST)



For Randstad's full report, including data for all engineering specialties and related professions, visit [www.randstad.ca/salary-guides](http://www.randstad.ca/salary-guides).

# Mechanical Engineering Salary Guide 2021

The following salary data is adapted from Randstad Engineering's 2021 *Professionals Salary Guide*, based on survey data supplied by the Economic Research Institute (ERI). All salaries are expressed in thousands of dollars and represent annual base salaries (before benefits) for manufacturing mechanical engineers only.

While not shown here, Randstad's 2021 salary guide does also include data for Construction and Oil & Gas industry mechanical engineers. Salary ranges quoted below correspond to the 25th and 75th percentiles for Entry (1-3 years), Mid (4-7 years) and Senior (8-12 years) levels.



<p><b>1 Greater Vancouver</b>  <b>Entry:</b> \$89.0 - \$117.2  <b>Mid:</b> \$100.8 - \$135.1  <b>Senior:</b> \$115.1 - \$153.6</p>	<p><b>4 Greater Greater Saskatoon</b>  <b>Entry:</b> \$86.4 - 114.6  <b>Mid:</b> \$98.2 - 132.5  <b>Senior:</b> \$112.4 - 151.0</p>	<p><b>7 Ottawa Region</b>  <b>Entry:</b> \$90.6 - \$119.3  <b>Mid:</b> \$102.5 - \$137.5  <b>Senior:</b> \$117.1 - \$156.4</p>	<p><b>10 Capitale-Nationale Region</b>  <b>Entry:</b> \$60.7 - 80.6  <b>Mid:</b> \$68.9 - 93.2  <b>Senior:</b> \$78.9 - 106.6</p>
<p><b>2 Greater Calgary</b>  <b>Entry:</b> \$79.7 - \$104.6  <b>Mid:</b> \$90.1 - \$120.3  <b>Senior:</b> \$102.7 - \$136.5</p>	<p><b>5 Winnipeg</b>  <b>Entry:</b> \$82.8 - \$109.8  <b>Mid:</b> \$94.0 - \$127.2  <b>Senior:</b> \$107.8 - \$145.1</p>	<p><b>8 Waterloo County</b>  <b>Entry:</b> \$84.7 - \$112.0  <b>Mid:</b> \$96.0 - \$129.4  <b>Senior:</b> \$109.8 - \$147.5</p>	
<p><b>3 Greater Edmonton</b>  <b>Entry:</b> \$76.8 - \$100.9  <b>Mid:</b> \$86.8 - \$116.2  <b>Senior:</b> \$99.0 - \$131.8</p>	<p><b>6 Greater Toronto</b>  <b>Entry:</b> \$91.0 - \$120.1  <b>Mid:</b> \$103.1 - \$138.7  <b>Senior:</b> \$118.0 - \$157.9</p>	<p><b>9 Greater Montreal</b>  <b>Entry:</b> \$58.0 - 77.0  <b>Mid:</b> \$76.0 - 90.0  <b>Senior:</b> \$88.0 - 115.0</p>	

For Randstad's full report, including data for all engineering specialties and related professions, visit [www.randstad.ca/salary-guides](http://www.randstad.ca/salary-guides).

# Speak the Language

*Protecting IT/OT environments from cyber threats requires alignment of security and business leaders.*



With the rise of IIoT, the convergence of the IT and operational technology (OT) worlds have introduced new attack vectors and allowed cyber threats to grow at alarming rates. The U.S. Cybersecurity and Infrastructure Security Agency (CISA), for example, recently warned about vulnerabilities in motion sensors in robotic controllers used in manufacturing and healthcare.

Similar attacks include the EKANS ransomware in 2020 that was designed to target industrial control systems. However, despite constant warnings and ongoing attacks, security teams often face challenges in aligning leadership to confront the issue of cyber risk.

The reality is that cyberattacks impose serious consequences on critical infrastructure and essential services. The pandemic has underscored this threat as the heightened reliance on essential services continues to pique cybercriminals' interests.

In fact, a recent study conducted by Forrester Consulting on behalf of Tenable found that, over the past year, 65% of organizations in the U.S. suffered cyberattacks or compromises that involved OT systems.

For these environments, bolting on a security solution alone is only half of the battle. Organizations need to integrate security into the business strategy and ensure close coordination



between security leaders and business executives – particularly in industrial environments.

In most organizations, this isn't happening. The study, which surveyed over 800 global security and business executives in a variety of sectors, shows that just 54% of security leaders and 42% of business executives say their cybersecurity strategies are completely or closely aligned with business goals.

At its core, this is due to inconsistent communication among leadership, spurring a split in priorities and strategies. According to the study, fewer than half of security leaders consult business executives all the time or very frequently when developing their cybersecurity strategies. On the flip side, four out of ten business executives rarely – if ever – consult with security leaders when developing their organizations' business strategies.

The good news is there are concrete steps organizations can take. The first is to begin a regular

cadence of communication with business leadership to understand priorities and establish a coordinated strategy. In converged industrial environments, this will initially require both OT and IT security personnel to align on approaches.

Historically, IT and OT security teams held different priorities. OT favors stability, safety and reliability, while IT staff focus on integrity, availability and confidentiality. With IT/OT security teams on the same page, they are better poised to strengthen communication with business leaders as well as address threats as a unified front.

Even with this IT/OT alignment, risks are often lost in translation when communicating with business leaders. In fact, fewer than half of security leaders are framing the impact of cybersecurity threats within the context of a specific business risk. To drive effective communication, security leaders must “speak the language”.

To accomplish this,

security leaders must adopt business metrics that identify the potential cost to critical OT assets and express how this can affect revenue over time.

From there, they can illustrate how an attack on a device, such as a robot controller, can directly affect the efficacy of the organization's ability to deliver on its value proposition. Lastly, security leaders should show how other industrial organizations have been impacted, and make investment and process recommendations to strengthen security.

The study notes that business-aligned security leaders are eight times more likely to be highly confident in their ability to report on their organizations' level of security or risk. Plus, 85% percent of them have metrics to track cybersecurity ROI and impact on business performance versus just twenty-five percent of their siloed peers.

Taking a risk-based, business-aligned approach to cybersecurity can help industrial organizations evolve from ‘check-the-box’ operations to a fortified, strategic cybersecurity program. With the right combination of technology, people and processes, industrial organizations can continue 24/7 operations with enhanced confidence in their ability to face the cyber threats of tomorrow.

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*This article was submitted by  
Tenable Inc.*

# Cleaning Up

Clean technology innovation in Western Canada looks to improve GHG emissions and bottom lines. **BY DON HORNE**



Experts point to Western Canada becoming a hot bed of innovation as players in several key resource-based industries explore new technologies to remain competitive on a global stage. From improved resource recovery to improved I/O modules, these stakeholders applaud ongoing efforts by industry leaders to nurture new approaches to old ways of doing business.

“There are global forces that are driving our resource-based industries to be more competitive,” says Mark Summers, executive director of technology and innovation for Emissions Reduction Alberta (ERA), a not-for-profit organization that funds the discovery, development and deployment of technology that reduces greenhouse gas emissions. “And as a result, our industries and businesses continue to look at technology acceleration and implementation of technology as a way to continue to be competitive on a global stage.”

## Resource Extraction

Summers points to the oil patch as the epicentre of several made-in-Alberta examples of innovation leading the way. For example, Imperial Oil Resources – in collaboration with ERA – is advancing a field trial of its enhanced bitumen recovery technology for its in-situ oil sands facilities. Where the reservoirs are



**For its Wapiti Gas Plant in northern Alberta, SemCAMS Midstream installed ABB’s Ability System 800XA with Select I/O platform, which moved the I/O from the motor control centre into the field, eliminated junction boxes and extensive engineering and cabling. The result was a cost savings of 30 to 40 per cent.**

deep underground, the trial is using a recovery solution to dilute and mobilize bitumen in the reservoir, reducing the amount of steam needed as much as 90 per cent compared to current methods.

It is also expected the technology could reduce emissions from in-situ oil sands extraction facilities by approximately 60 per cent compared to conventional steam-assisted gravity drainage (SAGD) production methods.

“Emissions and the oil sands are linked at the hip because it takes so much energy to take water and superheat it to create high-pressure, high-temperature steam,” says Summers. “Anything you can

do to reduce the amount of steam required to be put into the reservoir will ultimately reduce greenhouse gas emissions.”

In surface mining operations, Canadian Natural Resources Ltd. is exploring an in-pit extraction process that acts as a progressive reclamation approach and could eliminate tailings ponds. By putting the bitumen extraction plant in the mine pit, it’s estimated the process could reduce greenhouse gas emissions by 40 per cent and cut operational costs.

Summers, whose organization has invested more than \$571 million into 164 initiatives in Alberta over the past decade, notes technology acceleration is also a

way of doing business better. Outside of market forces, he points to societal forces that are driving Western Canadian resource-based industries to be better stewards of the environment in which we live.

“At ERA, we want to accelerate technology to help Alberta and our industries reduce greenhouse gas emissions,” he says. “But we don’t want to reduce GHG emissions at the cost of economic opportunities. So we always look at the dual benefit.”

In other cases, innovation in Western Canada is taking the form of simplifying a complex situation. In 2019, SemCAMS Midstream completed its Wapiti Gas Plant, located

Photo credit: Brad MacDonald, ABB



Photo credit: AVL Fuel Cell Canada

approximately 40 kilometers southwest of Grande Prairie, Alta. The plant is capable of processing up to 200 million cubic feet of raw sour gas and 20,000 barrels of condensate per day.

To ensure an on-time and on-budget completion of the project, SemCAMS installed ABB's Ability System 800XA with Select I/O platform. The single channel I/O (input/output) moved the I/O from the motor control center and electrical rooms into the field, eliminated junction boxes and extensive engineering and cabling. The result was a cost savings of 30 to 40 per cent.

"What we did was build a cabinet that could be put into the field with the option of which I/Os to include, whether that's starting a motor, opening a valve or measuring a temperature," says Brad MacDonald, automation product manager with ABB. "It removed the engineering design having to be done up front. Instead of having to know how many I/Os were needed at the start, we were able to put this cabinet into the field and just keep adding. And instead of having to create 27 cabinet designs, we created one cabinet

and supplied 27 units."

With one design for all remote I/O cabinets, engineering and project time was reduced compared with the traditional solution. The cabinets were built and shipped well in advance, decoupling site hardware and installation from back-office engineering, resulting in savings and improving project timeline.

"It reduced the cost of change," says MacDonald. "Change costs so much. The overhead of change is unbelievable because of hardware design. Now that they had this flexible system that's just plug-and-play, they didn't have that inherent cost of change. They only had the cost of the actual device."

MacDonald notes the Select IO is well received in the oil and gas and chemical industries since both contend with extreme and/or hazardous environments; the Select I/O can operate in a temperature range from -40 to 70°C and be mounted in Class 1 Div 2 Zones (volatile flammable liquids or gases) environments.

### Clean Energy Vehicles

Meanwhile, several recently announced B.C.-based research initiatives are taking aim at

expanding the province's growing clean energy vehicle sector (CEV). For example, Eagle Graphite, which owns one of only two natural flake graphite production facilities in North America, was one of five companies to receive funding as part of the province's Advanced Research and Commercialization Program (ARC) for the CEV sector.

The company is currently in the process of developing and commercializing silicon/graphite battery anodes made with graphite from its graphite quarry and plant located approximately 35 kilometres west of Nelson, B.C.

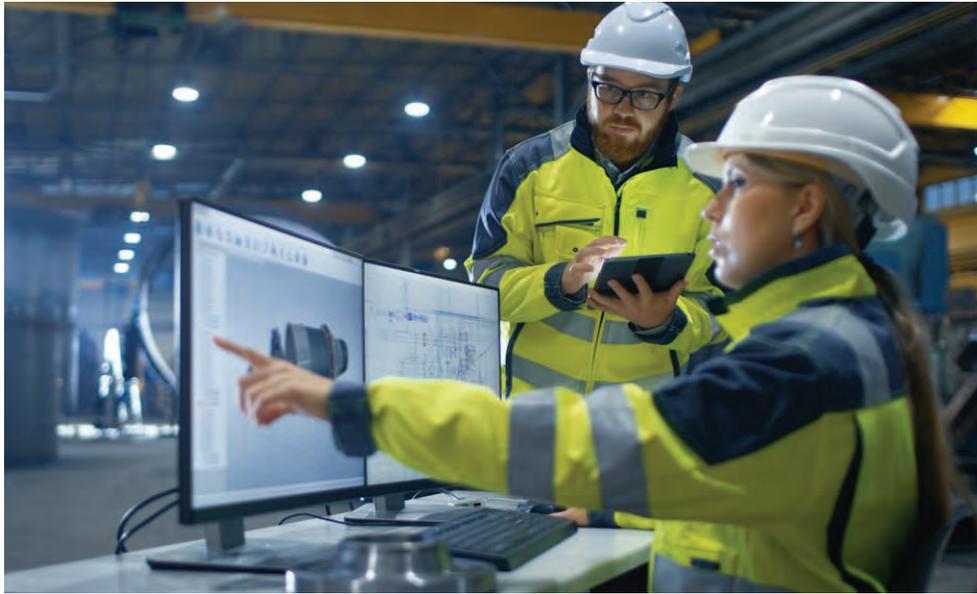
Similarly, AVL Fuel Cell Canada in Burnaby, B.C. also received support for its development of an advanced fuel cell model for research and series development applications in the automotive sector.

Established in 2018, the research and development center is owned by Austria-based AVL, which is the world's largest independent company for the development, simulation and testing of powertrain systems. The Canadian facility is focused is on adding to the company's existing capabilities in powertrain electrification development from electric battery and fuel cell systems to include hydrogen fuel cell stack development.

"The performance, durability and cost of fuel cells are linked, and improving any one of them will impact the other two," said Jose Rubio, managing director, AVL Fuel Cell Canada. "That's why it is so important to develop a comprehensive fuel cell model capable of simultaneously providing accurate measures of performance, degradation and cost." |DE

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**arcbc.ca**

*Don Horne is the editor of Process West magazine in which this article was originally printed.*



# THE FOUR MOST COMMON MACHINE SAFETY VIOLATIONS

*Experts weigh in on the areas of noncompliance encountered most frequently during risk assessments.*

**BY MICHAEL JOAQUIN, P.ENG AND TODD MASON-DARNELL, PH.D**



Safety is a central concern of any manufacturing application. With heavy objects moving at high speeds and sharp edges ready to slice, industrial machinery creates a host of hazards that good training can't fully protect against.

For this reason, protection must be built into the system itself by means of guarding, control of hazardous energy sources and other safety measures mandated by today's standards.

When the lives of machine operators and maintenance personnel are at stake, it's essential for manufacturers to have risk assessments conducted at regular intervals to provide a foundation for bringing all industrial equipment into compliance.

Here, we'll take a look at the typical areas in which risk assessment service providers find compliance lacking, as well as the reasons why some companies are tempted to cut corners.

## **1. No guarding or noncompliant guarding at point of operation (CSA Z432-16 c.10)**

CSA Z432-16 is a wide-ranging safety standard that brings all the safeguarding-related requirements for the design, installation, operation and maintenance of industrial machinery under one umbrella. One of its most commonly referenced sections is that which describes Operator Interface/ Point of Operation (PoO)

guarding requirements. This is one of the most dangerous parts of the machine, since it's where work is performed on a substrate.

Proper PoO guarding must accomplish two related goals: (1) preventing access to the machine when its motion could be hazardous; and (2) stopping the machine from moving when a person needs to access it (such as during maintenance).

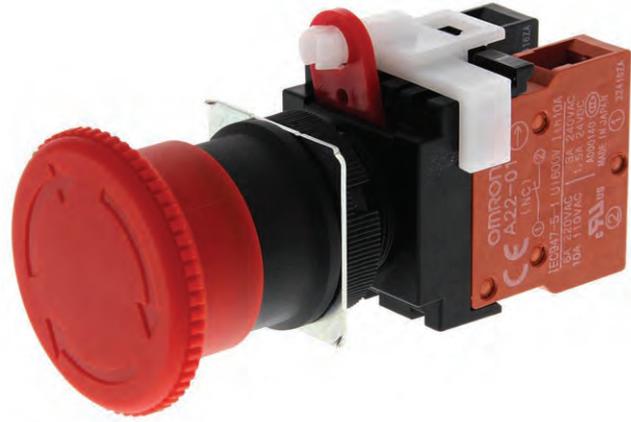
Violations of these requirements are unfortunately not uncommon, as poorly designed safeguarding is often removed when it starts to interfere with the task of operating the machine.



## **2. Inadequate functional safety performance (CSA Z432-16 c.8)**

Another well-known (and commonly violated) portion of CSA Z432-16, section c.8 discusses the requirements for functional safety performance, which refers to the performance level (PL) of the safety related parts of the control system (SRP/CS).

Typically, the SRP/CS must "fail to safe" for a high-risk machine to be



compliant. Lack of a safety-rated monitoring device for the safety circuit is a quick indicator of non-compliance.

The degree of redundancy and monitoring for the controls must be appropriate for the level of risk being assessed. Risk assessment providers often find that manufacturers connect light curtains and interlock switches on high-risk machines back to a regular PLC or relay instead of a safety-rated PLC or a safety relay. Standard (not safety-rated) equipment is insufficient for this purpose because it lacks the proper redundancy level.

**3. Noncompliant E-stop buttons (NFPA 79/CSA Z432-16 c.7.15)**

E-Stop buttons provide a quick, surefire way to shut down a hazardous machine in an emergency. Due to their great importance, they must meet strict guidelines that ensure standard functionality in addition to a recognizable look and feel. E-Stops must be red-colored pushbuttons mounted above a yellow background in an easily accessible location, and there can't be an automatic reset option (only manual reset is allowed).

Unfortunately, risk assessment providers find non-compliant E-stops somewhat frequently. This is typically due to a lack of knowledge about the requirements or a desire to prevent the E-stop from being pushed too frequently in non-emergency situations. Some manufacturers

choose to use E-stops for routine machine shutdowns, which is also a standards violation because it wears out the button's contacts.

**4. Non-compliant or missing energy isolation components (CSA Z460)**

Maintenance work typically requires direct contact with machinery in ways that would be extremely dangerous – or impossible – if the machine were running, so the equipment must be turned off.

However, if there's no way to lock out and dissipate hazardous energy during this time, it's possible that another worker could accidentally press a button that gives power to the machine being worked on. This could result in a serious accident.

To prevent such occurrences, manufacturers must control the machine's electrical, pneumatic or hydraulic power sources through a strategy known as lockout/tagout (LOTO). Unfortunately, many manufacturers find it difficult to isolate their hazardous energy sources in a way that complies with the

requirements set down in CSA Z460. The failure to do so may be responsible for almost 10 percent of the most serious accidents that occur on the plant floor.

To properly isolate hazardous energy sources, manufacturers typically use a number of retrofit devices. The device depends on the type of power involved. For pneumatics, there's an energy isolation valve with a bleeder to dissipate the energy and let the air out. For electrical energy, there's usually a panel with a big switch or a breaker.

Both must be lockable in the OFF position only. In addition to this, manufacturers need official written policy and annual LOTO training.

Although it can be challenging to achieve complete machine safety and standards compliance, there's no good reason to take the easy way out. By failing to provide a safe working environment, companies can be held responsible for serious accidents occurring on the plant floor.

It's essential for manufacturers to pay attention to proper safeguarding, safety control system performance, E-stop button requirements and the complete

isolation of hazardous energy sources. **IDE**  
**www.automation.**  
**omron.com**

*Michael Joaquin, P.Eng and Todd Mason-Darnell, Ph.D are, respectively, the safety services specialist and marketing manager at Omron Automation.*



# ROBOTS REMOVE DANGER IN PIPELINE REHAB WORK

*BC Hydro employs automated solution for safer, faster turbine maintenance.*

BY DAN THOMPSON



Owned by the Province of British Columbia, BC Hydro serves more than 4 million customers in an area including more than 95 percent of province's population.

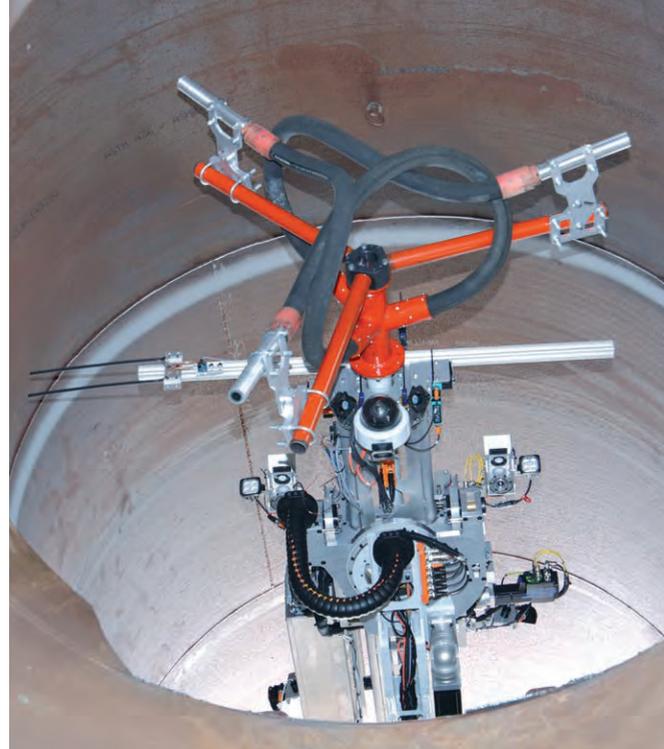
The utility company owns 30 hydroelectric facilities, more than 300 substations and 80,000km of transmission and distribution lines. In 2019, the Crown corporation's revenue reached \$5.4 billion.

Since residential users, manufacturing plants and businesses rely on it 24/7/365, the utility can't afford to let its guard down.

So, when a tragic accident in Colorado claimed the lives of five utility workers in 2007, executives at BC Hydro took note. Workers at Xcel Energy were applying an epoxy lining in a penstock pipe at the Cabin Creek Station, about 30 miles west of Denver, when a fire broke out.

Trapped in an access tunnel filled with deadly fumes, the workers died from asphyxiation. The plant was shutdown for a period after the tragedy as officials investigated the cause of the fire.

Penstocks – which channel water through turbine generators – are used at BC Hydro's



*The Crawler's blasting rate in a 10-foot penstock is about 500-600 square feet per hour. During the internal lining process, the unit can travel up to 46 meters per hour.*

hydroelectric facilities. Over time, the internal coatings need to be removed and replaced with a new lining system to prevent corrosion, repair leaks and keep the system running smoothly.

After the Colorado tragedy, BC Hydro sought a new solution to rehabilitate its vast collection of penstocks, and a Wisconsin company developed an automated solution.

A newly developed robotic device from Remote Orbital Installations LLC (ROI) and Big Sky Engineering delivers a faster and safer alternative to manual labor for pipeline rehabilitation. A robotic platform which ROI/Big Sky calls "The Crawler," the system can both surface-blast and line medium to large diameter pipe internals.

"Their ultimate intent is to take man-entry out of these jobs," said Mike Kronz, who helped design the unit for ROI/Big Sky. "Canada is pretty tight on restrictions for human safety. Their regulations and standards sometimes make the Occupational Safety and Health Administration in the United States look like child's play."

## **Finding the Energy**

Some of the primary components in "The Crawler" are energy chains from igus, the Germany-based manufacturer



Photo credits: igus

Designed by Remote Orbital Installations and Big Sky Engineering, "The Crawler" is designed to surface-blast and line medium to large diameter pipe internals.



of motion plastics. The chains are used to manage and protect electrical cables going from the lower control cabinets to the upper cabinets. They are used in the main boom raise, which allows the boom to extend and contract as it works within the pipe.

An energy chain also allows the wheel width of the Crawler to be adjusted as it moves within the penstock. Diameters vary from 1.5 to 4 meters, and the automated unit is adjusted through an umbilical cord that is controlled by a person in the command center, which is actually a modified shipping container.

“There is all kinds of feedback that can be read in the command center,” Kronz said. “The umbilical cord allows for remote operation 2,000 feet from the command center.”

While some energy chains can be made of metal, they require maintenance and the weight of those components has led to the use of more lightweight components, such as plastic. In contrast, igus energy chains require no maintenance, resist dirt and can reduce installation costs by 88 percent.

The Crawler also incorporates servo motor cables that direct boom movement, and in

*The Crawler includes several components from igus, including energy chains that protect electrical cables and also allow for the wheel width of the unit to adjust as it moves within the penstock.*

the umbilical cord that contains power and control cables along with fiber optic cables. An igus slewing ring allows the boom to pivot from side to side.

Slewing rings are one of igus’ most versatile and widely-used products. The self-lubricating rings are slim, lightweight and wear-resistant. They were especially critical in this application due to their ability to resist dirt, dust and humidity. They can be used in applications with high temperatures, moisture, chemicals and even food-processing.

The durability of the igus products was critical to the success of the Crawler, said Paul Garvoille, who helped lead the design of the robot.

“We’ve done several projects and we haven’t had a single failure with the igus components,” he said. “Other materials have failed, but not the igus products. The slewing ring, for instance, is comparable to a ball bearing. That would have been a real problem with all the dirt that the device experiences. The igus materials don’t require any seals to protect the bearing.”

### **Acing the Test**

ROI/Big Sky put their robotic system to the test under actual project conditions. At its Wisconsin facility, the partners

constructed a full-scale mock-up of a 2.5 meter diameter pipe 18 meters long with a 45-degree incline. The next phase tackled the rehabilitation project at BC Hydro’s Bridge River Facility, which opened in 1961.

The Crawler navigated through 1,371 meters, adjusting to the different angles while moving along descents as steep as 45 degrees. A second repair project occurred in 2019 at BC Hydro’s Cheakamus Facility, where the Crawler completed nearly 500 meters of pipe repair. In each instance, the robot performed the required work without incident.

Depending on surface conditions, the Crawler’s blasting rate in a 10-foot penstock is about 500-700 square feet per hour, and travels about 4.61 meters per hour. During the internal lining process, the unit travels at approximately 45 meters per hour.

The automated solution could not come at a better time. Infrastructure across the world needs repair. A 2019 report found nearly 40 percent of Canada’s roads and bridges were in fair, poor or very condition.

Similarly, the American Society of Civil Engineers reported in 2019 that the United States needs \$4.5 trillion to fix roads, bridges, dams and other infrastructure.

“There’s a global market for this,” Garvoille said. “If there is a pipe that transfers water, it’s not going to last forever. They have to be protected and repaired from time to time.”

With infrastructure aging and in dire need of repair, the Crawler and other automated units will play an important role in repairing it. British Columbia, as large as it is, is just the tip of the iceberg in the worldwide dilemma to find reliable and safe infrastructure repair. **IDE** [www.igus.ca](http://www.igus.ca)

*Dan Thompson is energy chain product manager for igus, N.A.*



**MOTION CONTROL**

**SERVO TERMINALS**

Beckhoff released its ELM72xx, an EtherCAT servo terminal that features a metal housing and delivers an output current (I<sub>rms</sub>) of up to 16A at 48VDC for the power supply. The servo terminals can connect directly to other EtherCAT Terminals and provide the direct connection of the motor, feedback and brake via the connector front end, an integrated absolute value interface and One Cable Technology (OCT).

Additional I/Os enable latching of position values. In addition, the integrated brake chopper control permits direct connection of braking resistors. The system also integrates programmable TwinSAFE Logic for direct implementation of the safety application in the terminal and safe drive technology either as STO/SS1 via Safety over EtherCAT (FSoE) or as a package of Safe Motion functions for safety-relevant drive technology via TwinSAFE. The line's five ELM72xx models are equipped with either STO/SS1 or Safe Motion. [beckhoffautomation.com](http://beckhoffautomation.com)

**IIOt PLC**

IDEC Corporation has released a firmware upgrade that enables MQTT protocol support in its MicroSmart FC6A Plus line of PLCs. The IIOt protocol is supported on Ethernet port 1,

so the FC6A can use existing wired, Wi-Fi or mobile data wireless networking to connect with on-site or cloud-based



brokers. No additional hardware is needed.

Users can take advantage of the traditional PLC control logic and I/O functionality, or they can use the FC6A as an IIOt data concentrator for many other PLCs and intelligent devices. The FC6A with MQTT supports Amazon Web Services AWS IoT Core today, with future support planned for Microsoft Azure and Google Cloud. [FC6A.IDEC.com](http://FC6A.IDEC.com)

**PLC I/O MODULES**

Automation Direct has added discrete I/O modules that snap onto the side of any BRX Micro PLC Unit (MPU) or BRX Remote I/O controller. The line includes



5, 8 and 16-point relay output modules with Form A (SPST) and Form C (SPDT) options. In addition, the line includes 16-point 2-5 VDC discrete input and output modules; a 16-point 2-5 VDC discrete combination input/output module; and the HSIO4 high-speed pulse combo module capable of handling up to a 2MHz frequency in differential or single-ended wiring configurations.

Also in the line is a Pluggable Option Module (POM) with full Ethernet capability and support for MQTT Client, Do-more and EtherNet/IP. Ethernet remote I/O. Modbus TCP protocols (for use with Ethernet MPUs only) has also been added to the lineup. [automationdirect.com](http://automationdirect.com)

**MINIATURE SLIDE GUIDES**

NB Corporation's SEBS-B type slide guides offer a drop-in replacement for standard brands and accurate radial clearance, the company says. All stainless models are suitable for high temp applications, clean room and vacuum environments. The company's application



assistance ensures two years of maintenance-free operation. Available in both non-retained- or retained-ball lines, these elements allow for easier handling since the guide block may be removed from rail without ball loss, the company says. Sizes start at 2mm with friction-free travels from 104mm to 1,000mm lengths. [nbcorporation.com](http://nbcorporation.com)

**LIFT STAGE**

OES has added three high precision vertical lift stages capable of elevating heavy loads by 30mm (1.18 in.) in an ultra-low profile design. The rigid box construction of the moving component of the elevator stage travels on six slide rails, powered by a two-phase stepper motor with 3.315 microns (full-step) resolution, 5 microns repeatability and 15 microns positional accuracy. Motor options include two-phase



stepper motor, single phase DC servo motor, and a 3-phase brushless servo motor.

The 100kg (220.5 lbs) vertical lift features a 500mm x 300mm (19.685 in. 11.811 in.) stage. The height at lowered position is 269mm (10.591 in.) Constructed with black-anodized aluminum alloy and steel shafting, it weighs 35kg (77.2 lbs).

[oesincorp.com](http://oesincorp.com)

**MOTORS/DRIVES**

**INTEGRATED SERVO MOTOR**

Maxon unveiled its IDX compact integrated servo gearmotor + drive that combines a brushless EC-i motor with an EPOS4 positioning controller, and optionally complemented with a maxon planetary gearhead when required. With an IP65 rating, the line also features configurable digital and analog inputs and outputs, and



software that enables commissioning and integration into master systems. According to the company, the IDX yields high continuous torques and power density. They are also suitable for use across the entire speed range (from standstill to maximum speed) and have a high overload capability. Together with its internal positioning controller and integrated single turn absolute encoder, absolute positioning is standard. Operating voltage ranges from 12 to 48 VDC.  
[idx.maxongroup.com](http://idx.maxongroup.com)

**DRIVE MODULE**

ACS launched the IDMSm, part of a line of high-performance intelligent drive modules. The IDMSm is a 2- or 4-axis EtherCAT DS402 universal servo drive featuring control algorithms and

processing technologies that enhance the performance of high-precision motion stages, the company says. Certified as EtherCAT Conformance Tested, the drive provides up to 5A continuous and 10A peak per axis with a 12-48 VDC drive supply. It's standard DS402/CiA402 CoE EtherCAT interface provides connectivity to any EtherCAT master controller. The drive also features ACSPL+ real time programming with up to four simultaneous threads, as well as Integral Safe Torque Off (STO), SS1 functional safety capabilities.  
[acsmotioncontrol.com](http://acsmotioncontrol.com)

**FLUID POWER**

**PNEUMATIC NETWORK PORTAL**  
Parker Hannifin released its



PCH Network Portal, an Ethernet node with IO-Link master capability that supports multiple industrial communication protocols. Classified as a Cyber Physical System, the PCH Network Portal uses fast and storable configurations, power in and out connectors with safe power capabilities and optional safe power zones. Its interfaces shorten start up time by taking advantage of Bluetooth connectivity, port pin configurations and built-in programming functions. Diagnostics to the PLC offer localized troubleshooting and can help minimize downtime.  
[parker.com](http://parker.com)

**HYDRAULIC RUN-TIME METER**

Webtec has developed the RFS200, a run-time meter designed so that specialist hydraulic attachments can be rented on a 'time-used' basis, rather than by machine hours. The Webtec run-time meter is activated by the passage of



hydraulic fluid and is unaffected by pressure. On the RFS200, the switch point is fixed at 10 litres per min. When the switch point is reached, the counter starts incrementing and keeps counting whenever the flow rate remains above the trigger point. All counting is cumulative. The run-time meter offers flow rates up to 200 lpm and maximum pressure of 420 bar. It is also bi-directional and will allow oil to pass in reverse, but the counter will not be

triggered. Suitable for use with hydraulic mineral oil to ISO 11158 category HM, fluid temperatures can be accommodated between -40°C and 100°C. Timer accuracy is ±0.2% over the specified temperature range.  
[webtec.com](http://webtec.com)

**NETWORKING**

**NETWORK BLOCK**

Balluff launched its CC-Link IE Field Basic network block with IO-Link that offers 100 Mbit Ethernet. The block uses the Seamless Message Protocol (SLMP) for communications and is built into an IP67 metal housing suited for industrial environments. It also provides



the benefits of IO-Link, which includes device detection and the automatic transmission of parameter and configuration data. Users can connect up to 16 standard I/Os or eight IO-Link ports. A display window reveals module information, while status LEDs at each port offer easy diagnostics.  
[www.balluff.com](http://www.balluff.com)

**MANAGED SWITCHES**

WAGO has expanded its line of managed switches with the introduction of four models. Each switch includes Ethernet Ring Protection Switching



(ERPS) and Rapid Spanning Tree (RSTP) for network redundancy, port mirroring and onboard firewall. They also incorporate a web-based dashboard and topology mapping to provide updates on network status and system health. Several variants are available. The 852-1812, 852-1813 and 852-1813/000-001 come with 8 RJ45 ports, with the 852-1816 equipped with 16 ports. The 852-1813 and 852-1813/000-001 also have two additional fiber optic ports. The 852-1813/000-001 also comes with Power over Ethernet (PoE+). All ports have a speed of 1 GB.  
[wago.com](http://wago.com)

**INDUSTRIAL WIRELESS**

Antaira Technologies introduced its ARS-7235 series, ARX-7235-AC-PD-T and ARY-7235-AC-PT wireless internet devices. The ARS-7235 series is an industrial IEEE 802.11a/b/g/n/ac wireless LAN access point with added router capabilities. The ARX-7235-AC-PD-T and ARY-7235-AC-PT are



industrial outdoor IP67 rated, IEEE 802.11a/b/g/n/ac wireless access points/clients/bridges/repeaters with router capabilities and are IEEE 802.3af/at PoE PD compliant. All three devices feature dual-band 2.4GHz/5GHz concurrent and support high-speed data transmission of up to 867Mbps. In addition, all three wireless products are capable of

operating in different modes, which makes them suitable for a wide variety of wireless applications including long-distance deployments.

[antaira.com](http://antaira.com)

### SMART GRID GATEWAYS

HMS Networks released two Ixxat SG-gateways that feature a 4G/LTE modem for cellular connectivity as well as 4-port Ethernet switching capabilities. The 4G



CAT1 connection offers 10 Mbps downstream and 5 Mbps upstream communication with low latency, high network coverage and a

universal data channel – independent of wired Ethernet, DSL or fiber optics. 4G can be used as either the main or backup communication channel.

All supported IP-based protocols – including IEC 61850, IEC 60870-5-104, MQTT and OPC-UA – can be transmitted over the wireless link. In addition to the 4G option, multi-port versions can securely connect networks through several independent interfaces on the data level. This simplifies data exchange between energy automation networks and industrial Ethernet systems (such as PROFINET or EtherNet/IP) as well as connection to IoT-systems and cloud applications.

[ixxat.com](http://ixxat.com)

### MACHINE VISION

#### INDUSTRIAL CAMERA

Teledyne DALSA unveiled its Genie Nano-CXP 67M and 37M cameras, which are based on the Teledyne e2v Emerald color and monochrome sensors and feature a CoaXPress interface. The cameras are engineered for industrial imaging applications requiring high-speed



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data transfer, a wider range of operating temperatures (from -20°C to 60°C housing temperature), and resilience in harsh environments. The Genie Nano-CXP 67M and 37M cameras are fully integrated with Teledyne DALSA's Xtium-CXP and Xtium2-CXP series high performance frame grabbers. The frame grabbers are also supported by Sapera LT SDK, an image acquisition and control software development toolkit (SDK) that includes a Trigger-to-Image (T2IR) framework. The four models come in 67.1- and 37.7-million-pixel monochrome and color versions.

[teledynedalsa.com](http://teledynedalsa.com)

**SMART CAMERA**

Mikrotron has released its EoSens Creation Series of FPGA programmable-ready smart



cameras. Designed for multi-camera industrial automation systems, the series allows the embedding of a custom IP into a Mikrotron 2-megapixel 10GigE GeniCam compliant camera that has the power to externally stream 10-bit pixel resolution images at 535 frames-per-second (fps) or internally stream 8-bit images at 2240 fps. EoSens Creation cameras also offer sensitivity of 20V/Lux at 550nm. In addition, the camera's SFP+ connection works with both copper and fiber interfaces. The cameras feature an XiLINX Kintex

Ultrascale FPGA plus an additional on-board 2GB DDRD of memory. By reducing the linear data flow, the design accelerates image pre-processing and unlocks the full potential of the 2MP sensor's resolution and frame rate. [mikrotron.de](http://mikrotron.de)

**CAMERA SENSORS**

Basler AG has expanded its boost camera series with a CXP 2.0 interface with six new



models based on sensors from ON Semiconductor's XGS series. The series models offer resolutions of 20, 32 and 45 megapixels (8k). They also incorporate CMOS sensors with global shutter technology and frame rates of up to 45fps. Thanks to their CXP 2.0 interface, Basler boost cameras are suited for applications with image transmission distances of up to 40m where high data rates and resolutions are required. These can be applications in the semiconductor industry, photovoltaics, display inspection, the printing and packaging industry and medical technology. [baslerweb.com](http://baslerweb.com)

**SENSORS**

**CAPACITIVE SENSOR**

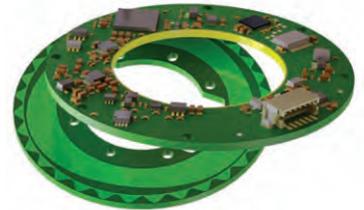
Rechner Automation added a high temperature tolerant model (KAS-80-A24-A-M30-PA-120C-Z02-1-NL) to its KAS capacitive sensor line. Rated to a temperature range of -25°C to 120°C (-13 - 248°F), the sensor also includes a



polyamide housing with a high resistance to abrasion, vibration and carries an IP67 protection rating. With a sensing range 2-25mm (min/max), the model features a 20-turn trim pot. Operating current ranges from 2 x 0...200 mA (voltage 12-30VDC) with a maximum voltage drop of ≤ 2V and a permitted residual ripple maximum of 5%. [rechner-sensors.com](http://rechner-sensors.com)

**ABSOLUTE ENCODER**

Netzer has added the VLX-60 to its line of ring encoders. The model offers an open frame, 2-plate design and is highly tolerant to temperature, shock, EMI, RFI and magnetic fields, the company says. Based on the company's



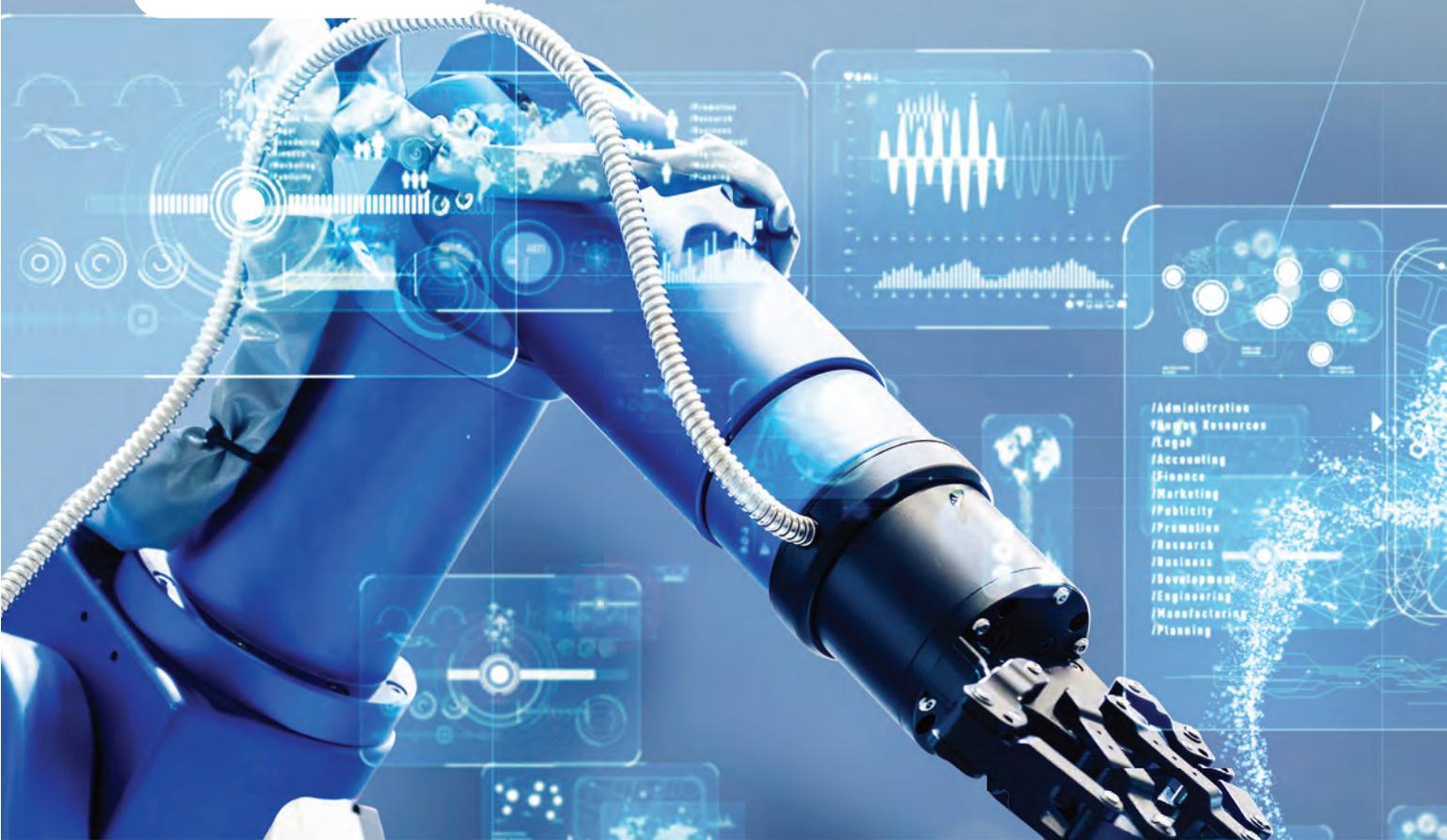
proprietary Precision Motion Sensor technology, the encoder features holistic signal generation, an 8mm profile and a 14 gram weight, due to the lack of ball bearings, flexible couplers, glass discs or light detectors. Its resolution is 18-20 bit with accuracy of ±0.010°. The electrical encoder's output is a digital serial synchronous with absolute position single turn; reading is the averaged outcome of the entire area of the rotor. It is available with an auto calibration option. [electromate.com](http://electromate.com)

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\* Compared with a combination of servo drive and servomotor

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