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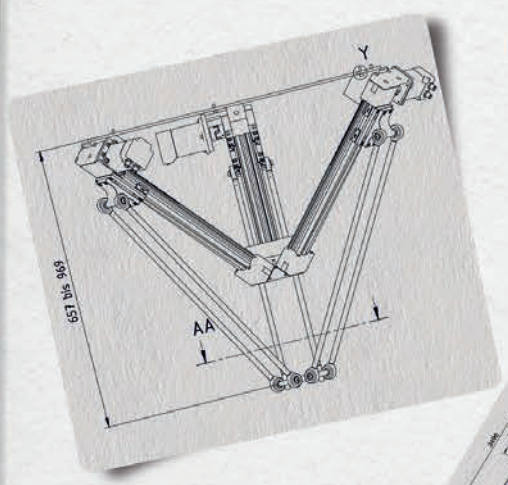

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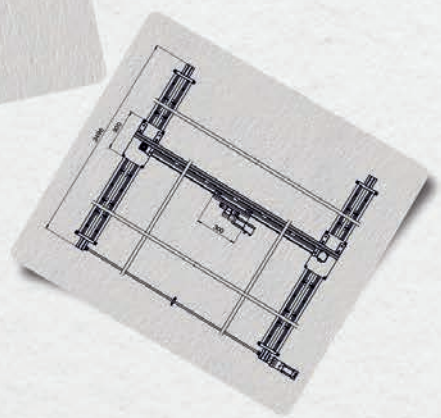

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INSIDE

Columns

Riding the EV Powertrain

Whether you're enthusiastic for or dismissive of electric or zero-emission vehicles, the coming transition from internal combustion engines to alternative powertrains represents a singular opportunity for Canada to re-ignite an auto industry that has been steadily declining for decades.

Since its zenith in the early 2000s, when Canada's auto industry ranked as the world's sixth largest, production has slipped over the past 20 years. Add in COVID, plus the microchip shortage of 2021, and Canadian production hit a low of 1.1 million light vehicles, a level it hasn't seen since 1967, according to DesRosiers Automotive Consultants.

At the same time, though, global automakers have pushed all-in on electric vehicles. Stringent governmental de-carbonization policies enacted by most industrialized countries have spurred automakers to lay the foundations for new plants or re-tool existing ones.

For Canada, that's meant new life for formerly flat-lining facilities. Stellantis' C$3.6B investment in its Windsor and Brampton assembly plants is the most recent example. In 2020, GM and Ford similarly committed to billion dollar investments in their respective Canadian plants to produce electric vehicles.

These are encouraging moves, but Canada's auto overall industry still faces an uncertain future. For example, according to a report released by NGen in April, Canadian ICE powertrain suppliers currently represent roughly C$10B in revenue but will see their business substantially impacted by the transition.

In place of gas-burning components, the report recommends a focus on high voltage batteries, which hold the greatest market potential at an estimated US$18 billion by 2030. In support, the report points out that Canada currently ranks in the top four globally in the production of cobalt, nickel and graphite and sixth in lithium production, all materials required by current EV battery chemistries.

On the downside, however, Canada currently lacks the capacity to refine and fashion those materials into EV battery components – processes that represent "55 percent of the battery cell's value and 65 percent of the value of the battery pack," the report states.

To secure it's future in the automotive industry, therefore, Canada will need to move beyond its traditional strategies to ride the EV powertrain. Settling for being mere hewers of lithium and drawers of cobalt won't cut it this time.

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DESIGN ENGINEERING

MAY/JUNE 2022
Volume 68, No.3
design-engineering.com

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Design Engineering, established in 1955, is published by Annex Business Media, 6 times per year except for occasional combined, expanded or premium issues, which count as two subscription issues.

Printed in Canada

Publications Mail Agreement #40065710

ISSN: 0011-9342 (Print), 1929-6452 (Online)

Subscriber Services: Canada: $57.50 for 1 year; $92.50 for 2 years; $10 for single copy.
Outside Canada: USA - $140.50; Overseas - $151.00; $10.00 for single copy.
All prices in CAD funds. Add applicable taxes to Canadian rates.

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Stellantis North America COO, Mark Stewart – flanked by Canadian Prime Minister Justin Trudeau and Ontario Premier, Doug Ford – announced an investment of C$3.6 billion to accelerate the company's EV production plans at its Windsor and Brampton plants.

Photo credit: Stellantis North America

AUTOMOTIVE

STELLANTIS INVESTS C$3.6B IN ITS CANADIAN OPERATIONS

Stellantis announced it plans to invest C$3.6 billion to secure the future of its Windsor and Brampton (Ontario) Assembly Plants and to expand its Automotive Research and Development Centre (ARDC). The investment is part of the automaker's Dare Forward 2030 strategic plan and electrification strategy that includes investing C$45 billion through 2025 in electrification and software, globally.

"These investments reaffirm our long-term commitment to Canada and represent an important step as we move toward zero-emission vehicles that deliver on our customers' desire for innovative, clean, safe and affordable mobility," said Stellantis North America COO, Mark Stewart, at an ARDC event attended by PM Justin Trudeau and Ontario Premier Doug Ford.

"We're grateful to both the federal and provincial governments for their shared vision to create a sustainable future. And, to Unifor and our workforce for their support in helping ensure the viability of our Canadian operations for the long-term."

According to the company, the investment will, in part, transform its Windsor Assembly Plant to produce a new multi-energy vehicle (MEV) architecture that will provide battery-electric (BEV) capability for multiple models. Retooling is expected to begin in 2023.

Similarly, its Brampton Assembly Plant will be retooled and fully modernized, beginning in 2024. When production resumes in 2025, the plant will introduce a new architecture to support the company's electrification plans. Both Ontario assembly plants are expected to return to three shift operations, the company said, with product allocation detailed at a later date.

In addition, Stellantis announced that ARDC will become North America's first battery lab and technology centre for the development and validation of BEV, PHEV and HEV cells, modules and battery packs. The Windsor-based ARDC will add a 100,000-square-foot facility to the existing building with completion expected by the end of 2023.

It will also add 650 engineering jobs with a focus on electrified propulsion systems, including batteries, power electronics, electric machines, motor controls, energy management and embedded software, the company said.

www.stellantis.com

DELOITTE CANADA OUTLINES PLAN TO SCALE SUSTAINABLE AVIATION FUEL

For Canada to achieve its goal of net-zero carbon emissions by 2050, a Deloitte Canada report argues, it needs to begin decarbonizing its economy quickly, particularly hard-to-decarbonize industries like aviation. The report – Reaching cruising altitude: A plan for scaling sustainable aviation fuel in Canada – advocates the production and use of Sustainable Aviation Fuel (SAF) as the key step in that effort.

Based on interviews, surveys and workshops with aviation and clean fuel industry leaders, the report states that Canada is well positioned to lead in the production of clean fuels but will need to introduce measures to accelerate its adoption.

Photo Credit: frankpeters / iStock / Getty Image

"The good news is that SAF is compatible with current aircraft and infrastructure and can substantially lower the life-cycle carbon emissions of aviation fuel," says Andrew Pau, Partner, Consulting, Deloitte Canada. "If Canadians do not find ways to scale the supply and uptake of SAF now, the aviation sector's contribution to greenhouse gas emissions will continue to grow and will cost Canadians more – in effort and impact – in the future."

To increase the supply and uptake of SAF, the report proposes a number of measures, including establishing a lead agency responsible for coordinating a multi-agency government task force composed of expertise in aviation, clean fuel, innovation and investment. In addition, report advocates for industry partnerships, the development of SAF-specific policies and early voluntary SAF procurement and agreement from public and private sectors.

Contributors to the report included SAF advocates (e.g. C-SAF, SAF+ Consortium, Advanced Biofuels Canada), oil companies (Shell Canada, Suncor, Irving Oil), aircraft makers (e.g. Airbus, Bombardier), Airlines (e.g. Air Canada, WestJet) and government agencies (e.g. NRC, Environment Canada, Transport Canada), among others. The full report is available from the company's website.
www.deloitte.ca

SASK POLYTECH NABS INNOVATION AWARD AT ECO-MARATHON 2022

An engineering student team from Saskatchewan Polytechnic took home a major prize from the Shell Eco-Marathon United States 2022 competition at the Indianapolis Motor Speedway early in April.

The annual event pits student teams from engineering schools in North America to design, build and drive hyper-energy efficient vehicles to see which travels the farthest on a limited amount of energy – be it gasoline, electricity or an alternative fuel. By optimizing weight, aerodynamics and engine efficiency, winning teams in the prototype internal combustion engine competition, for example, attain efficiencies north of 1,000 mpg.

Photo credit: Saskatchewan Polytechnic

A regular competitor since 2018, the Saskatchewan Polytechnic team entered two vehicles this year: An electric vehicle in the Prototype category and a gas burner in the Urban Concept category. While the Prototype vehicles weren't able to compete due to bad weather, the Sask Eco team's Urban Concept vehicle did take home fourth place with a showing of 372mpg (158km/l).

However, the team did win the off-track Technical Innovation Award for "demonstrating outstanding technical ingenuity along with optimal use of new materials, components, methodology or inventions."

Eco-Marathon judges highlighted the 3D printed body of the team's Urban Concept car, composed of a recyclable plastic filament with a temperature-triggered, active-foaming technology that reduces part weight to one third of traditional 3D printed parts. And, in a particularly Canadian touch, the frame of both Saskatchewan Polytech vehicles were built from recycled carbon fiber hockey sticks.

https://saskpolytech.ca
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INDUSTRY 4.0

ORACLE, FESTO PARTNER ON ORACLE INDUSTRY LAB

Oracle and Festo have partnered to develop the recently opened Oracle Industry Lab in Chicago. The lab provides hands-on, simulated industry settings for customers to experiment, learn, and bring transformative technologies to life, the partners say.

The 30,000-square-foot lab houses a Festo developed Learning Factory which models the next generation of Industry 4.0 production facilities and provides students with a holistic platform to understand smart manufacturing. The automated machinery uses sensors, controllers and software to produce "Lot Size One" simulated cell phones.

Photo credit: Festo Canada

The Oracle Industry Lab, provides hands-on, simulated industry settings for customers to experiment with.

The lab also integrates Oracle's portfolio of solutions and industry expertise to incubate and demonstrate new solutions across industries. Supported by Verizon 5G Ultra Wideband, the Oracle Industry Lab will first focus on use cases in utilities, construction and engineering, communications, and manufacturing, the company says.

"Many industries are at a crossroads as they look to navigate increasing regulatory, environmental, and customer-driven demands," said Oracle Industry Labs VP, Burcin Kaplanoglu. "We built the Chicago lab to bring together leading innovators like Festo Didactic so we can jointly help customers shape bold ideas into powerful solutions that improve productivity, operational intelligence and sustainability."

www.oracle.com/industries/innovation-lab

ENGINEERING RESEARCHERS DEVELOP NEW TYPE OF 3D PRINTING

Researchers at Stanford University announced the development of an AM technique that 3D prints objects within a stationary volume of resin. Similar in concept to stereolithography, in which blue laser light solidifies resin layer by layer, the Stanford process doesn't need to start at the bottom and work its way up.

Instead, the laser can be directed to begin the build at any XYZ coordinate within the liquid and then expand on it from any angle or direction. In effect, this eliminates the need for solid support structures during the 3D printing process since the part is buoyed by the surrounding viscous resin, the researchers say.

"The ability to do this volumetric printing enables you to print objects that were previously very difficult," said Dan Congreve, an assistant professor of electrical engineering at Stanford and former Rowland Fellow at the Rowland Institute at Harvard University. "It's a very exciting opportunity for three-dimensional printing going forward."

To create this 3D printing process, the research team couldn't use blue laser light, since not only would the desired point be solidified but also any resin along the laser beam as it entered the resin. In its place, the team used silica-encased nanomaterials, distrubuted throughout the resin. Pointing a red laser at these microscopic capsules sets off a series of energy transfers (called triplet fusion upconversion) that converts low energy red photons into high energy blue photons at a specific point.

While the process currently produces relatively low-resolution parts, the team is looking to improve the process by coordinating multiple lasers simultaneously to increase build speed, reach higher resolutions and create smaller parts. The team says it's also looking into other applications for the nanocapsules such as improving the efficiency of solar panels or study biological models that can be triggered with light. The team's research was featured in the most recent issue of *Nature*.

www.stanford.edu

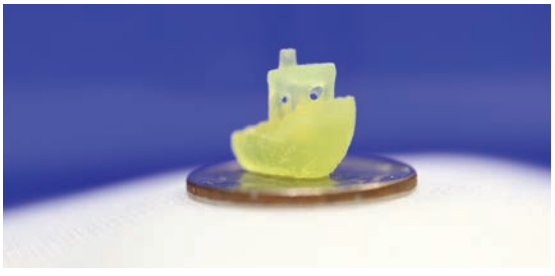

Photo credit: Dan Congreve, Stanford University

A boat figurine produced by a new 3D printing process that makes it possible to print an object within a volume of resin.

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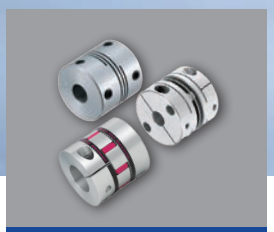

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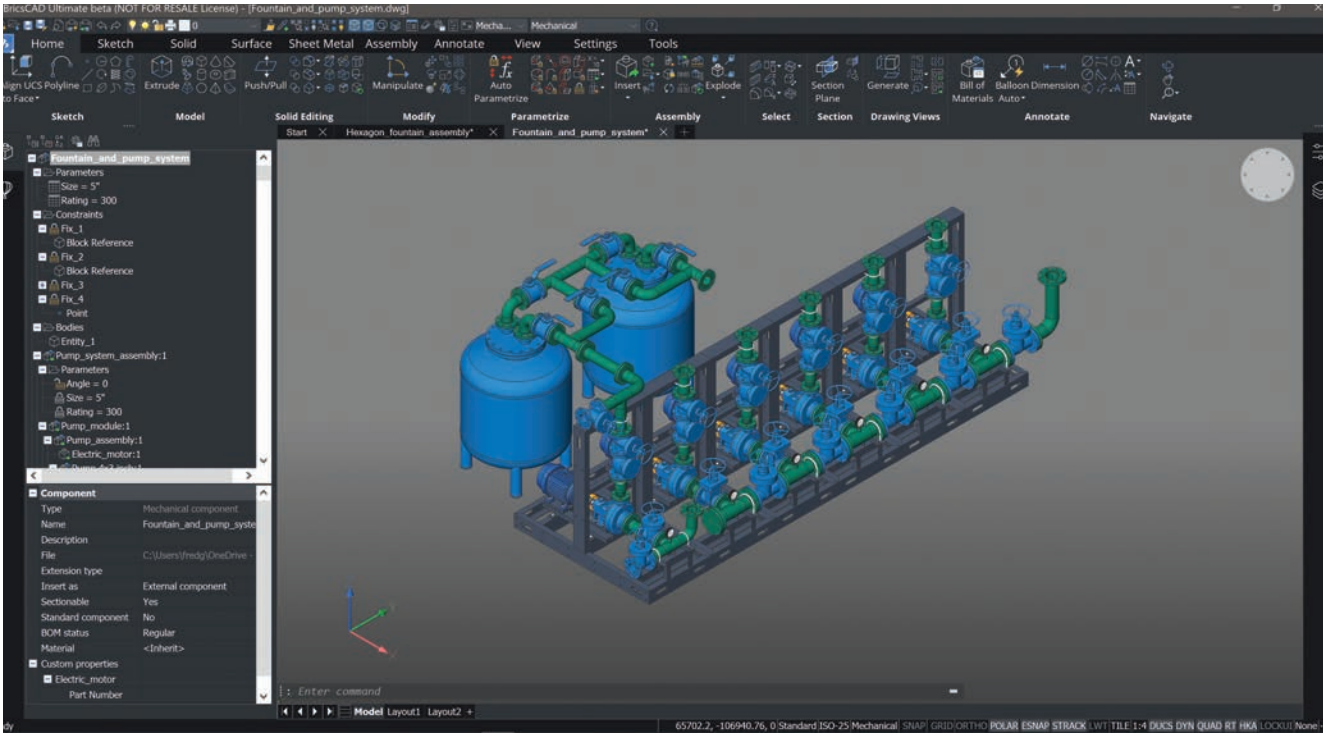
Another Way of Doing MCAD

Hexagon's BricsCAD diverts from the mainstream by embracing alternative CAD modeling approach. **BY RALPH GRABOWSKI**



BricsCAD mechanical CAD software designing a system of valves

With 1988's release of Pro/Engineer, Parametric Technology Corp (PTC) defined the approach to 3D modeling that holds sway to this day. Its two Russian mathematician founders came up with a way to draw 2D sketches that were parametric, and then extrude/revolve them into 3D solid models that also were parametric.

"Parametric" means the mechanical design software uses formulas to control the sizes and positions of sketches and parts in models. The two are linked such that changing a sketch changes the model – hence the "parametric' in the PTC company. Each step a designer takes along the way is recorded in a history of actions; editing an element in the history tree also changes related sketches and parts, allowing quick iterations of design ideas, like moving a hole or changing the size of a chamfer, without redrawing the model from scratch.

Nearly every MCAD program subsequently copied Pro/Engineer: Dassault Systemes' CATIA, Solidworks (the first parametric CAD on Windows), Siemens' Solid Edge, NX, Autodesk Inventor, you name it. Then parametric modeling migrated to other disciplines, such as architecture and piping.

I should add that parametric design was not invented by PTC; a CAD system that linked 3D models was first developed in the late 1970s in England as 2.5D RUCAPS (Really Universal Computer-Aided Production System) for architectural design, later replaced by 3D Sonata, resurrected as Reflex, and finally purchased by PTC. Although Pro/Reflex failed in the architectural market, PTC found great success at being first-to-market with parametric-based mechanical CAD, albeit on the Unix operating system.

The sketch/parametric/history approach, however, has drawbacks. Making changes to the history could take "forever" with complex models and, in some cases, regenerating new versions of the model unhappily crashed the system.

There is, however, another 3D design approach. It skips 2D sketching and history trees entirely: designers directly draw 3D solid primitives, like boxes and cones, and then use Boolean and other operations to mold the parts into the final shape desired. This is how HP's Co/Create (bought by, who else, PTC) and Autodesk's AutoCAD did 3D modeling from day 1.

Today, we call the second approach "direct modeling," and despite it having a long history, it was resurrected by newer MCAD programs like SpaceClaim (ANSYS), Creo (PTC) and Fusion (Autodesk). The history tree became history.

So, is a third approach to 3D MCAD possible? One day, I envision we might

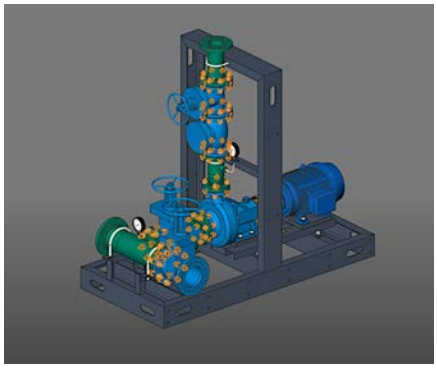
employ a clay-like modeling environment, poking and pulling a shape with our fingers through augmented reality, along with some kind of precision assistance.

BricsCAD Mechanical from Hexagon

Until that kind AR-based modeling becomes normal, if ever, let's take a look at the different approach to MCAD taken by BricsCAD. It combines parametrics with direct modeling, leaves out the history tree and makes sketches optional.

BricsCAD's history is older even than Pro/Engineer's, starting in 1986 as Bricsworks working on Architecturals, a 3D design program eventually sold to Bentley Systems as MicroStation TriForma. In 2002, the company now known as Bricsys came out with an AutoCAD-workalike based on IntelliCAD, yet a few years later rewrote the code so that it could develop CAD at a faster pace.

There was, at the time, speculation



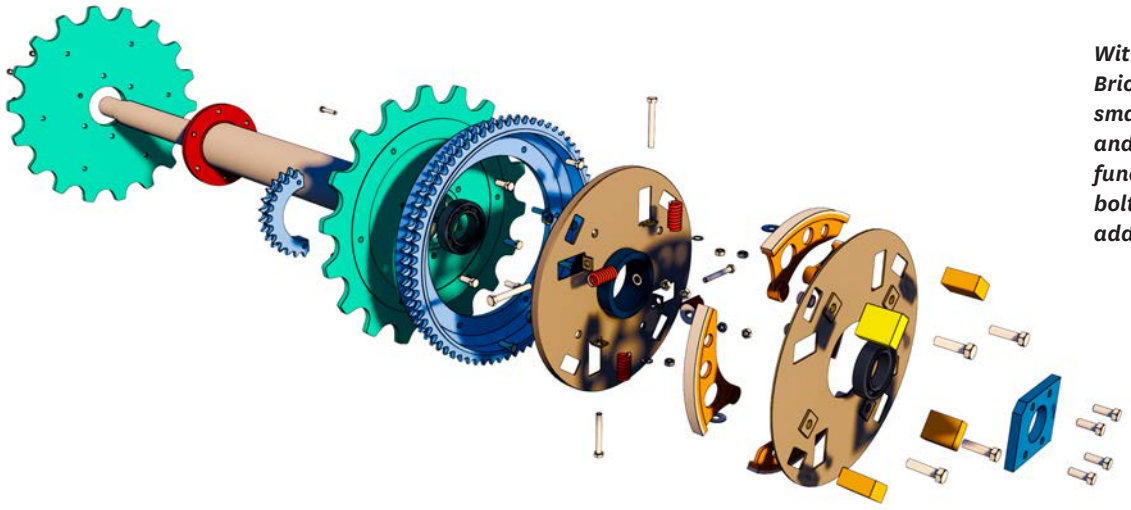
In BricsCAD, exploded assemblies can be bi-directionally linked to BOMs (bills of materials)

Bricsys might adopt the old Architecturals code to the new BricsCAD, but the company demurred, instead developing its own 3D modeling system based on the ACIS modeling kernel from Dassault Systemes' Spatial and a 3D design system developed by programmers at LEDAS in Russia.

The system combined parametrics with feature recognition and direct modeling/editing, and, more recently, artificial intelligence. It was good enough that Bricsys bought the intellectual property from LEDAS, as well as hired some of its staff. In a twist, however, BricsCAD employed LEDAS' 2D and 3D parametric system, not Spatial's, making it incompatible in that area with other design systems.

The workflow looks like this. First, you import a 3D model into BricsCAD Mechanical from another MCAD program with a separate, extra-cost option called "Communicator," which is the InterOp translator licensed from Spatial. At this point, the imported model is dumb, so you apply BricsCAD's features recognition, which add smarts (i.e. parametrics) to the model.You then change the model with BricsCAD's direct editing functions.

If this doesn't seem new to you, that's because MCAD competitors mimicked the workflow; others are scrambling to catch up in the area of automatic feature recognition. BricsCAD subsequently added semi-automated search-and-replace, in which



With BricsCAD's smart search and replace function, 42 bolts can be added at once.

you specify a feature (say a hole) and the block with which to replace it (like a drill tap), and BricsCAD finds all occurrences.

BricsCAD has a number of automation techniques that it calls A.I. One is "propagation," which searches for likely elements like joints and then adds connections. Another is "blockification," which looks for identical instances of groups of entities and then converts them to blocks. A third is "optimization," which finds lines at slight angles and straightens them.

There are a couple benefits to applying these techniques to drawings. One is that replacing repeated details (like gussets) with blocks greatly reduces a file's size.

The other, more important, benefit is hyper-fast detailing – think specifying details of joints (typically made of several bolts, cutouts and stiffeners) between dozens of columns and beams in structures.

BricsCAD BIM uses the same import/recognize/edit system to turn dumb IFC files into smart BIM ones. "Bimification" for instance defines vertical and horizontal slabs as walls and floors automatically.

Staying with DWG

In another divergence from mainstream MCAD, BricsCAD stores its design data in DWG files, the same used by AutoCAD. The DWG format is flexible enough to store all kinds of data not defined by Autodesk.

This makes drawings made with BricsCAD Mechanical compatible with BricsCAD BIM, something Autodesk cannot offer its mechanical and architectural customers, ironically enough.

Nevertheless, Bricsys had to come up with some workarounds. For instance, DWG does not support assemblies, and so BricsCAD connects parts stored in xrefs with 3D constraints. Other data is stored in other formats for optimization reasons, such as point clouds in BPT (Bricsys Point Tree) files.

Depending on the vertical edition, BricsCAD has built-in sheet metal design, civil terrain and roadway design, MEP (mechanical, engineering, plumbing), BIM (building information modeling), and kinematic analysis – all stored in DWG files.

A few years ago, the company released a free 3D modeling program, Shape, positioning it as a pre-design program, like SketchUp. Unlike SketchUp, it works with 3D solids. Drawings made with Shape are, however, limited to being imported into BricsCAD.

Sweden's Hexagon bought Belgium's Bricsys a few years ago, after being impressed how well BricsCAD replaced AutoCAD in its CADWorx plant design software.

The good news is that, so far, Hexagon seems to have left BricsCAD development alone, meaning it continues at its usual frenetic pace. As happens with acquisitions, some Bricsys executives eventually left Hexagon to form a new company, Qonic, which promises to create a new way of working with very large IFC and BIM files.

Despite Bricsys doing a lot of deep thinking on how CAD ought to operate, it continues to be a small company, with only 300,000 users, a number that hasn't seemed to change over the years.

It can never replace Pro/Engineer or Solidworks, so it places the emphasis on being different: a direct editor for MCAD systems incapable of direct editing at a third the cost, along with a dash of A.I. and everything stored in DWG files. **|DE**

www.bricsys.com

Despite Bricsys doing a lot of deep thinking on how CAD ought to operate, it continues to be a small company, with only 300,000 users.

Ralph Grabowski writes on the CAD industry on his WorldCAD Access blog (www.worldcadaccess.com) and weekly upFront.eZine newsletter. He has authored numerous articles and books on CAD, Visio and other design software applications

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TO THE MOON AND BEYOND

Aerojet Rocketdyne 3D prints critical titanium flight component to make it lighter, smaller and much less expensive.

On the afternoon of December 19, 1972, Apollo 17's command and service module CSM-114 "America" splashed down in the Pacific Ocean, bringing its crew and cargo safely home. The event marked the end of NASA's eleven-year lunar program and humankind's final visit to the Moon. Thanks in part to Los Angeles-based Aerojet Rocketdyne—a manufacturer with a proud heritage in spaceflight and rocket propulsion—we'll be going back soon, this time to stay.

In Greek mythology, Apollo was one of the twelve Olympian gods of the sea, sun, and sky. It's therefore only fitting that NASA has named its next lunar expedition after the deity's twin sister and goddess of the Moon, Artemis. And while those many Apollo missions were hugely successful and crucial to the continuation of the United States space program, Artemis' goals are much more ambitious.

Beginning in 2022, NASA will place unmanned Orion spacecraft into lunar orbit, followed by crewed landings, construction of lunar habitats and supporting infrastructure, and ultimately, preparation for a visit to Mars. According to NASA administrator Jim Bridenstine, the space agency and its partners will accomplish this by the end of this decade and do so with half the buying power it had back in 1964, when Apollo development was at its peak.

"As with any complex endeavor, the more affordable you can make it, the greater the chance that you will ensure its completion, and the moon is no different," said James Horton, aerospace engineer and mission architect at Aerojet Rocketdyne. "Metal AM plays a key role in achieving these goals."

NASA's Orion spacecraft, part of the Artemis moon mission, integrates Aerojet Rocketdyne's Reaction Control System (RCS) – 12 monopropellant thrusters mounted in 10 pod assemblies that will control the spacecraft's orientation during atmospheric reentry.

Photo credit: NASA

Building on a legacy

Aerojet Rocketdyne has a long history in metal AM. For more than two decades, the company has invested extensive time and resources into leveraging this important technology, focusing most of its energies on laser powder bed fusion (LPBF). It's due to these efforts that the aerospace manufacturer has been able to successfully design and integrate 3D-printed end-use components for a variety of projects, among them the massive RS-25 engines that will carry the Artemis mission into space.

Horton has been there for much of it. Since 2008, he's held lead roles in rocket engine design, development and test flight operations for NASA and the DOD. His advanced propulsion team at Aerojet Rocketdyne is currently working on chemical, electric and nuclear propulsion to support NASA's deep space exploration efforts, the Artemis project included.

He'll tell you that metal AM, when used in conjunction with advanced design and simulation software, gives today's aerospace engineers "an entire buffet of solutions that were completely unavailable to their predecessors, providing the unparalleled ability to innovate without compromise." Because of this, Aerojet Rocketdyne has been able to drive down propulsion costs, speed up time to market and improve the performance of its products.

Case in point

One recent example of this is a critical subsystem that Apollo engineers knew as a "quad" reaction control system (RCS). The

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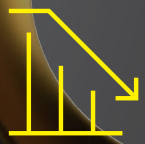

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The RCS is a modern version of the original Apollo mission's R-4D (left) engine system. The RCS injector body (right) was metal 3D printed to make it lighter and to integrate special geometries that could burn MON-25 fuel in a stable manner.

Apollo RCS included four individual R-4D bipropellant thrusters, originally designed by Marquardt Corp., that used hypergolic (spontaneously igniting) nitrogen tetroxide and hydrazine as propellants. Every lunar lander and service module had four quads, each of which generated more than 100 pounds of thrust to control the spacecraft's roll, pitch and yaw during flight. Following a series of acquisitions, Aerojet Rocketdyne eventually took ownership of the R4-D, intending to use what is now called the "reaction control system" (RCS) on the future spacecraft.

Given that the original RCS design is more than 60 years old, Horton and his team recognized an improvement opportunity and began what would become one of the many internal research and development (IRAD) projects intended to optimize the systems required for the Artemis program and other commercial lunar projects. In the case of the RCS, they looked for ways to reduce the number of engine parts, increase its reliability and make assembly and serviceability easier. Metal AM checked all these boxes.

"During the entire Apollo program, NASA produced more than 650 thrusters to support six Moon landings," said Horton. "It was a huge number, which led us to believe we were onto something big—we knew that, if we could bring affordability to the RCS, we could make a positive impact on any this and future programs."

They also wanted to take advantage of rocket fuel advancements. As Horton explained, propulsion engineers had learned over the years that adding 25% nitric oxide to the fuel oxidizer mentioned previously—nitrogen tetroxide—would reduce its freezing point from −9 °C (16 °F) to −55 °C (−67 °F).

Since this reduces the mass and power consumption of the heating systems needed to prevent frozen fuel lines in space, it presented Aerojet Rocketdyne with a significant opportunity. There was just one problem: The MON-25 fuel just described is unstable, a condition that Horton suggested is a "bad thing to have in rocketry."

Proving the concept

Here again, metal AM was the answer, as it allowed the team to print special injector geometries that could burn the fuel in a stable manner. They soon designed and built a concept model from the nickel-based superalloy Inconel 718, but unfortunately, ran into limitations with their metal 3D printer.

"We had to build the RCS injector body at a 45-degree angle, due to overhang concerns, and also add in a series of large support structures to prevent thermal warping during the build process," Horton said. "The supports would need to be machined away afterward, adding cost to the product, while the orientation angle created less than desirable surface quality. There was definitely room for improvement."

At the same time, they realized there was room for substantial lightweighting and topology optimization. Horton noted that they'd eliminated "large chunks" of unnecessary material during the redesign, but it was far from perfect. "Every single pound of material you can remove from a spacecraft saves money on launch costs," he said. "That's why we turned to nTopology for help with optimizing the design, and then Velo3D to build it for us."

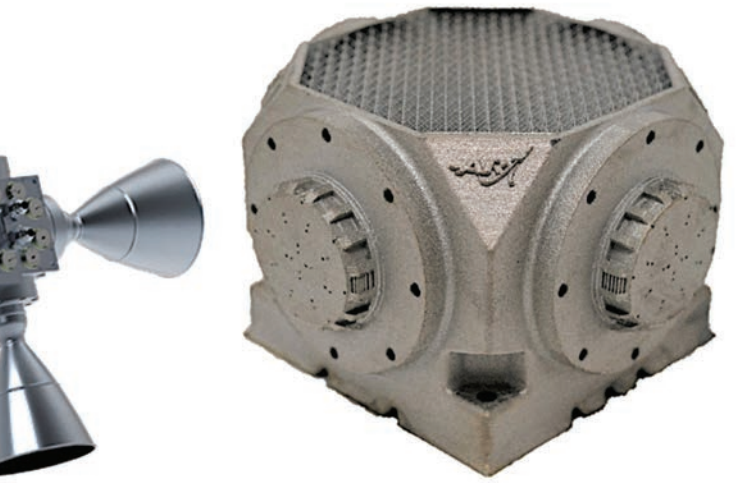
Shell, fill and print

Technicians from New York-based engineering and design software company nTopology were quickly able to "shell out" the injector body's blocky structure, leaving consistent wall thicknesses around the complex fluid ports and channels while eliminating stress concentration areas. They then filled the resultant void with a thin lattice structure, increasing its strength and stiffness while adding only minimal weight; because of its "implicit modeling" capabilities, nTopology was able to cut the quad injector's mass in half.

The Aerojet Rocketdyne team sent the optimized part file to Velo3D's facility in Campbell, California. It was there that the metal AM solution provider gave Horton some good news. Due to the company's mastery of 3D-printed titanium—a metal favored throughout the aerospace industry for its strength and light weight—the RCS injector body would weigh much less than its Inconel counterpart. And as Velo3D technical sales engineer Gene Miller noted, there'd be no need to build it at an angle or use the big, blocky supports as in the first iteration.

"Our proprietary, pre-print software is intuitive enough to recognize different geometric features and apply specific laser parameters to those areas so that they print as efficiently as possible and without the need for added support

Due to [Velo3D's] mastery of 3D-printed titanium, the RCS injector body would weigh much less than its Inconel counterpart.



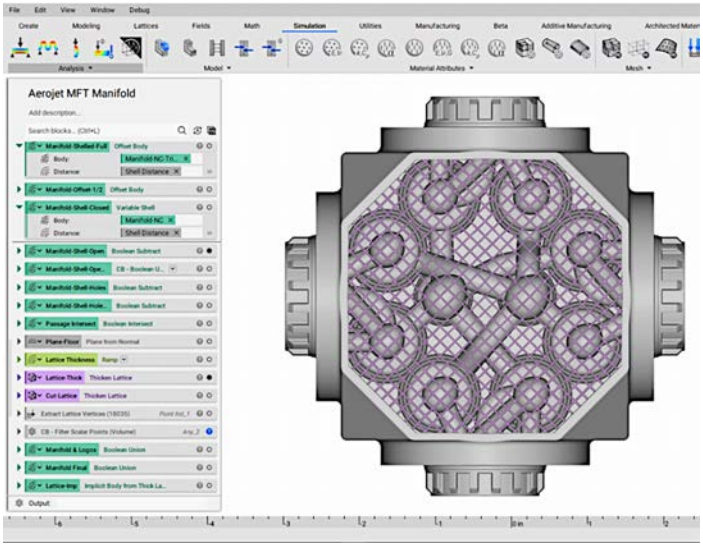


Photo credit: Velo3D

The implicit modeling function of nTopology's design software was able to quickly "shell and fill" the RCS injector body's first design iteration, increasing its strength and printability while greatly reducing weight.

material," Miller said. "In addition, we're one of the few metal AM system providers that can successfully print large complex titanium parts without cracking. We have a unique solution to mitigate accumulated internal stress within the printed material and can avoid cracking more so than other printers on the market."

The final result? Aerojet Rocketdyne now has an RCS thruster that is 1/5 the mass, 1/2 the size and 1/3 the cost of a conventionally manufactured version. And since it contains far fewer components, it's also easier to assemble, with much less chance of failure during operation.

"We've shown that by leveraging additive manufacturing and advanced software technology, we're able to interject affordability, reduce lead times and greatly improve upon system performance compared to the way we built parts in the past," Horton said. "Our next step is to demo this proof of concept, bringing it into actual field testing and, hopefully, final qualification. From there, it's headed into space." **|DE**

aerojetrocketdyne.com
https://velo3d.com

While suited to typical cobot applications out of the box, Kinova's Link 6 integrates a powerful controller with a local AI processing option designed to tackle highly complex applications.

CANADIAN COBOT

Montreal's Kinova Robotics leverages history of assistive robotics to develop its industrial Link 6 cobot. BY MIKE MCLEOD

In the field of industrial technologies, few have experienced the meteoric rise and projected growth of cobots. According to global tech market advisory firm, ABI Research, the cobot market had a global valuation of $475 million in 2020, expanded to $600 million in 2021 but will hit $8 billion by 2030, with a projected CAGR of 32.5%.

While Universal Robotics is credited with popularizing the technology and continues to hold roughly 50 percent of the global market, traditional robotics players (FANUC, ABB, etc) are catching up while other relative new comers jockey for position in this explosively lucrative industrial market.

One of the most recent industrial entrants is Quebec-based Kinova Robotics, which launched its Link 6 industrial cobot in March 2022. To classify Kinova as new to the overall industry, however, would be grossly misleading. Founders, CEO Charles Deguire and COO Louis-Joseph L'Écuyer, established the company in 2006 along with its first assistive cobot, the Jaco.

Inspired by a makeshift arm created by Deguire's uncle, Jacques, who suffered from muscular dystrophy, the 6-axis Jaco mounts to and draws power from a wheel chair and can be controlled with a joystick, head control or most other assistive interfaces. Shortly after its launch, the Jaco was lauded for its ease-of-use, especially for an end-user base with little to no robotics experience.

Since then, the Quebec-based robotics firm has released three cobot models (Gen2, Gen3, Gen3 lite) for the assistive, research and medical markets, earning a number of accolades and inspiring investor confidence along the way.

Most recently, the company landed on Deloitte's 2020 Technology Fast 500. It also raised C$40 million in February plus another C$20 million from the Canadian government under the Strategic Innovation Fund.

With ample financing in place, the company now looks to repeat its prior success in the crowded industrial cobot market. Analysts estimate there are more than 60 makers of cobots globally, collectively producing more than 200 individual models.

The question is how this Canadian cobot will stand out in the field. According to Jonathan Lussier, Kinova's Director of Business Development, Integrated Solutions, the Link 6 market edge starts with where it's produced.

"We are one of the only robot manufacturers left in North America," Lussier says. "That represents a big opportunity for us in terms of short lead times and responsive support. The support aspect is really important and has been built up based on our experience working with our assistive customers. If they lose a robotic arm for a day it's like chopping your own arm off for a day. So, it has always been critical for us to be very responsive in terms of those kinds of support requests."

Beyond its geography, the Link 6 includes a number of hardware and software capabilities that make it unique. At first glance, the six-axis Link 6 cobot shares the characteristics that loosely define this robot category (e.g. light-weight, rounded segments, software limited movement speed, ease-of-use) and targets the sweet spot of the market.

With a maximum reach of 1 meter, the Link 6 can handle payloads up to 6kg and up to 9kg in applications where the payload or the end effector is closer to the base of the robot. In co-operative mode, the

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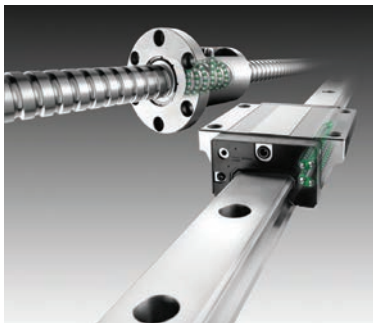

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The Link 6's "wrist" incorporates this UL-certified enabling device that enhances user safety and enables a streamlined "teaching mode" programming method.

Link 6 maxes out at 250-500mm per second but can speed up to 1.65m per second with a repeatability of .03mm. These specs put it roughly in the range of Universal Robot's popular UR5 and UR10 cobots.

The Link 6's controller, however, is considerably brainier than most cobots, Lussier says. The controller's compact, IP64-rated enclosure houses an Intel Core i7 processor, 8GB of DDR4 RAM and up to a 128 GB SSD running the company's proprietary Kortex software platform.

"Compared to our main competitor, we have 10 times the processing power and four times the memory," Lussier says. "That's a big differentiator when you're talking about more advanced applications."

The advantage, he adds, is that the Link 6 controller can handle tasks that would normally require additional external controllers to coordinate vision systems for inspection or quality checks or to deal with the complex end-effector tooling. And, in addition to its normal processing power, the Link 6 is also the first cobot with the option to incorporate a GPU to add AI capabilities, which opens up use-cases not typically associated with cobots.

"High speed is a funny word to use with a cobot but, if you look at traditional high-speed, vision-guided pick-and-place where the products are variable, the vision component is huge in terms of the cycle time," he says. "By integrating AI-based applications directly in the robot, you can reduce cycle time quite a bit, such that a cobot with a more advanced vision system can be faster than a traditional robot with a traditional vision system."

Moving up the arm, Lussier points out that the Link 6 is the first cobot with a dedicated gigabit line throughout the system, which allows for the integration of GigE vision cameras without requiring external wiring. The arm also delivers six to eight times more electrical power which enables advanced end-effectors and sensing systems.

It's at the cobot's wrist, however, where the Link 6 shines, drawing heavily from the company's history in the assistive robotics market. While cobots are already known for their integrated safety and ease-of-use, the Link 6 kicks it up a notch with a unique UL-rated enabling device. This a three-way switch acts as a kind of deadman switch; if the user releases it or presses too forcefully, the cobot automatically powers down. It also allows users to visually program the arm without needing to hold the teach pendant.

"The interaction between the buttons on the wrist and our visual programming is extremely tight," Lussier explains. "Basically, you can simply start clicking buttons on the wrist – to take waypoints, open and close the gripper and speed up or slow down the arm – and our programming interface will automatically create a visual program on the connected tablet or computer."

From there, he adds, users can refine the operation via high-level, low-code block programming or delve deeper into the code via Python and eventually C++.

For its initial release, Lussier says the Link 6 is setup to handle standard cobot applications, including CNC machine tending and pick-and-place. However, due to its high level processing capabilities and AI expandability, its the future applications that may not have been thought of yet, that Kinova foresees its Link 6's strengths coming to the fore.

"We are lucky to have our robots and 500 different institutions around the world, so we are very aware of what's going on in the market in terms of the research, which is 5 or 10 years ahead of the industry," Lussier says. "With the Link 6, we built a robot that was best adapted to those future applications." **|DE**

www.kinovarobotics.com

Developed by Titan Robotics, this depainting system employs continuous-wave lasers to burn paint off an airplane's surface, which reduces workers' exposure to toxic chemicals.

HIGHWAY FROM THE DANGER ZONE

Laser-equipped robotic system improves worker safety in toxic fighter jet depainting process.

BY THOMAS RENNER

As *Forbes* declared not long ago, "The 2020s Will Be The Decade of Process Automation." The pandemic accelerated the trend, and likely helped spur more ways to incorporate automation into new tasks.

While some industries are relatively new to automation, the aviation industry is not. Manufacturing aircraft with automation is now commonplace, and even flight operation can now occur through autonomous technology. Aerospace maintenance, however, has frequently required a human element, particularly in depainting of aircraft. According to Boeing, planes need to have their coatings removed about every five years. Most planes are stripped of coatings and repainting four or five times during their service life, due to branding changes, fading paint and structural integrity inspections.

Before automation, aircraft depainting proved time-consuming and unhealthy for workers, due to exposure to hexavalent chromium. The chemical compound – used in electroplating and stainless steel production – is known to cause lung cancer when inhaled. Depainting by hand also resulted in vast amounts of hazardous waste.

Now, a new automated solution is being used for aircraft depainting, developed by Titan Robotics. Established in 2014, the Pennsylvania-based firm develops flexible robotic systems for manufacturing and industrial applications. Of note is the company's robotic depainting system that employs two robots equipped with continuous-wave lasers to burn paint off a plane's surfaces.

"You had the human factors of a person working in a terrible environment for a long period of time," said Alex Klinger, a program engineer at Titan Robotics. "Then there was hazardous waste that had to be disposed of. With the laser processes, we take the people out of the hazardous environment, and we also contain the hazardous waste."

Rail-based System

Titan can design systems with mobile bases, rails, and fixed position robots. For off-aircraft components, rail-based systems are preferred, since they allow the robots to reach very long parts of the aircraft. For full aircraft systems mobile bases are used, where the robots drive themselves around the aircraft.

"Rail systems operate in a manner where we can roll the part in, right next to the rail, and as long as the robot can reach it, it will figure out where that part is, how to go across it, and how to take the paint off with the high-powered lasers," Klinger said.

In two-robot full aircraft systems, one robot is positioned on each side of the aircraft. The robots start with a rough outline of the plane. As the robots move down the plane, lidar sensors scan the surface to capture a detailed three-dimensional topography of the plane.

Instead of being exposed to the paint ash, workers monitor the robots in a control room to ensure the process goes smoothly.

"It's really about safety," Klinger said. "They're really just being the supervisor of the system, making sure it's doing what it's supposed to be doing."

Reaching the Point of Use

Among the most distinctive features of the automated assemblies are cable carriers that contain an assortment of connections. Electrical cables, hoses, laser fibers and utilities are among the connections in the carrier.

Mounted on rails, the robot starts with a rough outline of the plane. As the robots move down the plane, lidar sensors scan the surface to create a detailed 3D map of its topography.

Manufactured by igus, the triflex system holds up to 16 cables that are used by the robots to remove paint from the plane.

"It is all about delivering utilities to the point of use," Klinger said. "It is a laser depainting system. But we also have systems that do sanding, machining, inspection and x-rays. All of those have the exact same problem, which is getting those utilities to the point of use. It's important that we know where those cables are, know that they are protected and not worry about them getting snagged."

The primary advantage of triflex is the capability to handle the weight and protect the cables. "The weight and the volume are substantial," Klinger said. "I think it's 12-to-16 distinct cables and they can be held very nicely. For us, it's all about having confidence in those cables. We know the product will contain them, will limit how they bend, and it will hold them exactly where we want them to for the entire time."

The other advantage of triflex is the range of motion. "It can hold the cables, but it also has a three-degree freedom of movement," Klinger said. "A lot of cable chains move in a two-dimensional space, not a three-dimensional space. When you get to complex motions, where a robot is working in three-dimensional space, we need a flexible link that can contain the cables while

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the robot operates with six degrees of freedom. Triflex can do that."

Sophisticated Control

The key differentiator for Titan is its focus on software development. Unlike a traditional robotic integrator, Titan's systems use the latest sensor technologies to analyze complex surfaces for data collection. Applications include 3D scanning, non-contact thickness measurement and other inspection tasks.

"We add more complexity and software control on to the typical development of automated solutions," Klinger said. "With our software, the robots figure out where the plane is, how much paint is on the plane, what type of paint and how to burn the paint off.

The key differentiator for Titan is its focus on software development.

Once they know what they need to do, we plan how to move the robot over the surface to do that."

Retaining the structural integrity of the plane is of foremost concern. The robots need to carefully monitor themselves during the laser removal process to ensure they do not damage the plane. The planes are quite costly – one fighter jet can cost more than $130 million – and compromising aircraft materials could lead to deadly consequences.

"There is a tremendous amount of rigor on our side for our control systems and our robotics in making sure that we're not hitting the aircraft and making sure that our laser processes are not damaging the aircraft," Klinger said. "Our control system has a ton of protections in place for that, and it is all based on fundamental research that was done for the past 35 years. Every time we bring in a new aircraft or material, you go through the process again to learn the limits that we have to meet."

Depainting is just one process that can be accomplished with an automated solution. Klinger envisions a wide range of tasks which could be beneficial with automation from Titan Robotics.

"The robotics are the same, the software is the same," Klinger said. "We can remove the laser. Right now, we're taking on non-laser projects like sanding. We just changed the tool on the end of the robot from a laser to a sanding head and all of the sensing and control methodologies are still available and used. There's a lot of things that we can do with this system." **|DE**

www.titanrobots.com

Thomas Renner writes on engineering, construction and other trade industry topics for publications in the United States and Canada.

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INDUSTRIAL COMPUTERS

Moxa launched the V2403C, a series of industrial computers that comply with the E1 Mark, ISO 7637-2, and EN 50121-4 standards for vehicular and wayside applications. The series is built around an Intel Core i7/i5/i3 or Intel Celeron processor and come with up to 32 GB RAM, one mSATA slot, and two hot-swappable 2.5-inch SSDs. Embedded with two mPCIe slots for I/O expansion, the fanless computers support multiple display.

Compliance with E1 Mark, ISO 7637-2 and MIL-STD-810G requirements protects the V2403C computers from shocks and vibrations that are common in transportation applications. Models with a -40 to 70°C (-40 to 158°F) operating temperature range are available.

www.moxa.com

DRIVE SYSTEM

Siemens announced an upgrade to the firmware for its SINAMICS S120 drive system (V5.2) that integrates a web-server. With it, users can create, manage and delete parameter lists — even across axes, and backup/restore parameter settings. To test functions that are subject to license, it is possible to display and activate them in a temporary trial mode. By simultaneously connecting SINAMICS S120 Active Line Modules (ALM), operators can now use the Booksize format

continuously up to a rated power of 228kW. The simultaneous connection of the 55kW ALM also enables a higher peak power for high dynamic machines than a single 120kW ALM. The space-saving internal busbar can be used by suitable arrangement of the DC link components and 55, 80 and 120 kilowatts (kW) of ALM can be connected in two simultaneous circuits.

www.siemens.com

MULTISPECTRAL CAMERA

Teledyne DALSA released the Linea ML 8k, a multispectral scan camera line that provides spectrally independent RGB and NIR outputs, making it suited to inspection applications by detecting defects both on and under the surface of a wide variety of materials. The unit uses Teledyne DALSA's latest CMOS 8k quad linear sensor with a 5x5µm pixel size and delivers a maximum line

rate of 70 kHz x 4 using CLHS fibreoptic interface. The camera also has built-in SFP+ transceivers that convert electrical signals to optical signals and connects directly to fibreoptic cables using LC connectors.

www.teledynedalsa.com

NETWORK SWITCH

Moxa Inc. launched its EDS-4000/G4000 Series of industrial Ethernet switches that includes 68 models. The first IEC 62443-4-2 certified Ethernet switches, the series features built-in hardened security. It provides up to 14 ports and options that include fast Ethernet, Gigabit, 2.5GbE uplinks, SFP, and IEEE 802.3bt PoE connectivity.

The series is certified for NEMA TS2, EN 50121-4, IEC 61850-3/IEEE 1613, DNV, ATEX Zone 2, Class I Division 2. It also features Turbo Ring and Turbo Chain (recovery time < 20 ms @ 250 switches) and RSTP/STP for network redundancy.

www.moxa.com

MOTION CONTROL

LINEAR ACTUATOR

Moticont has added the SDLM-051-095-01-01 electric

cylinder to its line of linear voice coil actuators. The linear DC actuator features a 1.25 micron resolution, a continuous force of 33.9 N (7.6 lbs.) and a peak force of 107.2N (24.1 lbs.) and an integral thermistor. The actuator has a 50.8mm (2.000 in.) diameter, a 25.4mm (1.000 in.) stroke, and a housing length of 95.3mm (3.75 in.).

Each end of the housing features threaded mounting holes on a 25.4mm (1.000 in.) bolt circle for universal mounting. Its internally mounted linear encoder allows it to function as a DC servo motor in a closed servo loop. The non-rotating shaft is supported at both ends and can tolerate side loads up to 24.0N (5.4 lbs.).

www.moticont.com

PLC CONTROLLER›

WAGO introduced its PFC200 PLC controller that integrates a cellular modem. The controller's web-based management configuration software initiates the cell modem. This controller can deliver information directly to cloud servers and send or receive SMS messages.

The parameters from the PLC controller can be directly communicated to devices via wireless technology, allowing users running edge-of-network applications to collect data, control machine functions and connect to cloud servers without adding traffic to wired networks.

www.wago.us

CONTROL CABLE

AutomationDirect announced it has added LUTZE SILFLEX FBP control cables, specifically designed to meet all UL and FDA requirements for cabling used in food and beverage facilities. The cable has been evaluated by third-party tester Ecolab for resistance to commonly used cleaning agents and reduction of contamination risk.

The cables are available in sizes ranging from 20AWG to 12AWG and in shielded and unshielded versions. The Phthalate-free jacket is resistant to oils and fats that are common to food processing. Cables may be run without conduit in some areas due to the external wiring approval, washdown certification, and food-contact rating. The control cables can be ordered cut to length in 1-foot increments with a 20 ft. minimum.

www.automationdirect.com

FLUID POWER

PNEUMATIC ACTUATOR

Festo introduced its DSNB, a NFPA-compliant pneumatic actuator that's suited to multiple applications including sorting, stacking, and insertion, as well as lifting, clamping and for gate applications. The actuator comes in seven bore sizes, 11 variations and 15 NFPA mounting configurations. It features a polyurethane rod-wiper seal, a hard anodized aluminum cylinder and synthetic grease. It also comes with anodized aluminum end caps, a high strength steel piston rod with chrome plating and composite rod bushing and PTFE wear band. The actuator's rod bearing cartridge can be replaced without disassembling the cylinder. Customers have the option of air cushioning and customizing these units.

www.festo.com/ca

FLOW METER

Endress+Hauser has added its 0 x DN full bore option to its Promag P line of electromagnetic sensors units with line sizes 25 to 2400mm (1 to 96 inches). These sensors are designed for chemical and process applications with corrosive liquids or the highest medium temperatures. The full bore option is compatible with the Promag 10 transmitter and Promag W sensor, as well as its Promag 300/400/500 series transmitters. Flowmeters with the full bore option feature multiple measuring electrodes to detect abnormalities in the flow that can impact measurement accuracy. Promag W and P sensors all meet IP67/NEMA6 rating for permanent submergence or temporary submergence for up to 10 days.

www.ca.endress.com

SOLENOID VALVE

Emerson has expanded its ASCO Series 090 line of miniature solenoid valves to include a miniature three-way valve configuration. The Series 090 valve features a 10.8mm footprint and 50 million-cycle life. Like all Series 090 valves, the three-way valve is built to maximize gas flow, with a flow-to-size ratio that is well suited to portable medical device applications. The valve body is molded from polybutylene terephthalate (PBT) plastic, with seals made of fluorocarbon (FKM) elastomer. The Series 090 actuator combines high reliability with low power consumption, so battery life and device longevity are maximized. The valve is also compliant with all relevant Restriction of Hazardous Substances (RoHS) and Conformité Européenne (CE) directives.

www.emerson.com

VALVE POSITIONER

Emerson has released the TopWorx PD Series Smart Valve Positioner that integrates communication via a 4-20mA loop signal and HART proto-

cols. The PD Series uses Hall effect contactless position detection. Two PNP alarms can be configured throughout the full displacement range. The PD Series will launch initially with two models: The PD100 for general purpose applications and the PD200 for use in explosive atmospheres. The series can provide precision control on both single- and double-acting actuators. An LCD screen provides access to device status and optional magnetic key technology. The series is suitable for use in oil and gas, chemical, industrial energy, on-site utilities, power generation, pulp and paper, waste and wastewater and food and beverage applications.

www.emerson.com

POWER TRANSMISSION

LINEAR BEARING

LM76 introduced its SPEED DEMON EL300, a linear rail/roller bearing wheel system that featuring travel lengths of 400mm to 3000mm and a 90mm base. Attached to the base are parallel 12mm h2 steel shafts hardened to RC62+2. The shafts are secured to the base every 100mm at a 45 degree angle. The carriage features four sealed, low friction, dual angular contact roller bearings. On one side of the carriage, the roller bearings have eccentric bushings for adjusting preload. The maximum loads are: Vertical (down) - 2800N static and 1400N dynamic, and Horizontal (side)- 2600N static / 1300N dynamic. The maximum moment loads are: Roll - 125N-m static and 62N-m dynamic, Pitch - 165N-m static / 80N-m dynamic, and Yaw - 82N-m static 40N-m dynamic. The height of the carriage and base assembly is 54mm, and both are clear anodized.

www.lm76.com

SLEWING RING BEARING

igus has expanded its PRT slewing ring bearing series with the PRT-04, a compact slewing ring that is 60% lighter and has 50% more space savings than the PRT-01 series. The PRT-04 has an outer diameter

of 60mm and consists of three aluminum rings and a sliding element made of iglide J high-performance plastic. Like all igus bearings, the PRT-04 is 100% self-lubricating and insensitive to dirt, dust and moisture. The solid lubricants in the iglide material mean that the slewing ring bearing works without greases and oils.
www.igus.com

SENSORS

ROTARY ENCODER

POSITAL announced that its explosion-proof IXARC rotary encoders have been certified to comply with ATEX/IECEx directives for Category 3 electrical products. These devices are suitable for use in Zone 2 and Zone 22 conditions making them suited for oil and gas, chemical plants and grain handling facilities. The encoders feature aluminum or stainless-steel housings and are available in both incremental and absolute variants with optical or magnetic measurement systems. They deliver up to 16-bit resolution and resolution can set anywhere between 1 and 16,384 PPR. They are available with connectors (M12 etc.) or attached cables and support communications interfaces, including incremental, analog, SSI, Profibus, ProfiNet, CANopen, DeviceNet, EtherCAT, EtherNET IP, Modbus RTU, J1939 and Modbus TCP.
www.posital.com

INCLINATION SENSORS

AutomationDirect has added Gefran inclination sensors to its lineup of position transducers. Gefran sensors use MEMS technology (micro-electromechanical devices integrated onto a single silicon chip) to provide tilt angle measurement with respect to gravity. The Gefran sensors are suitable for the harsh environments. They come in an encapsulated, thermoplastic housing with a IP67/69K rating and are available with an integrated cable or M12 quick-disconnect; M12 quick-disconnect models are fully redundant, having two sensors in one housing.
www.automationdirect.com

SENSOR TRANSMITTERS

CAS Dataloggers announced the availability of Radionode RN17x Series sensor transmitters from DEKIST. The RN17x transmitter has a slot for a plug-in, USB sensor for the measurement of temperature, humidity and other parameters. The series units transmit this data via Modbus TCP or HTTP to either the user's PC/server or to the Radionode 365 cloud which provides a real-time dashboard, alarming, and report generation. The RN171WC provides an Ethernet LAN port while the RN172WC uses WiFi for wireless connection to the network. All transmitters in the series feature a 2-line/4-digit LED display, local alarm buzzer, USB configuration Port, external DC power or POE (RN171WC) and SMS, voice, and email alarms via the Radionode Cloud.
https://dataloggerinc.com

PHOTOELECTRIC SENSORS

Leuze introduced its 36 series of retro-reflective photoelectric sensors that detect objects with different optical properties – even at a great distance, the company says. Certified to protection class IP67, the series includes sensors with background suppression (with an operating range of up to 2.5 meters), as retro-reflective photoelectric sensors (up to 17 meters) or as through-beam photoelectric sensors (up to 80 meters). The sensors are available with both M12 connection sockets and with different ready-made connection cables as well as matching mounting accessories. In addition, all common switching logics are also supported, including NPN and PNP switching as well as light and dark switching.
www.leuze.com

2 SHOWS CO-LOCATED TO BRING YOU MORE!

DEX EXPO MRO EXPO

June 22
DEX-MRO Expo Barrie
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DEX-MRO Expo Hamilton
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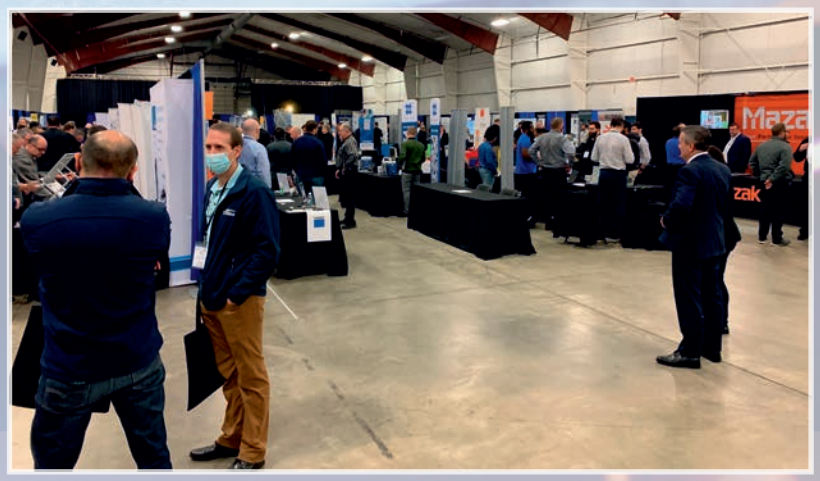
A series of one day tabletop shows highlighting the latest design and manufacturing technologies for the OEM market across Canada

An effective forum for face-to-face interactions where engineers, product developers, machine builders and systems integrators can discuss, network, solicit advice and 'kick the tires' on the latest technologies and applications that drive your business.



DEXEXPO.com

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To discuss exhibit options please contact:

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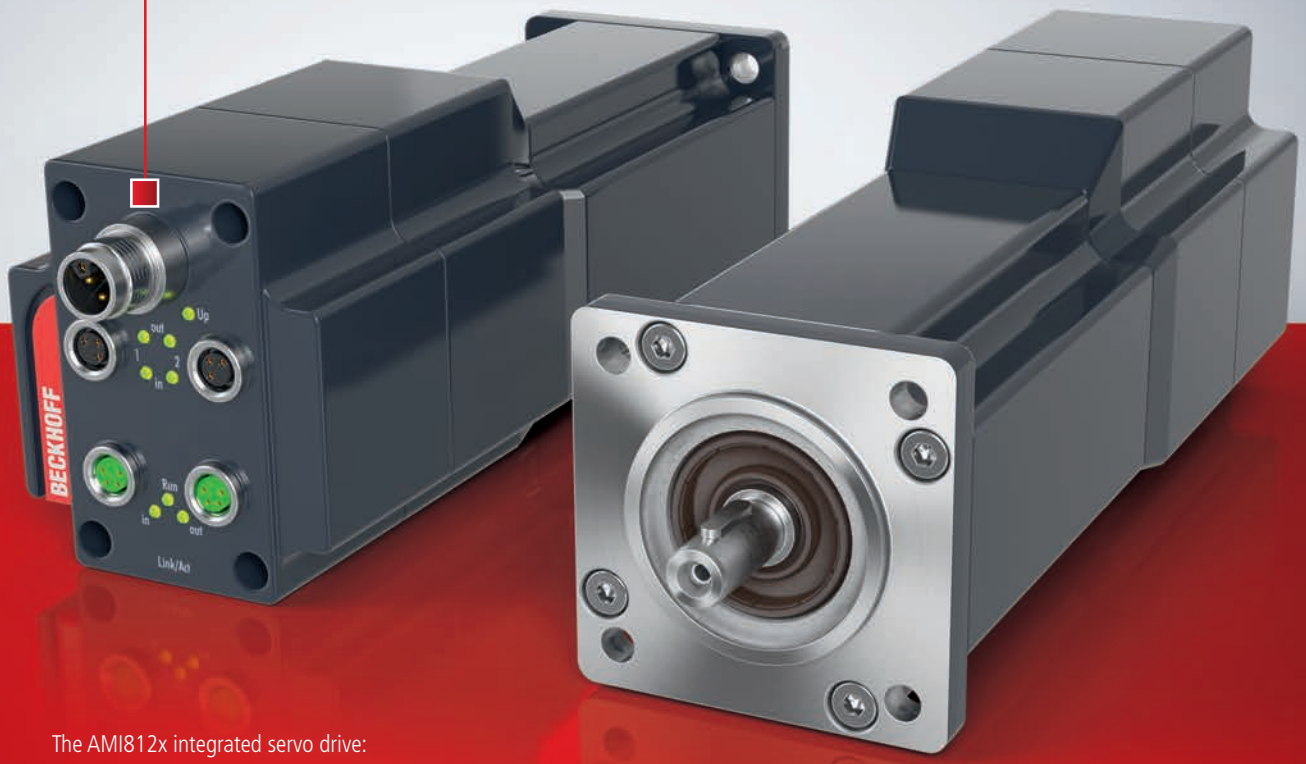
All-in-one servo drive and motor

The compact AMI812x servo drive

One connection level covers all interfaces: directly on the servo drive without requiring upstream I/O



The AMI812x integrated servo drive:

- integrated servo drive for compact drive technology (up to 48 V DC)
- combines highly compact servomotor, output stage and fieldbus connection
- for all motion requirements in the power range up to 400 watts
- for single axes or with daisy-chain solutions on the machine
- supports machine concepts without control cabinets
- IP65 protection degree possible with sealing ring option
- Safe torque off (STO) safety over FSoE (Safety over EtherCAT) reduces installation and integrates seamlessly into safety solutions

Beckhoff offers a complete, compact control solution including a range of compact motion technologies for servo, stepper, DC motors and more

Scan to experience the benefits of compact integrated servo drives

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