Where robots are doing the work

A long-term global trend and the technology used in Alaska

By LIZ BROOKS

Automation is a global trend prompting excitement about technology and potential savings as well as concern about what people will do when machines do more of the work.

The pandemic accelerated this trend as the need grew for contactless and distance delivery of goods and services, focusing on online services such as automated banking and virtual doctors' appointments. Conversations about automation have since expanded to include the potential and pitfalls of artificial intelligence. Researchers recently estimated 80 percent of workers in the U.S. do at least some tasks that artificially intelligent computer programs could do.

Robotics is another type of automation growing with technological advancement and demographic trends, and it's been around for a long time. (See "What's a robot?" on page 7.) In 2021, 3.5 million industrial robots operated worldwide, and the number has increased by 14 percent a year on average since 2016.

Last year, North American companies ordered a record 44,196 robots valued at $2.38 billion. These figures represented 11 percent and 18 percent increases, respectively, over 2021.

Robotics didn't boom nationwide during the pandemic in the same way as online services, but the pandemic did encourage some interesting experimentation. For example, the Juneau City Museum offered remote tours in 2020 via tablets mounted on wheels. Virtual visitors controlled the devices remotely, directing them around the museum to look at displays. The idea didn't stick, however, and the museum returned the devices.

Robotics is growing in Alaska, however. The clearest examples are of robots doing things humans cannot do, or can't do as fast, cleanly, or safely.

Alaska hospitals are home to 11 da Vinci sets used to perform robot-assisted surgery, usually in the torso. Surgeons move robotic "arms" via a console, enabling them to operate through smaller incisions than the surgery would otherwise allow.

Other examples include Ravn Alaska using ultraviolet lights on mobile robotic devices to disinfect plane cabins and Alyeska Pipeline Service Company using sensor-laden tools to inspect the pipeline's interior for wear and tear. A few seafood processors use robots to process fish and even to pack and palletize fillets. Robotic devices aid in research as drones or as underwater remotely operated vehicles.

This article will explore some of these examples and discuss how and why robotics is on the rise.

At left, biologists at the Alaska Department of Fish and Game use this submersible remotely operated vehicle, which they call "Buttercup," to study rockfish near Homer. Above, an Omron UV disinfection robot moves around inside a U.S. hospital. (Photos courtesy of ADF&G and Omron)

Percentages of manufacturing workers exposed to robots by state, 2019

Notes: Excludes estimates for states with unpublished data and those where margins of error exceeded 40 percent: Montana, Oklahoma, Vermont, Hawaii, New Mexico, and Wyoming. See the sidebar on page 7 for more about these survey estimates and their limitations.

Source: U.S. Census Bureau, Annual Survey of Manufacturers

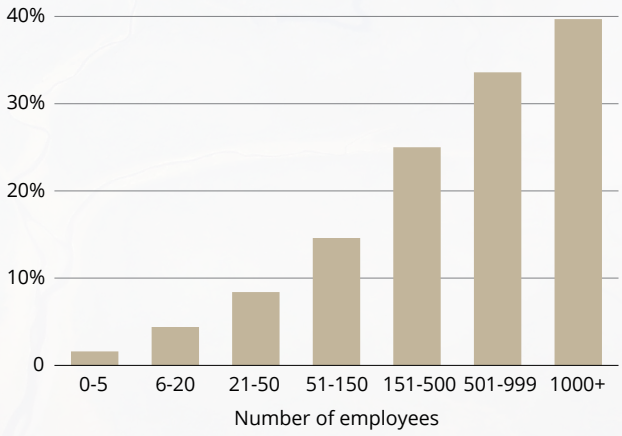
Multiple factors driving the trend

Robotics shows more promise for some types of work than others, but multiple technological and demographic trends are driving its integration.

While robots are sometimes used for intricate work such as surgery or jobs humans can't do, it's the dull, dirty, or dangerous work that's often targeted for automation. That's why 44 percent of robots installed globally between 2019 and 2021 were for materials handling: industry jargon for lifting heavy items.

Human labor has also become scarcer in recent years. The number of working-age people nationally is still growing, but growth has slowed. In Alaska, our working-age population has gotten smaller every year since 2013 — in 2022, it was 6 percent below the peak. (See the March 2023 issue of *Trends*.)

Shares of U.S. manufacturing plants using robots, by plant size, 2019



Source: U.S. Census Bureau, Annual Survey of Manufacturers

Much of that change came as the large baby boom generation reached retirement age, and the pandemic added pressure as employers everywhere reported trouble filling open positions, a challenge that continues three years later.

The growth in job openings — which hit a new high in 2022 — presented an additional obstacle in Alaska, where about 20 percent of the yearly workforce comes from outside the state, especially for seasonal work. Seafood processing, one of Alaska's largest seasonal employers, imports nearly three-quarters of its workers from outside Alaska, but attracting them has gotten harder.

While Alaska's average wages remain higher than the U.S. — a draw for out-of-state workers — that gap has been shrinking. (See the December 2022 issue of *Trends*.) Labor is getting more expensive, and as wages grow, so do operating costs.

As costs rise and technology advances, using robots has become increasingly appealing to employers.

Where the robots are globally

That shift is global. In 2021, China led with the number of new industrial robots installed at 268,000, followed by Japan (47,000) and the U.S. (35,000). Most customers of industrial robots in China and Japan were electronics manufacturers, whereas U.S. customers were mainly automotive manufacturers.

Auto manufacturers first introduced robots to their assembly lines in the 1960s, primarily to weld and handle heavy parts, and pioneered their use. By 2019, almost half of U.S. auto manufacturing employees worked in plants with robots. The larger the plant, the more likely it is to have robotic equipment, as the bar chart on the previous page shows. Twenty-five percent of facilities with 51 to 150 employees had robotic equipment in 2019, rising to 40 percent of facilities with 1,000 or more workers.

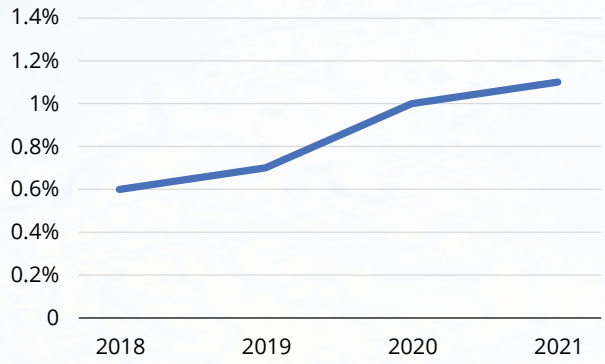
Manufacturers made up almost three-quarters of U.S. robotic equipment purchases in 2021. As the exhibits on this page show, U.S. companies spent $11.5 billion buying robotic equipment in 2021. That represented 1.1 percent of total equipment purchases made that year, up from 0.6 percent in 2018, the earliest year these data were available.

U.S. robotics capital spending, 2021

Industry	Robotics spending
Total	**$11,536,000,000**
Manufacturing	$8,581,000,000
Durable goods manufacturing	$6,259,000,000
Nondurable goods manufacturing	$2,321,000,000
Retail trade	$1,316,000,000
Health care and social assistance	$704,000,000
Wholesale trade	$265,000,000
Professional, scientific, tech svcs	$238,000,000
Transportation and warehousing	$190,000,000
Forestry, fishing, agriculture	$44,000,000
Real estate, rental and leasing	$34,000,000
Information	$30,000,000
Construction	$26,000,000
Accommodation and food svc	$26,000,000
Mining	$15,000,000
Other services (except public)	$14,000,000
Finance and insurance	$13,000,000
Admin, support, waste mgmt	$13,000,000
Educational services	$10,000,000
Arts, entertainment, and rec	$8,000,000
Utilities	$5,000,000
Management of companies	$4,000,000

Source: U.S. Census Bureau, Annual Capital Expenditures Survey, 2021

Robotics grows as a percentage of national capital expenditures



Source: U.S. Census Bureau, Annual Capital Expenditures Surveys, 2018-2021

Light use in Alaska manufacturing

In Alaska's manufacturing sector, about 14 percent of workers are exposed to robots on the job, which is well below the 26 percent of manufacturing workers nationally. That makes sense when you consider the prevalence of car manufacturing and massive meat plants in the Lower 48, whereas seafood processing makes up about two-thirds of all manufacturing in Alaska.

When the estimates are adjusted to reflect what

What's a robot, and where do the numbers come from?

The International Federation of Robots tracks annual installations of robots around the world by collecting data directly from robot suppliers. The Association for Advancing Automation tracks data on the U.S. robot market. Both of these sources use a strict definition of "robot."

The International Federation of Robots defines robots specifically as manipulators with at least three axes that are automatically controlled, reprogrammable, and multipurpose. Other similar mechanisms, such as those that are fully teleoperated (meaning they have no autonomy) but otherwise satisfy the definition, are called robotic devices.

The Census Bureau has also collected data on robotics since 2018 through two surveys (see the next subsection), which use the term "robotic equipment," a less restrictive category that includes semi-autonomous devices.

This article uses an expansive definition of robotics that technically describes several uses of robotic devices rather than true robots. Thus, "crawler pigs," which are remote-controlled sensor-laden devices that inspect pipelines' interiors and have cable tethers, are robotic devices. (They're used for inspecting narrow pipelines that can't accommodate larger inline inspection tools.)

Typical tasks that robots perform in industrial settings include assembly, cleaning, delivery, dispensing, inspection, machine tending, material handling, packaging, painting, palletizing, pick-and-place, rescue, security, and welding.

Our definition excludes automatic teller machines, computer numerical control machining equipment, and kiosks. Kiosks are stationary, consumer-oriented machines with a graphic interface and no visible moving parts.

More on the Census Bureau surveys

The Census Bureau's robotic device surveys cover:

1) Data on business expenditures for new and used robotic equipment collected as part of its Annual Capital Expenditures Survey. The survey represents all U.S. nonfarm businesses with and without employees. Data are published by industry, but not by state.

2) Data on the total number of industrial robots in operation at each manufacturing plant, the number of robots purchased during the year, and the capital expenditures for new and used industrial robotic equipment, collected through the bureau's Annual Survey of Manufacturers.

Estimates of robotic use derived from this source have high levels of uncertainty, which is why several states' data are missing from the large bar chart on page 5, and margins of error can be large.

Both Census Bureau surveys were recently discontinued and will be replaced by the new Annual Integrated Economic Survey, which will begin collecting data solely from employers in early 2024.

states' percentages would be if they had the same mix of manufacturing as the nation, Alaska drops to just 9 percent, and Minnesota, Nebraska, and Michigan rank highest. (See the chart on page 5.) Minnesota ranks first in part because it created programs to increase automation in small manufacturing facilities.

Seafood processing might seem ripe for growing robotics use, as the tasks are repetitive and performed in remote and sometimes dangerous conditions — but even nationally, the industry has been slower to adopt robots than some types of manufacturers.

Researchers who studied how seafood processors on the East Coast responded to the pandemic found the high cost of new technology was the primary reason plants didn't adopt robotic equipment. Space constraints and the need to adapt facilities to process different species depending on the season were also mentioned as reasons automation in seafood processing was less productive than it might seem.

Those challenges are amplified in Alaska, where costs are higher and logistics are challenging. Still, robotic solutions are beginning to appear in Alaska.

All large Alaska seafood processing facilities have already mechanized portions of their lines. Mechanization differs from robotics in that these machines can only perform one task, and mechanized plants still require hundreds of people to run. People orient fish before feeding them into the processing machines, keep facilities clean, and maintain the equipment.

Mechanized machines make a big difference, too, in that they are as good as human operators or better and they're definitely faster. Mechanized size-sorting, heading, gutting, washing, filleting, pin-boning, and skin removal are already common in the state. Makers of one machine advertise it can fillet up to 150 Alaska pollock per minute.

Robots can do even more, with fewer people. A machine that uses sensors to automatically adjust knives based on individual fish anatomy can fillet 25 salmon a minute while maximizing fillet size. Robots can also portion, vacuum seal, package, and palletize products. While these upgrades aren't yet widespread in Alaska, a few large plants have made the leap.

Robotic devices aren't common in the remainder of Alaska's manufacturing sector, which makes a range of products from beer to baked goods to custom furniture, usually in small businesses. Some of these other manufacturers told researchers robots aren't viable for the small quantities they produce. Robots are expensive and ultimately perform a small set of repetitive tasks — a poor fit for manufacturers that make custom products or handle one-off projects.

Pipeline inspection came early

Alaska's main oil transport company, Alyeska Pipeline, has used robotics in its operations for more than 30 years.

Specifically, sensor-laden tools that inspect the pipeline from the inside — the industry calls them smart pigs and inline inspection tools — are run through the pipeline every three years. Their use is standard in pipelines around the world.

Inline inspection tools are an early example of a growing trend called predictive maintenance, which can reduce unexpected breakdowns or interruptions. Sensors monitor the health of industrial machines rather than relying on routine maintenance schedules, so they can catch maintenance problems in their infancy.

Sensors continuously detect vibration, pressure, force, acoustics, or energy loads and share those feeds wirelessly with a computer. The computer's machine learning programs, which recognize the healthy states of those feeds, can detect anomalies in real-time.

Alyeska uses three kinds of inline inspection tools:

- *Ultrasonic transducer pigs* use sound waves to measure the thickness of the pipeline's steel wall. The transducer pigs receive echoes from the internal and external surfaces of the pipe and, by timing these signals and comparing them to the expected speed of sound through steel, they can determine wall thickness. Ultrasonic inspection tools to detect wall thinning and X-ray tools used for welding inspection were first developed in the 1970s.

- *Magnetic flux leakage pigs* saturate the pipe wall with magnetism. Sensors between the poles of the magnets detect damage from corrosion or physical impact. The first smart pigs developed in the 1960s used this technology.

- *Curvature pigs,* also known as deformation or caliper pigs, use navigation technology to provide a 3D model of the pipeline's centerline coordinates. Gyroscopes and accelerometers are used to calculate the pig's position rather than relying on external references such as satellites, which global positioning systems use. Comparing data to previous inspection runs allows engineers to monitor dents and "ovalities" in the pipe. (Ovalities are when a pipe is no longer perfectly round but bowed into an oval shape.) Engineers can also identify unstable ground by detecting pipeline movement.

Within the oil and gas sector nationally, advancing robotics centers on detecting methane gas leaks. Governments around the world have enacted regulations to reduce methane gas emissions. Methane is odorless and colorless, making it hard to detect, plus many points in the production stream are vulnerable to fugitive emissions. Sensors installed at production facilities or on aircraft, including drones, are two leading solutions launched recently.

Use in Alaska fisheries research

Fisheries researchers for the Alaska Department of Fish and Game use a remotely operated vehicle to assess the population size of yelloweye rockfish and other groundfish in Southeast Alaska and Prince William Sound. Researchers used a manned submersible until 2009, but high costs and limited availability prompted the department to switch to an ROV, which the department has owned since 2005 (shown in the photo on page 4). ROVs are equipped with high-definition video cameras and powerful lights.

Fish and Game has used its ROV, a Phantom 2 + 2 device nicknamed Buttercup, to assess the impact of development projects, to recover tools and moorings on the seafloor, and, more recently, to deploy and recover larval settlement structures for a deep sea coral study.

ROVs are tethered to a ship on the water's surface by

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a group of cables that provide electrical power from the ship and transport data through optical fibers. ROVs are technically robotic devices rather than robots, a term that typically applies only to programmable devices. (See the sidebar on page 7.)

Side-by-side analysis of data obtained from ROV and manned submersible surveys showed the ROV provided comparable estimates.

Drones show broad promise

The University of Alaska Fairbanks is home to one of the Federal Aviation Administration's seven drone technology testing sites in the country. Earlier this year, its drone research center received an FAA waiver to test pilot drones along a 20-mile stretch of the pipeline. A pilot will fly the drones — which could be used to inspect the pipeline in future applications — beyond the line of sight. Ideas abound for commercial applications of drone technology in Alaska, such as cargo and medicine delivery to remote areas — but the FAA requires operators to fly drones only within their line of sight.

Regulations will have to change before the business case for most commercial applications pencils out, but Alaska researchers will continue to test new technology. This summer, UAF-affiliated researchers and their commercial partners will fly autonomous Cessna Grand Caravans between Fairbanks and Nenana to test technology that uses sensors to autonomously detect and avoid other flying objects. The goal is to eventually develop both remotely controlled and autonomous technology to safely deliver cargo to remote places.

Liz Brooks is a research analyst in Juneau. Contact her to share additional examples of robotics or automation used in your industry. She can be reached at liz.brooks@alaska.gov or (907) 465-5970.

EMPLOYER RESOURCES

Resources for Alaska's agricultural employers

Agriculture plays an essential and growing role in sustainability and the production of commodities throughout Alaska. Local farmers, producers, and growers enhance the state economy, provide fresh products, and allow the state to remain competitive in the global marketplace.

With more than 1,000 farms primarily located in the Matanuska-Susitna Borough, Fairbanks, and Kenai Peninsula, Alaskan agriculture includes livestock, nursery work, tree farming, and crops such as hay, potatoes, and barley. Alaska's aquaculture produces aquatic plants, including kelp and seaweed, and shellfish such as oysters, mussels, clams, and scallops. Agriculture and aquaculture are expanding in Alaska as new technologies and methods have emerged for growing and producing food in some of the harshest environments in the country, primarily through seasonal work.

Alaska's job center staff help agricultural employers fill seasonal positions by assisting with job orders in AlaskaJobs and referring qualified Alaskan workers. Recruiting employers can call (877) 724-2539 to connect with their nearest job center and visit jobs.alaska.gov/employer to find comprehensive information on recruiting, labor laws, and hiring incentives such as tax credits and bonding.

Agricultural employers are required by state and federal law to post the Notice of Migrant and Seasonal Agricultural Worker Protection Act poster in a space conspicuous to their workers to ensure that housing for migrant and seasonal workers is safe and habitable and that those workers receive equitable treatment.

For information and assistance on migrant and seasonal farmworkers, contact Alaska's State Monitor Advocate at nakita.mongar@alaska.gov. Employers may also review Alaska's most recent Agricultural Outreach Plan incorporated in the 2022 WIOA State Plan Modification. For information about hiring foreign temporary agricultural workers, employers can contact Alaska's Foreign Labor Certification program at dol.flc@alaska.gov.

Employer Resources is written by the Employment and Training Services Division of the Alaska Department of Labor and Workforce Development.