THE ROBOTREPORT

EXPLORING THE BUSINESS AND APPLICATIONS OF ROBOTICS

A Supplement to Design World - April 2022
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2022 ROBOTICS BUSINESS REVIEW

RBR 50 INNOVATION AWARDS

Welcome to the 2022 RBR50 Robotics Innovation Awards

What do a universal operating system, mobile robot interoperability standard, sorting robot, and robotaxi have in common? Well, if you are reading this paragraph, you can probably guess "robotics," and you would not be wrong.

But the similarities do not end there, and they are more pointed and correlated. All the examples are representative of winners of the 2022 *RBR50 Robotics Innovation Awards* (RBR50).

For more than a decade, *Robotics Business Review* has produced the RBR50, which recognizes and celebrates forward thinking companies from across the globe and the original, impactful solutions they have created. Widely recognized throughout the world as a leading indicator of robotics innovation leadership, the *RBR50 Robotics Innovation Awards* are also a critical indicator of robotics sector growth.

For the robotics sector, the role, importance, and impact of innovation has never been greater. Moreover, it is the confluence of multiple, diverse innovation determinants - technological, business, and market – that act to accelerate robotics sector growth overall.

The 2022 *RBR50 Robotics Innovation Awards* reflect that diversity of innovation, and celebrates robotics innovation in all its forms including:

• **Business and Management Innovation -** Business and management initiatives or practices that enhance a company's commercial standing, fosters robotics sector growth or improves society.

• **Technology, Products and Services Innovation –** New commercial solutions that have the potential to positvely impact markets or the whole robotics sector.

• **Application and Market Innovation –** Industry specific, newly developed applications that deliver value, provide entry to new markets, or improve performance over existing approaches (i.e. improve productivity, increase quality, reduce cost, etc.).

The editors in WTWH Media's Robotics Group enjoyed the challenge of evaluating and selecting the 2022 RBR50 awards winners, and learned much during the process. We hope you share that enthusiasm, and the 2022 *RBR50 Robotics Innovation Awards* also acts to increase your understanding of the global robotics sector. In that small way, the *RBR50* will have done its part to drive the robotics sector forward. RR

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Inside the RBR50

A closer look at notable innovators and where this year's winners are from.

Steve Crowe
Editorial Director
The Robot Report

Thanks to self-charging capabilities and upgraded hardware and software to its Spot quadruped, Boston Dynamics made the RBR50 list for the third consecutive year. | *Credit: Boston Dynamics*

Each year, the RBR50 receives more nominations than can fit in the annual list. This year, the final selection reflects more rigorous judging criteria, current technological and business trends in robotics, and the world.

Since companies of different sizes build robots for widely differing applications, it is difficult to compare them directly. Add to that regional clusters, universities and research institutions, and new business models, and it becomes clear the best way to analyze robotics leadership is to see what categories and industries they fit into.

Notable Winners

An emphasis on innovation led to 36 RBR50 winners being recognized for their introduction of new products, services and technologies. This included both hardware and software for autonomous systems. Eleven companies were honored for application and market innovations, while three were honored for their business and management prowess.

Notable market innovators include Cruise, the autonomous driving subsidiary of General Motors. Cruise opened its Level 4 robotaxi service to a limited portion of the public in San Francisco on Feb. 1 2022. There are no human safety drivers inside these robotaxis. This is the first driverless robotaxi service to launch in a major US city. Over time, the service should expand its geofence and running time to gather important crucial operational data to continue to improve its already exceptional performance.

The Dronut X1 from Cleo Robotics is the first professional-grade, bi-rotor ducted-fan drone – a drone without exposed rotor blades. | *Credit: Cleo Robotics*

MassRobotics, the non-profit organization serving as the innovation hub for robotics, won for the development and release of the MassRobotics Interoperability Standard. The primary goal of the standard is to enable autonomous mobile robots (AMRs) from different vendors to integrate and work together seamlessly to support safe and efficient operations in factories, warehouses, distribution, and fulfillment centers. Interoperability of AMRs has been an important topic the last few years, and MassRobotics has been at the forefront of recent efforts.

Louisville, Ky.-based CRG Automation built a robotic system to help decommission a stockpile of 70,000 M55 chemical missiles at the Blue Grass Army Depot in Kentucky. The M55 missiles are filled with VX and sarin nerve agents. The system combines traditional industrial robotic arms, autonomous mobile robots, and custom pick-and-place robots to make the work safer and more efficient, processing more than 25 missiles per hour. The system is on track to complete the project by a Department of Defense (DOD) deadline of 2023.

Similar to the 2020 and 2021 lists, only one company was recognized for social good. The ARM (Advanced Robotics for Manufacturing) Institute's RoboticsCareer.org initiative is a collaboration between the industry, government and academia. It brings together resources from competing companies to make them more accessible, and highlights programs that address diversity, equity and inclusion in robotics.

By innovation class:	
11	Application & Markets
3	Business & Management
36	Technology, Services & Research

Last year's most innovative winner, NASA JPL, returns to the 2022 list with a continuation of its historic Mars 2020 Mission. The Perseverance Rover put its sampling and caching system to work on September 1, 2021, eight months into its exploration of Mars. It successfully cored its first rocks thanks to improved manipulation skills. But, perhaps more importantly, it brings NASA a step closer to their long-term goal of bringing those rock samples back to Earth for further study.

Within the US, organizations from 15 states were included on this year's list, with 14 winners coming from California. Massachusetts had the second-most winners on the 2022 RBR50 list.

A startup from California to keep an eye on is Pharm Robotics, which is developing the Sureshot robotic cow inoculator. When cows exit the milking barn, they are scanned by an RFID and camera ID reader that determines if the cows need immunizations. If a cow does, it will be held in place with a two-part bumper restraint, and scanned by another RFID that determines what inoculation the cow needs, and a robotic arm injects the cow. After the injection, the bumper restraints release the cow. Not only is Sureshot a unique solution, it automates the entire inoculation process and enables farmers to focus on other tasks while ensuring the health of the herd.

By the numbers:	
9	Repeat honorees from 2021
15	US states represented
37	Organizations from the US
13	Organizations from outside the US
11	Countries of origin

There are 9 repeat winners from the 2021 list, including: Boston Dynamics, GreyOrange, ModalAI, NASA JPL, Ready Robotics, Seoul Robotics, Smith & Nephew, ULC Technologies and Verizon. This is the sixth time in seven years GreyOrange has won an RBR50 Award.

Investment in RBR50 innovators

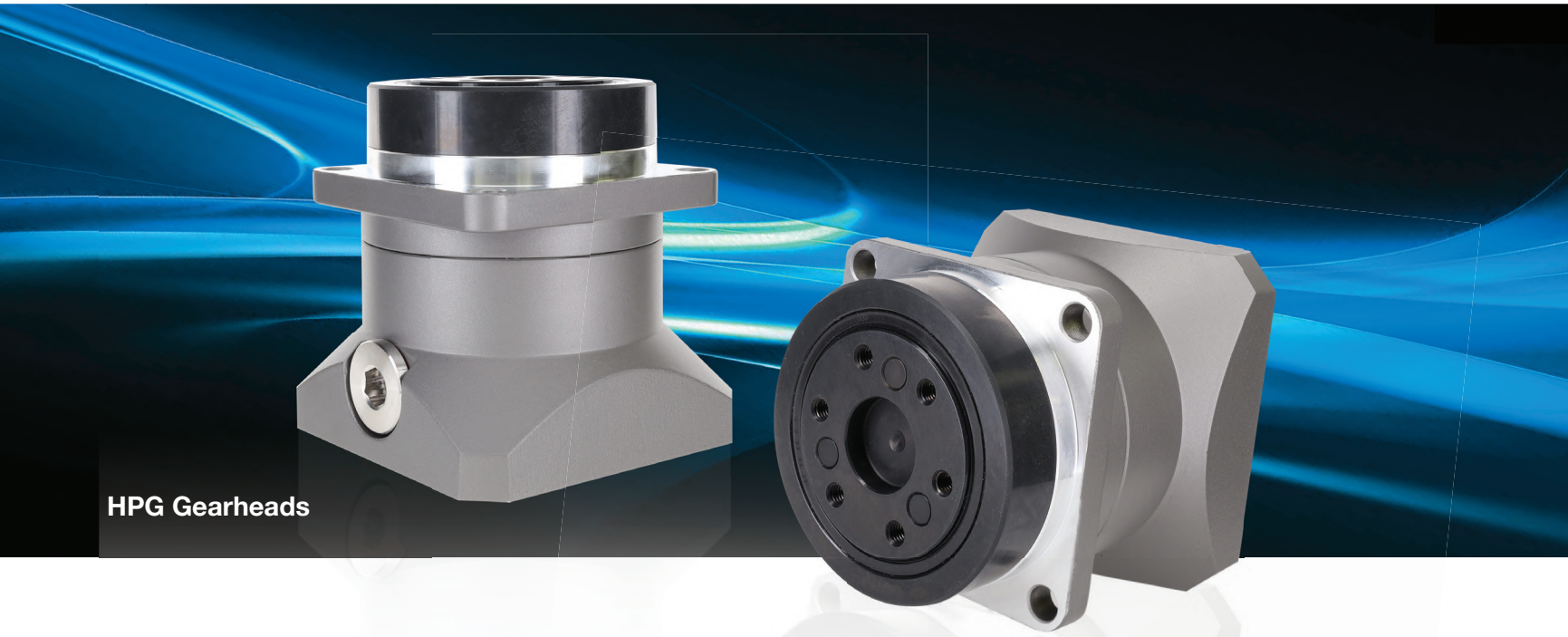
Several RBR50 winners raised funding to continue R&D or to scale commercial products. Similar to 2021, the most interesting financial move came from the Softbank Vision Fund. When Cruise launched its robotaxi service in San Francisco, Softbank was supposed to invest an additional $1.35 billion, on top of the original $900 million it invested in cruise in 2018.

GM stepped in to acquire Softbank's stake in Cruise and committed to investing an extra $1.35 billion to replace the SoftBank funding. It is unclear why Softbank reversed course with Cruise, but there is speculation it was no longer interested in an

Where the Innovators are From

While the majority of RBR50 winners are based in the US (37), 10 other countries were represented, including: China (2), Denmark, France, Germany (2), Israel (2), Korea, Netherlands, Poland, Sweden, Switzerland.

Servo Gearheads for AMR/AGV Propulsion



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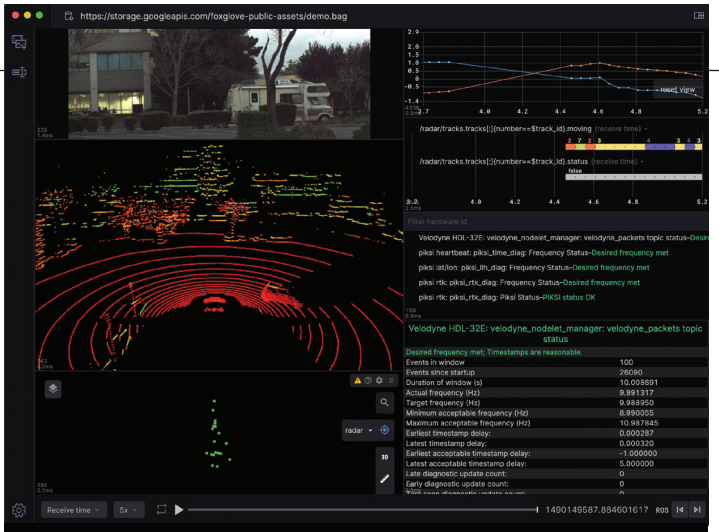
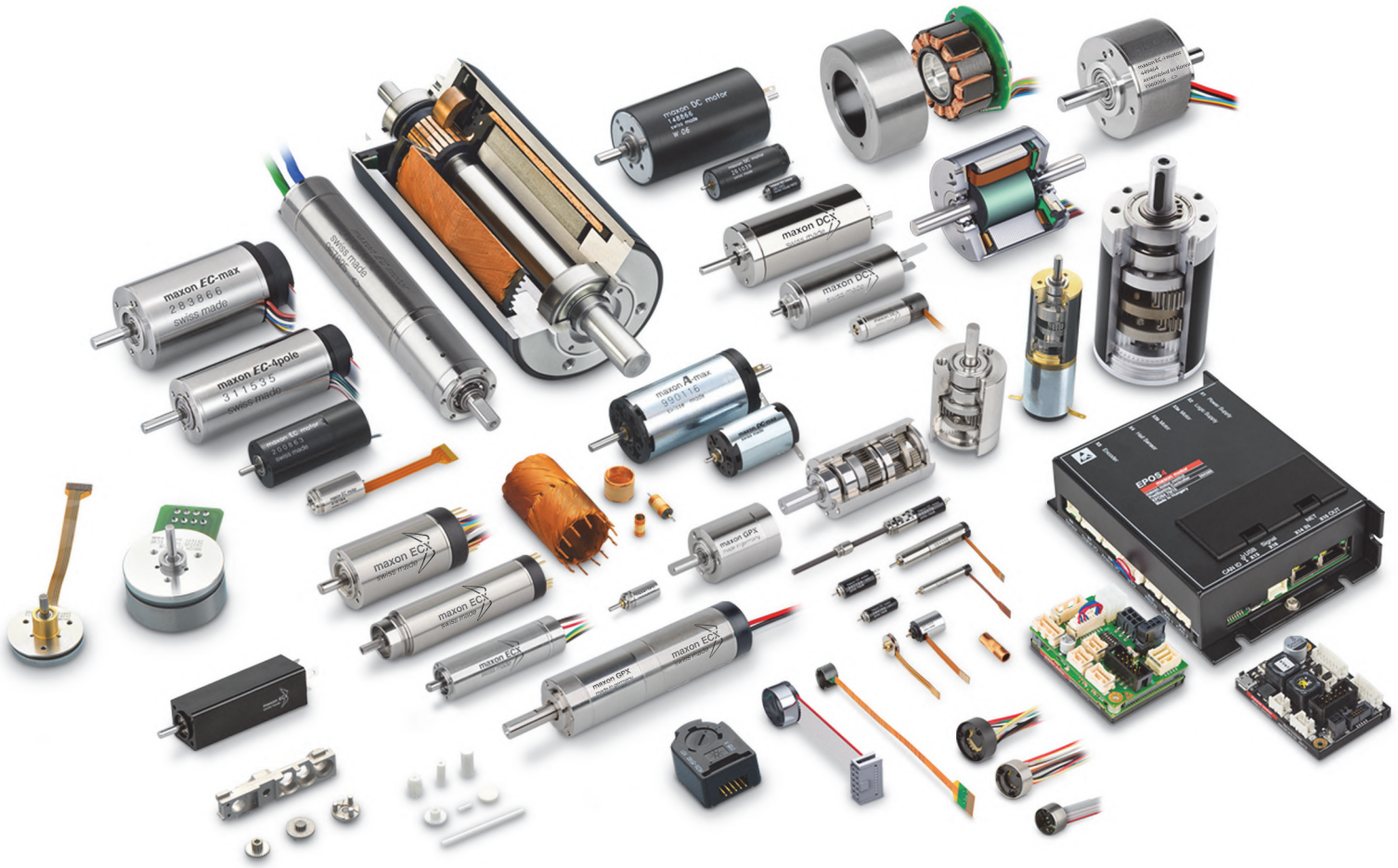
investment that won't yield returns anytime soon; after-all, Softbank has struggled recently with debt and several investments that have soured. There is other speculation that GM acquired the stake as a pre-emptive move to take Cruise public in the near future.

Berkshire Grey also made a major financial move in 2021, going public via a deal with Revolution Acceleration Acquisition Corp, a special purpose acquisition company. Berkshire Grey started trading on the NASDAQ on July 22, 2021. Berkshire Grey, a developer of integrated artificial intelligence and robotic solutions for e-commerce, retail replenishment, was founded in 2013 by CEO Tom Wagner, who is also the former CTO of iRobot. RR



Foxglove Studio provides data visualization and debugging tools to ease robotics development challenges.

| Credit: Foxglove



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Precision Drive Systems

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RBR50 CHART

Company	Innovation	Innovation Type	Innovation Subclass
3M	Finesse-It Robotic Paint Repair System detects and fixes paint defects on automobiles coming off of an assembly line	Technology, Services & Research	Product Introduction
ACEINNA	INS401 sensor provides precise autonomous vehicle positioning at low cost	Technology, Services & Research	Product Introduction
Aeva	Aeries II LiDAR perceives objects at a distance and measures instant velocity, increasing autonomous vehicle safety and performance	Technology, Services & Research	Product Introduction
Apellix	Tethered drone offers faster, safer method to cleaning and maintaining protective coating on elevated water towers	Application & Market	Utilities
ARM Institute	Career website brings together industry, government and academia to improve diversity, equality and inclusion in robotics	Business & Management	Social Good
Avular	Avular Essentials serve as building blocks for engineers to more quickly prototype and build autonomous mobile robots	Technology, Services & Research	Product Introduction
Berkshire Grey	Robotic Shuttle Put Wall handles surging e-commerce demand and mitigates labor shortages without disruption to ongoing operations	Application & Market	Logistics
Boston Dynamics	Spot Enterprise quadruped opened up to more real-world applications via self-charging capabilities, upgraded hardware and more	Technology, Services & Research	Product Introduction
cellumation	cv.DEPAL sorts objects onto three conveyor lines, eliminating need for additional depalletizing lines for many applications	Technology, Services & Research	Product Introduction
Cleo Robotics	Dronut X1 features innovative thrust-vectoring technology, making the drone applicable to new markets and applications	Technology, Services & Research	Product Introduction
Corvus Robotics	Fully autonomous inventory drone doesn't require extra fiducials or barcode label to navigate around a facility	Technology, Services & Research	Product Introduction
CRG Automation	Built a robotic system to decommission 70,000 chemical missiles, making the process safer and more efficient	Application & Market	Defense
Cruise	GM-backed company first to launch a L4 robotaxi service open to public in a major U.S. city	Application & Market	Transportation
Dorabot	Deployed first-ever sorting robot at FedEx's Chinese facilities to process higher volumes of e-commerce shipments	Application & Market	Logistics
FlexQube	FlexQube launches eQart navigator, a non-load carrying autonomous mobile robot that docks with motorized platforms	Technology, Services & Research	Product Introduction
ForwardX Robotics	Deployment of autonomous mobile robots and 5G enables flexibility in environment wrought with Wi-Fi blind spots	Application & Market	Manufacturing
Foxglove	Foxglove Studio provides data visualization and debugging tools to ease robotics development challenges	Technology, Services & Research	Product Introduction
GrayMatter Robotics	Scan&Sand's flexibility and easy implementation make it stand out from typical robotic sanders	Technology, Services & Research	Product Introduction

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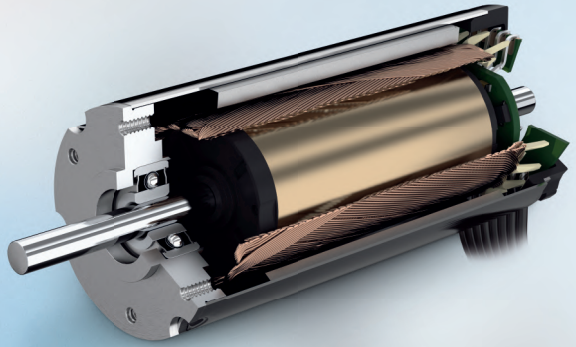

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RBR50 CHART

Company	Innovation	Innovation Type	Innovation Subclass
GreyOrange/Tompkins Robotics	By integrating Tompkins' tSort and GreyOrange's Ranger Goods-to-Person system, a worker can simultaneously fill hundreds of orders from one picking station	Application & Market	Logistics
GUSS Automation	Mini GUSS enables farmers and orchard spraying businesses to lower overhead costs and increase precision, efficiency, and safety	Technology, Services & Research	Product Introduction
Hai Robotics	Autonomous case handling robots offer significant space utilization and high goods handling without major infrastructure changes	Application & Market	Logistics
ifm efector	O3R democratizes robotic perception to increase efficiency of a system, leading to better ROI for companies	Technology, Services & Research	Product Introduction
Indoor Robotics	Tando drone combines advantages of innovative technology and human mobility to provide round-the-clock security	Technology, Services & Research	Product Introduction
Indy Autonomous Challenge	Racing competition pushed forward the boundaries of autonomous vehicle speed and control	Technology, Services & Research	Product Introduction
InsightTRAC	InsightTRAC Rover is a unique solution to help almond growers solve a winter sanitation problem	Application & Market	Agriculture
InvenSense	TDK RoboKit1 offers solid technical basis for prototyping and development that simplifies robotics engineering and reduces time to market	Technology, Services & Research	Product Introduction
John Deere	Ready for large-scale production, the new 8R autonomous tractor raises the bar for agriculture autonomy	Technology, Services & Research	Product Introduction
Labrador Systems	New class of robots - autonomous mobile robots for the home - help those with mobility issues be more independent	Technology, Services & Research	Product Introduction
Libiao Robotics	New 3D t-sort robot can climb racks and triple sortation rate within the same working space	Technology, Services & Research	Product Introduction
MassRobotics	MassRobotics Interoperability Standard enables autonomous mobile robots from multiple vendors to integrate and work together	Business & Management	Market Engagement
ModalAI	VOXL CAM Perception Engine is functionally impressive, offering drone developers options for ongoing innovation	Technology, Services & Research	Product Introduction
NASA JPL	Coring first rocks key part of Perseverance's mission, bringing NASA closer to long-term goal of returning samples to Earth	Application & Market	Aerospace
NVIDIA	Omniverse Replicator addresses machine learning data challenges with a powerful set of simulation technologies	Technology, Services & Research	Product Introduction
OnRobot	WebLytics one of first software tools to provide real-time, application-focused data across major robot brands	Technology, Services & Research	Product Introduction
Outsight	Augmented LiDAR Box simplifies and speeds 3D LiDAR sensing applications	Technology, Services & Research	Product Introduction
Pharm Robotics	Sureshot automates inoculations of cows, allowing farmers to focus on other tasks while keeping the herd healthy	Technology, Services & Research	Product Introduction

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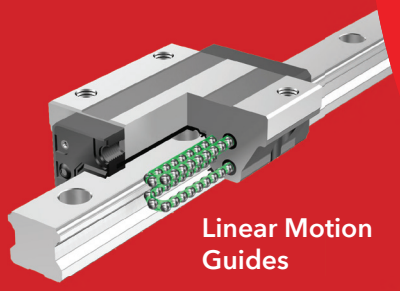
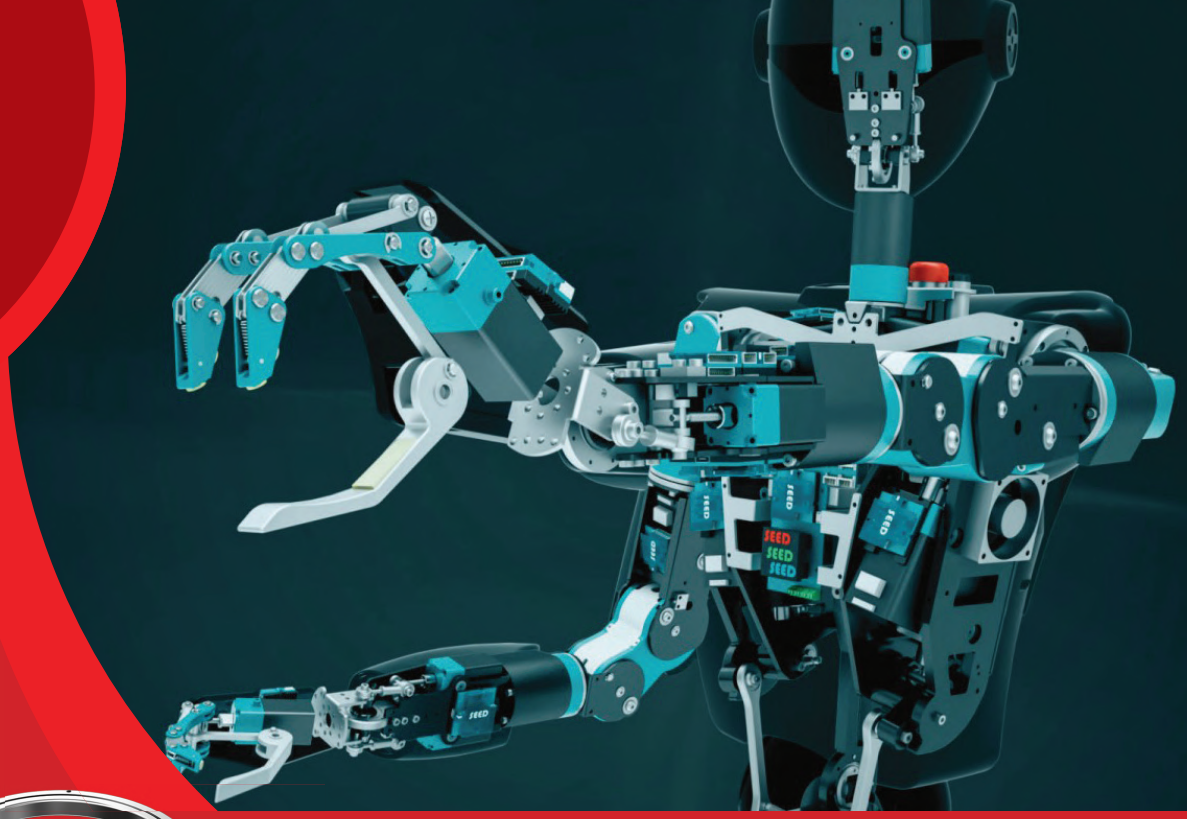


Linear Motion Guides

Cross Roller Rings



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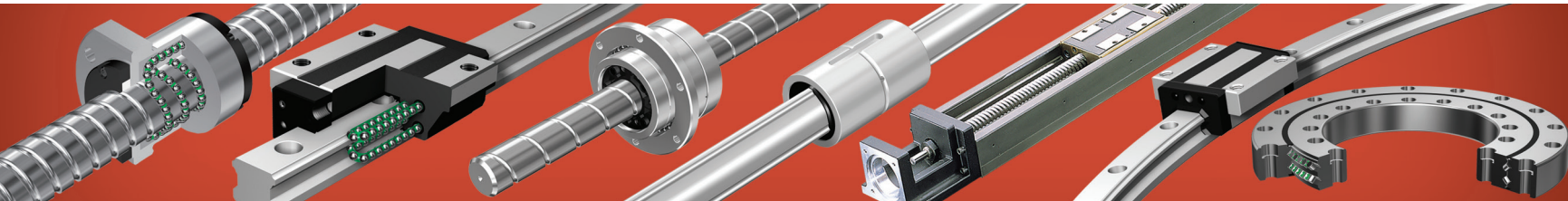

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The Mark of Linear Motion

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RBR50 CHART

Company	Innovation	Innovation Type	Innovation Subclass
Ready Robotics	Forge/OS 5 universal operating system eases programming challenges of major robotics brands	Technology, Services & Research	Product Introduction
R-Go Robotics	Perception Engine runs on low power, low cost compute infrastructure, enabling deployment of consumer-grade mobile robots	Technology, Services & Research	Product Introduction
Savioke	Relay+ delivery robot features new mechanical elevator interface to simplify deployment and increase product acceptance	Technology, Services & Research	Product Introduction
Seoul Robotics	Level 5 Control Tower takes a groundbreaking approach to achieving autonomy through infrastructure	Technology, Services & Research	Product Introduction
Smith+Nephew	Research center strengthens Pittsburgh robotics cluster and bolsters surgical robotics R&D and commercialization efforts	Business & Management	Market Engagement
Swiss-Mile	ETH Zurich spin-off extends capabilities of mobile robots by deploying hybrid system with both legs and wheels	Technology, Services & Research	Applied Research
Tangram Vision	Suite of tools simplifies development of perception-powered robots and enables more reliable real-world operation	Technology, Services & Research	Product Introduction
TerraClear	The 'Roomba of rocks' automates dull, dirty, dangerous task of removing large rocks from arable fields	Technology, Services & Research	Product Introduction
Toposens	Ultrasonic echolocation sensor offers advantages of 1D ultrasonic sensors, but provides greater sensing coverage for 3D perception	Technology, Services & Research	Product Introduction
ULC Technologies	Robotic Underground Survey System autonomously maps underground infrastructure before digging operations start	Application & Market	Utilities
Verizon Robotics Business Technology	Focused on 5G communication and edge computing, Verizon's new business unit will drive the robotics sector forward	Technology, Services & Research	Services Introduction
Virginia Tech	New FAA-approved testing methods open the doors for more companies to get their drones in the sky	Technology, Services & Research	Applied Research
Vissavi.tech	Viveka 3D stereovision solution is a ROS-based, modular, cloud-connected platform for image capture, processing and analysis	Technology, Services & Research	Product Introduction
XACT Robotics	ACE Xtend protects surgeons from harmful exposure to radiation and pathogens during procedures	Technology, Services & Research	Product Introduction

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3M Finesse-It Robotic Paint Repair System Fixes Paint Defects on Assembly Line

Organization Name:	3M
Country:	USA
Website:	https://www.3m.com/
Year Founded:	1902
Number of Employees:	10,000+
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

3M's Finesse-It Robotic Paint Repair System is able to identify defects using its advanced vision system and repair them accurately. The robotics system uses 3M's abrasive products to sand and polish vehicle's imperfections on the automotive assembly line.

The robotic system was made jointly with Ford Motor Co. It eliminates the need to have a person manually search for and repair imperfections on a vehicle.

Analysis:

The Finesse-It Robotic Paint Repair System fills a unique hole in the robotic marketplace. There are not many robots like it, and none that are as precise as 3M's system, despite the fact that nearly every car that comes off the assembly line needs some sanding and polishing. This is one of the most intensive manual operations on the assembly line, and 3M's system completely automates the process.

Automating this crucial part of the assembly line ensures that every car is finished off with consistent quality. No matter the color of the paint or type of car, the Finesse-It system ensures each one is finished accurately and quickly, while also reducing costs of operations. RR — *Brianna Wessling*

ACEINNA's INS401 Enables Precise Autonomous Vehicle Positioning at Low Cost

Organization Name: ACEINNA
Country: USA
Website: www.aceinna.com
Year Founded: 2017
Number of Employees: 20+
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In January 2022, **ACEINNA** announced the INS401, a low cost, turnkey Inertial Navigation System (INS) and GNSS/RTK solution for automotive positioning and localization in SAE Level 2 to Level 5 Advanced Driver Assistance Systems (ADAS). The small, compact INS401 incorporates a high performance, multi-band RTK/GNSS receiver (GPS, GALILEO, GLONASS, QZSS, and BeiDou satellite systems), and triple redundant inertial sensors. The INS401 is certified to Automotive Safety Integrity Level B (ASIL-B) according to the ISO 26262 standard for the functional safety of road vehicles.

Analysis:

INS sensors, including the INS401, are unlike sensors for perception, object recognition and obstacle avoidance such as cameras, LiDAR, and radar, in that they are extremely resistant to harsh environmental conditions such as rain, snow, dust etc. The INS401, however, has the added advantage of a low price point compared to other INS sensing solutions (below $500).

The combination of triple redundant inertial sensors, GNSS satellite navigation information, and RTK support, allows the INS401 to provide better than 10cm accuracy. It also allows the device to perform in GNSS challenged urban environments or during GNSS outages by filling in gaps between GNSS updates and supporting dead-reckoning for short durations.

For automotive Advanced Driver Assistance Systems, positioning solutions must be highly accurate, robust in the extreme, and work under challenging environmental conditions. They must also be as compact as possible and have a mass market price point. The ACEINNA INS401, which is part of ACEINNA's new product portfolio of turnkey enabling technologies for developers ADAS solutions for autonomous vehicles, checks all the boxes. RR — *Dan Kara*

Aeva's Aeries II 4D LiDAR Provides Camera-Level Resolution and Velocity Measurements

Organization Name:	Aeva
Country:	USA
Website:	www.aeva.ai
Year Founded:	2017
Number of Employees:	101–500
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In February 2022, sensing systems provider **Aeva** announced the Aeries II, a compact, Frequency-Modulated Continuous Wave LiDAR (FMCW) "4D LiDAR" sensor designed for the automotive and trucking industries. The Aeries LiDAR-on-Chip design locates all key sensor constituents – transmitters, receivers and optics – onto a silicon photonics chip and housed in a ruggedized, compact module.

The Aeries II can deliver high-resolution images with up to 1000 lines per frame with no motion blur from data captured in real time. In addition to the 3D position of points captured doing operation, the Aeries II sensor also measures the instantaneous velocity for each pixel, allowing vehicles to both recognize where objects are, but also how fast they are moving, at distances up to 500 meters.

Analysis:

As a rule, FMCW LiDARs such as the Aeries II have greater operational ranges compared to traditional time-of-flight LiDARs, and reduced risk of interference from extraneous sources such as other LiDAR systems, the light from passing vehicles, and other ambient lighting fluctuations. According to Aeva, the Aeries II can detect vehicles 500 meters away and pedestrians at approximately 350 meters away, and the system software can compensate for adverse conditions. But the Aeries II differs from other LiDAR systems in a more substantial way.

Aeva's Aeries II LiDAR solution differs from traditional LiDAR systems in that it can both perceive objects at a distance (their range) and measure their instant velocity (doppler velocity measurements). That is, it can differentiate between static and moving objects such as oncoming vehicles. This ability, together with the Aeries II 's high resolution and operational robustness, increases the safety and performance of autonomous vehicles using the system. RR — *Dan Kara*

Apellix Drone Offers Safer Method for Maintaining Water Towers

Organization Name: Apellix
Country: USA
Website: www.apellix.com
Year Founded: 2014
Number of Employees: 1–10
Innovation Class: Application & Market Innovation
Innovation Subclass: Utilities

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Working with a regional industrial and commercial cleaning company, **Apellix** used a tethered Opus X8 SW (soft wash) drone to clean an elevated water tower in Wooster, Ohio and replace workers at height. Connecting the drone and tethers to a truck-mounted system for power and materials, the system was able to spray 8 GPM of a Sodium Hypochlorite mix and rinse water at pressures of 3,000 PSI at the base, which were just over 1,000 PSI at the cleaning nozzle tip at 136 feet.

The Apellix Opus X8 SW tethered drone was hooked up to a fully outfitted and rigged self-contained soft wash pickup truck with skid-mounted equipment. On the truck were the materials reservoirs, compressors, power generators and other equipment.

Analysis:

Having human workers at height is an inherent risk. Allowing workers to remain on the ground operating a drone that is doing the work at elevation is a safer approach for these types of projects. Besides being safer, this human-machine tandem completed the job in less than one day, meaning it can also be done faster and at a lower cost than traditional methods of cleaning coated surfaces to improve their aesthetics and prolong the life of the protective coatings.

Maintaining water towers, which often are a source of clean water for homes and business, is vital to community health. The US EPA has regulations on the cleanliness of the exterior shells of clean water sources for communities. This cleaning process is estimated to have extended the life of the coating on this particular water tower by 3–5 years. RR – *Steve Crowe*

ARM Institute's RoboticsCareer.org Demystifies Careers in Robotics

Organization Name:	ARM Institute
Country:	USA
Website:	www.arminstitute.org | www.roboticscareer.org
Year Founded:	2017
Number of Employees:	50
Innovation Class:	Business & Management Innovation
Innovation Subclass:	Social Good

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

The **ARM Institute's** free resource RoboticsCareer.org connects those seeking an education with careers in robotics manufacturing. The site demystifies three standard robotics career pathways: robotics technician, robotics specialist and robotics integrator.

Anyone from high school students to incumbent workers looking to upskill can be connected with education opportunities in their area. The website was developed with ARM Institute's 300+ member organization consortium.

Analysis:

ARM Institute's resource is more than just a simple job posting site. It was created to make robotics careers more accessible by making resources organized and easy to find. Whether someone is looking to upskill their workforce, or begin a career in robotics, RoboticsCareer.org will be able to point them in the right direction. It lays out the exact skills needed for the three standard positions it focuses on.

The website is a collaboration between the industry, government and academia. It brings together resources from competing companies to make them more accessible, and highlights programs that address diversity, equity and inclusion in robotics. RR

— *Brianna Wessling*

Avular Essentials Accelerate Mobile Robot Development

Organization Name: Avular
Country: Netherlands
Website: avular.com
Year Founded: 2014
Number of Employees: 11–50
Innovation Class: Technology, Services & Research
Innovation Subclass: Production Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In December 2021, **Avular** introduced Essentials as building blocks for engineers to quickly prototype and build autonomous mobile robots (AMRs). The solution includes functional blocks that are all integration ready and supported by software, including Avular Celebra software or the open-source Robot Operating System (ROS).

Analysis:

Essentials are a logical product for robotics platform developer Avular. The company made a name for itself by developing both a complete flying drone platform and an AMR platform. Essentials productizes the necessary real-time computing components for building a mobile robot of almost any size. The units are available in three different industrial form factors.

The Exploration version is the least expensive, and designed for prototyping new systems. The Industrial version is production ready, waterproof (IP65) and includes industrial connectors. The Rugged version is production ready and the most expensive version. It's designed for the most demanding outdoor mobile robotic platforms, costing twice as much as the Exploration version. Robot builders will still need to design, spec and source the motors, gear train and motor amplifiers for their robot.

Avular also develops the real-time operating system Cerebra, and Cerebra can be easily deployed onto any of the Essentials units to configure, control and program your robotic application. Essentials are also compatible with the ROS software for developers that prefer an open-source development platform. RR

– Mike Oitzman

BERKSHIRE GREY

Berkshire Grey Robotic Put Wall Increases Order Sortation up to 300%

Organization Name:	Berkshire Grey
Country:	USA
Website:	www.berkshiregrey.com
Year Founded:	2013
Number of Employees:	110–500
Innovation Class:	Application & Market
Innovation Subclass:	Logistics

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Berkshire Grey launched the Robotic Shuttle Put Wall with Identification (RSPWI) in September 2021 to meet surging e-commerce demands and mitigate labor shortages. The solution can integrate with existing fulfillment processes without disruption to ongoing operations.

Analysis:

Berkshire Grey has established itself as one of the leaders in fulfillment operations, offering a variety of automated inventory handling and sortation solutions to meet any distribution center or fulfillment warehouse requirements regardless of size.

The RSPWI is unique because it can accommodate up to nearly 100% of typical SKU assortments, including challenging items like soft polybags and cylinders/tubes, such as those used for make-up, for a variety of industries including apparel, footwear, beauty, and general merchandise.

The solution helps improve productivity and increase customer order sortation throughput by up to 300% with a unique order sortation footprint that takes up just a little more floor space footprint than a typical manual put wall.

Berkshire designed the RSPWI to integrate with existing fulfillment processes to minimize disruptions to ongoing operations. It can be configured to provide sort locations for up to 240 orders to be processed at the same time in a single robotic put wall as opposed to the industry average of 80 orders for a manual put wall. RR – *Mike Oitzman*

Spot Enterprise Brings the Quadruped to New Places

Organization Name: Boston Dynamics
Country: USA
Website: www.bostondynamics.com
Year Founded: 1992
Number of Employees: 101–500
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR50 INNOVATION AWARDS

Description:

Spot Enterprise prepares **Boston Dynamics'** quadruped robot for long, remote deployments. Spot's upgrade includes self-charging capabilities via a docking station, upgraded hardware for improved safety and post mission data download.

With Scout, Boston Dynamics' web-based remote operations software, users can control Spot remotely. Scout enables the quadruped to respond to incidents at remote or unmanned facilities. Spot's arm, an RBR50 winner last year, can operate semi-autonomously or through telemanipulation.

Analysis:

Boston Dynamics does not have a lot of competition when it comes to commercialized quadruped robots, but that does not mean they will stop pushing to improve Spot. With Spot Enterprise, Boston Dynamics opens up the door for real-world applications with Spot. Self-charging capabilities means Spot is able to act without much human intervention and with more flexibility.

With Scout, users are able to control Spot anywhere they have access to their network. This expands Spot's commercial applications, and makes it so that Spot can go anywhere a human can. Spot's software comes with a simple user interface so that teleoperated or autonomous applications are easy to set up.

RR — *Brianna Wessling*

cellumation

cellumation's Compact, Modular cv.DEPAL Simplifies and Improves Depalletizing Systems

Organization Name:	cellumation
Country:	Germany
Website:	www.cellumation.com
Year Founded:	2017
Number of Employees:	51–100
Innovation Class:	Technology, Services & Research Innovation
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In 2021, **cellumation**, the producer of celluveyor (cellular conveyor) material flow systems used in manufacturing and logistics environments, released the celluveyor DEPAL (cv.DEPAL) system, a delayering (layer separation) system for automated depalletizing applications. The system consists of a flat array of hexagonal robot cells, each with three wheels, that can move multiple flat based objects simultaneously and independently in all directions. A 3D vision system recognizes and monitors moving objects, providing real-time position data. The system corrects any deviations automatically.

Analysis:

The use of layered pallets of goods and material for transportation is indispensable for many industries. Robotic palletizers and depalletizers efficiently automate labor- and time-intensive tasks, increasing the speed and accuracy of operations, while reducing damage to goods. Depalletization typically requires the delayering of goods (of same or different types), the process of breaking the layers into separate items for further processing.

Delayering automation solutions are provided by a number of suppliers, but they often require a large surface area, and can only move separated objects through a single exit point. cellumation's novel cv.DEPAL solution can sort objects onto three different conveyor lines, eliminating the need additional depalletizing lines for many applications. Moreover, delayering does not require prior knowledge of the composition of the layers. Due to the hexagonal shape of the individual cells in the cv.DEPAL offering, system configuration and maintenance is greatly simplified, and the area required much reduced compared to traditional layer separation solutions. RR — *Dan Kara*

Cleo Robotics' Thrust Vectoring Tech Powers Innovative Drone

Organization Name: Cleo Robotics
Country: USA
Website: www.cleorobotics.com/
Year Founded: 2016
Number of Employees: 1–10
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Cleo Robotics released Dronut X1, a stable and highly maneuverable ducted bi-rotor drone. Its patented thrust vectoring technology has made the hyper-efficient ducted fan design stable in flight. The drone uses counter-rotating propellers that are on top of each other surrounded by an enclosure, which allows the drone to bounce off objects.

The Dronut X1's shell is made out of carbon fiber, and the drone weighs 15 oz and measures 5.5 inches in diameter. It has a flight time of just 12 minutes and sells for $9,800.

The Dronut X1 is designed to be used for unmanned inspection of GPS-denied environments such as tanks, pressure vessels, crawl spaces and more. It can also be used by law enforcement involved in high-risk situations or as a flying surveillance camera for facility security.

Analysis:

The Dronut X1 is the first professional-grade, bi-rotor ducted-fan drone – a drone without exposed rotor blades. Offering a drone that sells for under $10,000, the MassRobotics resident has attracted several major customers in the industrial and commercial space, a major oil and gas company and the US Army.

Historically, drones have been limited to operating in open fields away from humans. According to ABI Research, at press time, indoor drones comprised no more than 2% of the overall market. Cleo's unique design could start to increase that percentage and open up drones to new markets and applications. RR

— *Steve Crowe*

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Corvus Robotics Makes Drone Inventory Management Flexible with Corvus One

Organization Name: Corvus Robotics
Country: USA
Website: https://www.corvus-robotics.com
Year Founded: 2017
Number of Employees: 50
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Corvus One is **Corvus Robotics'** fully autonomous drone for inventory management. The drone doesn't require any extra fiducials or barcode labels to make its way around a facility. It's able to tie SKUs to slots in 3D space to keep track of inventory levels.

The drone is able to scan 200–400 pallet positions in just one hour, and can operate without wifi so manufacturers don't need to worry about dead zones.

Analysis:

Inventory management drones and robots are not unique, but Corvus One stands out for its flexibility. Being able to operate without wifi means companies do not have to spend extra money making sure every inch of their facility is covered.

Corvus also removes the need for extra fiducials or barcode labels, making them easier to implement and can adjust quickly to inventory changes. Corvus One's level 4 autonomy means it does not require much human intervention. In fact, the drone can operate for weeks without a human ever being involved. Companies can start doing inventory counts up to 100 times more often than they are now with Corvus Robotics' drones.

RR — *Brianna Wessling*

CRG Automation Uses Robotics to Decommission Chemical Missiles

Organization Name:	CRG Automation
Country:	USA
Website:	crgautomation.com
Year Founded:	2000
Number of Employees:	11–50
Innovation Class:	Application & Market
Innovation Subclass:	Defense

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

CRG Automation built a robotic system to help decommission a stockpile of 70,000 M55 chemical missiles at the Blue Grass Army Depot in Kentucky. The M55 missiles are filled with VX and sarin nerve agents.

The system combines traditional industrial robotic arms, autonomous mobile robots, and custom pick-and-place robots to make the work safer and more efficient, processing more than 25 missiles per hour.

Some of the major improvements to the process increased safety by identifying and handling leaking rockets, as well as reducing in-person maintenance requirements, lowering the risk of injury. After an 18-month design and approval process, the system has been running and is on track to complete the project by a Department of Defense (DOD) deadline of 2023.

Analysis:

The new automated decommissioning process of chemical weapons is not only more efficient, but it requires less in-person maintenance and, thus, removes human workers from potential harm. When you can take a person out of handling a chemical weapon, you have increased safety by magnitudes.

This project also has major social and political implications worldwide. Under the Chemical Weapons Convention international treaty, the United States must destroy chemical weapons such as the M55 rocket by 2023. With the new automated destruction process now in full swing, the US is on track to meet its international treaty deadlines and dispose of these weapons properly. RR

— Steve Crowe

cruise

Cruise First to Launch L4 Robotaxi Service in Major US City

Organization Name:	Cruise
Country:	USA
Website:	www.getcruise.com
Year Founded:	2013
Number of Employees:	500+
Innovation Class:	Applications & Markets
Innovation Subclass:	Transportation

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Cruise, the autonomous driving subsidiary of General Motors, opened up its Level 4 robotaxis to a limited portion of the public in San Francisco on Feb. 1 2022. There are no human safety drivers inside these robotaxis. For now, the rides are free and those who join the waitlist don't have to sign a non-disclosure agreement before using the service.

California's Department of Motor Vehicles is allowing Cruise to operate its robotaxis around certain parts of San Francisco between 11 PM and 5 AM at a maximum speed of 30 MPH.

Analysis:

Cruise's robotaxi service is only open to a small number of people in a small section of San Francisco, but this is the first driverless robotaxi service to launch in a major U.S. city. Over time, the service should expand its operating area and timeslot to gather important crucial operational data to continue to improve its already exceptional performance.

Waymo's robotaxi service has been active since October 2020 in suburban Phoenix, where the driving environment is far friendlier than San Francisco.

This milestone also triggered the release of another $1.35 billion in funding for Cruise. Cruise is betting its model of tackling more complicated cities first will let it scale to other markets more quickly than its competitors. RR – *Steve Crowe*

Dorabot Helps FedEx Sort Higher Volume of e-commerce Shipments

Organization Name:	Dorabot
Country:	USA
Website:	www.dorabot.com
Year Founded:	2014
Number of Employees:	51–100
Innovation Class:	Application and Market Innovation
Innovation Subclass:	Supply Chain/Logistics

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Dorabot deployed its sorting robot, DoraSorter, at a FedEx Express shipment sorting center in Guangzhou, China. DoraSorter features an industrial robot arm, a custom designed drawer-shaped end-of-arm tool, and a rack system containing up to 100 parcel destination bins.

DoraSorter has a 40-square-meter reach and a maximum payload of 10 kg. It's equipped with a barcode reader to scan packages and determine their destination. At its peak performance, DoraSorter can process 1,000 items per hour.

Analysis:

DoraSorter was the first sorting robot FedEx deployed at its Chinese facilities. The robot's high accuracy and ability to process 1,000 items per hour increases efficiency and allows FedEx to withstand huge volumes during surges and peak seasons.

DoraSorter is configurable, allowing it to be deployed and applied for various scenarios. Using customized sort-to-locations, such as bags, totes, put walls and gaylords, the system is data integrated and handles complex parcel sorting tasks. For FedEx, the end result is increased productivity and reduced labor costs.

This is another move by FedEx to automate sorting tasks in its network. In August 2021, FedEx Ground deployed Berkshire Grey's Robotic Product Sortation and Identification systems at its station in Queens, New York. The system sorts thousands of small packages that arrive daily in bulk. RR — *Steve Crowe*

FLEXQUBE®

FlexQube Launches eQart Navigator, a Non Load Carrying AMR That Docks With Motorized Platforms

Organization Name:	FlexQube
Country:	Sweden
Website:	www.flexqube.com
Year Founded:	2010
Number of Employees:	51–100
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

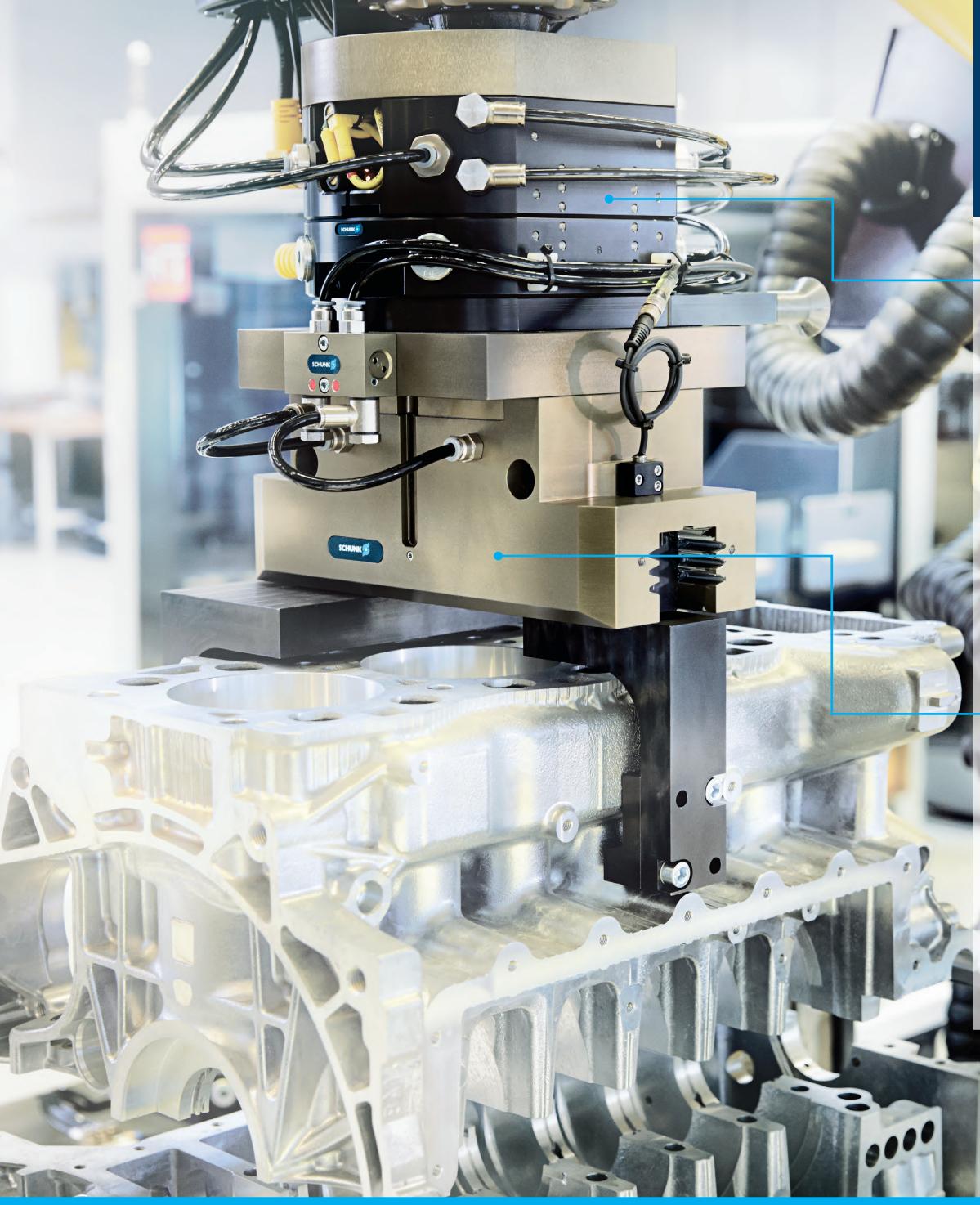
Description:

FlexQube established its reputation by developing an infinitely configurable cart structure for material handling applications. The new eQart Navigator enables the autonomous movement of powered FlexQube carts throughout the factory.

Analysis:

The FlexQube cart structure is employed by manufacturers around the globe to create custom material handling carts that can be custom built for any material handling task. Initially developed for manual cart operations, FlexQube introduced the eQart as an autonomous powered option for turning a manual cart into an autonomous, powered one. However, each eQart needs to be occasionally recharged and a cart might stand still in a queue for hours at a time while waiting for its next task.

The eQart Navigator is a new concept that packages the autonomous motion intelligence into a separate "tractor-like" device that can attach to an eQart platform, power the onboard motors and sensors, and move the eQart platform to its next process step. The eQart Navigator can then detach the eQart and leave it while it goes on its next mission. eQart Navigator uses intelligence by Bluebotics to run all of the obstacle avoidance and navigation processes. This solution is novel because the eQart Navigator powers the motors onboard each eQart while driving the eQart between pickup and drop-off locations. This improves the efficiency of the entire material handling process. RR — *Mike Oitzman*



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ForwardX and TCL Implement the First 5G AMR Deployment

Organization Name:	ForwardX Robotics
Country:	China
Website:	en.forwardx.com
Year Founded:	2016
Number of Employees:	101–500
Innovation Class:	Applications & Markets
Innovation Subclass:	Manufacturing

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

ForwardX's deployment at TCL's Huizhou factory involves dozens of ForwardX's Max 300 Lift autonomous mobile robots (AMRs) connected and communicating with a 5G network. ForwardX's AMRs are being used to move materials across the facility.

ForwardX's AMRs offer 360° obstacle detection and avoidance, making it ideal for busy facilities. The 5G connectivity connects to the AMRs wherever they are in the facility, regardless of blindspots in wifi coverage.

Analysis:

ForwardX's deployment marks one of the first 5G AMR deployments. 5G makes AMRs more flexible, especially in environments that are wrought with wifi blind spots. The company faced a challenge when implementing at TCL's factory and operations center. Not only is it the central point of TCL's global supply chain and manufacturing, it also has the second largest production capacity in the world.

The companies decided to use 5G as part of TCL's 5G+ Smart Factory Initiative. Since implementing the AMRs, the factory has seen improved productivity, less labor dependency and quicker inventory turnover. Additionally, ForwardX's robots offered TCL the guarantee of safety the company needed to put robots on the floor of such a busy factory. RR

– *Brianna Wessling*

Foxglove's Studio and Data Platform Make Robotics Development Easier and Faster

Organization Name:	Foxglove
Country:	USA
Website:	https://foxglove.dev/
Year Founded:	2021
Number of Employees:	11–50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Foxglove Studio is an integrated development environment that provides data inspection and debugging for robotics. It can connect directly to a ROS 1 stack through the native ROS connection.

The studio includes a suite of visualization tools organized into modules to help developers understand their data. The Foxglove Data Platform perfectly complements the studio, allowing roboticists to store, stream and explore their data. The petabytes of data the platform can handle is indexed to be easily accessible.

Analysis:

A spinout from Cruise, Foxglove was founded to fill a gap in off-the-shelf tooling for robotics development. While working at Cruise, Foxglove co-founders Adrian Macniel and Roman Shtylman learned how crucial a fully integrated robotics development platform was. It can be timely and costly for robotics companies to develop their own platform, but Foxglove eliminates the need for that.

While the founders began working with visualization for autonomous vehicles, Foxglove Studio works for a variety of robots. The company examined the most repetitive parts of robotics development to optimize workflows. The program is customizable, allowing users to pick which modules best fit their workflow. It's also open sourced, allowing roboticists to build their own panels into the app. RR – *Brianna Wessling*

GrayMatter Scan&Sand a Flexible Robotic Sanding Solution

Organization Name:	GrayMatter Robotics
Country:	USA
Website:	www.graymatter-robotics.com
Year Founded:	2020
Number of Employees:	11-50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

GrayMatter's Scan&Sand is a uniquely flexible robotic sander. Scan&Sand can adjust to different object shapes and sizes in just minutes. Typical robotic sanders are used only in mass production, where a sander works on hundreds of pieces of the exact same size and shape. Scan&Sand is able to adjust to objects with complex geometry precisely and quickly. Everytime the robotic system encounters a part, it treats it like a brand new one.

Analysis:

Scan&Sand's quick adjustment times and flexibility are what make it stand out from other robotic sanders. Operators do not need to know how to code to program the robot, and can learn how to program it in just a few hours.

Scan&Sand can work with a variety of products ranging from 1 m to 12 m. The robot can handle parts of different materials like composites, metals, solid surfaces, acrylics, plastics, wood and stone. Additionally, the robot can be deployed on existing shop floors without drastically changing infrastructure. Altogether, Scan&Sand's exceptional flexibility and easy implementation make it surpass typical robotic sanders. RR

– *Brianna Wessling*

GreyOrange and Tompkins Robotics Offer "Zero Walk" Fulfillment Solution

Organization Name:	GreyOrange Robotics and Tompkins Robotics
Country:	USA
Website:	www.greyorange.com and www.tompkinsrobotics.com
Year Founded:	2011; 1975
Number of Employees:	101–500
Innovation Class:	Application & Market
Innovation Subclass:	Logistics

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In April 2021, the two companies announced a combined solution that starts by using a **GreyOrange** Ranger goods-to-person (G2P) robot to bring racks of inventory to a stationary human worker. The worker then picks items and places them onto a **Tompkins** t-Sort robot, which sorts items into bins with other items from the same order. The human picker remains in one place throughout the process, thus making it a "zero walk" solution.

Analysis:

The solution is unique in its implementation as it leverages the best elements of both companies' solutions. The GreyOrange Ranger G2P mobile robots are designed to queue, pick up and move inventory shelves. A Ranger mobile robot will present a human picker with the correct SKU for a specific customer order. Guided by the GreyOrange GreyMatter warehouse orchestration software, the picker will pull the correct SKU count from the Ranger mounted inventory shelf and place the item(s) onto a waiting Tompkins t-Sort robot. This where the t-Sort does its job of moving the product to a waiting order bin.

The tabletop structure for the Tompkins t-Sort system can be sized to service any number of customer order bin locations. Tompkins can be configured for multilevel operation, effectively doubling throughput. Likewise, the GreyMatter Ranger fleet can be sized to support the inventory storage and retrieval requirements. RR

– Mike Oitzman

GUSS Launches Mini GUSS Sprayer for Vineyards and High-Density Orchards

Organization Name:	GUSS Automation
Country:	USA
Website:	gussag.com/
Year Founded:	2017
Number of Employees:	11-50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Mini **GUSS** is a smaller version of its predecessor, GUSS. The newer autonomous mobile robot is designed specifically for the spraying needs of vineyards and high-density orchards where the larger GUSS is too big to operate.

Analysis:

The original GUSS has been notable for its precision and efficiency. GUSS enabled a single operator to manage up to eight units operating in an orchard.

Mini GUSS is smaller than GUSS, and it is refined in every detail, building on five years of real field experience with GUSS. Mini GUSS has a narrower girth and shorter stance, which allows it to operate within the tight row spacing of vineyards and many orchard crops. It doesn't replace GUSS, and now GUSS Automation has expanded the market opportunities for its autonomous sprayer solutions.

The solutions allow farmers, growers and orchard spraying businesses the ability to lower labor and overhead costs as well as increase precision, efficiency, safety, and profitability with this autonomous machine. Mini GUSS is 6-feet wide, 5-foot 4-inches tall and 20-feet long. It has a 400-gallon tank and a 3.8-liter Cummins diesel engine to tackle the most strenuous terrain. GUSS Automation offers two tower options for Mini GUSS: a vineyard tower for two row applications and an apple tower for high-density trellised orchards. RR – *Mike Oitzman*

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HAI ROBOTICS

Hai Robotics' ACRs Significantly Improve Goods-to-Person Picking

Organization Name:	Hai Robotics
Country:	China
Website:	www.hairobotics.com
Year Founded:	2015
Number of Employees:	500+
Innovation Class:	Application & Market
Innovation Subclass:	Logistics

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Hai Robotics' autonomous case handling robot (ACR) Haipick can pick and place totes or cartons on storage shelves up to 5-7 meters high using a telescopic lift. The robots can carry up to eight loads to continuously feed goods-to-person picking stations. The robots use QR code navigation to move throughout their environment.

The ACR robots are currently being used in a variety of industries, including 3PL, e-commerce, apparel, retail, electronics, manufacturing, pharmaceutical and more.

Founded in 2016 with headquarters in Shenzhen, China, Hai Robotics has set up five subsidiaries in Hong Kong, Japan, Singapore, the U.S. and the Netherlands, serving customers from more than 30 countries and regions.

Analysis:

The Haipick ACR system is a poor man's automated storage and retrieval system (ASRS). It offers significant space utilization and high goods handling precision and efficiency without all the infrastructure changes required to install a typical ASRS.

Hai Robotics is a high-growth startup that already has 300-plus customers worldwide that have experienced improvement in operating efficiency, storage density, time to deploy, speed, and accuracy. The technology has also enabled warehouse owners to address labor shortage issues. And with $200 million in new investment capital, Hai Robotics can continue to scale around the world. RR

— *Steve Crowe*

ifm efector O3R Democratizes Robotic Perception

Organization Name: ifm efector
Country: USA
Website: www.ifm.com/us/en
Year Founded: 1969
Number of Employees: 500+
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

The O3R platform consists of compact camera heads (VGA cameras and time-of-flight sensors) and a vision processing unit (VPU) with NVIDIA Jetson TX2 for the evaluation of the data. Up to six camera heads can be connected to the Linux-based device, including sensors from other companies.

The software architecture on the VPU is Open Source (Linux + Docker), allowing the customer full access to the CPU/GPU with the ability to deploy their preferred software platform.

The camera heads are about the size of the Intel RealSense D Series cameras, but with full industrial specifications rated for shock, vibration, and dust. As different Use Cases require different visibilities, heads are available with both low (38K) and high (VGA) depth resolutions and both narrow (60x45°) and wide (105x78°) opening angles to increase flexibility.

Analysis:

The O3R design democratizes robotic perception to increase the overall efficiency of a robotic system, leading to better ROI calculations for SME companies. For under $2,000, the O3R is an affordable industrial perception stack. Combined with ifm's 15 years of 3D camera experience and supply chain excellence, the O3R could help the robotics industry reduce the TCO for robotic perception use cases.

Adding better environmental awareness through perception will lead to more efficient robots. A more efficient robot performs missions at a faster rate, leading to smaller fleets required to accomplish the desired business goals. Smaller fleets reduce capital investment and require less maintenance over the lifecycle of the fleet. RR – *Steve Crowe*

Indoor Robotics

Indoor Robotics' Tando a Scalable Security Solution

Organization Name:	Indoor Robotics
Country:	Israel
Website:	https://www.indoor-robotics.com/
Year Founded:	2018
Number of Employees:	11-50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Production Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Indoor Robotics' Tando offers a fully autonomous indoor drone fleet for security and inspection. Its system involves the Tando drone, which maps and navigates indoor environments and collects visual and thermal data. Tando can charge itself with its docking Tile, a ceiling mounted docking and charging station.

Analysis:

There are lots of advantages Tando has over a human security guard. Tando is able to work around the clock, constantly monitoring visually and with thermal sensors. Drones are good at repetitive tasks, like monitoring and patrolling. Tando is able to identify dangers or leaks and alert a human monitor who can verify it remotely.

Tando is also easy to scale. Its mapping capabilities mean that going from one drone to an entire fleet for large buildings is simple. The drones operate fully autonomously and can follow set patrols schedules. Overall, Tando is a smart security solution that ensures constant and persistent monitoring. RR

– Brianna Wessling

Indy Autonomous Challenge Pushed Boundaries of Autonomous Vehicle Speed and Control

Organization Name:	Indy Autonomous Challenge
Country:	U.S.A.
Website:	www.indyautonomouschallenge.com
Year Founded:	2019
Number of Employees:	1–10
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

This autonomous vehicle (AV) racing competition setup a $1M prize and developed new class of autonomous Indy race cars as the test bed for the development of advanced autonomous driving algorithms. The competition featured engineering teams from over 20 international universities. The **Indy Autonomous Challenge** (IAC) is a collaboration between The Indianapolis Motor Speedway, Energy Systems Network (ESN), and an advanced energy technology initiative of the Central Indiana Corporate Partnership (CICP).

Analysis:

The challenge was conceptualized in a similar paradigm to the DARPA Grand Challenge that took place 15 years ago, off-road, in the desert southwest. DARPA gave birth to a new generation of AV industry leaders, and the IAC is now on record as its successor and a viable incubator for a new generation of AV leaders and innovators.

The IAC organized two race events, the first competition at Indy Motor Speedway in October, 2021 and a second competition at Las Vegas Motor Speedway in January 2022. At the IMS event, a new IMS track lap record for AV's was set at 135-plus MPH. At the Las Vegas event, a new autonomous passing speed record was set at 175-plus MPH. RR

– *Mike Oitzman*

InsightTRAC Automates Time-Intensive Sanitation Problem for Almond Growers

Organization Name:	InsightTRAC
Country:	USA
Website:	www.insighttrac.com
Year Founded:	2019
Number of Employees:	2-10
Innovation Class:	Application & Market
Innovation Subclass:	Agriculture

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Almond growers struggle to remove navel orangeworm-infested nuts, also known as mummies, each year during winter sanitation. **InsightTRAC** has innovated the removal of mummies from almond trees using an autonomous mobile robot with a vision-guided pellet gun to shoot the mummies from the tree.

Analysis:

The InsightTRAC Rover is a unique solution designed specifically to help almond growers solve a winter sanitation problem. Until the creation of the InsightTRAC Rover, the mummy removal process required the growers to re-shake the almond trees during a wet period after the end of the harvest, or knock the individual almond mummies from the trees by hand (a labor-intensive solution).

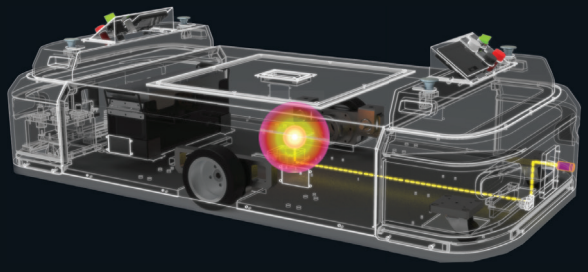
The InsightTRAC Rover is an autonomous mobile robot with a top mounted, vision-guided pellet gun. The rover moves through the orchard, identifies mummies on the tree's branches, and then targets and removes the mummies by hitting them with biodegradable pellets.

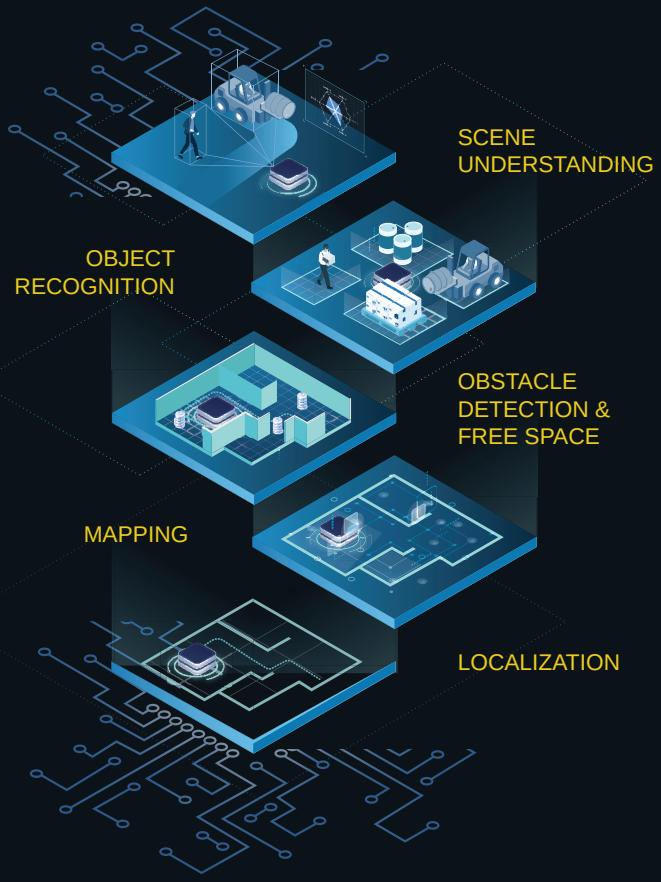
The solution also gathers data about every tree and makes this information available to the orchard owner.

The company plans to start with deployments in Australia in summer 2022, then move to California for the winter of 2023. These two regions are the primary market for the initial go-to-market of the solution. RR – *Mike Oitzman*

DRIVING THE ARTIFICIAL PERCEPTION REVOLUTION IN MOBILE ROBOTICS

RGo Robotics' AI-powered **Perception Engine™** provides mobile machines with human-level visual perception, enabling them to see, understand and navigate autonomously in complex environments.





RGo Robotics

InvenSense's TDK RoboKit1, a Solid Development Platform, Joins SmartRobotics Solutions Set

Organization Name: InvenSense
Country: USA
Website: https://invensense.tdk.com
Year Founded: 2003
Number of Employees: 500+
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In January 2022, **TDK Corporation** subsidiary InvenSense announced the TDK RoboKit1, a development platform and reference design for robotics systems. The TDK RoboKit1 board, powered by an ARM Cortex-M7 processor, incorporates a number of sensors, including a 6-axis IMU, a barometric pressure sensor, a magnetometer, digital I^2S microphones, a temperature sensor, and ultrasonic Time of Flight (ToF) sensors. Also included with the TDK RoboKit1 are software libraries, as well as ROS 1- and ROS 2- compliant drivers.

Analysis:

As a robust, highly functional development platform, the TDK RoboKit1 provides robotics developers with a solid technical basis for prototyping and development that simplifies robotics engineering and reduces time to market. But more importantly, the TDK RoboKit1 is just the latest addition to TDK's SmartRobotics product family and solution set. The SmartRobotics 'platform' also includes a number of boards, SoCs and reference designs developed by partner Qualcomm Robotics, and other TDK technologies.

With the release of the TDK RoboKit1, InvenSense, and its $13B multinational parent company TDK, is making a statement regarding the business opportunities presented by the burgeoning robotics sector, and that its intentions for providing critical enabling technologies for robotics developers extend beyond a single development board. Taken together, the TDK RoboKit1 and SmartRobotics suite demonstrates that a company with boatloads of technical wherewithal, deep pockets, and similarly equipped partners, is clearly intent on producing a solutions ecosystem for robotics development going forward. RR — *Dan Kara*

John Deere Launches 8R Autonomous Tractor

Organization Name:	John Deere
Country:	USA
Website:	www.deere.com
Year Founded:	1837
Number of Employees:	50,000+
Innovation Class:	Technology, Services & Research Innovation
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In January 2022, **Johne Deere** launched the new John Deere 8R autonomous tractor. This tractor is ready for large-scale production and will begin shipping to farmers in 2022. John Deere raised the bar for a new level of agriculture autonomy from one of the most trusted and recognizable brands worldwide.

Analysis:

The concept of tractor autonomy received a huge validation with the launch of the John Deere 8R autonomous tractor. Farmers trust the John Deere brand, and the standard 8R tractor is a well-loved, established and familiar farming platform.

The autonomous tractor uses six pairs of stereo cameras, which enables 360-degree obstacle detection and the calculation of distance for things seen in the cameras. Obstacle avoidance, navigation and localization is achieved by fusing information seen in the cameras together with information from other sensors, including GPS.

The autonomous tractor continuously checks its position relative to a geofence, ensuring it is operating where it is supposed to, and with accuracy of +/- 1 inch.

At its heart, the John Deere 8R tractor leverages the autonomous guidance technology that John Deere acquired from Blue River Technology. This platform more than four years of development and testing behind it. The autonomous package is a dealer installed option and can be retrofitted on any 8R tractor from model year 2020 or later. RR

— *Mike Oitzman*

Labrador Systems Creates New Class of Home Robots

Organization Name: Labrador Systems
Country: USA
Website: www.labradorsystems.com
Year Founded: 2017
Number of Employees: 1–10
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Labrador Systems unveiled at CES 2022 its Retriever and Caddie mobile robots for home use. The target users are those with mobility issues, including the elderly and people with disabilities. The robots are designed to carry items around users' homes.

Both robots have a maximum payload capacity of 25 lbs and can autonomously navigate through a home. The Retriever robot also has the ability to adjust its height and "retrieve" special trays, which can hold up to 10 lbs, off countertops and tables. The entry-level Caddie robot operates at a fixed height of 30 inches and can't retrieve items.

Analysis:

Labrador's assistive robots are tackling important problems – enabling individuals to be more independent and reducing strain on caregivers. An increasing percentage of the population is above the ages of 65 and 85, and there's a decreasing percentage of individuals below 65 to support them. To empower its customers, Labrador has developed seemingly simple robots that are affordable and help solve major challenges. That is not an easy task in robotics, and it is even harder when building robots for the home.

Labrador also created a new class of robots: autonomous mobile robots (AMRs) for the home. Prior to this, AMRs with this level of functionality were confined to warehouses and other commercial environments. Labrador has many challenges ahead as it continues to commercialize its technology, but Caddie and Retriever are two of the more exciting and useful home robots we have seen in years. RR – *Steve Crowe*

Libiao 3D t-sort Maximizes Sortation Applications

Organization Name:	Libiao Robotics
Country:	China
Website:	www.libiaorobot.com/cn/home
Year Founded:	2016
Number of Employees:	101–500
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Libiao Robotics' new 3D t-sort consists of sorting robots running in 3D mode, shelf-type pack box collection grids, plane sorting robots, sorting robot operating platform, and Libiao control software system in the background. The entire system can expand original sorting grids from hundreds to thousands and tens of thousands, with the sorting efficiency of each single-layer module reaching 3,000 picks per hour.

Analysis:

The 3D t-sort system builds off of Libiao's first-generation sortation robots, which it sells around the world with well-respected partners Körber, Tompkins Robotics, and Toyota Material Handling. The space-saving system features a modular design with flexible expandability, which can be deployed in a quick and staged manner.

Libiao claimed 350 robots operating continuously for 24 hours can process up to 400,000 parcels. It said the sorting efficiency of the 3D t-sort is 2-3 times higher than that of manual sorting. RR — *Steve Crowe*

massrobotics

MassRobotics Releases First Version of Mobile Robotics Interoperability Standard

Organization Name:	MassRobotics
Country:	USA
Website:	www.massrobotics.org
Year Founded:	2015
Number of Employees:	1–10
Innovation Class:	Business & Management
Innovation Subclass:	Market Engagement

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

The new standards initiative enables autonomous mobile robots (AMRs) from multiple vendors to integrate and work together seamlessly to support safe and efficient operations in factories, warehouses, distribution, and fulfillment centers.

Analysis:

One of the core missions of MassRobotics is to enable collaboration and cooperation between robotics companies, while helping them grow and scale. MassRobotics sponsored the AMR interoperability standards group and facilitated the development of the new standard.

The standard was issued in 2021 after months of discussion, research, debate and collaboration, with the first public demonstration of the standard at the FedEx DART Lab in October 2021.

The primary goal of the standard is to enable AMRs from different vendors to operate within the same workspace and share information seamlessly between the fleet management solutions in a non-proprietary fashion. This information is also available to customers to enable unified AMR tracking and reporting on dashboards, including the location of all AMRs within a facility. RR – *Mike Oitzman*

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ModalAI's VOXL CAM Perception Engine Functionally Impressive, Provides Developers with Options for Ongoing Innovation

Organization Name:	ModalAI
Country:	USA
Website:	https://modalai.com
Year Founded:	2018
Number of Employees:	1-50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In November 2021, **ModalAI**, a Qualcomm spin out, released the VOXL CAM perception engine, a credit card sized, pluggable, Printed Circuit Board (PCB) that provides robotics systems, drones and IoT devices with GPS-denied navigation, indoor and outdoor depth mapping, simultaneous localization and mapping (SLAM), object detection and avoidance, Unmanned Aircraft Systems (UAS) flight control and cellular connectivity. The VOXL CAM incorporates Qualcomm's Snapdragon 821 chipset and ModalAI's Flight Core, a PX4 drone flight controller.

Analysis:

The functional capacities of ModalAI's VOXL CAM solution are impressive – powerful compute, imaging and navigation – particularly given its small size. The base VOXL CAM weighs just 57.5 grams, 87 grams with the flight controller and modem installed. To emphasize the point, ModalAI released a second product with the VOXL Cam, namely the Seeker, a micro-development drone capable of both indoor and outdoor autonomous navigation.

ModalAI's VOXL CAM and Seeker drone, along with the company's VOXL Flight computing platform and controller for drones (released in 2020), provides developers of drone-based solutions with a range of powerful technical enablers for drone (and robotics) applications, many of which are sure to be for indoor operations. This range of solutions provides engineers with many design and development options, a necessary requirement for ongoing innovation. RR

— Dan Kara

NVIDIA Omniverse Replicator Improves Synthetic Data Generation

Organization Name:	NVIDIA
Country:	USA
Website:	www.nvidia.com
Year Founded:	1993
Number of Employees:	13,000+
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In November 2021, **NVIDIA** announced the NVIDIA Omniverse Replicator data generation engine that produces synthetic data for training deep neural networks based on physical simulations in photorealistic, physically-accurate virtual environments. NVIDIA also introduced two replicator applications for generating simulated data. The first, NVIDIA DRIVE Sim, is a virtual world for accommodating autonomous vehicles digital twins. The second application, NVIDIA Isaac Sim, supports virtual robotic manipulators. NVIDIA representatives expect third-party developers to build additional domain-specific data-generation engines using the Omniverse Replicator engine.

Analysis:

Machine learning is a powerful enabler when developing software for a range of autonomous systems, including robots, drones and autonomous vehicles. Unfortunately, the process of collecting, labeling and managing the large datasets used for machine learning model training is costly, laborious and can be error prone, with the resulting data often incomplete or inappropriate for the application at hand. The use of simulated data addresses these challenges, but low-quality simulations often result in physical systems performing poorly in the real world.

With the Omniverse Replicator, and the DRIVE Sim and Isaac Sim introductions, NVIDIA is addressing the machine learning data challenge. As its name suggests, the Omniverse Replicator is powered by NVIDIA Omniverse platform, a powerful, well featured set of simulation technologies, including GPU-accelerated PhysX 5 physics engine, real-time path tracing for high levels of photorealism, and a material definition language for rendering physical objects. The Omniverse Replicator, coupled with developer access to the DRIVE Sim and Isaac Sim virtual worlds (and the potential for additional virtual environments), all undergirded with and supported by NVIDIA's increasingly expansive support technologies for robotics development, are critical enablers for robotics development going forward. RR — *Dan Kara*

OnRobot WebLytics Captures Real-Time Performance Data for Robotic Workcells

Organization Name:	OnRobot
Country:	Denmark
Website:	www.onrobot.com
Year Founded:	2015
Number of Employees:	101–500
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In November 2021, **OnRobot** released its first software product. WebLytics is a production monitoring, device diagnostics, and data analytics tool to simultaneously monitor multiple robotics applications. WebLytics is compatible with all leading collaborative and lightweight industrial robot arms.

WebLytics can identify trends in a robotic cell in real-time such as patterns, peaks and disturbances in productivity. The software uses the overall equipment effectiveness (OEE) standard to measure the percentage of manufacturing time that is productive. WebLytics can be deployed on a shop floor's local network or added to a virtual network that connects to the robot cell.

Analysis:

WebLytics is one of the first software tools to provide real-time, application-focused data for collaborative applications across major robot brands. WebLytics transforms equipment data into visualized device and application-level intelligence. This can improve productivity, eliminate manual data collection, and reduce costly downtime and overall cost of ownership.

WebLytics is not just a powerful tool for end users, it also creates new revenue opportunities for system integrators by providing the software required to offer customers data-backed custom service agreements and engineering services for cell optimization.

OnRobot has long said its goal is to become the one-stop shop for collaborative automation. By diversifying its product portfolio with its first software offering, to accompany its array of accessories, grippers, sensors and tool changers, that goal is becoming more of a reality. RR – *Steve Crowe*

Outsight's Augmented LiDAR Box Simplifies and Speeds 3D LiDAR Sensing Applications

Organization Name:	Outsight
Country:	France
Website:	www.outsight.ai
Year Founded:	2019
Number of Employees:	51-100
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In May 2021, **Outsight** announced the launch of its Augmented LiDAR Box (ALB), a feature rich, pre-processor for 3D LiDARs. The ALB, which is LiDAR agnostic – LiDAR suppliers Velodyne, Robosense, Ouster, Hesai and others are strategic partners – acts as a hardware-based abstraction layer that converts raw (and proprietary) 3D LiDAR input into a standardized open data format (Outsight's Open SErialization format). The ALB also supports multi-LiDAR data fusion, and boasts of a number of features and functions for common sensing and perception applications.

Analysis:

LiDAR is a critical enabling technology for sensing and perception in systems as wide ranging as mobile robots, articulated robots and self-driving vehicles. Unfortunately, developing applications using raw 3D LiDAR data is difficult and time-consuming, especially given the many different, proprietary LiDAR solutions on the market and the proprietary LiDAR data formats and protocols they utilize. Even experienced engineering teams are challenged when LiDAR data processing must be done in real-time, which is the case in the majority of applications.

The difficulty of integrating LiDAR sensing into applications limits robotics experimentation, increases costs, and extends time to market. Outsight's Augmented LiDAR Box simplifies the integration of LiDAR solutions and reduces the complexity of utilizing the raw 3D LiDAR data they produce, as well as the processed, and often fused, information from one or more LiDAR systems.

RR — *Dan Kara*

Perseverance Rover Cores First Rock on Mars

Organization Name:	NASA/JPL
Country:	USA
Website:	https://www.jpl.nasa.gov/
Year Founded:	1936
Number of Employees:	500+
Innovation Class:	Application & Market
Innovation Subclass:	Aerospace

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Perseverance put its sampling and caching system to work on September 1, 2021, eight months into its exploration of Mars. The system uses a rotary-percussive drill and a hollow coring bit, with a sample tube sitting inside. The drill and bit sit at the end of its robotic arm, which it uses to extract samples. Perseverance then transferred the tube to its interior, measured and imaged the core, sealed the container and stored it.

Analysis:

Perseverance's first successful coring was a crucial step in its already historic mission. The samples the rover takes from Mars will eventually be sent back to Earth to be studied, but acquiring them is anything but simple.

NASA scientists spent days pouring over data from Perseverance's previous attempt at coring a rock. Unlike the Curiosity Rover, Perseverance collects intact samples of rocks, which can give more insight into how areas on Mars were formed than rocks sitting on the surface. Perseverance's improved manipulation skills make picking the unaltered rocks possible.

Successfully coring rocks is a key part of Perseverance's mission, and brings NASA a step closer to the long-term goal of bringing those samples back to Earth. RR

– *Brianna Wessling*

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Pharm Robotics' Sureshot Automates Every Step of the Cow Inoculation Process

Organization Name:	Pharm Robotics
Country:	U.S.A.
Website:	https://www.pharmrobotics.net/
Year Founded:	2019
Number of Employees:	1–10
Innovation Class:	Technology & Services
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Pharm Robotics' Sureshot is a robotic cow inoculator that starts when cows exit the milking barn and scanned by an RFID and camera ID reader that determines if the cows need immunizations.

Next, a cow will be held in place with a two-part bumper restraint, and scanned by another RFID that determines what inoculation the cow needs, and a robotic arm injects the cow. After the injection, the bumper restraints release the cow.

Analysis:

Pharm Robotics' certainly isn't the only company looking to solve problems in agriculture with robotics, but it stands apart from others in its application. Additionally, Pharm Robotics makes it so that farmers do not have to intervene in any part of the inoculation process.

Immunizations are given to the cows in precise doses measured by peristaltic pumps and sensors. Every inoculation is automatically recorded in Pharm's dairy management software and linked to the cow via its RFID tag. Farmers are able to access the records from their computer, and are notified if anything goes wrong. In all, Sureshot gives farmers more time to do other important tasks while ensuring the health of the herd. RR – *Brianna Wessling*

Ready Robotics Forge/OS 5 Eases Programming Challenges

Organization Name:	Ready Robotics
Country:	USA
Website:	www.ready-robotics.com
Year Founded:	2015
Number of Employees:	11-50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In May 2021, **Ready Robotics** released Forge/OS 5, a universal operating system compatible with hundreds of robots from leading brands ABB, Epson, Fanuc, Kawasaki, Staubli, Universal Robots, Yaskawa and more. Forge/OS 5 unites all the hardware in a workcell under a single programming platform, making automation accessible to any operator no matter their experience.

To reduce programming complexity for customers who use multiple brands of robots and peripherals, Forge/OS 5 abstracts brand-specific robot programming languages into a no-code programming app. The system uses blocks of code organized into flow charts depending on the application at hand.

Analysis:

A 2019 study by McKinsey found 41% of organizations trying to scale with robotics cited a lack of a common programming interface as a major challenge to success. Forge/OS 5 is a step towards resolving that problem as it eliminates fragmentation. Instead of staffing up with engineers to program in OEM-specific programming languages, organizations can leverage operators to program and maintain robots across brands using Forge/OS.

Forge/OS' visual programming platform reduces programming time, deployment time, and enables anyone to control robots. It empowers people and reduces the friction of using robots, making them more accessible to more companies to accelerate adoption. RR

— *Steve Crowe*

R-Go Robotics Perception Engine Helps AMRs Perceive the World

Organization Name: R-Go Robotics
Country: Israel/United States
Website: www.r-gorobotics.com
Year Founded: 2018
Number of Employees: 11-50
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In 2021, **R-Go Robotics** pioneered an artificial perception technology that enables mobile robots to understand complex surroundings and operate autonomously. The Perception Engine is comprised of patent-pending computer vision and AI technology, which runs on ultra-low-cost, low-power hardware.

Analysis:

R-Go Robotics' Perception Engine enables mobile robots to detect obstacles, recognize people and other machines in complex environments. The solution uses vision-based perception, but combines the visual information with other sensor data to build a robust understanding of the world around it.

The solution can run on low-power, ultra-low cost compute infrastructure, enabling the deployment for low-cost, consumer-grade mobile products. The company built a reference hardware design and offers the hardware for evaluation and low-volume production. For higher-volume applications, manufacturers can license the reference design and source the boards or components from their preferred vendors. The reference design supports multiple communication protocols, including CAN bus, Ethernet, EtherCAT, UART, and SPI. The API can be accessed via a C++ or ROS wrapper. RR

— *Mike Oitzman*

savioke relay
delivery robots

Savioke Relay+ Features New Mechanical Elevator Interface and Knocks Down a Major Hurdle to Product Acceptance

Organization Name: Savioke
Country: USA
Website: www.savioke.com
Year Founded: 2015
Number of Employees: 11–50
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In December 2021, **Savioke** released the Relay+ with a new mechanically actuated elevator button pusher that eliminates the need to communicate electronically with the elevator control unit. Savioke is positioning this feature as "quick install" capability, as the robot uses a vision camera to identify the call buttons and floor buttons and then position the robot to manually push the buttons, just like a human would.

Analysis:

The original Savioke Relay was designed to operate in hotels to deliver sundry items from the front desk to guest rooms. The company is one of the first to deploy its solutions solely in a robots as a service (RaaS) business model.

Savioke quickly learned that each hotel had an elevator from a different elevator vendor, and depending on the vintage of the elevator and the breadth of local laws, that it was difficult to gain automatic control over the operation of a public elevator. The result was that many customer installations slipped months behind schedule while permits were attained and inspections were passed.

As a result, the Relay+ was engineered to use a mechanical actuator along with vision guidance and AI to quickly learn the configuration of any buildings physical elevator controls (i.e. the buttons used by humans). This process can be completed in as little as four hours, after which, the Relay+ is able to successfully make deliveries from the front desk to any room in the facility. RR

— Mike Oitzman

Seoul Robotics Takes Groundbreaking Approach to Autonomy

Organization Name:	Seoul Robotics
Country:	Korea
Website:	www. seoulrobotics.org
Year Founded:	2017
Number of Employees:	51–100
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

During the 2022 CES event, **Seoul Robotics** announced the Level 5 Control Tower (LV5 CTRL TWR), a mesh network of sensors and smart software that autonomously guides vehicles simultaneously at manufacturing facilities using vehicle-to-vehicle (V2X) communications and/or 5G without having to incorporate sensors into the vehicles. LV5 CTRL TWR uses Seoul Robotics's SENSR AI-powered, 3D perception software, working with collections of fixed LiDAR sensors (traffic lights, buildings, light poles, overhangs etc.), as well as 5G, allowing vehicles to guide themselves to parking lots following their manufacture.

Analysis:

The logistics of moving finished vehicles is one of the least automated processes at automotive manufacturing plants. The manual transportation of vehicles is time consuming and costly, and runs the risk of product and facility damage, along with worker injury. Working in inclement weather poses additional difficulties.

While the cost of implementing the Seoul Robotics LV5 CTRL TWR solution is not insignificant, the ROI is immediately obvious, easily calculated, and substantial. Seoul Robotics have indicated that their Level 5 Control Tower 'solution is resonating with other automotive OEMS following the positive results of a well-publicized BMW LV5 CTRL TWR installation in Munich.

Seoul Robotics' representatives also believe that their LV5 CTRL TWR solution can be applied in other industries including truck manufacturing, car rental sites and more. But perhaps more importantly, the company's "autonomy through infrastructure" approach will encourage other forward-looking companies to apply the technique in areas unimagined thus far. RR — *Dan Kara*

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Smith+Nephew

Smith+Nephew's Turns to Pittsburgh for Surgical Robotics R&D Center

Organization Name:	Smith+Nephew
Country:	UK
Website:	www.smith-nephew.com
Year Founded:	2016
Number of Employees:	10,000+
Innovation Class:	Business and Management
Innovation Subclass:	Market Engagement

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In October 2021, London-based **Smith+Nephew**, a $5B multinational medical equipment and technology supplier, opened a new 65,000-square-foot robotics research and development center in Pittsburgh, PA's Robotics Row. Work at the facility will focus on the development and testing of surgical robotics platforms used for hip and knee replacements. The new center will host approximately 200 employees in a wide range of research and technical roles, including electrical engineers, mechanical engineers, software engineers, and cybersecurity experts.

Analysis:

With the opening of the new robotics research center, Smith+Nephew is expanding its presence in Pittsburgh. In 2016, the company acquired Carnegie Mellon University spinoff and Pittsburgh-based Blue Belt Technologies, the developer of the Navio surgical system for knee replacement, for $275 million. According to Smith+Nephew, the number of local Smith+Nephew employees has more than tripled since the acquisition (over 180 local full-time workers).

The Blue Belt subsidiary alone made Pittsburgh the obvious choice for the location of the new research center. But that was not the only decision criteria. Smith+Nephew officials have indicated that three cities were in the running for the new facility.

Pittsburgh has a well-deserved reputation as an international robotics cluster. It is home to world-class robotics research universities — Carnegie Mellon University and University of Pittsburgh - and many commercial robotics companies. The reinvigorated and dynamic Pittsburgh Robotics Network is one of the world's leading robotics clusters. Smith+Nephew's new robotics research center further solidifies the Pittsburgh area's international robotics standing, but more importantly will bolster surgical robotics R&D and speed commercialization efforts. RR

— *Dan Kara*

Swiss-Mile

Swiss-Mile's Hybrid Mobility Benefits Quadruped Robots

Organization Name:	Swiss Mile
Country:	Switzerland
Website:	www.swiss-mile.com
Year Founded:	2021
Number of Employees:	1-10
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Primary or Applied Research

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Swiss-Mile, a spin-off of ETH Zurich's Robotic Systems Lab, is commercializing robots that have both legs and wheels to perform a variety of tasks, including mapping, inspection, disaster relief, and logistics in urban environments. The robot is based on ETH's ANYmal quadruped and can travel at speeds up to 13.87 MPH (22.32 kilometers per hour) with a payload capacity up to 110 lb (50 kg).

The hybrid robot uses a combination of GPS, LiDAR, and cameras to autonomously navigate city streets and avoid obstacles. According to Swiss-Mile, the robots have a two-hour runtime per battery charge.

Analysis:

Swiss-Mile is extending the capabilities of mobile robots by deploying a hybrid mobility platform that can overcome challenging obstacles like stairs and enable seamless navigation in indoor and outdoor environments. Being able to use both wheels and legs helps robots efficiently adapt to different situations, trading the ability to traverse rough terrain for speed, and likely outperforming wheeled mobile delivery robots or quadrupeds.

This is not the first time we have seen a robot with both legs and wheels, but it could be one of the first hybrid systems to be commercialized. Boston Dynamics' Handle robot initially had both, but that system evolved into Stretch, which uses only wheels. Marc Raibert, founder of Boston Dynamics, has said a wheel-leg hybrid robotics system could go anywhere in the world as it offers "the best of both worlds." RR — *Steve Crowe*

Tangram Vision Simplifies Perception-powered Robotics Development

Organization Name: Tangram Vision
Country: USA
Website: www.tangramvision.com
Year Founded: 2020
Number of Employees: 1–10
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

The **Tangram Vision** Platform (TVP) is a suite of tools to streamline adding and maintaining sensors for robots and autonomous vehicles. TVP includes a number of sub-modules to manage many of the most complicated yet essential perception tasks.

TVCal, Tangram Vision's flagship calibration suite, is designed to simultaneously calibrate any number of sensors of the most commonly used modalities. TVMux, Tangram Vision's sensor multiplexer module, makes sensors stream immediately when plugged in, listens for failures to attempt automatic restarts, and maintains total system stability should a sensor stop working. And Hub is a perception-specific database that makes sensors and sensor data savable, organizable and searchable.

Analysis:

The TVP makes it simpler to develop perception-powered robots, while also letting those platforms operate more reliably when faced with real-world challenges. Robots and AVs rely on perception sensors to let them understand and interact with the world around them. Yet the sensors that are meant to enable these autonomous platforms frequently hold them back. This is largely due to a reliance on open-source perception tools from robotics' hobbyist past and a lack of interoperability between sensor manufacturers and sensor types.

This house-of-cards approach results in perception performance that becomes particularly stressed when a platform starts to scale. The Tangram Vision Platform replaces this with an enterprise-grade system to bring scalability and reliability to the perception systems that are becoming ubiquitous as more robots and AVs are deployed worldwide. RR — *Steve Crowe*

TerraClear Creating 'Roomba' of Rock Picking

Organization Name:	TerraClear
Country:	USA
Website:	www.terraclear.com
Year Founded:	2017
Number of Employees:	11–50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

TerraClear's rock picker, which attaches to skid steers and compact loaders, can collect up to 400 rocks per hour, picking rocks weighing up to 300 pounds without any manual labor.

First, the system uses a drone to map a field and determine the size and location of every rock that needs to be picked. That information is mapped and the most efficient path for picking up the rocks is plotted. The picker follows the path on the map and with the push of a button picks up each rock.

TerraClear is working to integrate artificial intelligence and computer vision with tractor guidance systems to fully automate the entire rock picking process.

Analysis:

Robots are ideal for tasks that are dull, dirty, and dangerous. Thus, rock picking is a perfect application for robotics. These large, heavy rocks not only break the backs of those picking them up, but they can also damage expensive precision farming machinery that is in common use by farmers for planting, irrigating and harvesting.

TerraClear founder Brent Frei grew up on a farm in Idaho, meaning he has firsthand knowledge of the problem to guide development of the product. There are 400-plus million arable acres worldwide that have been waiting for a cost-effective and productive solution to removing rocks. The system TerraClear is developing has a vast opportunity and can reduce the labor and time needed to prep fields for planting. RR

— *Steve Crowe*

Toposens Launches ECHO ONE DK Ultrasonic Echolocation Sensor for Object Detection in 3D Space

Organization Name:	Toposens
Country:	Germany
Website:	www.toposens.com
Year Founded:	2015
Number of Employees:	11–50
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In October 2021, Munich, Germany–based **Toposens GmbH** released the ECHO ONE DK, a low power, ultrasonic echolocation sensor and development kit for 3D collision avoidance. The ECHO ONE DK, which features a IP67 protection rating, provides for 3D object detection in an ultra-short operating range from 20cm up to 3m. It offers a wide field-of-view of up to 180° in ultra-short range and up to 110° at 3m. The ECHO ONE DK also ships with the Toposens Sensor Library (C++), ROS Implementation Package, and cross-platform Toposens 3D Visualizer.

Analysis:

Ultrasonic sensors, which use pulsed, high-frequency sound waves and time-of-flight measurements to determine distances to objects, have the advantage over other sensing systems in that they can detect objects regardless of the makeup of their surfaces and in challenging conditions (weather, reflections etc.). As such, conventional 1D ultrasonic sensors possess many qualities that make them suitable for close-range object detection and avoidance. However, 1D ultrasonic sensors have a limited field of view and cannot detect objects in 3D space.

Toposens' ECHO ONE DK solution offers the advantages of traditional 1D ultrasonic sensors (robustness, reliability, light tolerance etc.), but provides for greater sensing coverage, supplying rich and reliable data for 3D perception. This makes the ECHO ONE DK extremely well-suited as a sensing solution for autonomous mobile robots (AMRs), automated guided vehicles (AGVs) and other types of robotic systems where perception in 3D space is necessary for safe and efficient operation. RR — *Dan Kara*

ULC Technologies Automates Underground Infrastructure Mapping

Organization Name:	ULC Technologies
Country:	USA
Website:	ulctechnologies.com
Year Founded:	2001
Number of Employees:	101–500
Innovation Class:	Application & Market Innovation
Innovation Subclass:	Utilities

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

The most common cause of underground infrastructure damage is not knowing where the infrastructure is located. The increased use of plastic pipes also reduces the reliability of existing underground scanning devices. The Robotic Underground Survey System (RUSS) employs the latest Ground Penetrating Radar (GPR) sensors to autonomously map underground infrastructure before the start of a digging operation.

Analysis:

In 2019, the Common Ground Alliance DIRT Report estimated that the annual societal costs of damages to buried utilities in the U.S. is approximately $30 billion.

RUSS is a semi-autonomous system that assists utility crews in locating and surveying underground infrastructure and by creating accurate maps of buried pipelines and cables.

The robot employs a dual antenna Ground Penetrating Radar (GPR) with multiple degrees-of-freedom to adjust antenna polarization angles and initiate multiple scanning modes. This allows for improved performance compared to conventional manual scanning that employs a human operator pushing a single antenna mounted in a cart.

Precise positioning of the dual antenna system is performed autonomously to provide finer resolution scans than a manual scan.

The base unit navigates along a predetermined path and avoids collisions leveraging several sensors that include Global Navigation Satellite System (GNSS) receiver, ultrasonic and LiDAR. RR

— *Mike Oitzman*

Verizon Forms Robotics Business Technology Business Unit

Organization Name:	Verizon
Country:	USA
Website:	www.verizon.com
Year Founded:	2000
Number of Employees:	500+
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Services Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In August 2021, **Verizon's** New Business Incubation group announced the formation of a new business unit – Robotics Business Technology (RBT). According to Verizon officials, the new group combines Verizon's Skyward, a drone management subsidiary, and incubed IT, a developer of software for autonomous mobile robots, which is also owned by Verizon. An additional engineering team focused on robot control using 5G Ultra-Wideband rounded out the group.

Analysis:

It is important that the RBT is focused on 5G communication and edge computing, specifically the development of software for unmanned aerial vehicles (drones) and mobile robots. Compared with earlier generations of mobile network technology, 5G provides for greater levels of raw speed and security, as well as lower latency and higher capacity. As such, 5G (coupled with edge computing) provides for capabilities that were largely impossible prior to the advent of 5G such as mixed vehicle communications between fleets of drones or mobile robots, and offloading compute to cloud-based services.

The real significance of the RBT unit's formation, however, is not just the group's intentions and objectives, but the ability to deliver on those aims and meet its goals. Other companies can launch dedicated robotics- or 5G-focused business units (or both), but Verizon is not just another company. Verizon is a multinational with massive resources at its disposable, and equally massive 5G and edge computing expertise, that combined can contribute significantly in ways that will drive the global robotics sector forward. RR — *Dan Kara*

Virginia Tech's FAA Approved Methods Open Doors for Drone Companies

Organization Name: Virginia Tech
Country: USA
Website: https://vt.edu/
Year Founded: 1872
Number of Employees: 13,000
Innovation Class: Technology, Services & Research
Innovation Subclass: Primary or Applied Research

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Virginia Tech's newly FAA-approved testing methods open the doors for many companies to get their drones in the sky. The university's testing methods take into consideration drones that are designed with intentional structural weaknesses.

The FAA's criteria for drone flight over people is based on the amount of kinetic energy it transfers upon impact. It doesn't take into account drones designed to crack or break upon impact, which lessens the amount of energy transferred.

Analysis:

Safety regulations are one of the biggest hurdles the drone industry is facing. In December 2020, the FAA updated its rules for drone flight, allowing drones that met certain conditions to fly over people. Under the new ruling, a drone's speed and weight, as well as if it has exposed propellers, are the main deciding factors in whether the drone can fly over people.

Virginia Tech's methods take into consideration how drones actually act in the real world by adjusting for drones that are designed to break on impact. With Virginia Tech's testing, more drones can be designed to meet the FAA's standards. This makes them able to fly in more places and brings us a step closer to wider drone adoption in the U.S. RR — *Brianna Wessling*

Viveka 3D Stereovision Solution Born of Necessity

Organization Name:	Vissavi.tech
Country:	Poland
Website:	https://vissavi.tech/
Year Founded:	1986
Number of Employees:	500+
Innovation Class:	Technology, Services & Research
Innovation Subclass:	Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

Vissavi.tech's Viveka 3D stereovision solution is a ROS-based, modular, cloud-connected platform for image capture, processing and analysis. Initially developed for through-hole assembly of electronic components on PCB boards, the Viveka 3D system delivers high levels of measurement accuracy (<0.03 mm), and can acquire images, process them, and then transfer the data to robotics systems in less than 300 milliseconds.

Central to the Viveka 3D system is the THT Check Component module for detecting the position of electrical component leads, the first vision module designed for Vissavi.tech engineers. The company has indicated that additional vision-based measurement modules for electronics manufacturing operations such as PCB hole detection, component edge detection, and shape detection, are under development.

Analysis:

The Viveka 3D system was developed following a survey of existing commercial solutions were evaluated for a complex electronics component assembly process at a customer site (inserting components into a PCB board). All were found to be lacking. As a result, Vissavi.tech decided to develop their own solution for component insertion.

Prior to the development of the Viveka3D solution, the cycle time for robots inserting components into PCBs was greater than that of manual methods, and even then the accuracy was suboptimal. Not so after the Viveka 3D system was implemented.

Using images from two cameras, Vissavi.tech's software builds a spatial model of the leads of electronic components in which deviations in their position can be tracked with great exactness. Robots utilize this detailed information to insert electronic components into PCBs quickly and with a high level of accuracy (yield of 99.8%). For Vissavi.tech engineers, the Viveka 3D stereovision solution attests to the truth of the old adage "necessity is the mother of invention" - and opportunity. RR — *Dan Kara*

XACT Robotics's ACE Xtend Protects Surgeons and Others

Organization Name: XACT Robotics
Country: USA
Website: https://xactrobotics.com
Year Founded: 2013
Number of Employees: 51-100
Innovation Class: Technology, Services & Research
Innovation Subclass: Product Introduction

2022 ROBOTICS BUSINESS REVIEW RBR 50 INNOVATION AWARDS

Description:

In October 2021, **XACT Robotics** introduced ACE Xtend, a remote control add-on solution that allows the company's XACT ACE Robotic System for image-guided percutaneous procedures (ex. biopsies, ablations and site-specific drug delivery) to be operated from a control room at a distance.

Analysis:

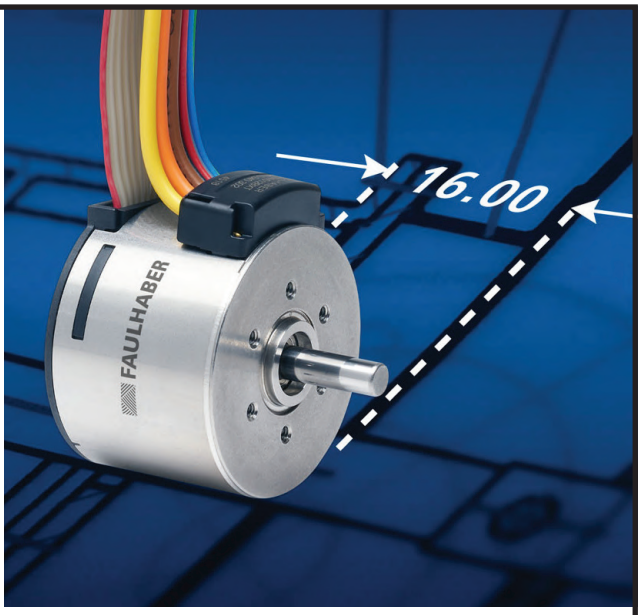
XACT Robotics's XACT ACE Robotic System has proven to be highly effective for robotically assisted percutaneous procedures. The system allows for CT-guided, hands free, robotic insertion and instrument steering, dexterously and exactingly positioning instruments within the body. According to XACT Robotics, the ACE system is the only product that can steer an instrument through a non-linear trajectory.

The advanced capabilities of the XACT Robotics's solution underscores why the use of robotics assisted surgical systems continues to increase steadily in number and the types of procedures they support. In addition, investment funding for surgical robotics firms remains high and shows no signs of abatement. As expected, new systems and supporting technologies come to market with regularity.

XACT Robotics's ACE Xtend solution is such a type of supporting technology. ACE Xtend protects surgeons and others from harmful exposure to radiation and pathogens during procedures, while reducing physical strain on the system's operator. That is a good thing, which will also generate additional opportunities for using XACT's ACE Robotic System, as well as remove one more adoption barrier for robotics assisted surgical solutions overall. RR — *Dan Kara*

Robotics

Small installation space? Don't compromise on performance



Generally speaking, electric motors are not "lone wolves" but for most applications need to be combined with gearheads for speed reduction as well as encoders. To ensure that the components are perfectly matched to each other and to minimise installation requirements, it is recommended to obtain the individual components as a complete solution from a single source. Even in cases where installation space is extremely tight and where high-torque drives are required which, owing to the installation situation, need to be as short as possible, there is a practice-oriented solution that is especially suitable for applications in robotics, prosthetic joints, laboratory automation, pumps, medical technology or aircraft cabin equipment.

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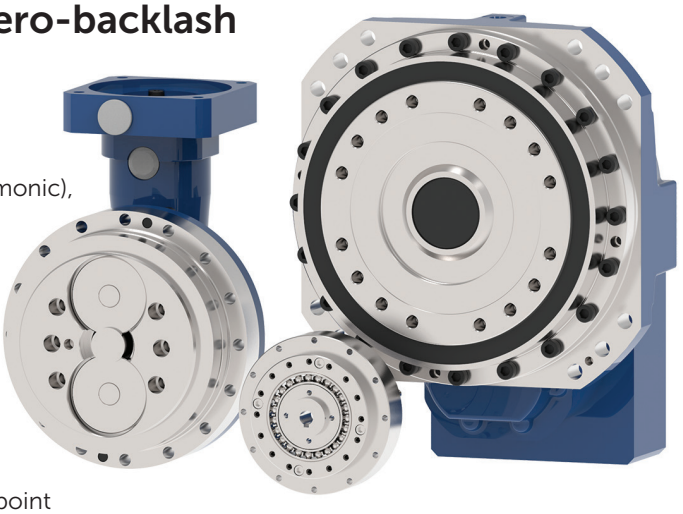
Robotics

GAM provides a full range of zero-backlash robotic flange gearboxes



GAM's extensive product offering includes three different zero-backlash gearboxes: Strain Wave (harmonic), Cycloidal, and the revolutionary Zero-Backlash Planetary.

- GPL zero-backlash planetary gearbox features a unique design ensuring backlash of ≤ 0.1 arcmin for the life of the gearbox. The GPL provides vibration-free motion and high positional accuracy for precise smooth path control and repeatability with a life of 20,000 hours.
- GCL cycloidal gearbox provides precise point-to-point motion and high impact resistance of 5x nominal torque with the option of an integral pre-stage.
- GSL strain wave gearbox uses harmonic-type gearing for high accuracy and drops in for popular competitor gearboxes.

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Robotics

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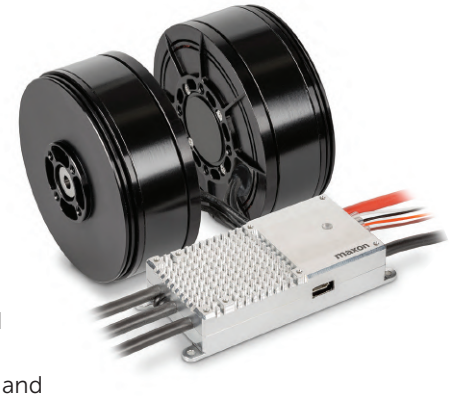

Unmanned vehicles require reliable components and, above all, energy-efficient drives that ensure the longest possible uptime. maxon DC motors meet these requirements without difficulty. Unmanned aerial vehicles enable dangerous missions, such as flying in disaster areas. maxon engineers transfer their knowledge from custom projects to other projects, whether actuators in passenger planes or stabilizers in unmanned aircraft.

- **Observation:** Inspection, agriculture, mapping and delivery drones.
- **Payload mechanisms:** control surface actuators, electro-optics, gimbal and load drives, winch and load mechanisms.
- **Drive systems** consisting of an optimized combination of motor, controller and propeller for multirotor, fixed-wing and VTOL aircraft.

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maxon actively supports UAV manufacturers with their ambitious designs, up to certification. Our UAV product portfolio offers matched combinations of motors, ESCs and propellers, for optimized propulsion systems providing maximum efficiency and reliability. Hence, operational safety and flight time are maximized, and costs of ownership dramatically cut down. maxon is continuously enhancing its portfolio to offer customers an extensive range of solutions. Reach out to us to get your ideas off the ground!

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Robotics

Maximize Robot ROI with Efficient Re-Deployment

Robots are flexible and adaptable. Quickly re-tasking robots for job variety can be challenging.

Some common solutions:
Changing workpieces – Quick-change gripper fingers and gripper changeouts are easily automated for workpiece variety or changing workpiece characteristics during manufacturing.

Flexible machine table fixtures – Robots are widely identified for their ability to handle workpieces. They also excel at automatically replacing fixtures and other peripheral tooling.

Automating multiple tasks – Use the robot to accomplish a secondary task. Instead of remaining idle during machining, the robot can automatically deburr workpieces.

Adjustable custom tooling – Use dove tails and adjustable mountings in EOATs to expand tools for changing conditions or reach requirements.

Many standard solutions are available - make the most of your investment with automation expert support today!

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