ANNUAL REVIEW 2023

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construction TECHNOLOGY

IN ASSOCIATION WITH INTERNATIONAL CONSTRUCTION AND CONSTRUCTION EUROPE

ROBOTICS & AUTONOMY

3D PRINTING

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PACE OF CHANGE HAS NEVER BEEN THIS FAST

FROM THE EDITORS

The headline above is a paraphrase from a famous quote: "The pace of change has never been this fast, yet it will never be this slow again." These words were said by Canadian Prime Minster Justin Trudeau at the World Economic Forum at Davos, talking about technology in general. They are worth remembering as, at times, we can get impatient that construction hasn't made greater strides in its adoption of technology – the reality is that great leaps have been made, and the speed of these changes will only accelerate in the future.

Construction is one of the world's most essential industries and it is currently facing serious challenges, such as a lack of workers, a need to reduce carbon emissions and rising inflation squeezing already tight profit margins. The answer? You've guessed it: technology. It is through technology that construction can become more efficient and productive than ever before, which will enable vast swathes of data to be shared between both competing companies and all aspects of the ecosystem, from the smallest of contractors through to the multi-billion-dollar company leading the project.

In these pages you will see a selection of the features, interviews and news that we've produced throughout the year on topics such as AI, surveying, alternative power, BIM, robotics and much more. We are also delighted to be hosting an in-person Construction Technology Summit in Austin, Texas, US, on March 18-19 2024. The event will feature keynote speeches, roundtable debates and multi-media presentations looking at where the industry is now and where it will evolve in the future. We hope to see you at what we are sure will be a fantastic event.

MIKE HAYES
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Deputy Editor

Reliable GPS pays off

Integrating GPS/GNSS receivers which avoid failure in machine guidance systems saves operating time and costs, writes Maria Simsky.

Highly accurate GPS / GNSS multi-frequency receivers are being installed on excavators, loaders, haul trucks and other heavy machinery as part of a machine guidance system which helps operators execute their projects faster with improved accuracy. Investing in reliable positioning components in a guidance system means smoother project completion and reduction of costs incurred during idling and support. Costs can run high when receivers lose positioning in challenging conditions such as during heavy vibrations, around structures which reflect satellite signals or when the view of the sky is partially blocked.

Some of the largest 3D machine guidance integrators across the world are using Septentrio's receivers because they ensure efficient operation and failure avoidance. Ruben Hensen, Chief Operating Officer at Makin, a leading integrator of machine guidance solutions, shares his experience of investing in highly reliable positioning sensors.

"Robust [Septentrio] GNSS receivers in our guidance systems helped us get the reputation we needed to become number one machine control company in Norway in under two years, "said Ruben Hensen, Chief Operating Officer at Makin.

GNSS heading for bucket positioning

Machines such as excavators have a platform that rotates independently of the undercarriage. To calculate the position of the bucket, it is important to know the orientation (or heading) of the platform. With two antennas, the AsteRx-U3 GPS receiver can calculate the heading of the platform as well as either the pitch or the roll, depending on how the antennas are placed. Septentrio also offers other GNSS receivers for machine control in various form factors such as ruggedized boxes, OEM boards or compact modules as well as compatible GNSS antennas.

Read more about Makin's experience with reliable GNSS receivers
https://web.septentrio.com/Makin

ON THE COVER

In print and online, the Construction Technology brand has covered the technologies and products reshaping the industry.

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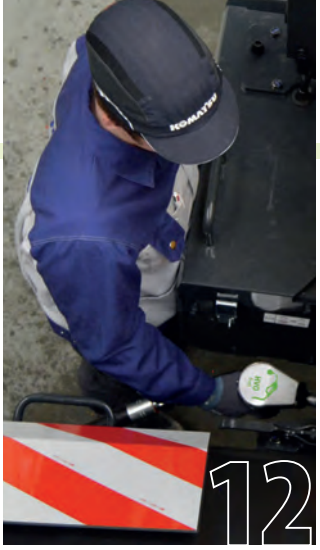
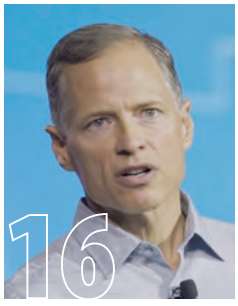
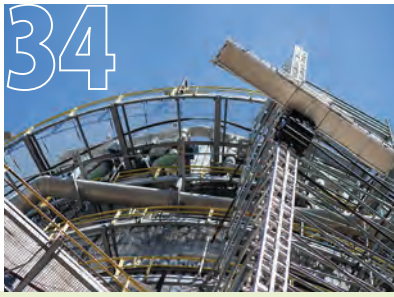


WHAT'S INSIDE?





HIGHLIGHTS

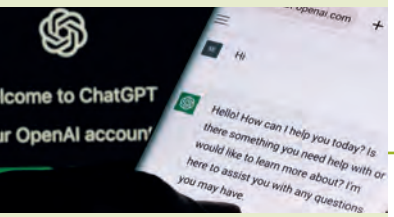
PHOTO: ADOBE STOCK

STUDY SHOWS CONSTRUCTION FIRMS EMBRACING AUTONOMOUS TECH AT 'UNPRECEDENTED RATES'

A new study by tech company Hexagon has found that 84% of technology decision-makers at general contracting firms across North America, the UK, and Australia have adopted some form of autonomous technology in the last year to address key business challenges.

Hexagon's Autonomous Construction Tech Outlook highlights the impact that autonomous technology can have on the construction industry, from improving safety and efficiency to supporting sustainability and profitability.

However, the study also reveals that many firms are struggling to identify the best autonomous or automated technology to address their specific challenges and pain points.



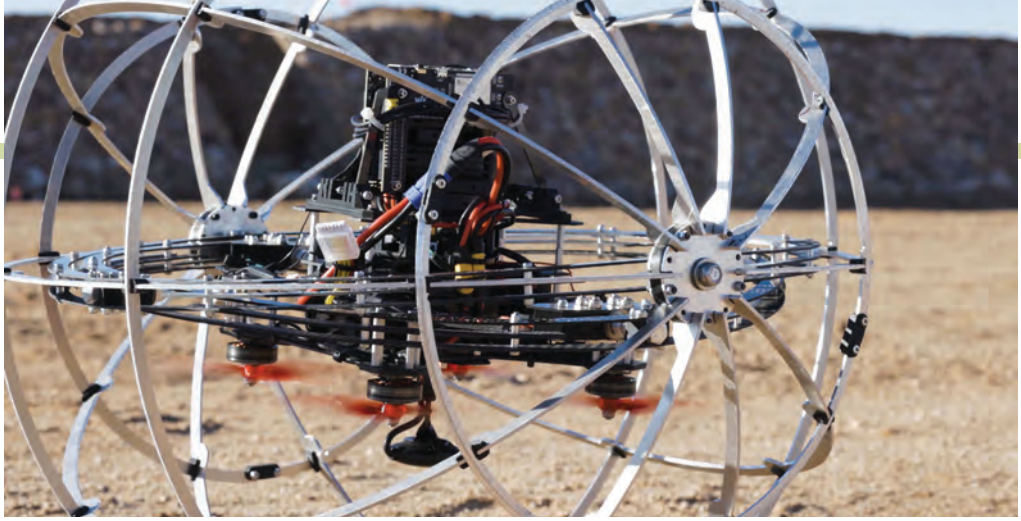
CHATGPT TO POWER UP CONSTRUCTION WITH AI

Chatbot phenomenon ChatGPT looks set to become part of the construction industry, with its artificial intelligence now allowing contractors to talk to their plans.

Furthermore, their plans will talk back to them.

The announcement was made by Togal.AI, a construction technology business that produces estimating software.

The company says the system allows construction professionals to use semantic search functionality to quickly access information across thousands of pages of, for example, plans, schedules and budgets.



REVOLUTE ROBOTICS INTRODUCES DUAL CONCEPT ROBOT

The core technology behind this robot is said to involve a drone housed within a spherical exoskeleton

US-based Revolute Robotics is introducing an innovative robot that possesses the ability to fly through the air while also being able to drive and roll on the ground, enabling it to access and carry out hazardous tasks in areas where conventional robots cannot operate.

The core technology behind this robot is said to involve a drone housed within a spherical exoskeleton, complemented by a unique mechanism that facilitates smooth rolling on the ground when aerial flight is unnecessary. According to CEO Collin Taylor, this design allows the robot to drive for five times longer than it can fly, as it conserves energy by not having to counteract gravity. If the situation demands navigation around obstacles or swift travel, it seamlessly switches back to flying. Taylor adds that this adaptability makes it an exceptional choice for manoeuvering in tight spaces and complex environments, surpassing the capabilities of both drones and rovers.

NEW TOPCON SOFTWARE AIMS FOR GREATER DIGITAL ADOPTION IN CONSTRUCTION

US-based technology company Topcon Positioning Systems has launched the Digital Layout, which aims to drive greater adoption of digital workflows in construction.

Topcon said that Digital Layout has a focus on ease of use. It hopes to encourage contractors who still rely on traditional methods to use the software to boost efficiency, accuracy and productivity.

The business is targeting general contractors, concrete contractors, mechanical, electrical and plumbing (MEP) contractors, steel erectors, fire suppression companies and others with Digital Layout.

The software is designed to work in combination with a 3D laser – the Topcon LN – or a Topcon GT robotic total station, providing a step-by-step guide to streamline routines and workflows.

Ray Kerwin, director of global product planning for Topcon, said, "With today's job site challenges, contractors need the best and easiest way to perform layout. Topcon provides that with this software dedicated to building construction applications."

HIGHLIGHTS

HP LAUNCHES SITE PRINTING ROBOT

HP's SitePrint robot, which was launched in the US last year, is now being made available to customers in the UK and Ireland.

The SitePrint robot was available to customers in the UK and Ireland from May 2023, extending the Early Access Programme launched for customers in the US and Canada in September 2022. Commercial availability is expected for the SitePrint robot in North America later this year.

SitePrint is a robotic solution that uses autonomous operation to print complex construction site layouts accurately and with consistent repeatability, improving the productivity of the site layout process. It also prints text, providing additional data from the digital model to the construction site, and has the ability to avoid obstacles.

FERROVIAL'S NEW AI ASSISTANT

Ferrovial has launched a new generative artificial intelligene (AI) assistant for its employees.

The tool, developed in partnership with Microsoft, aims to assist employees with their day-to-day work and increase efficiency and competitiveness.

Employees will be able to use the tool to write texts, analyse information, and summarise and translate documents.

Ferrovial said it hoped that in future the system could be trained with information from the company's business units.

KOMATSU ANNOUNCES HYDROGEN EXCAVATOR

Komatsu has announced the development of a medium-sized hydraulic excavator concept, powered by a hydrogen fuel cell.

The manufacturer said the machine's development is in line with its aim to achieve carbon neutrality in construction equipment.

The company said Proof of Concept (PoC) tests are underway and it is now accelerating efforts to bring medium-sized and large construction equipment powered by hydrogen fuel cells into commercial production "in the near future".

Komatsu collaborated with Toyota Motor Corporation on the new excavator, with the development project led by operating officer and president Koji Sato.

The company integrated a hydrogen fuel cell system and hydrogen tank on the hydraulic machine.

The company said it combined Toyota's hydrogen fuel cell system with its own control technology and key components, achieving zero exhaust emissions, significantly reducing noise and vibration.

Komatsu said the excavator also delivers performance, in terms of digging efficiency and operability, equal to that of the comparable engine-driven machine.

The company states that it aims to reduce CO_2 emissions by 50% from the use of its products and equipment production by 2030, compared with 2010 levels, and has set itself a target of achieving carbon neutrality by 2050.

Komatsu claims that, due to hydrogen's higher energy density and shorter refuelling time compared with battery-electric technology, it has focused its research and development efforts on hydrogen fuel cells as a promising electrification choice for medium-sized and large models.

EUROPE'S LARGEST 3D-PRINTED BUILDING

German construction company Kraus Gruppe is using a 3D printer to construct Europe's largest 3D-printed building in the city of Heidelberg.

The construction firm is using Cobod's BOD2 printer. The machine will print walls for the building, which is almost 600 sq m in area (6600 sq ft), 54m (162 ft) long, 11m (121 ft) wide and 9m (30 ft) high.

The building will become a 'server hotel' for data centre provider Heidelberg IT Management.

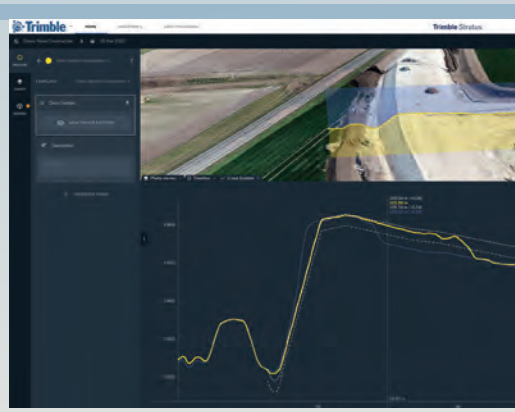
Formwork and scaffolding specialist Peri's 3D construction arm will provide the know-how for the construction, which involves using 200 cubic metres of pumpable concrete.

The high-speed BOD2 printer can print 4 sq m of building per hour and the entire process of printing the walls of the building is expected to take 140 hours in total. Because of the size of the building, the printer will have to be moved several times during the process.

Without 3D printing, the unusual design of the walls would have required bespoke formwork, which Cobod said would have made the project "incredibly expensive."

THE SKY'S THE LIMIT

Drones are increasing accepted as part of the construction process and their applications for the sector are ever evolving, discovers ANDY BROWN



Drones, also known as unmanned aerial vehicles (UAVs), have been around the construction industry for a number of years, but it is only in more recent times that their use has become more accepted and their benefits almost universally understood.

Part of this is the common cycle of anything new – it takes time to figure out the best way of utilising a new tool. Jim Greenberg, product manager in the Trimble Civil Engineering division remembers that, "In 2018 there was a lot of hype around drones. We were all trying to get ours heads around what it really was and what it really meant… There were a lot of things to figure out, and surveyors were getting up to speed with it."

Finding someone to fly the drone could be an issue, but it wasn't the biggest one – that was collecting data (and the right data) and then knowing what to do with it, what it meant. These kinks have now been ironed out to the point that Greenberg, who is a surveyor by trade, says, "now I feel like it's just a given; like GPS and machine control, people don't question if it is good anymore.

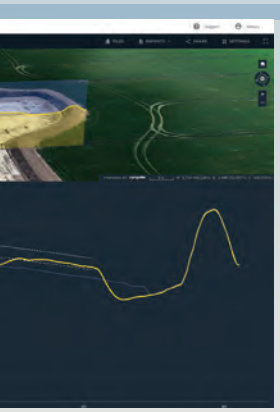
"They just question how they can apply it. We feel that it's at the point where it's accepted and everyone's starting to look at it. When you put it in someone's hands, they figure out the added value they can get from it. We have companies that say this is as transformational as machine control was."

This viewpoint is backed up by Pascal Martinez, director, OEM Development at Bentley Systems. When asked if drones are more accepted in construction now, he answers emphatically, "Yes. Drones have evolved incredibly over the last ten years and, with prices down and an increased ease of use, they are becoming a key tool to monitor construction progress.

"Of course, they are mostly used in horizontal construction and the structural work on vertical construction, but there are new drones that can also fly indoors. And their utilisation can be combined with 3D laser scanning to create a complete reality model of a construction site. A key driver of this adoption is also the autonomy, it relieves the need for an expert pilot and enables

PASCAL MARTINEZ DIRECTOR, OEM DEVELOPMENT AT BENTLEY SYSTEMS

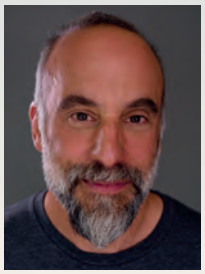
BARRY MCGINN, SALES DIRECTOR, CAPITAL PROJECTS, CYBERHAWK



TRIMBLE STRATUS SOFTWARE HELPS CIVIL CONTRACTORS USE DRONES TO MAP, MEASURE AND SHARE ACCURATE INFORMATION ABOUT THEIR WORKSITES AND ASSETS

repeat flights and acquisition at high pace."

As the technology has developed so has the speed that data can be processed – data can be uploaded to the cloud and be available shortly afterwards for evaluation thanks to the processing power now readily available. Some contractors are even flying multiple flights in one day and uploading them simultaneously.



JIM GREENBERG, PRODUCT MANAGER, TRIMBLE CIVIL ENGINEERING

The increasing automation of drones is playing a role in their adoption, as is the fact that the way they are being used has also evolved. Initially, drones were used across construction to get to locations where people couldn't get to or were considered too dangerous. However, this is changing, says Barry McGinn, sales director, Capital Projects, Cyberhawk.

"The role of drones is evolving, and they are now being deployed to survey the progress and performance of a project. They're enabling stakeholders to monitor the site from anywhere in the world," he comments.

"Drone survey images are now at the same level of terrestrial surveys, but the benefit of drones is that up to 30 times more distance can be covered in a day. The efficiencies that can be made are astronomical. We also now have drones operating with what's effectively a force field around them, enabling them to fly indoors through structures without risk of collision. This allows for the collection of incredible imagery, giving a photo-realistic view of assets."

TRACKING CHANGES

That construction is not the world's most efficient sector is well known – the industry's relative lack of productivity gains has been

NEW AUTONOMOUS DRONES

Drone manufacturer Skydio has announced the launch of its new product line, which includes Skydio Dock and Skydio Dock Lite, powered by Skydio's new Remote Ops software.

US-based Skydio says that its Dock solutions give users complete remote and autonomous visibility into tasks like site inspection and monitoring, mapping, and situational awareness.

Skydio drones housed in Dock and Dock Lite can fly safely with a single off-site operator, or autonomously. Skydio Remote Ops software is said to enhance the drone's AI-powered autonomy so operators can perform streamlined missions.

Adam Bry, CEO of Skydio, says, "Skydio Dock and Skydio Dock Lite, combined with our Remote Ops software, deliver autonomous capabilities for our customers, whether they are monitoring their warehouses, inspecting a security perimeter, or assessing infrastructure following a natural disaster – finally realising the promise of efficient, scalable remote operations."

This announcement is made with the participation of Skydio's Early Access customers and partners, such as the North Carolina Department of Transportation, Southern Company, Caltrans, the Oracle Innovation Lab, and Japan-based Obayashi Construction.

SURVEYING TECHNOLOGY CAN BE ACCURATE TO WITHIN A FEW CENTREMETERS

well documented. In order to become more productive and efficient, it first needs to be known what work has taken place; this is where drones and the data they collect is essential.

Collecting data on a site makes it possible to track progress over time to enable project stakeholders to see what areas could become more efficient and also the optimum time for materials to be moved. Swiss-based software company Pix4D is one such company that offers these services.

"PIX4Dcloud Advanced allows constructors to use its timeline feature to track changes over time. The workflow is very straightforward: collect data via drones or mobile devices, process it online with PIX4Dcloud, and then analyse the site," says Gabriele Ruggiero, business development manager, AEC Solutions at Pix4D

"You can measure distances or volumes, share 3D models, and monitor stockpiles. To track and manage progress, the timeline tool allows you to overlay design plans and maps in order to identify errors early and avoid expensive rework. All of this can be shared online with stakeholders via links as it is hosted online, which means processing and analysis can take place off-site."

Using drones and software enables firms to document their progress. It means they no longer have to guess how long it takes them to move material – they know exactly. "Drones not only give you great pictures, but you have data you can measure with, like areas, your footages and volume metrics," says Jason Anetsberger, director of customer solutions at Komatsu. "That data can become the truth for the job site."

During a preconstruction flight it is possible to compare the real site to the engineer's model, which allows for any miscalculations to be fixed.

"We had a customer recently who realised they had to move 40,000 cubic yards more than what the engineer quantities were saying they needed to do at the beginning of the job," comments Jim Petry, Smart Construction solutions manager.

"For them, that was a big revelation. That was the first time that they used a drone. They quickly found a lot of value in it. They can see where their cut and fills are on the site, where that is taking place, and if it's a large site, they can make better decisions on equipment."

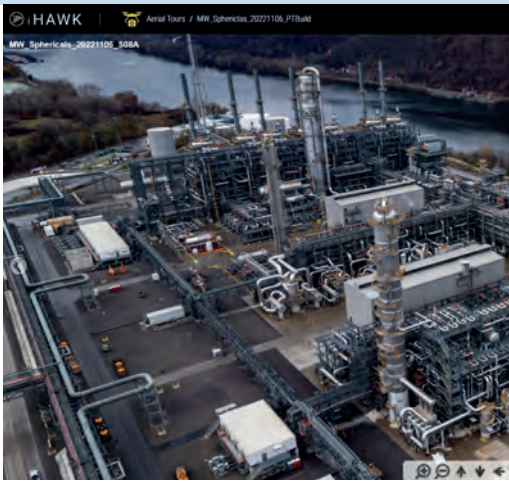
FUTURE APPLICATIONS

The potential of this technology goes even further than monitoring – and optimising – a construction site. One of the ways it can be used is to help create and update 3D models.

"This feedback from the field leverages multiple techniques, but companies are now making reality modeling and surveying an essential component of this process, with an increasing adoption of 3D laser scanners, drones, timelapse cameras, and photogrammetry," says Bentley's Martinez.

"Moreover, surveying is not only used to monitor progress and control the quality of the construction, but also to create 3D snapshots at key project milestones, that can be archived and reused during maintenance and operations. It is also used to update design models to keep digital twins evergreen and improve the communication between designers and constructors."

THE PRICE POINT FOR DRONES IS REDUCING



At the moment, in most countries, a drone can only be flown to a point where they remain in the pilot's line of sight but that may change, says McGinn from Cyberhawk. "I believe we'll eventually shift to remote flying, which will be transformative in terms of productivity for linear civil engineering projects like roads and railways," he says.

In addition to this he believes that "In the next five to ten years, we'll see widespread use of drones for delivery, supporting modern methods of construction. Site data gathered by drones will alert off-site manufacturing assets when facilities such as bathroom pods or heating, ventilation and air conditioning systems are required, and drones will be used to deliver those materials at the right time."

Construction is a fractured industry, with just one large-scale project commonly having numerous contractors and even more subcontractors working on it. Numerous stakeholders can make sharing data difficult but, says Pix4D's Ruggiero, "Construction platforms are also becoming more straightforward to integrate with, which helps us to support our clients that work with multiple products and service providers."

Another potential change could be the move towards LiDAR, which uses the light from a laser to collect measurements. At the moment most drones use photogrammetry, which provides consistent ground models. Trimble's Greenberg says LiDar has advantages, but a change won't happen for a little while yet.

"When you are flying a drone with LiDar, it has lots of advantages – it can penetrate foliage, but you have to have really accurate orientations and the accuracy just isn't as good as what we can get out of photogrammetry," he says.

"If the price point was right and the LiDar

DRONES CAN ENSURE THAT A SITE'S PROGRESS IS ACCURATELY MEASURED

was good enough, I'm sure we'd have all drones with LiDar and photos, so maybe five or ten years from now. But I don't see LiDar taking over from photogrammetry for our applications in the near future."

There will doubtless be changes to both the physical drones themselves and the software in the future, as well as to how the data is used. One thing that will remain constant though is this branch of construction technology being used to keep the 'real' world and the digital world in step. For example, a drone flight on a Sunday night will provide accurate data for a whole team on Monday morning about the exact state of a project.

As Greenberg says, "the real and digital world go out of sync all the time. When you see that the real and digital world are diverging, it's a way to pull them back together." As the influence of the digital world grows ever more in construction, having the ability to make sure that this world and the 'real', physical world are the same will only grow in importance. CT

HEXAGON'S LEICA BLK2FLY NAMED ONE OF TIME'S BEST INVENTIONS OF 2022

Time compiled the list via solicited nominations from its editors and correspondents around the world, and through an online application process. The company then evaluated each contender on a number of key factors, including originality, efficacy, ambition, and impact.

Hexagon says that the BLK2FLY can quickly and accurately capture everything from large outdoor spaces to complex structures and environments. The resulting colourised 3D point clouds are instrumental in building information modeling (BIM) processes, documenting site conditions, and improving any asset's operation.

"Having our reality capture technology recognised by Time as one of the year's best inventions is both humbling and inspiring. It validates our mission to build Smart Digital Realities that empower an autonomous, sustainable future," says Hexagon President and CEO Ola Rollén.

MIKE HAYES **looks at the power technology for construction equipment that may – or may not – be replacing diesel in the coming years**

IT'S NOT ALL-ELECTRIC

If, in the past, the thought of renewing your fleet of construction machines has caused you anxiety, look away now; things are about to get a lot more complicated.

And if you thought the issue was about when to switch from diesel to electric, well, even there it's not so simple.

One of the major drawbacks of the lithium-ion batteries that are beginning to make inroads into construction is their modest power density, which currently holds back their ability to power heavy equipment for a full working day.

Another drawback – perhaps even more significant – is the cost. Whereas it was anticipated that the cost of batteries – and therefore the cost of battery-powered equipment – would fall as the technology became more widespread, in fact the cost of lithium has skyrocketed.

This is one reason for the purchase price of a battery-electric machine currently standing at between two and even three times that of its diesel equivalent.

Even allowing for potential reductions in fuel costs and maintenance over the total lifespan of the machine that do exist, many contractors will be hesitant to take the plunge, especially given the current power density challenges.

POWERING UP

A 20-tonne excavator, for example, will be hard-pressed to give a full day's unbroken service on lithium-ion batteries, although Volvo Construction Equipment's recently unveiled and fully-electric 22 tonne machine, the EC230, does promises an eight-hour shift, with a high-powered charge "during a lunch break".

This machine is currently being piloted with customers, but will constitute a major breakthrough for machines in this size class when it comes to market.

Notwithstanding a number of larger battery-electric machines making waves in construction, the fact remains that, without significant developments, in both power storage capacity and cost, electricity is likely to remain the 'fuel' of choice for compact mobile machines only.

In compact equipment, the technology does present some clear advantages – especially for projects taking place in urban or sensitive areas. These include: zero local emissions, significant noise reduction, and simplified maintenance and servicing.

As an example, Wacker Neuson – a specialist in urban construction equipment – recently launched its 1.7 tonne EZ17e electric mini-excavator; the first of its kind with zero tail swing.

VOLVO'S ELECTRIC EC230 EXCAVATOR PROMISES UP TO A 70% REDUCTION ON RUNNING COSTS VERSUS DIESEL
PHOTO: VOLVO CE

PHOTO: WACKER NEUSON

WACKER NEUSON'S 1.7 TONNE EZ17E FULLY ELECTRIC COMPACT EXCAVATOR

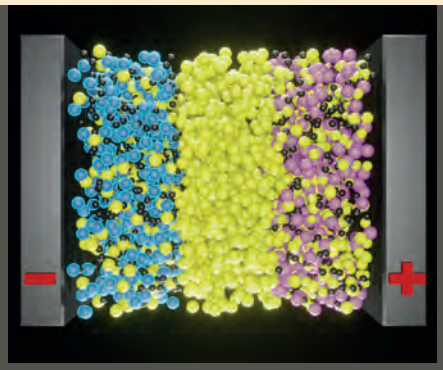


PHOTO: ADOBE STOCK

BATTLE OF THE BATTERIES

New battery-electric machines are entering the market at a quick rate, but significant barriers remain to greater adoption of the technology.

Among new battery developments currently being investigated two, in particular, are showing potential in terms of improving power density and safety and reducing cost.

The first is solid-state battery tech, which uses ceramics or other solid materials in place of liquid electrolyte. These liquids have always been something of an issue in batteries, as they are highly flammable. Solid-state batteries are also proving able to move charge around more rapidly.

On the downside, there have been issues with battery degradation and it is unlikely we will see them powering construction machines until that issue has been overcome.

The second technology involves exchanging lithium with sodium – a mineral that is found in far greater abundance than the metal currently being mined at increasing cost.

Furthermore, a sodium-ion battery is likely to improve safety, being less flammable than its lithium-ion counterpart.

So far, however, sodium has not proven itself in terms of improving on or even matching lithium's power density, but tests are ongoing.

One change we will almost certainly see in future batteries is an improvement in the cathode material, which currently tends to be graphite. Alternatives such as silicon, which are now being tested, could improve energy density and speed up charging.

The company says the machine can run for a typical workday, as well as operating continuously in a stationary position, with a power source connection. The OEM adds that the excavator can be recharged in five to six hours using a common 240-volt, single-phase outlet.

While still in its infancy in construction, battery-electric machines such as this

are increasingly being seen as must-have technology for contractors tendering for inner-city projects.

Other power technologies, however, are available and all are nibbling away at the pie that was once the sole preserve of diesel.

THE VEGETABLE EQUATION

HVO (Hydrotreated Vegetable Oil) is of particular interest to many equipment manufacturers. It is obtained from, for example, cooking oil waste, grease and fat residues, waste fats and vegetable oil. The manufacture and use of HVO is nearly climate-neutral when only renewable energy sources are used in the production process.

PHOTO: KOMATSU

FILLING A KOMATSU MACHINE WITH HVO AT THE COMPANY'S HANNOVER PLANT IN GERMANY.

In its pure form, or as an additive to conventional diesel, many machines can already operate in an almost climate-neutral manner, as HVO can be directly used in conjunction with conventional combustion engines without having to convert the machine. CO2 emissions can then be significantly reduced – up to 90% compared with conventional diesel.

Major construction manufacturer Liebherr says all of its engines are approved for HVO, without having to be retrofitted. The company says it ensures that the HVO it uses is mainly from vegetable waste and completely free from palm oil.

The problem with this fuel is its availability; the amount of suitable wastes required for HVO production are unlikely to be available in sufficient quantities on a permanent basis.

Nevertheless, Liebherr believes HVO currently represents a fuel option that can make an important contribution to de-fossilising the industry.

Another leading manufacturer, Komatsu, is also making a strong commitment to vegetable oil, having recently announced a switch to HVO as factory-fill fuel for equipment produced in Europe. The move started last month at plants in Germany and the UK.

Much like Liebherr, Komatsu says the combustion engines in its machines – including those produced for the construction and demolition industries – can be operated with HVO with no modifications required and describes the swich as a major step towards reducing its environmental impact.

This shift to HVO runs alongside Komatsu's continuing research into and development of a range of alternative power technologies and solutions, such as electric and hydrogen-powered machines.

HYDROGEN AS A FUEL

Speaking of hydrogen, the jury still appears to be out on whether hydrogen fuel cell technology or hydrogen as a fuel within an internal combustion engine will prevail.

However, following extensive research in both technologies, JCB has been extolling the virtues of hydrogen as a fuel.

Talking to KHL's Becky Schultz about the time and effort JCB has put into developing this technology, Tim Burnhope, the company's chief innovation and growth officer, said, "We studied the 76 papers – experiments by universities, top companies – and what we realised when we got to the end of it was that the majority of those engines were conversions."

The researchers realised that most academic attempts involved trying to put hydrogen into an existing spark ignition engine.

Burnhope said, "You wouldn't put petrol in a diesel engine and expect it to work. And that's really what people have been doing with hydrogen.

WHY BATTERY TECH IS A HOT TOPIC

Thermal management of battery packs plays a crucial role in extending its working life and operational efficiency.

Diesel Progress International discussed this aspect of electric equipment with the CEO and founder of Flash Battery, Marco Righi.

He said, "In construction or agricultural machinery there is no super-quick charging: usually these vehicles have a charger on board or on the ground with limited power capacity.

"These charging modes do not create too much heat inside the battery, so a cooling system is not necessary. A cooling system is usually necessary for applications requiring ultra-fast charging or in hybrid systems where the battery is discharged quite rapidly."

A heating system, though, is highly recommended in a lithium battery designed for a hybrid or electric vehicle. Flash Battery implements it in almost all its batteries to avoid safety issues on the battery pack. Heating is automatically managed by the battery management system (BMS) according to operational need.

PHOTO: FLASH BATTERY

One of the limitations of lithium batteries is that they are unable to charge at a temperature below 0°C. In addition, if left at temperatures below 10°C, their internal resistance suffers, which causes the voltage to drop and leads to a loss in efficiency.

A heating system has a low impact on the overall cost of the battery and allows the vehicle or machine to be left outdoors regardless of weather conditions.

Additional advantages of a heating system include no drop in battery performance, increased overall efficiency of the vehicle or machine, and immediate use of the vehicle after a period of inactivity at low temperatures.

LIEBHERR SAYS ALL OF ITS ENGINES ARE READY TO ACCEPT HVO, WITHOUT THE NEED FOR CONVERSION

PHOTO: LIEBHERR

PHOTO: MAN

"The problem was the combustion was probably high pressure, high temperature. The fuels were probably too rich. So, the outcomes were fairly poor."

After dissecting the studies, JCB engineers identified 11 key technical challenges that needed to be addressed. Of these the majority, said Burnhope, came back to how you combust hydrogen in the first place, including the need to combust at much lower temperature and pressure and at a very lean mix of hydrogen to air.

JCB now has its hydrogen combustion engine fitted and working in multiple pieces of equipment, and pre-production engines are rolling off a dedicated production line in the UK.

Paul McCarthy, JCB's chief engineer for hydrogen engines performance, controls and integration, said of the developments, "We've actually built our 50th hydrogen engine, so this isn't a science experiment. This is real. This is happening. We're already proving out our production techniques [so that it] will be ready to build."

JCB IS USING HYDROGEN COMBUSTION ENGINES IN WORKING TEST MODELS OF ITS 3CX BACKHOE-LOADER AND 542-70 LOADALL TELEHANDLER.

PHOTO: JCB

ARE SYNTHETIC FUELS THE FUTURE?

MAN Energy Solutions recently supplied a methanol reactor to a pilot project in Chile that is creating synthetic, climate-neutral fuel.

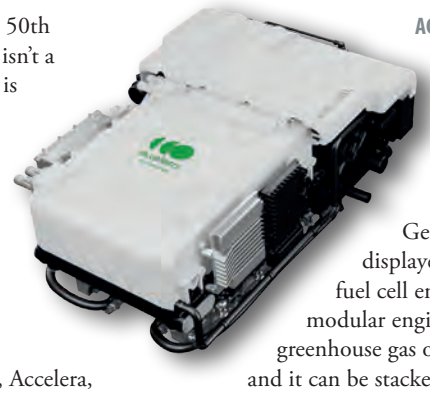
The Haru Oni project takes advantage of excellent wind conditions near the city of Punta Arenas in southern Chile to generate so-called eFuels, with the help of renewable power.

Uwe Lauber, CEO at MAN Energy Solutions, said, "Synthetic fuels are an important component on the road to a climate-neutral future. They have the potential to decarbonise all those sectors and processes where direct electrification is not possible or practical."

In the first process step, electrolysers use the wind power to split water molecules into their basic components, oxygen and hydrogen.

The green hydrogen is then combined with CO2 filtered from the air in MAN Energy Solutions' methanol reactor. The result is green methanol, which is then converted into climate-neutral gasoline in a further step.

In the pilot phase, the large-scale plant is producing around 130,000 litres of eFuels. By next year, capacity is expected to be increased to around 55 million litres of eFuels per year. By 2026, it is hoped production will have increased to around 550 million litres per year.



ACCELERA'S FOURTH GENERATION FUEL CELL ENGINE – THE FCE150

PHOTO: ACCELERA

STACKS OF FUEL CELLS

At the recent Hannover Messe event in Germany, Accelera, a division of engine maker Cummins, exhibited a range of hydrogen solutions, including the latest in fuel cell technology.

The company says its proton exchange membrane (PEM) fuel cell technology uses pure hydrogen to generate zero-emissions electricity, which can be used in heavy construction equipment.

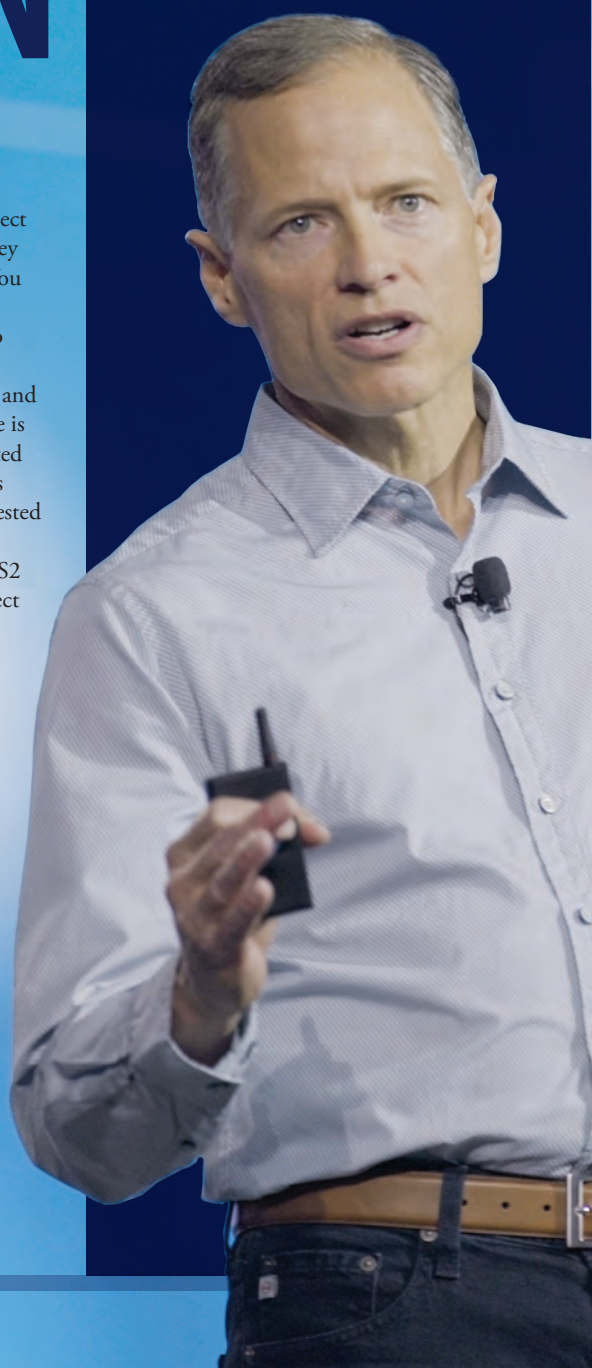
In fact, Accelera claims the technology is scalable and lightweight and can be customised to meet the demands of applications of all sizes.

At its booth in Germany, the company displayed its fourth-generation fuel cell engine, the FCE150. The modular engine operates with zero greenhouse gas or common emissions, and it can be stacked to generate a 300kW solution, making it suitable for heavy duty off-road machines.

A cynic might say engine makers and equipment manufacturers are sitting on the fence about the future of power technology. They themselves would say that there is no single power source that will replace diesel in the construction industry. When it comes to the power sources of their future equipment purchases, contractors will likely be given more choice than ever before. CT

TECHNOLOGY'S VALUE PROPOSITION

Technology has the potential to help solve many of construction's pain points, such as a lack of workers and the need to reduce emissions, ROB PAINTER**, Trimble CEO, tells** ANDY BROWN



The first time I meet Rob Painter, CEO of Trimble, it is alongside thousands of other people. Painter had appeared on the rather large main stand at the Trimble Dimensions event in Las Vegas, US, and was talking to the crowd of Trimble employees, customers and dealers. I'm sure I wasn't the only one in the audience 'meeting' Painter for the first time – he has been with the company since 2006, but became CEO and President in 2020 and, due to the Covid-19 pandemic, this was the first time Dimensions had been held in four years.

Painter spoke well on stage, setting out his vision for the company before inviting Apple co-founder Steve Wozniak on stage for an enjoyably un-corporate conversation. Over 5,700 people attended Dimensions, making it the largest in Trimble's history, as people embraced the opportunity to meet face-face. When I next met Painter for a relaxed conversation on a sofa later in the week, it was clear how much he was enjoying the event and the opportunities that technology can provide for construction.

TECHNOLOGY AS A PROBLEM SOLVER

"Look at the value proposition of what technology delivers. We have a labour shortage; our technology enables an inexperienced operator to become good and a good operator great," he says.

"We can bring in a new set of workers into this industry, upskill workers. We literally have examples of people who've worked at a sandwich shop and become competent operators within a matter of weeks through the application of technology."

This lack of skilled workers, alongside supply chain issues and rising prices of materials is also providing those in the industry, whether it is contractors or project owners, extra incentive to look at how they can be more productive and cut costs. "You need technology more than ever in that inflationary environment to be able to do more with less," says Painter.

Another reason for the Trimble CEO – and indeed all in construction – to be positive is the amount of money that is being invested into infrastructure around the world. It is estimated that US$79 trillion will be invested in infrastructure in the next 15 years.

In our conversation he mentions the HS2 rail link in the UK, the Grand Paris Project in France, and some 'thought-leading' infrastructure work in the Nordics, as well as President Biden's infrastructure bill in the US. On this, Painter says, "It's a generational opportunity to do something about our infrastructure. The size of it and the opportunity that comes along with it is a positive catalyst for the results that we have, and many in the industry are growing right now."

The growth that Painter talks about has been substantial, with the CEO saying, "It's been a record year for our business across the board. We're seeing levels of growth that exceed anything we've had in the past. We have the mix of software and hardware, and I think that's working. It provides the connection between the field and the office and the physical and the digital world."

MACHINE CONTROL IS AN INCREASINGLY IMPORTANT ASPECT OF THE CONSTRUCTION INDUSTRY

At Dimensions there were several new product launches, including the Trimble Construction Cloud powered by Microsoft Azure, an industry cloud to streamline construction projects. The product has been designed to help accelerate the digital transformation of construction. One of the ways it will do this is by providing a 'common data environment' – having one centralised and common data environment that connects the office with site operations tools should mean that data is less fragmented and in fewer silos.

Painter tells me a key focus is, "making it easier for customers to access more of the technology. There's also an aspect of moving more of the business models to recurring business models turning CapEx [capital expenses] into OpEx [operating expenses]. When you go through these turbulent times, it's making it easier for a customer to adopt."

> Reducing costs from a large upfront payment to a monthly subscription charge and having all the data in one place
>
> ROB PAINTER, CEO OF TRIMBLE

should make it easier for customers. But what about the fact that data from different technology providers and OEMs doesn't always talk to each other – how big a problem is this? "Oh, I think it's a very large issue for the industry," he replies.

"Our platform strategy is an open interoperable system. This is a gigantic industry, it's a fragmented set of stakeholders that come together. Think about a subcontractor, sub-subcontractors on a project. There's no such thing as one ecosystem that's going to do it all, or one company that's going be able to meet every single need that's in a project. That drives a mentality we have around being open and interoperable with the data."

DATA AND AUTOMATION

Trimble has spent around US$2 billion in recent years on research and development, and of that strikingly large figure the largest proportion has been invested in data and autonomy. The Trimble Construction Cloud powered by Microsoft Azure would be an example of investment in data, and Painter says that automation and autonomy is an area where the company has "stepped up investment" over the last couple of years.

Painter comments that Trimble sees, "autonomy as a progressive series of automation," and in a way the company have been doing it for 20 years; it was just called machine control. So-called 'full' autonomy is a long way off, but automation can play a key role in increasing productivity.

"The ability to add perception sensors and functional safety is really one of the gaps to be overcome as we move higher up the technology stack. We think about workflows that make sense to be further automated and to become autonomous. I don't think everything should be automated; construction is generally a very bespoke operation, it's not a mine, which is more of a closed loop, controlled environment," he says.

"We don't think that every site project is going to make sense to be done autonomously or every linear project to be done autonomously. We do think that they can become more automated. We do think they can become more productive, and we can take two person operations and make them a one-person operation."

Being more productive ties into a major issue – arguably the major issue – facing construction: how to be more sustainable. In simple terms, the more efficient a project is then the fewer emissions are produced. As Painter neatly summaries, "The first place where you achieve sustainability benefits is through productivity." He says that on a recent trip to Europe and Asia sustainability was in the top two priorities for "every customer."

When talking about the potential of technology to play a key role in the drive for sustainability, Painter – who comes across as calm, measured and thoughtful – becomes excitable and animated. "It's an exciting, inspiring time. How do you use your heartbeats in life? What do you want to work on, what do you want to do? Do you want to make a positive difference? With this work our ability to make a difference is enormous. That's inspiring."

It would be no surprise to anyone if at the next Trimble Dimensions, Painter, from the oversized stage, devotes a large section of time talking about sustainability and exactly what the technology sector is doing to help the giant and fractured construction industry reduce its emissions. CT

THE EXPO HALL AT TRIMBLE DIMENSIONS SHOWCASED A HOST OF TECHNOLOGY

Construction's path to autonomy is underway and, while a fully autonomous jobsite is far away on the horizon, the benefits of this technology are being felt today, writes ANDY BROWN

CONSTRUCTION'S AUTONOMOUS PATHWAY

Construction has long held a reputation – often justifiable – of not being the quickest of industries to adopt new technologies and methods of working but, at least when it comes to autonomy, that could be changing.

This view is given weight by a survey from Hexagon, specifically on Autonomous Construction Tech. The survey of more than 1,000 technology decision-makers from general contracting firms of all sizes across North America, the UK and Australia revealed that 84% of firms have already adopted autonomous technology at some level.

Of these, the majority report clear benefits, ranging from sustainability improvements and waste reduction to improved safety compliance. In addition, the construction firms surveyed plan on investing an average of US$7.1 million in autonomy within the next three years.

"Construction firms are turning to autonomous solutions to mitigate risks better and improve the effectiveness of operations, which are both key to overcoming the productivity, sustainability and profitability issues they face every day," says Thomas Harring, President of Hexagon's Geosystems division.

The benefits that autonomy can bring are clear: autonomous tech makes jobsites safer, more efficient and sustainable. A key way it does this is by what Harring refers to as the 'data leverage gap'. He explains this as, "that ever-widening chasm that exists between the data created during the lifecycle of a project and the data actually used to produce meaningful insights, outcomes and opportunities for growth.

"Autonomous technology is transformative technology that will define the next era of construction. The key right now is to help the industry leverage technology in a way that ensures optimisation and lasting, scalable results."

PETER BLEDAY, HEAD OF AUTONOMY, DANFOSS POWER SOLUTIONS

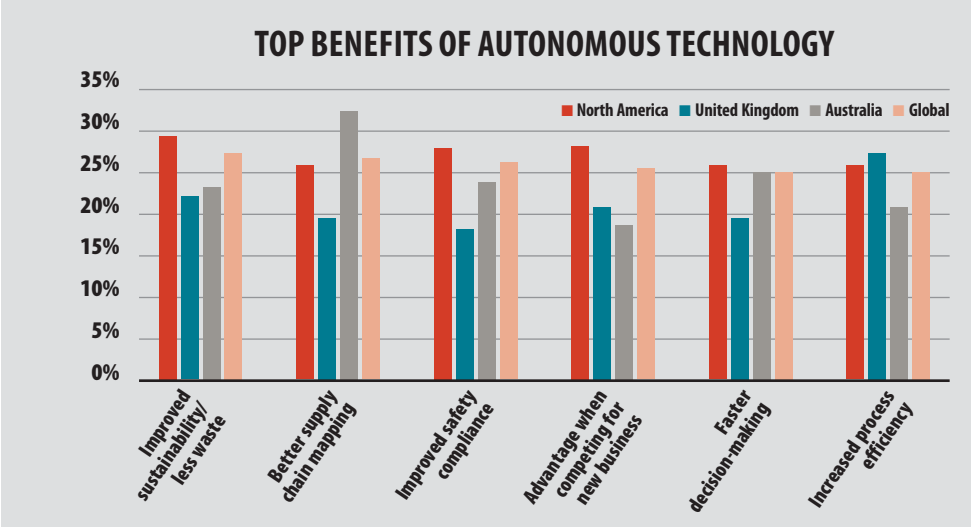
DIFFERENT STAGES

Autonomy isn't binary; something isn't either not autonomous or fully autonomous. There is a whole spectrum of semi-autonomy, of which the technology has long been used in the form of machine control and the automation of some process in the construction cycle.

In fact, there are generally considered to be five levels autonomy – from level one where the operator performs most tasks with some basic AI guidance, to level five where the machine operates with full autonomy, doing anything that an experienced human operator could achieve. So, where is construction on this continuum?

"We're seeing a lot of spectrum between Level one and three, across a lot of vehicles, with a bigger push toward Level three, in construction specifically," says Peter Bleday, head of autonomy at Danfoss Power Solutions.

AUTONOMOUS EQUIPMENT IS INCREASINGLY BEING TESTED ON CONSTRUCTION SITES ACROSS THE WORLD



SOURCE: HEXAGON

"The reason for this is an increasing lack of experienced labour, let alone a lack of labour in general. Rework, quality of work, things that are costly to a contractor; if you can add some capability onto the vehicle, you can give the vehicle that five years of experience that you don't have with a novice operator. There's a lot of value around driver assist technology."

Regardless of what level of autonomy is being used, what is key is that it is providing tangible benefits, agrees Scott Scheffler, Moog Construction's marketing manager. "There are increasing levels of autonomy, from augmented operation to full autonomy. All along the way, it's critical to introduce technology that improves productivity while working safely with people."

AUTONOMOUS MINING TRUCKS CAN BE CONTROLLED USING A DIGITAL TABLET PHOTO: ADOBE STOCK

Autonomy can mean a task being done by a piece of equipment – such as an excavator with machine control digging to a depth of 30m automatically – or processes being done by a machine rather than a person, such as the reformatting and organisation of data. These processes may be less eye-catching than a 20-tonne machine moving by itself, but they are just as important, if not more.

"When you've got the design and you're doing costings and bidding, a lot of the times things are just fed over on paper plans and contractors are having to redigitise and create a model when it already exists," says Cameron Clark, Earthmoving Director for Trimble's Civil Infrastructure Solutions Division.

"It sounds simple but so many people are complaining that, 'I'm getting all these paper plans, I've got to spend time recreating, redigitising, remaking all these models.' When you've got people involved doing that you get errors. Having a process that can automate taking it in and pulling the information that they don't need out saves time."

IMPACT OF AUTONOMY TODAY

Construction is a much harder industry in which to automate equipment due to it being more 'dynamic' than other sectors, such as mining. There are more moving parts and different equipment on a construction site and it may also only be there for a short period of time. Despite this, autonomy has already impacted equipment used on sites around the world on a daily basis, such as bulldozers.

Almost all bulldozers now produced come with grade control as automatic and this means that contractors can use them slightly differently, and even eliminate the usage of some machines. "Maybe before you'd have a dozer work and a grader would finish it, clean it up. Now you don't necessarily need the grader to finish it," says Clark. He adds that on many sites machine control on excavators means that they can do work on slopes where previously bulldozers would have been used, freeing up these machines to do other work.

"Adoption is growing and then, as we add more value, it's around people understanding it to make sure it's going to fit in their workflows," adds Clark. "It's a good business to be in at the moment because we all have to do more with less, and this is what we do. A side effect is sustainability, which is awesome, as the technology enables us to do things quicker, cheaper, and faster."

HUMANS REMAIN KEY

A point all of those involved in this

> AUTONOMOUS TECHNOLOGY IS TRANSFORMATIVE TECHNOLOGY THAT WILL DEFINE THE NEXT ERA OF CONSTRUCTION

SEMI-AUTOMATION AND SUSTAINABILITY

A new report from Topcon, *The Future of Machine Control*, explains how machine control technology can help reduce emissions.

The survey of around 1,000 managers across the European construction industry revealed that 67% of respondents agreed that construction would hit net zero by 2050 – but 30% still highlighted hitting sustainability targets as a key challenge on projects. Machine control is a significant step that construction businesses can take towards greener operations.

Companies are under pressure from soaring material costs, shrinking margins, combined with increasingly strict environmental regulations. Senior vice president, Topcon, EMEA, Luc Le Maire, says that machine control can provide a solution to these issues. "Machine control can be a game-changer – the improvements in demand from clients mirror those most selected as the main benefits of machine control in our research, with accuracy and improving efficiencies both chosen by a quarter of respondents," he says.

"Combine that with the fact that machine control emerged as the joint most selected factor for meeting future sustainability goals, and the consensus is clear – a more efficient and accurate industry is a more sustainable one. A lot needs to change before construction hits net zero, but machine control can be a crucial catalyst for construction companies looking to reach higher levels of accuracy and efficiency, deliver lower carbon footprints for clients, and submit healthier sustainability reports."

CAMERON CLARK, EARTHMOVING DIRECTOR FOR TRIMBLE'S CIVIL INFRASTRUCTURE SOLUTIONS DIVISION

technology make is that – for the foreseeable future – humans will remain central to the process of automation and the technology is there to make their lives easier, not to replace them.

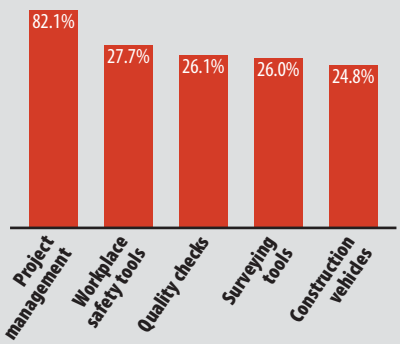
Construction sites are typically dynamic and quickly changing, making full automation of equipment extremely difficult. It is likely that the first fully autonomous machine that will be used on working construction sites is the roller; compaction is very important, but it is also straightforward, with a machine moving in a straight line to set parameters. Trimble recently announced that its autonomous roller has been successfully trialled on a working jobsite in Canada, but there is no date for when this might be commercially available.

Rather than thinking about machines being automated it makes more sense, suggests Trimble's Clark, to focus on workflows being automated. "Fully autonomous sites with no people are a long, long way away. What's more realistic is there are going to be certain workflows and machines doing certain tasks that it makes sense to automate.

"We're not going to be able to automate everything and it doesn't make sense to even try to do that. Our autonomous workflows are all sitting on top of Trimble Earthworks, where the machines have got a system where they can provide guidance and automation for operators. You can put in your complex design, and the operators do that. Then, if the machine needs to dig a 200m trench the machine can be tasked to do it in an autonomous workflow. It's not an autonomous machine; it's an autonomous workflow."

This point is echoed by Bleday.

TOP 5 MOST UTILIZED AUTONOMOUS TECHNOLOGIES



SOURCE: HEXAGON

"Don't think necessarily about automating the machine but think about all the tasks a machine can do and automating those," he says.

"In construction, you have excavators, skid steers, compact track loaders, wheeled loaders, etc, that are utility vehicles – they don't just do one task, they do many. So, while there are some vehicles, like a soil compactor or a double drum roller, that might be more single-task oriented, that's not often the case in construction."

ADAPTING TO NEW TECH

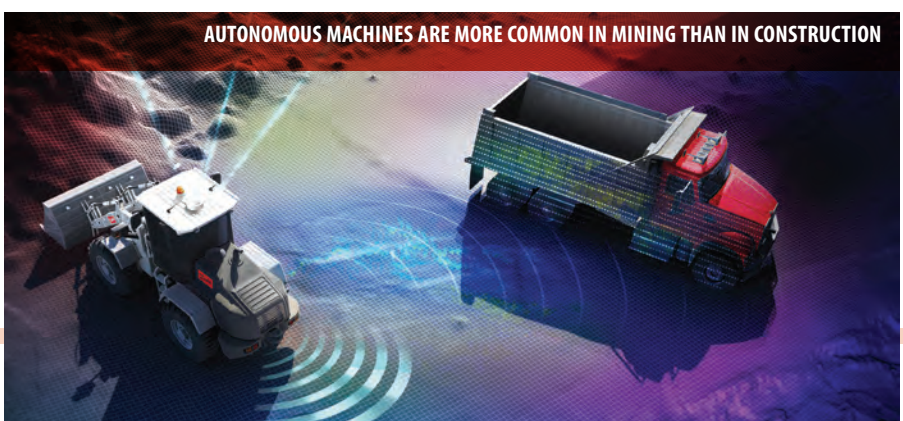
Regarding equipment, Moog – which works with OEMs including Bobcat, Komatsu, and Case – suggest that owners and operators being able to adapt as the technology progresses is key. "To design automation solutions for construction, engineers must consider the consequence of failure, which depends on the machine's environment and application," says Scheffler.

"The smart path is building vehicles with a control platform that owners can easily adapt and evolve as technology and industry processes adapt."

Being able to evolve with new technology is obviously key but Clark says that fully autonomous equipment is not something that we will see for a long time. "When I see these machines with no cabs and other things, I just cringe because that's a long, long, way away. People are critical, they do the complex things. We need operators; we're just going to use them a little bit differently."

The idea of a construction site with machines operating autonomously is, for now, science fiction. However, the technology that is being used now to automate machines, data and processes, would also have been unthinkable a few decades ago.

It is also clear that, as the industry takes its steps on this path, there are significant benefits that will be delivered along the way such as sustainability, increased productivity and efficiency and being able to do more with fewer people and machines. **CT**


AUTONOMOUS MACHINES ARE MORE COMMON IN MINING THAN IN CONSTRUCTION

THE POWER OF KNOWING

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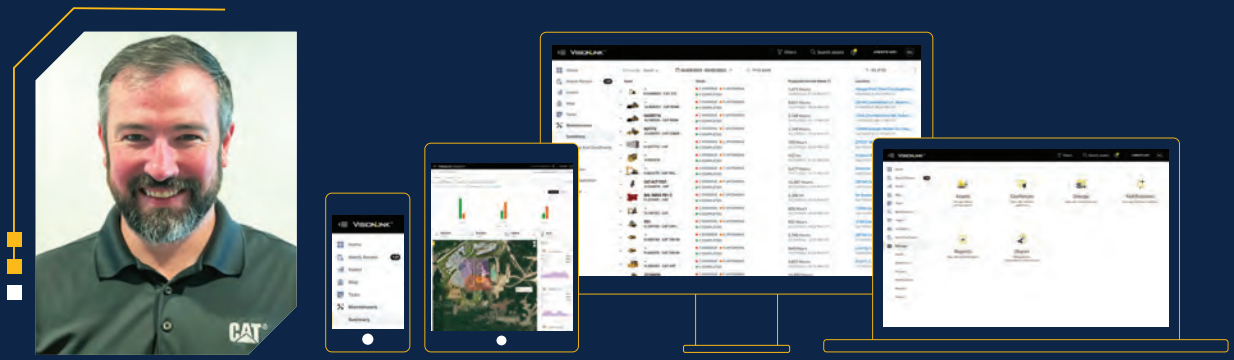

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RESPONDING TO GROWING CUSTOMER NEEDS

Over time, we have seen Caterpillar customers, like you, becoming increasingly technology savvy. Business is moving too quickly for you to afford to be left behind, and you've acknowledged that the key to better management of operations is having access to more insights. Indeed, the very best contractors – the most successful ones – are extremely good at managing their logistics, enabling them to better manage their costs. Once it was all about the machines, but we are increasingly seeing a demand from customers for insights from telematics and data. This is where VisionLink is so useful. Whether it's helping contractors manage their workflow, schedule maintenance or assign tasks – you name it, VisionLink is ready for it.

Importantly, VisionLink was developed in close consultation with dealers and customers such as yourselves, and feedback was incorporated every step of the way. The number one request we received time and again was to make this new interface more intuitive and easier to use.

We recognize that when you're on the jobsite, you are focused on getting the job done safely – on time and on budget. You need to have complete confidence that the data you're receiving is one hundred percent right. This is never more important than when bidding for jobs. Being accurate is the "secret sauce", especially when overquoting can lose you a job and underquoting can cost you the shirt off your back. The beauty of VisionLink is that it makes all the data from previous jobs available for the next, allowing you to learn as you go.

We appreciate that technology adoption is a journey. That's why we've packaged VisionLink to grow as you do. Our advice is to start training your people now because we're only getting started. With VisionLink, the sky is the limit.

WING CHOI,
VISIONLINK DIGITAL PRODUCT MANAGER

ABOUT NEW VISIONLINK

NEW VISIONLINK GIVES YOU NEW ADVANTAGES

Asset tracking? Maximizing machine uptime? Optimizing utilization? New VisionLink provides your business with the integrated full-fleet management solution you've been looking for.

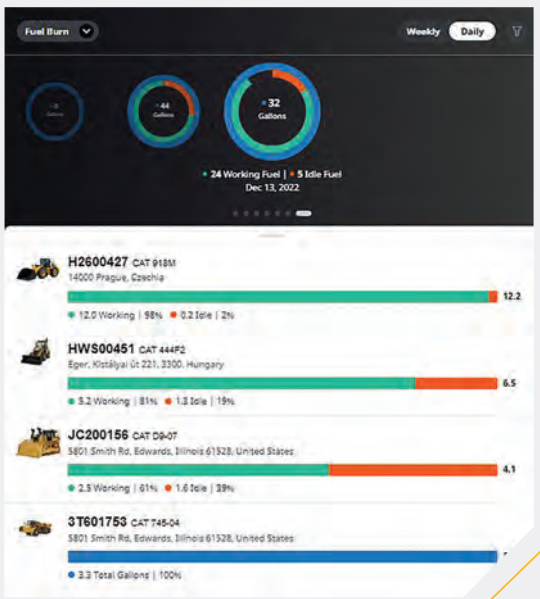
The platform's refreshed intuitive interface will help you efficiently manage your entire fleet, regardless of manufacturer. Whether your equipment is owned, leased or rented, you'll now have access to data to make better informed asset management decisions.

VisionLink is cloud-based, making it completely accessible from your desktop, tablet and mobile device. It allows users to stay up to date on key metrics, location of assets, fuel level, idle time and more. Easy-to-use dashboards allow for asset management by groups and geofences.

Plus, you get to decide who can and cannot edit settings and configurations by defining access levels for personnel. That way, customized reports can be generated and sorted automatically to facilitate tasks such as identifying underutilized equipment.

VisionLink also consolidates My.Cat.Com, the Cat® App, and the previous version of VisionLink applications into one centralized solution for easy fleet management.

Today's VisionLink also offers streamlined subscription levels designed to reduce complexity and provide the right combination of features for businesses of any size. It continues to offer core telematics data standard with every machine to answer important questions about assets, including daily machine location, utilization, fuel usage, maintenance reminders and integration with Caterpillar's extensive digital ecosystem.



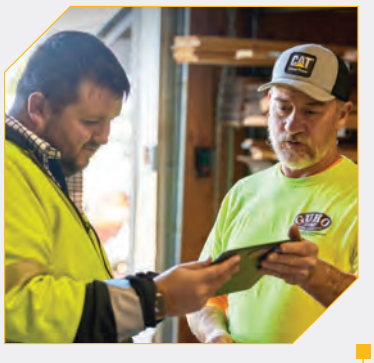
VISIONLINK®

THE BEST MADE BETTER

The evolution of VisionLink also includes VisionLink Productivity (previously Cat Productivity), scalable to any size operation, to help you analyze machine and jobsite performance and improve productivity based on actionable information. It is a cloud-based application, and can be accessed anywhere via mobile, tablet or desktop. As a site manager, owner or operator, it is critical that you understand how your assets are being utilized and how work is flowing through your operations. The data summary provided by VisionLink Productivity delivers a deeper level of actionable insights, allowing users to improve machine efficiency, productivity, utilization, and reduce per-unit costs.

WHAT CUSTOMERS HAVE TO SAY

Before VisionLink, our equipment management was very reactive... VisionLink has really improved our maintenance program, really reduced planned downtime, and maximized efficiency.



"Guho Corp is a family-run construction business based in Idaho, operating since 1919. We're using the VisionLink platform and data to help us achieve the absolute highest level of success that we can. Our equipment management used to be very reactive. Now we can instantly see the hours on each piece of equipment, when the last maintenance was done and get when the next one is due."

ANTHONY GUHO,
GUHO CORP, IDAHO, USA

Before we used VisionLink, we were very manual-driven. Now it's immediate. We can look at problems almost in real-time, and attend to them immediately.

"WBHO is one of the biggest construction companies in Africa, with sites all across the continent. Before we used VisionLink, we would have guys onsite who would inspect on a daily and weekly basis. But now it's immediate. If there's an alert, we can action it immediately. We can look at problems in real time and fix them."

ZANE BAILY,
WBHO CONSTRUCTION, JOHANNESBURG, SOUTH AFRICA

VisionLink has enabled us to free up our time as a company, to be on site and take care of our customers as they expand and grow.

"VisionLink has allowed us to expand our company and grow our fleet. Once we implemented VisionLink, we were able to see fuel usage, see our idle time versus working time, what equipment was being utilized the way we designed it, and what was being underutilized. It's all automated and right there, seeing patterns that we may not have recognized doing it the manual way."

MATTHEW KORANDA,
GOODMANSON CONSTRUCTION, MINNESOTA, USA

It's essential for Blattner to have software such as VisionLink, to help us see insights of our equipment, maintenance for our equipment, to have the machine health at our fingertips.

"Blattner Company is a renewable energy contractor, in operation since 2000. Before VisionLink we were doing a manual process. Spreadsheets, Excel sheets – it could take a week or two to find out that we had a fault with one of our machines. Now we're able to view that information right away in one piece of software. Our jobsites are so huge and so remote that just having that data on hand is very important."

CLAY YOUNCE,
BLATTNER COMPANY, MINNESOTA, USA

VisionLink is the biggest reason we have a successful preventative maintenance program. Because we get accurate information in regards to utilization, location and machine health.

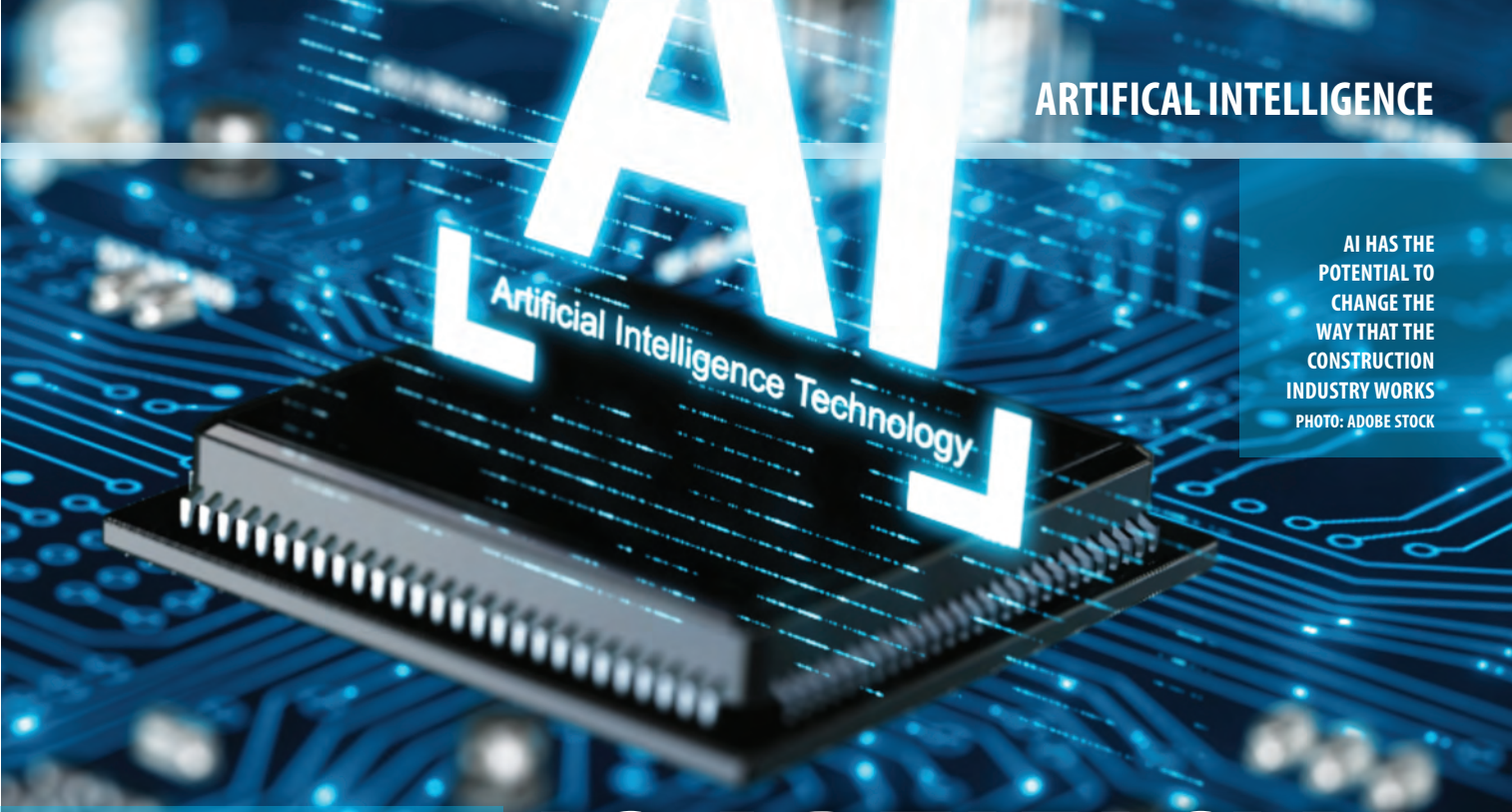
"VisionLink allows us to manage our fleet, without needing to be physically on site, 24 hours a day, 7 days a week. It gives us accurate information regarding utilization, location and machine health. There's a lot of things that help us not only stay in front of failure, but help us maintain a safe working environment."

COURTLAND ACOSTA,
DUININCK INC, MINNESOTA, USA

DISCOVER UNTAPPED PROFIT AND PERFORMANCE WITH NEW VISIONLINK®

What have your machines been keeping from you? Well, no matter how big or small your fleet – even if it's a mixed fleet – new VisionLink® gives you the insights you need to take action. Its updated interface identifies machine faults and shows you how to improve fuel efficiency and reduce idle time. It all leads to greater profitability. VisionLink puts the power of knowledge in your hands.

Speak to your local Cat dealer or visit cat.com/visionlink today.



AI HAS THE POTENTIAL TO CHANGE THE WAY THAT THE CONSTRUCTION INDUSTRY WORKS
PHOTO: ADOBE STOCK

IS ARTIFICIAL INTELLIGENCE OUT TO STEAL YOUR CONSTRUCTION JOB?

The use of AI in construction is growing but fears that it could soon replace humans is misplaced, although it likely will change the way the sector works, discovers Neil Gerrard

In Douglas Adam's fictional novel of the same name, the Hitchhiker's Guide to the Galaxy was a very advanced but unreliable electronic guidebook to space travel. The Guide bore a simple but reassuring message on its front cover: 'Don't Panic'.

It's advice worth remembering as the wider world grapples with the advent of artificial intelligence (AI). It has rapidly entered the public consciousness thanks to the arrival of services like ChatGPT, Google's Bard, and image generation tools.

Microsoft co-founder Bill Gates declared AI the most important technological advance in decades and professionals in all sorts of industries have started to ask themselves what it means for the world of work and whether it could ultimately make some jobs redundant.

So, what does it mean for construction professionals in particular? Might it replace humans completely? Or could it serve as a means to enhance productivity and take the mundanity out of work to allow humans to focus on what they are really good at?

IT'S NOT AS NEW AS YOU THINK

AI isn't as new a phenomenon as it appears to be, says Stefana Parascho, tenure track assistant professor, in the laboratory for creative computation at the École Polytechnique Fédérale de Lausanne (EPFL).

Parascho now works on developing robotic construction methods and the practical implication of those methods. But she originally trained as an architect.

"AI has been around for a while now. It's true that it has been evolving quicker and quicker: We can see that with Chat GPT, Midjourney and things like that, that are so accessible now to everyone. But it's worth being aware that it's not a completely new thing," she comments.

"There's always been this fear of AI and robots replacing human workers. Even though it's evolving so fast, it's nowhere near a place where it can fully replace humans."

STREAMLINING WORKFLOWS

Where AI can help almost immediately is by taking over repetitive and mundane office tasks.

"I'd imagine zero to almost zero architects, engineers and construction managers want to spend their time reviewing emails, answering basic questions, preparing PowerPoints or formatting Excel reports," says Danny McGough, assistant professor in the school of energy, construction and environment at Coventry University in the UK.

McGough specialises in Building Information Modelling (BIM), architectural technology and construction management.

"Being focused in these areas I'm a natural advocate of digital fluency and technology

AUSTRALIAN COMPANY FBR HAS DEVELOPED THE HADRIAN X BRICKLAYING ROBOT TO LAY BRICKS AUTONOMOUSLY IMAGE: FBR

adoption. However, the downside of this is that we spend a lot of time learning new software, processes, reviewing data and putting this information into accessible formats such as design plans, 3D models, visualisations, presentations, and spreadsheets," he says.

"AI could reduce the load of these processes, allowing us more time to innovate."

AI is likely to prove very effective for planning construction processes more efficiently. But Parascho doesn't think that this threatens the role of a human project manager or construction manager.

"Planning construction processes is a very complex task and AI can make it more efficient. But I do think there is a danger that if everything is planned out computationally, it relies on assumptions on what a human's role is in the process and what they are capable of," she says.

She cautions against regarding humans as machines in a big system. This is where human project managers can continue to play a valuable role because they understand their colleagues' day-to-day capabilities and limitations better than a machine.

Where Parascho does see AI being able to make a significant impact in construction is by making robotics and autonomous machinery more accessible.

"Right now, every robot has its own programming language and interaction protocols. You need to have someone with quite specific skills to set these robots, programme them and get them to do what we want them to do," she explains.

"AI can make the use of robots more accessible. There's a lot of use of AI and computer vision to make autonomous machines more aware of their surroundings, which is necessary for construction because sites are messy and unpredictable."

In time, the successful application of such technology could reduce the need for machine operators as well as some manual trades, but it is still a long way off.

Where it is perhaps closer to being ready is when it comes to certain tasks like site surveys, where machines like Boston Dynamics' Spot robot mounted with Trimble data collection sensors, or hard-hat-based technology like Open AI are already starting to have an effect.

Meanwhile, Parascho sees the potential for AI to help engineers with complex calculations. "I think there is a lot of potential for making these calculations faster and easier to access," she says. AI also has the ability to carry out extensive quality control checks. For example, it could be used to make sure that engineers have met all the safety standards with the structural design.

TOOLS LIKE CHAT GPT HAVE BROUGHT THE USE OF AI INTO THE MAINSTREAM

PHOTO: ADOBE STOCK

DATA MANAGEMENT

AI could provide a major advantage in the management of the huge volumes of data that construction projects now create. "Vast amounts of this data currently go to waste and stay lost in the limbo of closed-off and redundant project information," McGough says. "We can utilise AI to help interpret this data and make it more accessible for expert users to analyse and validate."

He points to the way in which construction already uses complex software to evaluate energy design data.

"Software helps assist in breaking down this information through accessible tools and interfaces such as Autodesk Insight, Green Building Studio and Integrated Environmental Solutions (IES), which convert the raw data into useful and accessible information.

"As AI evolves and develops, we can use machine learning to take our analysis software to the next level. Instead of spending hours and days preparing models and pushing them through the software we can instead concentrate on key project and design decisions," he adds.

BOSTON DYNAMIC'S SPOT ROBOT MOUNTED WITH TRIMBLE DATA COLLECTION SENSORS IMAGE: TRIMBLE

CONCLUSION

Parascho declares herself an optimist when it comes to technology and AI. "It has never been a question of replacing humans," she says. "I really do see the advantages of it and where we can employ it. It really is a means of enhancing what we can do."

What AI can't do – and what it shows no signs yet of being able to do – is to handle a construction project from start to finish. McGough warns that AI can and will get things wrong. "Discipline experts will be required to validate any outputs it produces," he says.

"We can't just leave a tool like Copilot AI to write out an email to a client or our boss unmoderated. For the foreseeable future, we need experts to review the data and information AI produces using the experience and knowledge they have gained over the years."

The upshot is that your construction job is safe for now, but AI will probably change the way you work.

McGough concludes, "AI won't suddenly make all roles redundant but will naturally force roles to evolve and adapt, learn where new technology can assist, and adopt the areas of AI and machine learning, which add value. If they don't then they do risk becoming obsolete." CT

THE ONLINE GUIDE FOR **BUYERS** AND **USERS** OF GLOBAL CONSTRUCTION EQUIPMENT

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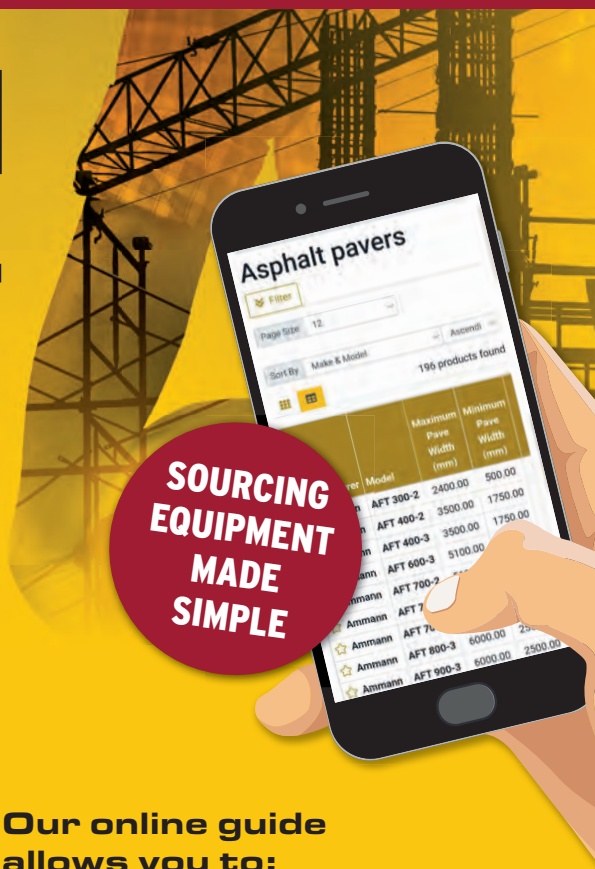

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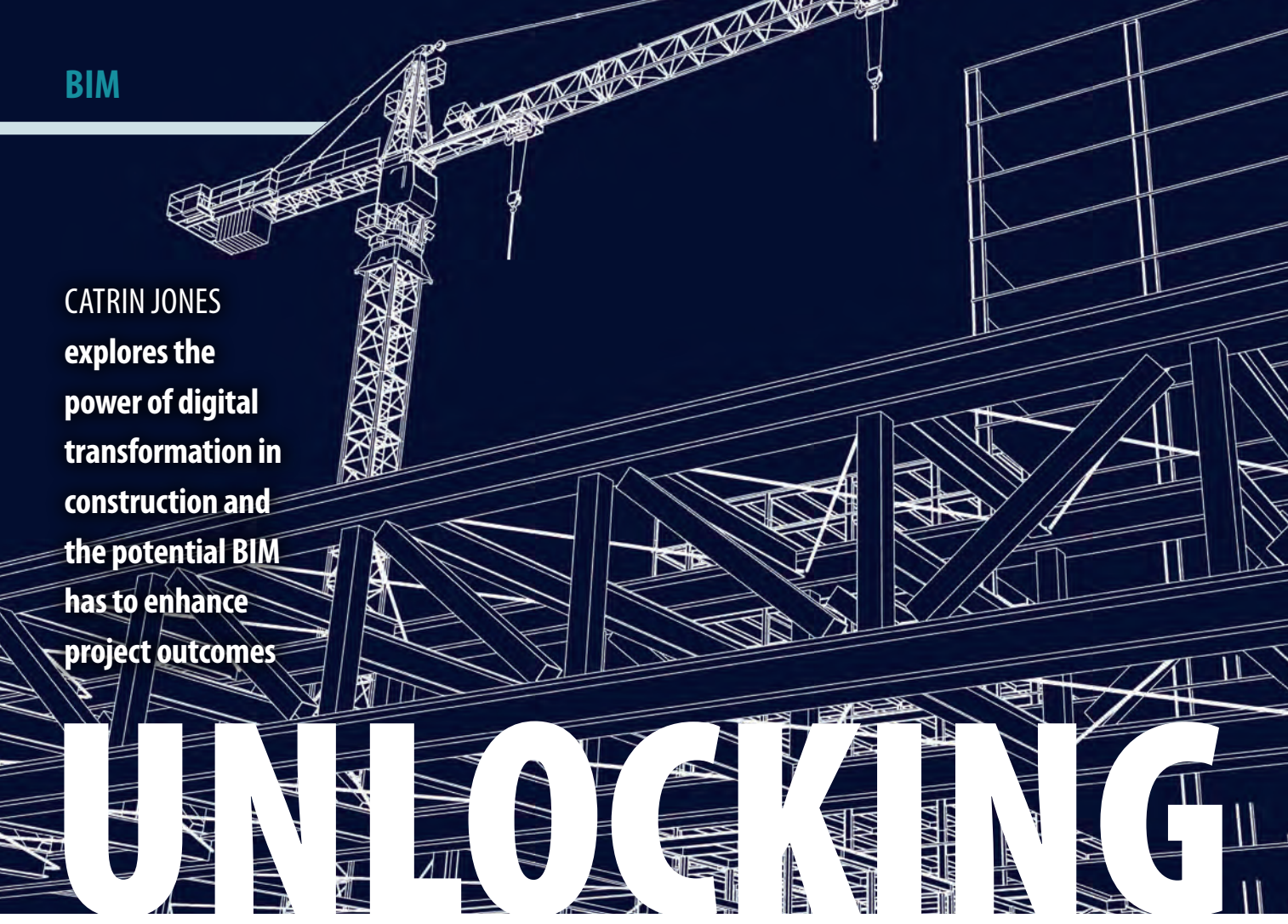


CATRIN JONES **explores the power of digital transformation in construction and the potential BIM has to enhance project outcomes**

UNLOCKING EFFICIENCY

The construction industry recognises that Building Information Modelling (BIM) technology is not a one-size-fits-all solution, but there is increasing evidence of its significant benefits. The use of BIM can offer project stakeholders precise information and a better understanding, particularly through improved data and visualisations that can be shared across different teams working on a project.

Accuracy is crucial for complex construction projects; even the slightest mistake can cause major issues. To mitigate errors and minimise the need for rework, BIM has become an invaluable asset.

BIM is a collaborative process that employs digital 3D models of building and infrastructure assets' physical and functional characteristics. It aims to support the decision-making process during an asset's life cycle, all the way from inception to demolition. The core of BIM lies in creating, using and exchanging these digital models among stakeholders.

UPWARD TRAJECTORY

The latest report on the BIM software market from UK-based Cambashi forecasts it will grow to a value of US$30.7 billion (€28.2 billion) by 2027. The research company reveals that the market will see double-digit growth CAGR of 11.5% from 2022 to 2027, an increase in revenue of around US$12.9 billion (€11.8 billion) over that period.

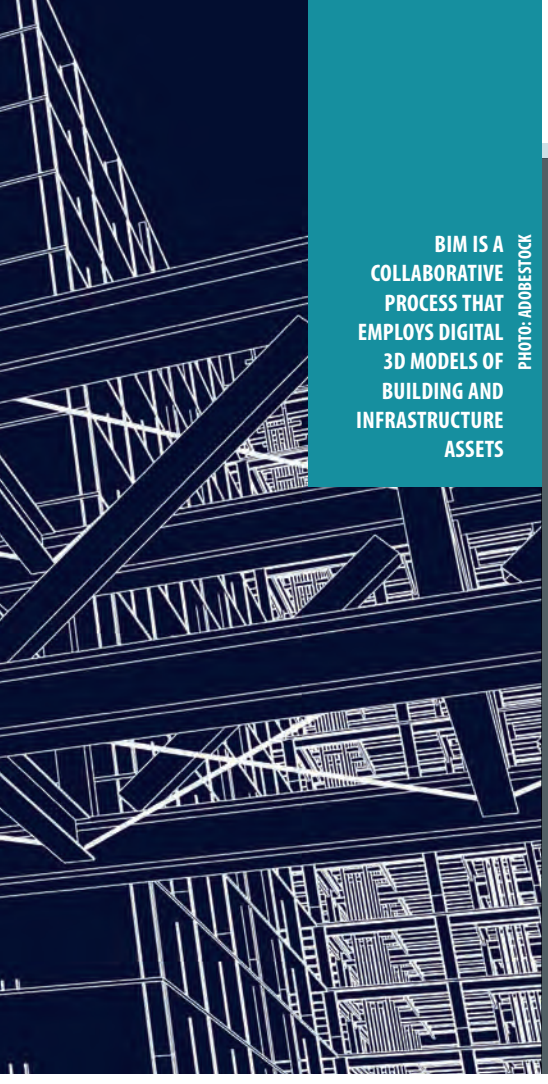
Joe Brooker, industry analyst at Cambashi, said, "BIM Design, Construct, and Operate showed positive growth during the worst lockdown periods caused by the Covid pandemic – displaying strong growth in 2021 and peaking in 2022.

"In 2023, a struggling global economy will slow down BIM software growth. However, BIM Operate software will show some resilience as building management and maintenance are ongoing needs that cannot be postponed indefinitely."

At present, the BIM industry is witnessing remarkable growth in the Asia-Pacific region, emerging as the frontrunner in the global market, says Spherical Insights & Consulting.

This can be attributed to the region's rapid urbanisation and infrastructure development, creating a surge in construction projects and fuelling the demand for efficient project management and coordination through BIM.

Additionally, there is a growing focus on



BIM IS A COLLABORATIVE PROCESS THAT EMPLOYS DIGITAL 3D MODELS OF BUILDING AND INFRASTRUCTURE ASSETS

PHOTO: ADOBESTOCK

GAMMA TECHNOLOGIES PARTNERS WITH PROCORE APP MARKETPLACE

Gamma Technologies, a Luxembourg-based company known for its Gamma AR technology that brings Building Information Modelling (BIM) models to the construction site through augmented reality, has announced its partnership with the Procore App Marketplace.

Procore Technologies, a global provider of construction management software, launched the Procore App Marketplace in 2016 as a centralised platform for third-party integrations and applications supporting the expanding construction ecosystem.

Through this integration, Procore users will be able to incorporate issues generated in GAMMA AR directly into the Procore Coordination Issues tool. The integration addresses common challenges faced in the construction process, such as errors, rework, redundant documentation, and follow-up tasks. By seamlessly connecting the construction site with the office, users can continue working within their existing workflows, thereby enhancing efficiency.

"We're thrilled to partner with Procore, which has become an essential tool in the construction industry and revolutionised issue management.

"By leveraging the power of augmented reality, this integration will help reduce rework and foster seamless communication by bringing BIM directly to the construction site," shares Caner Dolas, CEO and co-founder of Gamma Technologies.

sustainable and environmentally friendly building practices in Asia-Pacific, which amplifies the use of BIM for energy-efficient design and construction purposes. Technological advancements, increased awareness about the benefits of BIM, and supportive government initiatives are also playing a pivotal role in driving its adoption.

Stefan Kaufmann, product manager of BIM strategy and new technologies at global provider of BIM solutions, AllPlan, believes that, "BIM's significance in the construction industry is tremendous."

Kaufmann adds that, "It provides a coherent, comprehensive, and easily communicable representation of a building or asset, enabling the effective management of information about that asset throughout the construction lifecycle.

"BIM not only aids in visualising the building before it's built but also assists in better coordination, resulting in higher accuracy, efficiency, sustainability, and profitability. BIM data is machine-readable and, unlike 2D plans, can be used directly in subsequent use cases."

A WORLD WITHOUT BIM

But of course, there was a world without BIM – as Dr Jonathan Ingram recalls. Ingram is recognised as 'the father of BIM', having created and developed the initial BIM systems such as Sonata and REfLEX.

He also taught the first BIM courses at Harvard University and won the Prince Philip Gold Medal from the Royal Academy of Engineers for his work. Ingram spoke to Construction Briefing earlier in the year on why BIM has become so important to construction.

"There were a number of problems with construction before BIM. One was the coordination of information.

"You would have separate plan drawings, elevation drawings, and quantities being done by different groups of people in different offices and there was no physical link between them. This could lead to expensive errors. For example, the windows being in the wrong place. That information needed to be coordinated."

Ingram goes on to mention that BIM provides consistent information in terms of drawings and physical data. "Data is not duplicated in a true BIM system. You have one source of data, which is correct."

> "IT PROVIDES A COHERENT, COMPREHENSIVE, AND EASILY COMMUNICABLE REPRESENTATION OF A BUILDING OR ASSET"

STEFAN KAUFMANN, PRODUCT MANAGER OF BIM STRATEGY AND NEW TECHNOLOGIES AT ALLPLAN

PHOTO: ALLPLAN

As interest in BIM continues to increase, Ingram looks back at its early adoption and how construction isn't to blame for its slow progress. "It was just too difficult and, to some extent, too specialist and heavy for your average designer.

"It has been 40 years and it was a very hard sell in the early days, trust me. When you have various people using a system, it is very easy to get the next person to use the system. When no one is using it, then finding people to use a system which is meant for sharing is hard."

REVIZTO AND OPENSPACE COLLABORATE TO UNLOCK THE VALUE OF BIM FOR CONSTRUCTION

OpenSpace, a 360° reality capture and AI-powered analytics company, has announced a new strategic relationship with Revizto, the Integrated Collaboration Platform.

This partnership aims to enhance transparency and coordination in the construction industry by streamlining project workflows and communication.

Both companies share a common goal of unlocking the potential of Building Information Modelling (BIM) on construction sites and improving the exchange of information between Virtual Design and Construction (VDC) teams and field teams.

OpenSpace says that it has made substantial investments in its reality capture platform and BIM capabilities. The technology aims to simplify BIM visualisation and make it actionable in the field, thereby enhancing coordination between office and field teams.

Revizto is collaborating with OpenSpace to provide integrated workflows to their shared customers, further promoting seamless coordination and information exchange within construction projects.

Ingram stresses that BIM needs a good rewrite to bring it into the modern environment and to make it comprehensible, intuitive and powerful.

WHAT IS BIM'S POTENTIAL?

Since Ingram's first systems, BIM has made considerable progress, and many decision-makers have likely contemplated its usefulness for their companies. It is well-known that it is capable of streamlining the planning stages of a project but can the technology go beyond this?

"Absolutely," says Kaufmann. "The BIM value chain extends far beyond project planning. BIM revolutionises the design, execution and operation of buildings in a multitude of ways.

"For starters, it enables better context capturing and accelerated conceptual design techniques, providing an integrated visualisation of the project early on in the planning stages. This allows for proactive issue detection, leading to fewer design revisions, lower project risk, and overall cost savings."

But that is not all. During the execution phase, BIM is said to have the potential to improve construction planning and delivery through enhanced coordination, minimising construction errors and material wastage.

Organisations looking to benefit from BIM may face challenges such as the need for upfront investment in software and hardware, a learning curve for staff and an initial productivity dip.

Despite this, Kaufmann highlights that the key to overcoming these is an organisation-wide commitment and a phased implementation strategy. An efficient data management and exchange system is crucial to navigating these challenges.

Kaufmann says, "By integrating project data across different asset types – for example, buildings, roads, and bridges – and through their whole life cycle, organisations can ensure data consistency and interoperability."

As companies strive to enhance their sustainability efforts and adopt innovative technologies to support this goal, Kaufmann emphasises that BIM's capabilities are not to be understated.

"BIM provides precise data and metrics, which allows for the optimisation of resources and materials," he says. "For example, by enabling early identification of potential issues and efficient resource management, BIM can reduce wasted materials on-site and unnecessary expenditures."

Additionally, BIM could have the potential to help design teams make informed decisions about how a building will work in operation. It allows for precise analysis and simulation of energy consumption, aiding in the design of more energy-efficient buildings.

KAUFMANN EMPHASISES THAT BIM'S CAPABILITIES ARE NOT TO BE UNDERSTATED

PHOTO: ADOBESTOCK

EFFECTIVE DATA MANAGEMENT COULD BE KEY TO LEVERAGING BIM'S FULL POTENTIAL

> THERE WERE A NUMBER OF PROBLEMS WITH CONSTRUCTION BEFORE BIM"

DR JONATHAN INGRAM

PHOTO: COURTESY OF JONATHAN INGRAM

It can also enable the owner or end users to better visualise the completed building so any adjustments can be made before construction begins and materials are wasted.

SUCCESSFULLY INTEGRATING BIM

When it comes to implementing BIM for the first time, construction companies should begin with a clearly defined vision and strategy, according to Kaufmann. This includes gaining a thorough understanding of their business needs and objectives.

Equally important is investing in employee training and ensuring top-down commitment.

"We recommend companies explore platforms that can automate processes and reduce manual work," says Kaufmann.

"Furthermore, solutions that promote interoperability and facilitate collaboration among different stakeholders – in other words, an open BIM approach – will ensure interoperability and data exchange across different software platforms, contributing to overall project efficiency and success."

The key is that organisations looking to adopt BIM must view it as a comprehensive process change rather than simply a replacement for 2D CAD systems.

"BIM requires more than just learning to use your chosen platform – it's a collaborative and integrated approach to design and construction which brings together various AEC disciplines," says Kaufmann.

Therefore, promoting a culture of interdisciplinary cooperation will not only enhance the overall design and construction process but also maximise the benefits derived from BIM."

Effective data management is also key to leveraging BIM's full potential. Organisations should ensure they have robust systems and protocols for handling and sharing BIM data across all phases of the construction lifecycle.

"This, of course, stems from good management," says Kaufmann.

"This support is another significant influence on the success of BIM adoption. When the leadership team is committed to the process, it motivates the entire organisation to embrace the changes that come with BIM."

Although some might see investment into BIM as an 'all-or-nothing' approach, Kaufmann says that this does not need to be the case.

"Organisations can start small, perhaps with a pilot project, and gradually expand their use of BIM as they become more comfortable with the processes and tools," he says.

"By taking a strategic, patient, and iterative approach, organisations can effectively navigate the transition to BIM, reaping significant rewards in terms of efficiency, cost savings, and improved project outcomes." CT

PEREGA ACHIEVES ISO 19650:2:2018 CERTIFICATION FOR BIM EXCELLENCE

Perega, an independent structural and civil engineering firm in the UK, has announced its attainment of ISO 19650-2:2018 certification after undergoing an evaluation conducted by global assurance partner LRQA.

ISO 19650 is the internationally recognised framework for effectively managing information throughout the entire life cycle of a built asset, utilising BIM.

First introduced in 2018, the framework now comprises five parts, with part two specifically outlining the process for information management and collaborative production during the asset delivery phase.

Integral to the assessment process was the involvement of third-party assessor LQRA, responsible for auditing and providing a final evaluation. This rigorous assessment spanned two days, culminating in Perega officially obtaining certification to ISO 19650-2:2018 in February.

Mark Asplin, Perega's Group BIM Manager, commented on the achievement, "ISO 19650-2:2019 represents a remarkable milestone and aligns perfectly with our core business values. To thrive in a highly competitive environment, we must remain fully committed to innovation and consistent improvement.

"By closely scrutinising our processes and ensuring their value to the organisation, we can guarantee our clients the best possible service. As the demand for accreditations continues to rise in our industry, this certification sets us apart from our peers."

TRANSFORMING CONSTRUCTION

Rich Humphrey from Bentley Systems tells Andy Brown how construction can take its next step on the tech journey

"I guess the question is: when do we hit this big inflexion point? When do we cross the chasm? We're not there yet," says Rich Humphrey, Vice President of Product Management at Bentley Systems. Humphrey, who has been playing a role in helping to drive construction's digital adoption for the best part of two decades, is answering where he thinks construction is on its technology journey.

> "WE'RE MEETING CUSTOMERS WHERE THEY ARE TODAY BUT ENABLING THEM TO EVOLVE AT THEIR OWN PACE AND GO FULL-BLOWN DIGITAL TWIN IF THEY WANT TO"
>
> **RICH HUMPHREY, VICE PRESIDENT OF PRODUCT MANAGEMENT AT BENTLEY SYSTEMS**

The first step of this journey – and one that is increasingly being taken – is digitising paper and processes. CPM scheduling tools are much more common now, as is project management software and, to a lesser extent, mobile apps. The issue with this, says Humphrey, is that they aren't transformative, they are, "evolving and automating what we already did with paper and Excel spreadsheets and 2D CAD with PDFs."

Once he gets on a roll talking about technology Humphrey is the kind of character who hardly pauses for breath, such is his enthusiasm and knowledge. He believes that what will be transformative for construction is a true model that updates in real time and can be broken down into different components: in other words, a digital twin.

Talking about such models, he says, "the adoption is still low, but it's the way that we're going to create a true construction model. That's what we're trying to advance." He adds that, "They start to change the way you work. When I say transformative, I think about 4D scheduling, when you add time to the model, and then you can add things that aren't designed like staging and sequencing.

"Then you can pull in reality models on top of that and run a simulation of how you're

going to build a project. You find all sorts of issues and mistakes and ways to optimise your resources. You'll never go back to doing planning the way you did before."

Having the opportunity to run a simulation model before construction takes place, allowing the contractor to find mistakes before they do them in the field, could play a key role in boosting the industry's productivity.

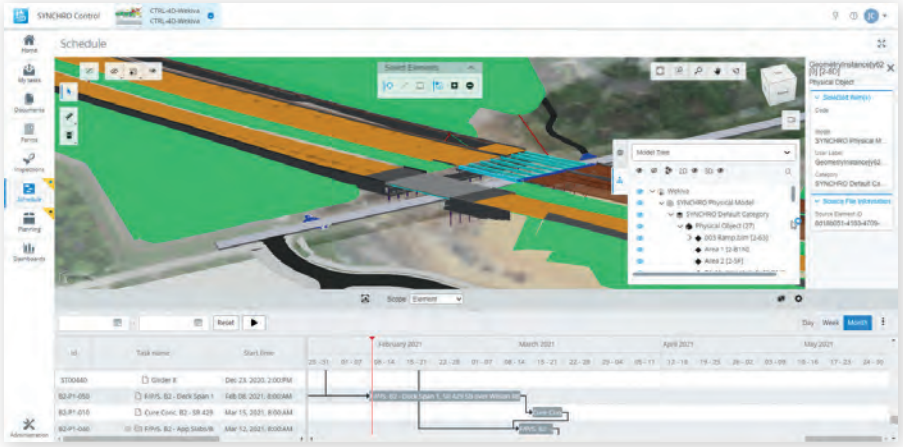
TURNING POINT FOR CONTRACTORS

Few in the industry would argue that construction is in need of a transformative process – almost all large projects come in over budget and late. Humphrey believes that we are at a turning point where public agencies, such as Department of Transports (DOTs) are starting to demand more transparent processes from the contractors that they award projects to.

"We need to transform our workflows so that we have more predictable project outcomes," he says. "This will also help on the funding side, because I don't think public agencies are going be able to fund and close the supply and demand gap that we have. We have to make infrastructure more investible to help close that gap and not just rely on public funds.

"I think we're at the critical two years with the US DOTs [Departments of Transport] in terms of them seriously figuring out how to change how they've been working and what their expectations are with contractors."

Bentley's key weapon in the battle to transform construction's digital journey is Synchro. There's a few ways to describe Synchro, depending on just how technical you want to get, but the top-line version is that it is the company's construction management platform for the full life cycle of a programme; from planning all the way through to execution and handover. It is part of Bentley's larger idea of an infrastructure cloud that manages data through the life cycle of a project.



BENTLEY SAYS THAT SYNCHRO ALLOWS THOSE IN CONSTRUCTION TO ACCESS, MANAGE, COLLABORATE, AND ANALYSE PROJECT DATA ALL IN ONE PLACE

Humphrey says what's key about Synchro is that it meets customers where they want to be. It can do relatively straightforward tasks like use AI to capture and index pictures, manage PDFs, do form-based workflows, document controls and project management or allow them to create a digital twin.

"We're meeting customers where they are today but enabling them to evolve at their own pace and go full-blown digital twin if they want to. They like it because it's future proofed," he says. "When they get contracts that require that, they don't have to change systems. That's been our approach to helping the industry evolve."

COLLABORATION

One of the ways that Bentley is working with the industry is through a 'collaboration initiative' with engineering firm WSB to encourage civil infrastructure owners and contractors to adopt and use infrastructure digital twins.

WSB has launched a new digital construction management solution and advisory service, based on Synchro, to help the civil infrastructure market overcome the challenges of adopting model-based digital workflows and leveraging the power of digital twins. The company is the first to join the Bentley Digital Integrator Program for construction.

Construction work is often based on 2D drawings, spreadsheets, and document-based workflows that can result in errors, waste and rework that cause most projects to be over budget and schedule. The collaboration between Bentley and WSB aims to change this and help firms adopt technology and digital delivery.

"WSB are involved with a lot of contractors doing complex design-build projects. They've decided to start a new business to help drive the adoption of model-based workflows, leveraging Synchro. They're providing a whole new service to the industry," explains Humphrey.

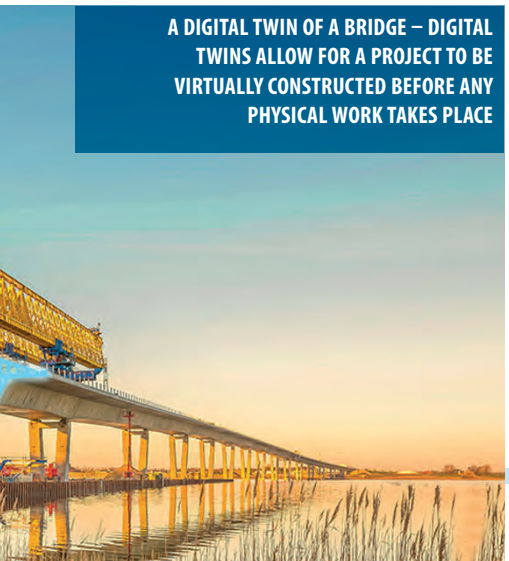
"That model of us partnering with an engineering firm to help owners and contractors cross the chasm in terms of digital delivery is another important step to help the industry move forward."

All connected with the growing sector of construction technology want to see it develop and for adoption to increase.

Humphrey says that, in a few years' time, he hopes that project management tools and basic field capture is common, that everyone has reached that stage of the evolution and are now thinking about how to get into a position where they are able to progress to digital twins.

"The digital twin is the hub for how you access, manage and pull all different technologies together," he says. "It's not just about construction execution. It's about how we deliver for owners and the public who rely on infrastructure. How do we connect the entire lifecycle better than in the silos like we see today?"

Getting to that point will no doubt be more challenging and complex than automating some processes and having basic field capture as standard, but the opportunities that it will bring are also much bigger – perhaps even transformational. **CT**



A DIGITAL TWIN OF A BRIDGE – DIGITAL TWINS ALLOW FOR A PROJECT TO BE VIRTUALLY CONSTRUCTED BEFORE ANY PHYSICAL WORK TAKES PLACE

3D printing has been around for a while but, as of yet, has not become commonplace in construction. However, as NEIL GERRARD **discovers, this could be about to change**

WHAT DOES THE FUTURE LOOK LIKE FOR 3D CONSTRUCTION PRINTING?

Few recent projects have illustrated the potential of 3D printing in construction as effectively as the reconstruction of the walls of 370m² school in Lviv, Ukraine. The high-profile scheme saw Danish 3DCP Group use Cobod's BOD2 printer for the one-storey building, using locally sourced concrete.

The four-day build involving just a handful of people showed off some of 3D printing's chief advantages: speed and a lack of reliance on skilled labourers, perhaps even more scarce in war-torn Ukraine than in many other parts of the world. Then there's the potential for more economical use of concrete, lower wastage and, consequently, lower embodied carbon.

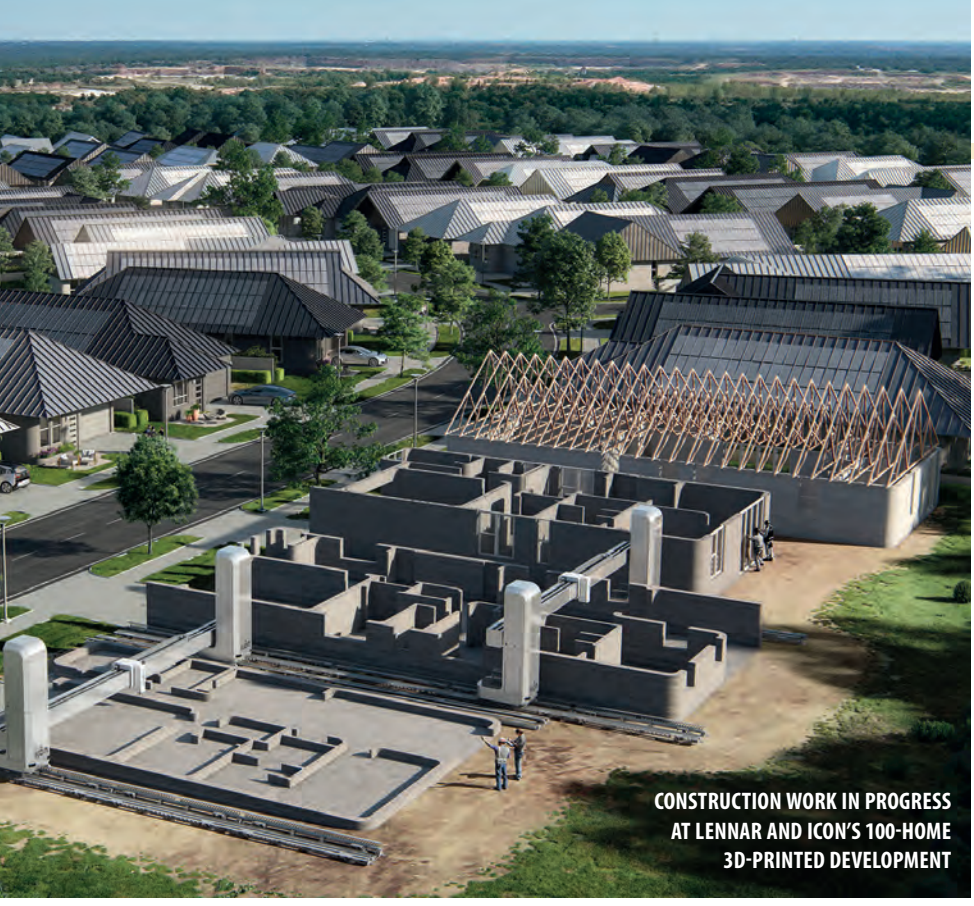
However, even after several years of development, 3D printing in construction is not widespread. So, where does it go from here in terms of its wider adoption? And what new advancements in technology could help spur that adoption?

REAL-WORLD 3D PRINTING

Luca Stabile, a director of Arup Italy, led a project to build Europe's first 3D-printed house as a demonstrator for Design Week in Milan in 2018. The 100m², one-storey house, called 3D Housing 05, was built in concrete using a robot from Dutch 3D printing specialist CyBe.

IMAGE: WEBER SAINT GOBAIN

UK CONTRACTOR BAM NUTTALL INSTALLED THE UK'S FIRST 3D-PRINTED STAIRCASE TO A BRIDGE ACROSS THE M8 IN GLASGOW IN 2022, USING ELEMENTS PRINTED BY WEBER SAINT GOBAIN



CONSTRUCTION WORK IN PROGRESS AT LENNAR AND ICON'S 100-HOME 3D-PRINTED DEVELOPMENT

IMAGE: ICON

As with any new technology, there was an initial flurry of interest before it died down. But now Stavile says that he sees 3D printing entering a new phase where it starts to have practical, real-world applications.

"We are convinced that we can go beyond the pavilions and the demonstrators and there is the potential for many more real applications than in the past," he says.

His colleague, Amsterdam-based Mathew Vola agrees. Arup was lead structural engineer on a project to build the world's first 3D-printed steel bridge in collaboration with Dutch technology company MX3D.

"3D printing is going to grow exponentially," Vola says. "As skilled labour reduces, we are going to become more dependent on these types of technologies. In the Netherlands, we can't find any more bricklayers. Robots are getting better and better at printing and they don't need much skilled labour compared to more traditional methods of construction, even in a factory."

Henrik Lund-Nielsen, whose Denmark-based company Cobod supplies gantry-based 3D printers to construction companies around the world, also sees the potential for major growth.

"Our company started in 2018 and we had eight people. We have more than 100 now and sales are around €20 million. So it has gone very fast," he says. "You have small, entrepreneurial organisations adopting 3D printing to disrupt the construction sector and then we also have much larger customers who clearly see it as part of the future and understand that we are just scratching the surface here."

3D PRINTING'S USE CASE IS EVOLVING

Up until now, 3D printing in construction is probably most closely associated with housing. One of the world's first projects involved China-based engineering company WinSun building a 3D-printed villa and flats in 2015. More recently, US 3D printing company Icon announced late last year that it would 3D print 100 houses at Wolf Ranch in Georgetown, Texas, in partnership with US housebuilder Lennar.

But that is starting to change as the technology evolves, Lund-Nielsen explains. "When you have a relatively small printer that can extrude a concrete-like material, you think about making a little house, right?" he says.

"That's how it started and spurred the first interest from people. But it's not, in my opinion, the most interesting application – there are others."

He points out that while 3D concrete printing can handle walls and foundations and potentially also the roof, this represents only 25%-40% of the structure of a house. Where 3D printing can't help currently is with plumbing, electricity, wooden floors, or marble bathroom fittings, for example.

"But there's lots of other applications where, basically, it is only reinforced concrete," he says. "You can think about bridges, tunnels, wind turbine bases, tanks, silos and industrial warehouses. These are more raw structures and we are trying to convince our customers to look in that direction because it can have a much bigger impact."

It's a similar line of thinking to the one that Stabile has adopted in the wake of the deadly floods to have swept his home country of Italy this year.

"One of the main issues we have now is that we have to rebuild the infrastructure and make cities more resilient. 3D printing can be used to create tanks and bespoke stormwater collection," he suggests. "It's not fancy, but it's useful."

IMAGE: ICON

THE POTENTIAL OF 3D PRINTING IS HUGE, ESPECIALLY WITH THE LABOUR SHORTAGE

It will also play an important role in disaster-struck areas – the school in Ukraine serving as just one example – as well as for facilities like military barracks that could require rapid construction.

Meanwhile, 3D printing specialist Weber, part of construction products giant Saint Gobain, has decided to focus on 3D printing concrete in factory conditions to make slope stairs, and other load-bearing structures like bridges. Business unit manager Peter Paul Cornelissen is "100% confident" that 3D printing will grow and says the ultimate goal is that it is considered as a means of production alongside casting and moulding concrete.

LIMITATIONS AND OBSTACLES

There's no doubt though that there are headwinds when it comes to the wider adoption of what is still a nascent technology. Some of those are technological – gantry printers are currently limited by how high they can build. In the case of Cobod, this is around the 9m mark at the moment. However, Lund-Nielsen is confident that this will change and that the technology exists to allow its printers to go as high as seven storeys.

Certification, regulatory environments, and a traditional mindset among some people within the construction industry could prove tricker to solve.

Vola sees certification as an issue but adds, "People are interested in getting involved in 3D printing and that's something that can be overcome."

Regulation is more difficult though. "We experienced that on our 3D printed bridge. To get someone to approve it on the government side was a bigger challenge than designing it and maybe even constructing it, although that wasn't easy either," Vola says.

Regulation also varies by country. The regulatory regime in the Netherlands is actually more flexible than some, Vola says. "If you test something rigorously, you can say: 'Well, we tested it rigorously so it will likely work.' And that was our way around it. There area many countries where regulation is very top-down and there's no engineering judgement allowed."

In those countries, a more piecemeal, hybrid approach may be required, where 3D-printed components are mixed with more traditional building methods. "There are no codes for 3D printing at the moment, so to continue with it you need to test and prove the technology. A hybrid model could be the best way to progress," Stabile says.

Cornelissen agrees that certification and building codes will take a long time to catch up. In the meantime, Weber has developed a strong relationship with the Eindhoven University of Technology in order to test and validate the technology in a bid to increase confidence and drive adoption.

He also highlights Weber's rigorous quality control programme, producing 3D-printed elements in factory conditions.

"The dry mortar we get from Weber is certified and when you add the water we have parameters to control the viscosity and the temperature – and all of this is included in the quality reports for the printed parts," Cornelissen says. "And I think that is key to persuade the market and the organisations that permit and sign off on these objects."

IMAGE: COBOD

A COBOD 3D PRINTER PRINTS THE WALLS OF THE SINGLE-STOREY SCHOOL IN UKRAINE

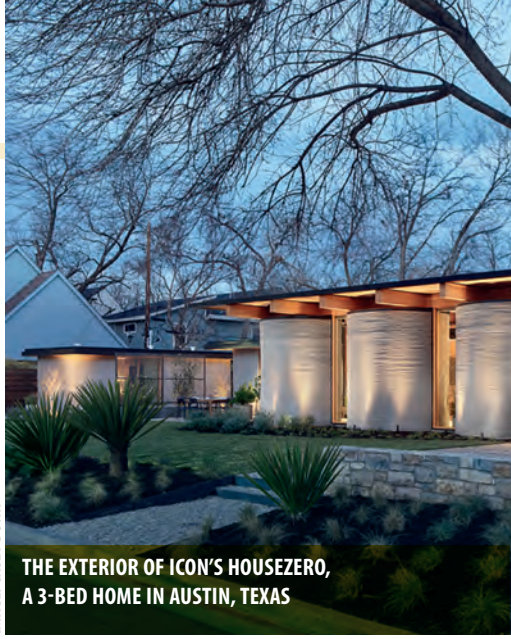


IMAGE: CASEY DUNN

THE EXTERIOR OF ICON'S HOUSEZERO, A 3-BED HOME IN AUSTIN, TEXAS

Meanwhile, US builder Icon recommends maintaining a close working relationship with regulators. "Consumers are excited about this new technology for sure, but construction is the largest industry on earth and it takes a lot of time to steer a ship that big," says Michael Harper, Icon's director of business development.

"For example, building departments and regulatory bodies are intentionally risk averse, and for a lot of good reasons. We work very closely with authorities of jurisdictions and regulatory organisations to ensure that we're meeting or exceeding existing building guidelines and acceptance criteria," he adds.

TECHNOLOGICAL ADVANCEMENTS

While still a relatively new technology, 3D printing is advancing rapidly. "If you look at MX3D and the quality of the 3D printed bridge and the speed it was printed at compared to what they do now, it's a different ballgame," Vola says. "All these companies are getting better and better at it."

He explains that 3D printers, regardless of the material they are working with are getting bigger, and therefore able to print larger volumes, as well as faster.

Meanwhile, there's the potential for what was a mono-material process to start involving multiple materials to allow for more complex structures.

He points to tests that have been done with timber pulp, which would allow printing with waste timber materials. Highlighting the possible advantages 3D printing can bring when it comes to circularity, he says, "If you imagine how much waste timber there is in the world then it becomes very interesting.

"If we could upgrade waste material, turn it into pulp, and build our buildings with

MX3D'S 3D PRINTED BRIDGE AT DUTCH DESIGN WEEK IN EINDHOVEN

IMAGE: IIVQ/TIJMEN STAM, CC BY-SA 4.0 VIA WIKIMEDIA COMMONS

it then imagine what that could do for your carbon footprint."

Then there is the continuous improvement of the steering mechanism of the printer itself, allowing them to become more precise and producing a product that is cheaper as well as better.

For Cornelissen, it's less about making more technological advancements and more about convincing the market to adopt the technology.

"We need to show to the market what is possible so that the market can come to us and say, 'Guys, if this is possible, it would be great if you could help us with this'," he says.

Meanwhile, Lund-Nielsen says Cobod is devoting a considerable amount of its time and effort towards research and development.

He considers how the company's gantry system, which currently carries a print head through three dimensions with millimetre precision could be used for other types of tools.

"We have the capability to place a tool and the ability to give it materials. Why couldn't it also do insulation or painting, for example?" he asks.

"We are going from being a manufacturer of 3D construction printers to making multifunctional construction robots based on 3D printing technologies."

He very neatly sums up the exciting future for 3D printing in the construction industry in just four words: "Faster, taller, more automation." CT

THE RISE OF CONSTRUCTION ROBOTICS

BUILT ROBOTICS' EXOSYSTEM AT WORK

PHOTOS: BUILT ROBOTICS

ROBOTIC EXOSYSTEM ON THE BACK OF A KOMATSU MACHINE

The construction industry is facing numerous challenges and more companies are looking to automate tasks to relieve some of the pressure. CATRIN JONES **examines how robotics has the potential to help the industry through tough times**

When we think of the term robot, we often refer to the humanoid depictions in TV programmes and films, but the definition of robots on a construction site is not so clear cut.

Over the past decade, the robotics industry has been developing numerous robotic solutions to automate processes and streamline projects.

For example, US-based Canvas has developed a drywall finishing robot while Okibo's robot provides painting and coating applications. Boston Dynamics has led the way with more mobile robotics solutions – such as 'Spot the Dog' and their research-based humanoid robot 'Atlas'.

WHAT IS A ROBOT?

In construction terms, a robot is generally understood as a machine that operates autonomously, doing one specific (and usually repetitive) job.

Robots in construction have vast and varied roles with solutions that target pre-construction right through to adding the finishing touches to a project. Despite the possibilities robotics has, Erol Ahmed, director of communications at Built Robotics, believes that the definition of robots is often misconstrued when it comes to construction.

"When we imagine robots, we think of human-like machines with the full set of capabilities of a person," he says. "When it comes to construction, robots really mean autonomy and assistive technologies that help skilled workers perform work safer, more productively, and more accurately.

"These can be small devices, custom-built machines, or aftermarket upgrades for existing equipment. Robots take all shapes and forms."

For David Burczyk, construction robotics lead at Trimble, a robot holds a somewhat similar meaning. Upon being asked the question, 'how do you define what a robot is?', Burczyk has to pause for a moment, despite the fact that he has been working in the industry for over ten years. This would seem to demonstrate that robotics has come a long way in the past few years, and that development shows no signs of slowing down.

"It's interesting because we have our total stations and we refer to those as robotic total stations," says Burczyk. "We took an approach where a traditional mechanical total station had two people operating it – so we had one person at the instrument and one with the layout stick – and those two were communicating back and forth to take their survey measurements. For us, that became a robot.

"We took a two-man job and turned it into one operator. It is not necessarily moving around with legs or wheels or anything of that nature, but it is acting in a robotic fashion where it becomes a co-worker on the job site."

Both Ahmed and Burczyk agree that a 'one size fits all' approach to the definition of robotics in construction does not capture the magnitude of possibilities of the technology.

AUTOMATING CONSTRUCTION

Robotics can play a role in a variety of tasks on site but automation is what sets it apart from other technologies. Automating construction processes is something that is becoming more common – especially in larger urban projects where time and money are obstacles.

Automation has the potential to carry out injury-plaguing and dangerous tasks that construction workers sometimes have to face, thereby reducing worker fatalities.

Matthew Johnson-Roberson, director of the Robotics Institute at Carnegie Mellon University, US, sees the continued trend of automation for the future of robotics. He sees the technology developing for subtasks and more scalability in terms of reliability while decreasing costs.

Trimble's Burczyk has been speaking with those on the ground and discovered that it's about investing money into a product that can ›

PHOTO: TRIMBLE

> "IT IS ACTING IN A ROBOTIC FASHION WHERE IT BECOMES A CO-WORKER ON THE JOB SITE"
>
> **DAVID BURCZYK, CONSTRUCTION ROBOTICS LEAD AT TRIMBLE**

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BOSTON DYNAMICS' SPOT ROBOT WITH TRIMBLE X7 3D SCANNING SYSTEM

PHOTOS: TRIMBLE/BOSTON DYNAMICS

be used again and again that really adds value to a project.

"What we're hearing when talking to our customer base is that they really want to automate the processes. The general contractors that are using the laser scanners, they're taking budgets that they already have, to document the construction with laser scanners," he says.

"Typically, in those applications today it gives them one opportunity to come to the job site, capture a scan and that's it. By taking that same budget and investing it into robotics, they now have the ability to take the data from the very beginning of the project all the way through to the end of the project – captured as many times as they want. This is opening a whole new frontier for them to get some data analysis and have new insights into the project that they just didn't have before."

Market research company IDTechEx says that autonomous mobility is one of the most important parts of robot autonomy. With the increasing demand for autonomous solutions across a number of industries, including construction, autonomous mobility could see unprecedented growth.

CO-DEVELOPING SOLUTIONS

Back in October 2020, Trimble announced a strategic alliance with Boston Dynamics to co-develop a solution to bring robotics into the building and civil construction industry.

For collecting construction data on the job site, Trimble has three different payloads that they're planning to focus on. The first one the US-based company has come out to market with is reality capture: the Trimble X7 scanner. This is currently being used with Boston Dynamics 'Spot the dog' – with further plans for robotic total stations in the future.

Trimble's X7 Scanner is a terrestrial laser scanner, which goes from different positions or waypoints and captures AA360 laser scans from each of those waypoints.

Burczyk is one of the minds behind Trimble's scanner collaboration with Spot. "With Spot you teach it a path or a mission that you want it to walk, and it can then run that mission autonomously, as many times as you want.

"Once you train it where to go, you're telling it where it's safe for it to operate and where the areas are that you want to collect. It is along that path that you define those waypoints and at each waypoint that's where the laser scanner works."

The laser scanner performs the same task over and over again while maintaining a consistent level of data collection – a role that is both repetitive and menial for skilled workers.

As robotics has made its way into the construction industry, there has been debate about whether this supports the skills shortage or encourages job losses.

Burczyk believes that it is a matter of collaboration. "When I first came on board, around ten years ago, we introduced the robotic total stations on the job site. That was the first introduction ›

NEMETSCHEK GROUP INVESTS IN ROBOTIC START-UP

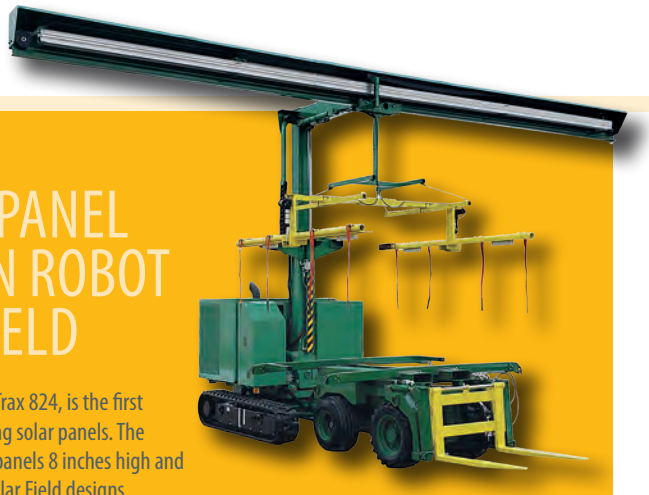
The Nemetschek Group, software providers for the construction and media industries, recently announced that they participated in a financing round for the robotics startup Kewazo.

The company says that Kewazo's robotic products enable the automation and digitalisation of the on-site material flow by combining robotics and data analytics. By being involved in critical on-site activities, the robotic products collect key operational data.

This data is then processed and provided to customers as actionable insights via the data analytics platform, enhancing the transparency of what happens on-site at construction sites and industrial plants.

"The investment by the global player Nemetschek is a big step forward for us. It closes the gap between onsite hardware and software, which is often only used in offices. It allows us to make the construction site more digital, smarter, and safer for everyone," comments Artem Kuchukov, CEO and Co-Founder of Kewazo.

PHOTO: KEWAZO



FIRST SOLAR PANEL INSTALLATION ROBOT OUT IN THE FIELD

Solar panel installation robot, Solar Trax 824, is the first production robot in the field installing solar panels. The machine from Bailey Cranes can lift panels 8 inches high and traverse 24 inches to handle most Solar Field designs.

The company behind the robot says that the base machine is track driven, providing a high degree of traction and terrainability. Designed for rough terrains and increased slopes, the upper assembly is said to automatically level itself for increased stability and ease of panel placement.

The robot works via hydraulic functions that include Programmed Motion which combines multiple steps, such as 'Raise-Left,' which raises the panels from the centre position, trolleys sideways to the support frame and lowers it in place.

Other functions include 'Home,' which returns the tray to the centre position for reload and 'Drive-Increment,' which drives the machine forward the exact distance for installation of the next four panels.

Bailey Cranes says that incorporating vision systems from the autonomous vehicle industry allows the robot to precisely locate the solar panels onto the mounting structure.

of a robot into construction. There was a lot of fear at that time that you were taking away jobs; then, as it got implemented into more workflows, people saw it as a collaborative piece and it wasn't something that was replacing them."

Johnson-Roberson of Carnegie Mellon University agrees with Burczyk, saying the introduction of robots onto the construction site will require teamwork. "I do think collaboration is critical. There isn't any full system anywhere near ready to take over all construction elements.

"I tell workers to think about doing excavation without a backhoe [loader] or building tall buildings without cranes. It is unthinkable. I think the next generation of all those kinds of tools will be smarter and safer, in addition to reducing injury and improving efficiency, which will be positive for workers and developers."

IDENTIFYING BOTTLENECKS

Alongside the apprehension surrounding jobs, many are concerned that this could be the start of robots taking over entire projects. Built Robotics' Ahmed is quick to debunk this myth.

"Instead of asking if robots would ever completely take over, we should instead ask, do we need them to take over? The short answer is no," he says.

"We should create robots thoughtfully and in original ways, which is the approach the construction, mining, and agriculture industries have been taking. Instead of trying to recreate human behaviour, these industries have identified their biggest bottlenecks in terms of workforce, productivity, and hazards, and work from problem to solution. This way, we create robots that make sense and have immediate economic value while creating safer and more efficient jobsites.

"At the end of the day," says Ahmed, "robots are tools in the hands of skilled workers, who ultimately decide how and when a robot makes sense."

Robots in construction are proving to be effective tools that are being welcomed by workers and contractors. Built Robotics says they have trained skilled workers to become 'Robotic Equipment Operators' (REOs). Ahmed adds that this keeps workers involved with the latest advancements in autonomy and allows them to manage Built Robotics' robots on jobsites.

By training and involving everyone in how robots are built and deployed, construction can ensure people and machines work together in ways that grow the industry, which benefits everyone at all levels.

"This approach allows us to overcome the common misconceptions about robotics and keeps us focused on practical, common-sense applications of advanced technologies – something that has and will continue to grow the construction sector," says Ahmed.

Overcoming the misconceptions surrounding robotics in construction is a key starting point if the industry is to see adoption grow rapidly in the future.

Whilst some are apprehensive as to whether robotics is the way forward, there are other companies in the industry that are making great strides in ensuring that they are a part of the future.

CANVAS' DRY WALL FINISHING ROBOT

PHOTO: CANVAS

US-based manufacturer of lifting and material-handling Terex has recently bought into robotics company Apptronik with plans to co-create potential robotic applications for Terex products. The technology company specialises in the development of versatile, mobile robotic solutions.

Apptronik's co-founders have worked on advanced human-centred systems including the NASA Valkyrie Robot for the DARPA Robotics Challenge.

Other Apptronik projects include Astra, an upper-body humanoid robot packed into a small form, enabling it to be placed on any mobility platform and most recently, Apollo, a NASA-backed versatile humanoid designed to scale and apply to numerous applications.

As more robotic solutions come to market there is hope that these could begin to solve some of the challenges that the construction industry face – be it the skills shortage or enhancing health and safety measures.

Perhaps there will come a time, in the near future, where robotic solutions are just as common and accepted in construction projects around the world as other pieces of more traditional equipment. CT

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