



// THE CURRENT STATE OF AUTOMATION IN THE FREIGHT INDUSTRY // //

A tractor-trailer loaded with beer traveling over 100 miles of freeway without a human driver. A port terminal with no dockside workers. Warehouses with more robots than people. Given the type of automation already underway across the nation's freight system, the most pertinent question isn't *if* freight automation will happen but *to what extent* and *when* freight automation will occur.

In this section, we characterize the current state of freight automation as well as the pace of its development. Although our focus is primarily on the near term, especially the next 5 to 10 years, the longer-term horizon is critical to keep in mind, because increases in automation serve as stepping stones to potentially more significant automation later.

Freight automation is not an all-or-nothing proposition: levels of automation can range from making a worker's job easier and safer to eliminating the need for a human being entirely. Similarly, automation may shape the entirety of the freight system or be concentrated in a portion of it.

COVID-19'S UNCERTAIN IMPACT ON FREIGHT AUTOMATION

About midway through writing this report, the coronavirus pandemic surged across the globe, killing more than two million people, sickening tens of millions, and wreaking havoc on local and global employment and economies. The United States has been particularly affected, with more cases and deaths than any other country. Naturally, the spread of COVID-19 is impacting the freight transportation system too.

In April 2020, for example, more than 88,000 trucking jobs evaporated, “wiping out four years of trucking employment growth in one month.”⁶ But, by later in the year, the Ports of Long Beach and Los Angeles saw a surge of traffic due to increased e-commerce from consumers ordering more online.⁷

Many questions remain about the pandemic's implications for the state of freight automation in the United States. In the near term, community residents and advocates have expressed concern that the pandemic will result in less transparent decision-making processes, not only for automation but for freight decisions in general. In Joliet, IL, for example, residents were able to successfully slow the development of a massive warehousing facility. The coronavirus changed that: “With much of the nation sheltering in place and ramping up the need for home deliveries, supporters of the warehouse project have used the pandemic as a reason for government officials to quickly approve the development. And opponents...have felt hamstrung to fight back, because COVID-19 is forcing government meetings to be held virtually,”⁸ which prevents a more robust city hall presence.

For the longer term, there is concern that the pandemic will ultimately speed up freight automation. For example, concerns about spreading the virus through physical interactions, like handing a paper document from a driver to a warehouse operator, has accelerated freight companies' interest in digitalizing their operations.⁹ Such digital platforms, in turn, are foundational to broader automation efforts. Others see human-beings' vulnerability to something like COVID-19 as the impetus for more automation. As one freight analyst put it:

The supply chain is, at heart, physical. It moves large amounts of physical goods around, and at almost every step of the way it is propelled by human labor. Truck drivers. Crane operators. Workers loading and unloading containers. Stevedores. Seafarers. As the pandemic spreads...we will see a decline in the availability of all these people. Some fall ill themselves, others need to stay home to care for their family. ... Just as with digitalization, automation of the physical part of the industry has also been under way for several years and as such the pandemic is not a game changer, but will serve to accelerate the development. We will see a more rapid uptake in remote-controlled technology that enables the use of skilled

people without a physical presence at a specific location. We will likely also see an acceleration in the use of fully autonomous equipment in settings where this can be practically incorporated.¹⁰

The counterargument to the view that the coronavirus will speed automation rests on matters of money and the heart. First the money: ever increasing levels of automation are more expensive. Given the fallout in the US economy in 2020, the freight transportation system will need time to recover. McKinsey & Co., for instance, predict a “full recovery will take about three to five years, a rough patch in which companies will be severely tested.”¹¹ During this time, it may be difficult for companies to invest in increased automation. Then there's the heart: Throughout the pandemic, the public and policymakers have hailed frontline essential workers as the heroes of the moment as they've kept supplies on shelves and food delivered to our doors. That sentiment could be leveraged so their work is protected, enhanced, and made safer—not simply replaced with automation. ■

Predictions are fallible, of course. Apart from technological uncertainties, external factors—legal, economic, political, public sentiment—may also play a major and, at times, unpredictable role in shaping the pace and scope of freight automation. The complexity of these types of factors add a great deal of variability to identifying freight automation trends.

With the above caveats in mind, following is a sector-by-sector breakdown of freight automation, including where things stand now and what's likely ahead.

TRUCKING

It's difficult to overstate the significance of trucking to the country's freight transportation sector. Trucks handled more than 11 billion tons of freight in 2019—greater than 70% of the domestic total.¹² More than 3.5 million people work as truck drivers, and between 2012 and 2016, trucking businesses grew at a rate that outpaced total industrial growth. More than half of trucking businesses are considered long distance, shuttling goods from one corner of the country to the other and beyond.¹³ In 2017, the American Trucking Associations estimated that all registered trucks traveled more than 297 billion miles,¹² which equates to more than 60,000 round trips to the moon.

The extent of truck automation

Truck automation is varied. In some instances, the driver is in complete and total control. In others, the truck may not even be built with a steering wheel or space for a human occupant. Between these two extremes are more nuanced levels of automation, where a human may

still control some specific driving functions (e.g., steering but not braking) or portions of a journey (e.g., more complicated roadways). The US Department of Transportation categorizes six levels of driving automation, from none (zero) to full automation (five).¹⁴

Levels of Driving Automation Used by the Department of Transportation

No automation	Driver assistance	Partial automation	Conditional automation	High automation	Full automation
0	1	2	3	4	5
Human driver controls all aspects of dynamic driving task	Automation controls one vehicle function (steering or speed) with the expectation that the human driver performs all remaining aspects of the dynamic driving task	Automation controls both steering and speed with the expectation that the human driver performs all remaining aspects of the dynamic driving task	Automation performs all aspects of the dynamic driving task with the expectation that the human driver will respond to a request to intervene	Automation performs all aspects of the dynamic driving task under certain roadway and environmental conditions, even if a human driver does not respond to a request to intervene	Automation performs all aspects of the dynamic driving task under all roadway and environmental conditions that can otherwise be managed by a human driver

Source: GAO analysis of U.S. Department of Transportation information (GAO-19-161)

Driver-assistance technologies are a major category of truck automation. Examples include automatic braking for emergency situations and technologies like lane-departure warnings and blind-spot detection, neither of which automates driving functions, but they provide alerts to the truck driver.* Another example is adaptive cruise control, which automatically adjusts the vehicle speed to maintain a safe distance from traffic.

Freight and technology stakeholders see automation efforts focused first and foremost on long-haul trucks (i.e., those traveling hundreds of miles on a single route). Those automation efforts generally fall under one of three different scenarios:

- *Platooning*: Linked by various communication technologies, one or more trucks follow behind a lead truck at distances that are much closer than would be safe without automation. Should the lead truck brake quickly, the remainder of the trucks would brake nearly instantaneously. A more advanced platooning variation has a human driver in a lead truck followed by one or more “drones”—driverless trucks that track the lead truck’s speed and movement.
- *Self-driving a portion of a route*: Also called exit-to-exit automation, trucks would have high or full degrees of automation, but only on certain predetermined portions of a long-haul route. For example, a driver might steer a truck to a freeway on-ramp and then engage the automation system, reclaiming control at the appropriate off-ramp.
- *Self-driving a full route*: From the local roads near freight warehouses to the open highway, an automated truck would handle it.

* Technically, warning systems aren’t typically classified as automation. We include them here, however, because of their increasing prevalence and because they’re foundational to more advanced types of automation.

The timing of truck automation

As different truck automation scenarios unfold, the time frames in which various forms of automation happen will vary considerably. Although these time frames can be uncertain, there are clear trends.

Time Frame and Technologies	Anticipated Deployment
<p>0-5 years:</p> <p>Driver-assistance technologies</p> <p>Platooning</p>	<p>Adaptive cruise control, automatic braking for emergency situations, and other technologies like lane-departure warnings and blind-spot detection are commercially available now for new and older trucks. Market demand for these types of technologies is “quite strong,”¹⁵ so their use will grow considerably in the future.</p> <p>A range of platooning technologies is commercially available now. More basic are those where the following drivers are responsible for steering but not for speed or braking. More advanced forms are in the precommercial state of development but are close to commercial use.¹⁵</p> <p>Given what we have now, “platooning will likely deploy within the next 5 years and will be the first automated trucking technology to be widely available.”¹⁴ Others estimate an even faster deployment.¹⁶</p>
<p>5-15 years:</p> <p>Self-driving a portion of a route</p>	<p>Per one comprehensive summary, “Automated trucks that are self-driving for part of a route may become available for commercial use within the next 5 to 10 years, according to several stakeholders, including technology developers.”¹⁴ Other researchers and reports make similar estimates.</p> <p>An important caveat: this type of highway-centric automation will likely be concentrated at first in the “southwest United States because of its good weather and long highways,”¹⁴ such as interstate highways I-10 and I-40. Such automation will likely then spread over 10-15 years to other “key freight lanes nationally on a seasonal basis.”¹⁶</p>
<p>≥20 years:</p> <p>Self-driving the full route</p>	<p>It will likely be several decades “before driverless trucks will be able to routinely navigate local streets packed with cars, pedestrians, cyclists, road work, and other unexpected challenges. Humans will also be needed to handle the many non-driving tasks—coupling tractors and trailers, fueling, inspections, paperwork, communicating with customers, loading and unloading, etc.—that drivers currently perform.”¹⁶</p>



WAREHOUSES

Warehouses occupy a critical nexus between the creation of a good or product and the delivery of that product. Also known as distribution centers, warehouses are “responsible for the storage, flow and rerouting of goods to consumers or retailers.”¹⁷

There are nearly 17,000 warehouses in the United States,¹⁸ generally clustered around major population centers and close to the nation's transportation thoroughfares. This includes places like inland southern California, the greater Chicago area, Dallas–Fort Worth, and the New York–New Jersey area.¹⁷ Driven in part by the explosive growth of e-commerce, both the number and size of warehouses have increased over the past two decades. The average size of warehouses built between 2012 and 2017 increased by 143% (184,693 sq. ft.) compared with warehouses built between 2002 and 2007.¹⁹ In the Inland Empire of California, the average size of new warehouses is approximately 338,000 sq. ft.¹⁹—equivalent to nearly six football fields.

More than one million people were employed in the warehousing and storage sector in 2018, a number that excludes warehouse workers hired through temporary staffing agencies.²⁰ Typical warehousing activities include unloading and putting away goods; storing them until they are needed elsewhere; “picking,” or selecting items for later shipment; and shipping, including preparing orders and loading goods.¹⁷

The extent of warehouse automation

Warehouse automation starts with increasingly sophisticated warehouse management systems (WMS) – software that helps control and manage day-to-day operations as goods flow to and from the warehouse. On their own, WMS are typically used to increase operational efficiencies and reduce user error.

Warehouse management systems also serve as a foundation for more hardware-focused automation. The range of automation applications is rather diverse; below are examples of foundational and/or significant advances in warehouse automation, as captured by a recent comprehensive report.¹⁷

- **Automated guided vehicles:** Technology-enabled material moving vehicles...that transport goods along preset routes in a facility
- **Robotic picking:** A robotic arm is equipped with hand-like or suction-cup grippers that can reach into a pick location, grasp an item, and place it into a tote.
- **Goods-to-person systems:** Goods-to-person systems bring items to the worker for order picking. This can, for example, take the form of a shelf mounted on a robot that makes its way to the picking station...or a hanging bag sorter that brings individual items to a worker via an overhead-mounted pouch.

- **Voice-directed systems:** Workers wear a headset that provides instructions on what items to pick or put away and where they are located, and workers confirm the location and items by speaking standardized commands.
- **Autonomous Mobile Robots (AMRs):** Automated carts that travel around a warehouse, moving items for orders between picking and sorting or packing locations. Two subcategories exist: “relay” carts and “follow-me” carts. Relay AMRs can work with most picking processes; the order picker selects the items for the order, places them in the cart or tote, and the AMR delivers the tote to the next task station. A follow-me AMR leads a worker through the warehouse, setting the pace and directing the worker to select particular items.
- **Sensors:** Sensors have many applications in the warehouse, from dynamically tracking inventory, to monitoring the movements of workers, to controlling energy usage.

The timing of warehouse automation

Significant warehouse automation is already in place now. For example, across Amazon’s 175 fulfillment centers worldwide, 26 have “robots and people working together to pick, sort, transport, and stow packages.”²¹

Generally, the presence of such automation is limited to a smaller portion of early adapters across the warehouse sector. For example, WMS, which help control and manage day-to-day operations as goods flow to and from the warehouse, are “considered to be a fundamental building block for the adoption of other technologies,” but an estimated 33% of warehouses do not use one.¹⁷ Even for the majority of warehouses that do use WMS, that doesn’t mean that incorporating additional automation happens readily or quickly.

There are significant barriers to full adoption of automation within the warehouse sector, including that the “industry is characterized by slim profit margins and cost-sensitive competition, which leads to a cautious approach to technology adoption.”¹⁷ That isn’t likely to change much in the next 5 to 10 years. A variety of other factors comes into play too. For example, companies’ heavy reliance on outsourcing warehousing services to third-party logistics companies acts as a brake on automation. Outsourcing contracts tend to be relatively short (e.g., 3-5 years), thus making it difficult for a third-party logistics company to realize an automation-related return on investment. There’s also the question of how advanced automated technology is versus how advanced it needs to be for large-scale adoption. As one warehouse manager put it, “I struggle to find the robot that will be able to handle a bag of plaster of Paris, a bit for a jackhammer, a galvanized steel garbage can, a saw blade, and a five-gallon bucket of paint. Oh, by the way, what happens when that [plaster of Paris] bag ruptures? How does the robot know that the bag is ruptured?”¹⁷

In contrast, labor dynamics and conditions act as powerful tailwinds to support automation. Between a very low national unemployment rate (albeit prior to the COVID-19 pandemic) and low wages within the warehouse sector, the warehouse sector has had a difficult time meeting its labor needs, a dynamic that intensifies during the holiday season when e-commerce spikes. Another issue is the rising cost of real estate. Rents are increasing as vacancy

rates are on the decline, putting more cost pressure on the sector, which creates the need for cost cutting. Last, there's the ever-increasing push to deliver goods more rapidly. Within the industry, automation is seen as a potential way to address these cost and efficiency factors.* Indeed, one 2019 industry survey indicated that 39% of respondents anticipated investing in some level of automation technology within the next 5 years.²²

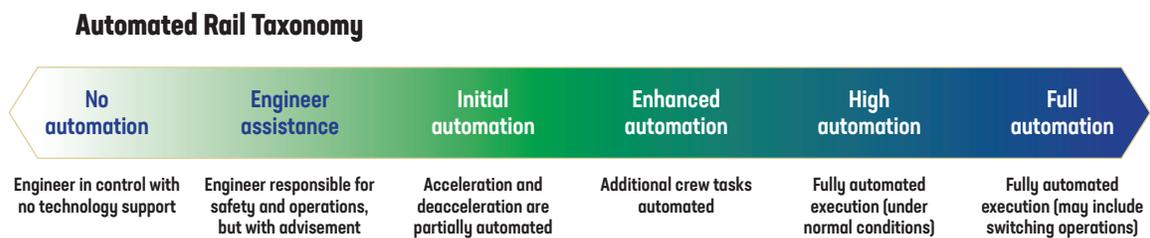
These factors make it difficult to predict exactly when large-scale warehouse automation will occur. Still, on balance the warehouse sector is moving toward an ever-more automated future: "Over the long term, in the absence of major shifts in the economy or context of firms' technological adoption strategies, the increasing use of technology points to a labor reduction."¹⁷



Composed mostly of large national rail lines, approximately 140,000 miles of track, and anchored by sprawling rail yards in each region of the country, freight railroad companies haul fuel, agricultural products, manufacturing components, consumer goods, and more—57 tons of goods per American per year.²³ Over the past several decades, the rail industry has grown more integrated with the rest of the freight system: the American Association of Railroads estimates that nearly half of its carloads are intermodal, meaning the trains carry containers designed to be transferred to other forms of transportation, such as trucks and ships. More than 160,000 people are employed by rail companies.²⁴

The extent of rail automation

Much like the trucking sector, train-related automation is varied and can easily be thought of along a spectrum ranging from zero automation, where humans are in full control of all operations, to full automation involving no human input. In between are levels of semiautomation whereby portions of an operating crew's workload are either supported or replaced by specific technologies. The Association of American Railroads (AAR), an industry group representing major railroad companies, recommends the following taxonomy²⁵:



* For an in-depth overview of the factors facilitating and constraining warehouse automation, see this publication by Beth Gutelius and Nik Theodore: *The Future of Warehouse Work: Technological Change in the U.S. Logistics Industry*. UC Berkeley Labor Center, Working Partnerships USA; October 2019.

Currently, all types of automation on this spectrum are technologically feasible. There is fuel and energy management technology (think cruise control but for trains), train sensor data and alarms to provide crews situational awareness while in operation, and positive train control (PTC) technology to prevent collisions by controlling train speeds and movements.²⁶ Although there is no fully autonomous freight rail service commercially operating in the United States, it's not because of lack of technology: the mining company Rio Tinto uses fully autonomous trains to shuttle iron ore on approximately 1,000 miles of track through the Australian Outback.²⁷

The timing of rail automation

Many of the mid-spectrum automated technologies for trains, particularly those related to fuel use and safety, are in place already. Various technologies have been implemented piecemeal by different railroad companies as “add-ons.” In other instances, automated systems have been adopted at a system-wide level. For example, after a 2008 freight and commuter train collision in Los Angeles, CA, that killed 25 people when an engineer missed a stop signal, Congress mandated the adoption of PTC technology. Twelve years and \$10 billion dollars later, the safety system is mostly in place.²⁸ Automated technologies are also being put to use to inspect wheels and tracks.²⁹

Full automation under limited or all conditions is rare. There is the example of Rio Tinto, and also a successful test in Colorado in 2019, when “three locomotives and 30 loaded wagons carrying [5,208 tons] were moved without human intervention along a 48-mile test track.”³⁰ Beyond these examples, it is hard to predict the next 5 to 10 years, because of opposing political perspectives.

Opponents of high levels of train automation frequently raise safety and employment concerns. The Transportation Division for the Sheet Metal, Air, Rail, and Transportation Union has stated: “In valuing safety as the highest priority, it is important to understand the essential roles that human employees play in the safe operation of trains. There are countless essential functions that humans perform, using their perception and judgment that cannot be replaced by automation, especially on America’s vast rail system that covers an incredible geographical and weather diversity.”³¹ The Union also emphasized the role onboard workers can play in “thwarting hostile actors and terrorism,”³¹ and cited concerns about cyberattacks in which a fully autonomous train could be taken over with no onboard worker to intervene. The Union has expressed strong worries about job loss: “The automation of train operations has the potential to cause the loss of tens of thousands of good paying union jobs across America. The potential for the dislocation of workers in the event automated rail operations become common practice is extreme.”³¹ The Union was not alone in its concerns: the Federal Railroad Administration’s call for comments on rail automation received more than 3,300 comments and, by one estimate, 99% of them were in opposition.²⁸

In contrast, the AAR, a proponent of increased train automation, has said: “If railroads are to continue to improve their efficiency, increase their capacity to transport their customers’ freight, further reduce congestion on the highways, use less fuel to get goods to their

RAIL YARD AND INTERMODAL RAIL AUTOMATION

At rail yards across the country, a substantial number of switching and other operational activities have already been automated. Complex computer systems help manage the flow of rail cars in and out of yards, flag certain cars for inspection, and even help heat rail lines and equipment in extremely cold conditions.

More fully automated systems are being developed and deployed. For example, in 2019, Canadian National Railway introduced an “automated inspection portal, a machine that relies on artificial intelligence that can evaluate 120 cars in the same time it takes a worker to check a single car.”³⁶ Canadian National Railway would like to use the portals in the United States. Elsewhere, at least one company is using drones and artificial intelligence programs to inspect rail yards and tracks for safety concerns.³⁷

Intermodal rail automation (e.g., automating portions of a facility where a container might be transferred from a train to a truck) is yet another area poised for implementation. That’s not surprising; for example, much of the automated cargo-handling equipment in ports has similar functions to operations within intermodal and rail facilities.

Still, in-depth information about the broad extent and timing of future automation within rail yard and intermodal facilities isn’t readily available. It’s an area worth additional exploration. ■

destination, and, most importantly, make the industry even safer than it is today, a paradigm shift is required. Automation is that paradigm shift.”²⁵ The AAR acknowledged concerns such as cyberattacks, but framed them as a “challenge, but not an obstacle, to autonomous rail operations [that] can be addressed through proper design and constant vigilance.”²⁵ The AAR also promotes increasing rail automation as a job generator: “the development and deployment of PTC [technology], for example, has created numerous new jobs on the railroad, and has employed and will continue to employ many people,”²⁵ and warns that without automation, rail is unlikely to remain competitive with other modes of transportation, which will result in substantial job losses.

These differing perspectives are reflected in various regulatory and legislative actions. For example, at least five states currently mandate a minimum of two-person crews on trains, and another 21 states are actively considering similar legislation.³² At the federal level, Congressional bills would require a minimum of two-person crews, although no bills have advanced substantively.* In addition, the Federal Railroad Administration’s more recent actions may have tipped the regulatory and legal scales in automation’s favor: whereas in

* Specifically, S. 1979 sponsored by Senator Markey and H.R. 1948 sponsored by Representative Young.

2016 it proposed setting a two-person train crew mandate, it rescinded that proposal in 2019 and summarized that “no regulation of train crew staffing is necessary or appropriate for rail-road operations to be conducted safely at this time.”³³ Such moves may support legal efforts to overturn state crew mandates on the grounds they interfere with interstate commerce.³⁴

In early 2020, the nation's largest freight railroads and unions, representing more than 125,000 rail workers, launched a contract negotiation process, and crew size will be at the heart of the likely multiyear negotiation.³⁵ Predictions about rail automation will likely become much easier to make once that negotiation is finalized.



From massive, sprawling complexes to relatively smaller facilities, waterside ports are another significant hub for the nation's freight infrastructure. Connecting ships with trucks and trains, and vice versa, the top 25 maritime ports in the United States handled 1.88 billion tonnage in 2018.³⁸ If all of the containers that went through these ports were lined up, they would circle the earth more than 43,371 times.

The extent of port automation

Similar to warehousing, software-based decision-making tools, tracking and tracing programs, and analytical supports serve as both the brain and central nervous system of all automated port operations. These digital technologies provide the foundation for a wide range of port equipment that moves containers from ships to docks to trucks and vice versa. These include:

- **Quay cranes**, which move containers from ships to the dock
- **Straddle carriers**, which transport containers from the quay cranes to storage areas within the port
- **Yard cranes**, which stack containers within the yard for storage and later retrieval
- **Gates**, where containers are loaded and unloaded from short- and long-haul trucks

Similar to other freight transportation sectors, automated technologies span a spectrum that includes assisting human-performed tasks to fully replacing them. For example, although automated quay cranes may not have an operator located on the physical crane, and although some of its movements may be computer controlled, a remote operator may still be monitoring its performance and may step in to handle certain tasks. Straddle carriers, in turn, guided by underground magnets, may move about without any human involvement.³⁹

The timing of port automation

Extensive port automation is currently in place in the United States. Both the TraPac terminal at the Port of Los Angeles and the Long Beach Container Terminal (LBCT) at the Port of Long



Beach are mostly automated. For example, the LBCT has 48 stacking cranes. “In a traditional terminal, workers operate them from booths on top, but in the LBCT, four people can control all 48 cranes at once” from a remote location.⁴⁰ The Global Container Terminals in New York and New Jersey and the Virginia International Gateway terminal in Norfolk, VA, are two other terminals that are semiautomated: container stacking is automated, whereas the “horizontal transportation of moving containers from the berth to the stacks in the yard is performed by conventional yard tractors driven by longshore workers.”⁴¹

Still, this level of automation is limited. The LBCT, for instance, is only one of 22 terminals at the site; the others are conventionally operated.⁴⁰ The use of automation at ports in the United States is less than what is used at many ports in Asia and Europe. For example, the Port of Shanghai launched a fully automated terminal in 2017, and the automated terminal in Rotterdam, the Netherlands, launched in the early 1990s.

Although technological feasibility would suggest high levels of port automation, economic and labor factors have created an uncertain future. McKinsey & Company note that “the up-front capital expenditures are quite high, and the operational challenges...are very significant... [W]hile operating expenses decline, so does productivity, and the returns on invested capital are currently lower than the industry norm.”⁴² An analysis by Moody’s raised similar concerns.⁴³

Among the factors influencing the future of port automation, labor plays an outsized role. Dock jobs are some of the most highly compensated heavy-labor work in the United States, and the workers and the unions that represent them are concerned about how port automation has already cut into workforce levels. The International Longshore and Warehouse

Union (ILWU), which represents West Coast dockworkers, “estimates that two-thirds of the longshore jobs at LBCT have disappeared due to automation.”⁴⁰ Moody’s analysis notes “labor-saving is a key feature of automated terminals, which may have between 40 and 70 percent lower labor requirements than traditional facilities.”⁴³

Although the pace of port automation in the United States is currently difficult to predict, that likely won’t be the case in a few years. Automation will be a central and contentious issue for the ILWU and the Pacific Maritime Association, which represents terminal operators and owner companies, when they negotiate the current labor agreement that ends in 2022.⁴⁴ On the East and Gulf Coasts, the current labor agreement (which ends in 2024) coupled productivity targets with limits on terminals’ ability to automate.

The current state of freight automation offers a window of opportunity.

Any amount of automating of the freight system will not happen overnight, nor will it replace all workers with new technology. Automation happens with an array of decisions and choices, which affords policymakers, industry stakeholders, frontline workers, community members, and the public time to better understand the implications of freight automation. More importantly, they can make decisions to enact and support policies and programs that promote health and equity for frontline workers and fence-line communities.

The next sections of this report take a closer look at several health and equity implications of freight automation.