Transcript for Session 1: How Valued Workers Can Use Autonomous Mobile Robots to Improve Efficiency & Boost Productivity

Mary: good morning everyone. Thank you. It is great to be here. I am really excited to have this opportunity to introduce these fantastic sessions your team has brought together. We would like to find out where attendees are dialing in from. If you would venture to your sidebar chat window, make sure under the 2, make sure that is selected panelists and attendees and post where you are calling or viewing from. Texas. Sheila is there. Oh my goodness, so fast I cannot even see them. Oklahoma, Wisconsin, Washington state, Washington DC, hi Mary go by, whoever that was, hi. Alabama, Virginia, Maryland, California, holy cow, pretty much everywhere, Washington, that is close to this home picture. That is great. If you have not posted, feel free to post. Always nice to look back and see where people came from. One other thing we are going to do is we would like to know how you are associated with supply chain. You should see on the screen our question to you. In what area are you affiliated with supply chain or environment. The primary one. Many of you are in more than one. Pick your primary one and we will let it for a few more seconds and then we will show you the results. Keep them coming. Looks pretty close. I'm looking at a number of responses. Not entirely surprising. Heavy predominance of education training folks in the room. Terrific. What we have scheduled for the next two days will align perfectly with that what they will be covering -- with that but they will be covering a lot of other items on the list. That gives us a better sense of who is in the room. Thank you for your input. We are really glad you are here. Let's get rid of the polling. With nothing holding us back, let's do it. I am pleased to introduce our first presentation. Our co-presenters are Jason Walker and Patty Katsaros. They have joined us on the screen. One note before we launch, please remember to post any questions as they come up in the chat window and remember to keep it selected so that everyone can see the questions you are posting and we have set some time aside at the end of this to look at those questions and get to what we can. Join me in welcoming them.

Patty: thank you, Mary. So excited to be here from Nashua, New Hampshire. We're excited to talk to everybody about autonomous mobile robots and how they are helping workers and the opportunities afforded with this new technology

being brought in. We're going to start out with learning, talking about what is an autonomous mobile robot? Jason Walker will talk about that.

Jason: Thanks Mary and Patty. When we talk about A MR's -- it is a robot that can perceive the world and make decisions about what it perceives and do something to act in the world based on that decision it made. AMR's do that by using onboard sensors. They have a computer on board, the decision-making capability along with all software. Usually wheels and motors are the things that allow them to act on their decisions. AMR's learn their environment by creating a map. In a set up process, a person will drive the robot and the robot will make a map for them. That is the map it uses to navigate. While the robot is navigating, it is autonomously deciding what is the best path to go through the building and can reroute and navigate around obstacles, go down aisle six if aisle seven is blocked in the autonomous part of AMR, that is really what it means. It has the decision-making authority and ability to act to achieve objectives instead of executing each individual command. Something that looks like that from a distance is older technology called automated guided vehicles. The guided part means there is something in the physical environment that the vehicle is following. That could be a magnetic strip buried in the concrete or some other kind of navigation aid. These AGB's can only go where those lines on the floor already exist. If you need to change the direction the robot goes or you want to change your workflow and you need to go a different direction, AGB's are pretty much inflexible in that way. They can really only do what they are currently set up to do.

Patty: That talks a little about what AMR's are but how are they helping workers? Certain ways they can do this is they can reduce time consuming tedious tasks, automate loading and unloading of materials, reduce long walks, transport heavy materials and keep people safe and socially distanced. There is potential benefits for these AMR's. We want to show you examples of these applications.

Jason: AMR's could be used for the most basic task of moving something from A to B. Where a person may have been pushing a cart before, they can put materials on the AMR and send it to a destination and it will figure out how to get there. That is an example of the AMR taking instructions from a person and controlling it but sometimes you want to integrate them with other machinery/ software systems and that is another way movement can be initiated. One of the things that is handy is to be able to have the robots automatically load and unload

materials. For that, we use a variety of accessories, we call them top modules, to automatically load and unload the robots. This allows the workers to keep doing the things that only workers can do at each end without having to synchronize their activities with the activities of the mobile robot. Having those activities decoupled at the beginning and end of the trip makes the people at each end more efficient and the robots more efficient, so they can each work in their own time. This is an example of the kingpin top module, it is a lift deck that can pickup and drop-off totes. You can use a cart and kingpin can hitch to a cart and pull it around the facility. It can carry a tote one way and move a cart back going the other way. That decoupling of activities is one of the key benefits to having automatic loading and unloading. There are other types of material, for example, a conveyor is a common thing you would find. The same value applies here. Being able to quickly and accurately dock to a conveyor and have it communicate with the fixed conveyor to exchange the tote or box or whatever material, that again decouples the activity of whatever is supplying the materials and receiving them as well as the people working around it. The objective is to take those dull, dangerous or boring tasks and let the robots do them. The most sophisticated top module is a mobile manipulator, a collaborative robot arm combined with an AMR base. The best ones, like what we think we have have a really complete integration of the systems. If they are really easy to set up, this is a robot that can move in spaces and in ways that people are already moving. If you wanted to automate mail delivery at a huge facility, this is an example of a robot that does not need a pickup and drop-off station or a conveyor or cart. You can use all the things you have already been using with a person and have the robot go, pick up a tote full of mail and drop it off at the appropriate stations without having to do anything additional to the environment. Another application is heavy lift stuff and things that forklifts have traditionally been used for. We have had a lot of requests from customers over the years to try to reduce the safety risks associated with forklifts. It is shocking how many injury and deaths are related to forklifts. It is not entirely surprising when the extremely long distances a forklift has to travel are the least interesting and most high-speed parts of the job. If you can concentrate activity of forklifts in a certain part of the facility and limit pedestrian traffic in that part, you are decoupling activities and separating people from danger. You also have an AMR that does not blink, get bored or get distracted. It makes the long trip through the facility. Our customers are always talking about needing more people. The workforce challenges are really driving all of this. Forklift drivers are a great example of a skilled worker that has a lot of

valuable experience and expertise that are frankly hard to find and retain when there are better offers. Being able to utilize the great team you already have for the things that only they can do and then let Mav3k or any other heavylift robot carry the big items through the facility is a big win. I will steal Patty's joke. You also get a free pallet wrapper. That is a good deal. This following video is a case study we did with an e-commerce company. This is a company that was already sprinting growth and needed to expand. They ship medical supplies to older folks in their homes and when the pandemic hit, talk about essential business, their business was just booming. We were already in the process of deploying an AMR fleet in their facility and that highlighted how necessary it was. When the added AMR's and voice picking system to their facility compared with the previous method of using manual pushcarts , they were able to triple their picking efficiency and double the overall output of their facility with a 99.9% accuracy rate. They went from being barely able to keep up to actually getting themselves in a position where they are meeting all promises to customers and all demand and also positioned so they can grow the company in a way they want to grow. This is an extremely scalable solution. The voice picking system sends the robots and the people to the same destination independently. When they meet at that location, the picker gets instruction to pick a certain box and place it in a certain location and when they scan the code, the robot goes to its next location and the picker sends the person to its next location. This decoupling of material movement from the things humans are uniquely great at doing is one of the things that makes this such a powerful technology.

Patty: We talked a lot about the potential benefits and AMR's can offer workers per companies are reluctant to adopt and workers are hesitant. We want to dive into this more. We hear all the time, this make sense to us, that workers push back when change is forced upon them. Like everybody, kind of often feel fear of the unknown. When you have tools that aren't -- they are complicated and not really made with them in mind, they might hesitate and be fearful of the tools. They will often, we will hear they will often resent these outside experts that come in and pretend -- they might know the technology of the robot or automation piece but they don't know the company, the task, job, the trade like they do, those valuable workers that have been there and have such great expertise. They will resent those experts. Then they are going to naturally worry about job security. If a complicated tool comes in and they think immediately, we might get displaced, especially lower skilled workers -- the data shows that can

happen -- if it is complicated tools difficult to work with, understandably, they are going to resist and be fearful of change. So what can be done? It starts with -- there are two parts. It starts with the tools themselves. We strongly believe the tools like AMR's need to be designed with the worker in mind from the start. We are thinking of that crate worker on the job today that knows the job the best. The features and functions from the ground up need to be designed with them to be easily deployed immediately so they can take that as soon as possible and embrace it and figure out -- they will be the best people to figure out and use their expertise and creativity to figure out how these tools can improve the process of workflow. They will be the best people to do that. Making accessible automation tools like AMR's and if you can make it to put it in their hands immediately, that is going to be your best chance for people to feel comfortable immediately and to adopt and embrace, not just adopt but really embrace the tools. There is the aspect of the tool but then there is OK have you get them involved in the beginning so we feel like you need to fully understand the worker's perspective with honest conversations about what plans are. And as I said, involve them from the beginning. First, explain why automation is necessary and how it will help the company. More importantly, how it will help them individually and be beneficial for them. Include the employees, asked the employees to help document the material functions and you might be surprised. You might find things you had not thought of where the employees might have ideas on how these tools can be used, the mobile robots or any other kind of automation tool can be used. Ask them about things that are the most challenging part of their job, physically and psychologically. You will learn their perspective. The project as a whole is going to be that much better. Get their input as to what automation tools can improve their day-to-day. To do that, what is really helpful is when you have vendors come in -- you want vendors to come in with AMR's and newer tech, but include the workers and your front line in those demos and have them ask questions about how it will work and how it will improve the process that they know so well. You can have workers design tests based on their experience and best practices and work with the engineering team, whether outside or inside, to work, to help them create the process with the new tools. Testing criteria, part of it should be -- how do these workers interact with the robots and how easy it is for them to interact with robots? If you think about easy to use tools and ones designed for workers and you include workers from the start, the wonderful thing about this new technology is that there is a lot of great opportunities for workers of all skill levels to be involved in the automation future

of the company. We put together with AMR's specifically, how workers can upscale themselves with tasks that need to be done for AMR's. Example. No code programming. Easy to use robot set up and used visual programming tools -- the workers can do this. They are able to get the robots set up from the beginning and likewise, AMR's are designed to be easily reconfigured as workflow changes so the workers can be involved in that reconfiguration. Preventative maintenance is something you want to think about for all types of equipment. AMR's, no exception. Think about inspecting the hardware, cleaning the lenses, software updates -- all things that need to be done. Then connectivity, keeping robots and other warehouse equipment connected, monitoring network performance, eliminating sources of interference are all things that need to be done and workers can do when they are involved in the process from the start. We talked about the importance of choosing tools that are accessible. We will talk about features to look for specifically for AMR's. We want them to enable fast set up an intuitive operation without the need of robotics experts. You want to look for user-friendly functionality that will engage workers from the start. Jason will walk us through.

Jason: What to look for in an AMR that delivers on the needs Patty described -- they need to be easy to set up and we mean for the shipping and receiving clerk's, assembly-line workers, warehouse workers. It needs to be easy for them to configure and reconfigure without having to go to community college. It needs to make sense to them. What we have done to address that is we have built our dispatcher software as the main interface when you're setting up the robot. We try to look at the entire user experience of setting up and AMR -- an AMR and really think about every part of it we can improve and do for the users to make it easy to set up. With dispatcher, there is always a big green button that is probably the thing you want to do next. If you pick the map button, you use a game controller, which people are familiar with to drive the thing around like a remote control car and it makes a map for you, you use dispatcher to set up keep out zones, which is where you want the robots to stay out of and then you want waypoints, where you want the robot to stop and you can make a playlist of waypoints and the robot will be no advocating as fast as that. You do not have to involve I.T. When we do demos at customer facilities -- in the old days and hopefully soon -- we always have the frontline workers involved. That is the set up process. Day-to-day operation, it also should be easy and intuitive. We have made whistle as a product that has a familiar interface. This thing works like an elevator.

The set up of whistle happens in the background when you doing previous stuff. You push the "come here" button and just like an elevator, the robot shows up, you put the package on it, push another button and the robot goes there. A lot of the technology we baked into robots has intuitive usage and behavior at the heart. That is the most valuable part. When you are setting up a mobile robot, you either have to have a robot that can perceive the world in a way that makes sense to someone or you have to really educate someone a lot about how the robot sees the world. We have given our robots 3D perception so the robot can see the world in a similar way and that means the robot will do what the users expect. It doesn't make sense to people that a sophisticated mobile robot could not see a pallet jack. A lot of robots cannot see one. They cannot see small objects on the floor. Because of that, you either have to give them a lot of training to know where to put keep out zones and what kinds of things it cannot see or you need a robot that can do that on its own. Another key thing is maneuverability. It needs to not only see the world the way we do but it needs to move in spaces and in places and in ways people move so that when a person wants to have the robot do an activity, it will be able to do it in a way and place that they are used to seeing it done. Again, if you have to explain the kinematics of particular drivetrains, then you have already lost them. This needs to be a tool that they can drop into their existing facility, it can go into a work cell or a piece of machinery in any direction/ orientation and it can do that automagically without having to have a complex set up. While these things are cool from a robotic standpoint, the real value is how intuitive it makes it for users. Batteries and charging are another thing we are all kind of used to the burden of plugging in cell phones every night and cordless drills and things like that. The battery maintenance in our lives is something that is almost a constant subtext. Talking about AMR, it is not just about convenience, it is about readiness and longevity of product and the expense of maintaining it. We wanted to take batteries and charging off the plates of users. We came up with the end zone wireless charging system so it does not have to be perfectly aligned. You do not have to clean the contacts and perform maintenance. You don't have to replace the contacts. The robot will dock itself when it is ready for charge. It has to get close to the transmitter. If someone walks by the robot and bumps it, and becomes misaligned, it will continue to transfer power and be ready to use when you get there in the morning and the batteries will stay healthy and the organization can count on that piece of equipment, without having to train workers about batteries and charging. Network independence is something that does not come up as often as it should.

No offense to I.T. folks in the room. Anytime anybody has to involve I.T., it can add weeks to your project. We have built our robots to be network independent. All of the systems, sensors, intelligence, data they need is on the robot. It does not need Internet access or local area network access to do its job. That means, again, intuitively, a worker can get this thing, take it out, set it up and start doing real work without having to involve the I.T. department, as soon as they get it. That is a critical differentiator. You want to get started quickly. But you also want to make sure it is scalable. Interoperability and communication with external devices and software systems is equally critical but it shouldn't be dependent. Nobody wants to trust their livelihood to Comcast. No one wants to be handcuffed by a system that cannot communicate with lots of different devices. These things are extremely important. We hear feedback from customers of all sizes that network independence, whether it is because they have a huge facility and it does not have Wi-Fi all over or because their corporate policies make it really onerous to get anything new on the network, this is something that is critical. People need to think about it. Obviously, safety is critical. Having any piece of equipment that is not safe is not a win. We have built our AMR's with a three stage safety system and it has a safety kernel architected in the same way as personal transport systems. The way it works is independent of the navigation systems. It will sense obstacles, reroute, stop, slow down, steer around. In addition and separate to that , there is this wrapper of a three stage safety system. The way it works is dual safety rated laser scanners monitor the area close to the robot. If someone or something gets too close to the robot, the safety system overrides any software at the hardware level and limits top speed to .2 meters per second, so it slows. If anyone or anything gets within the next circle close to the robot, they decelerate to zero function kicks in and at a hardware level, the system is putting on the brakes and it will wait until obstacle is clear. Third stage is the ease out phase where if necessary, power can be cut to all the propulsion devices. This is separate and independent from the navigation system. We have architected this system, in all of our robots, ahead of the international standards just released, we built our robots to be compliant with those standards in anticipation of the release. There's a lot of ways to measure ROI. I'm going to talk about the ones that are harder to quantify but really easy to understand. When you are a worker that has unique talents, you feel really good when you are doing those, in the moment, in a flow state. Let's say you are rebuilding a transmission. That is expertise which takes brainpower. Let's say you have to stop and grab a 300 pound transmission and push it across the facility. That is not fun.

We have heard that directly. They would love to not do that. It is not work they are proud of. It is physically exhausting. It wears out their bodies. If you are thinking about one transmission per manufacturer that has to do that and another manufacturer where the workers are only engaged in the work they are most proud of and they don't have to do that laborious, interrupting task -- that will be better. If they can go home with more energy for their friends and families, that is better. If they have longer, more productive careers and their bodies do not wear out, all things being equal between those companies, you are going to go with the one where you have got all those benefits. Those are easy to understand. People are not used to trying to calculate them.

Patty: Likewise companies, leaders who give workers those tools, those easy to use tools, whether it is a mobile robot or any other type of automation implement, they need to look for tools that are designed for workers and are easy for them to use. Those ones that get those exciting tools, the companies will have an easier time attracting people and retaining them as they are keeping them happier day to day. We hear this from workers. If they have these tools they feel are for them, they feel the company is investing in those tools for their workers and they tend to be happier with the companies and want to stay longer. The companies get the benefits of the automation, that easy to quantify benefits, but they also get the loyalty of an empowered and happier workforce.

Jason: We hear that directly from workers. There is a big difference between someone bringing in an automation tool to display some, or it feels that way, versus one that is obviously meant for them. It shows that not just automation is the future of the company but those workers are also. Let's take questions.

Patty: Thank you. Very much.

Mary: This is where I come back. We had some in the chat and via message to me. What basic skills should we be teaching future supply chain technicians in preparation for working with AMR's in warehouses and manufacturing plants?

Jason: Generally speaking, any kind of computer interaction, activity is good. They need general exposure to computers. They will interface with them no matter what. Tools that we use, user experience tools we have used in our systems -- a lot of other companies have tried to use similar tools although we think we have

done it better -- a lot of the activities and tools they use in STEM now, a lot of the robots look a lot like those toys. And those tools. We use a game controller, right? When we were growing up, it was like, what are you going to do with your life playing video games? Well, I will heard robots -- herd robots. I think understanding those things -- a lot of kids coming up in this time with those tools and exposure to them are going to already be immersed in it. The thing great to reinforce is that it matters and if they pay a little more attention during the scratch programming lesson, that will pay off.

Mary: Related question. Michael Galloway. Does your company have any simulations incorporated into college-level classes?

Jason: We have a simulator built for integrator partners or software development partners. It is an integration target. This is a simulation of our dispatcher software including 3D simulation and virtual 3D world of a robot moving around. We are not necessarily using it for physics, for load-balancing. The purpose of that simulator is to enable customers to get started with integration well in advance of the robot delivered and in parallel and work out any new or, new integration with software ahead of time. Yes to simulator. It is not currently integrated in college courses. We are working on that.

Mary: What skill sets could be needed for software development in terms of robotics? Any specific things you recommend?

Jason: Mary: Scratch.

Patty: Yeah.

[LAUGHTER]

Jason: One of the cool things about vector, when we were building it, one of my former teammates started a company called root robotics, which was later acquired by irobot. The way vector works is you make the map, put down waypoints and make a playlist. Everyone understands a playlist. What is cool is you can save it as a program in that program is a visual programming language. If you know what the playlist does and you can look at the visual language, you can teach yourself how it works even if you have not had exposure before. There is a

third step which is a coding interface. It is a Python code interface. For advanced users, they can use the Python they know but if you don't know Python, you can know what a playlist looks like, what a visual program looks like, then you can see what the code looks like. You can teach yourself. This route robot, educational tool that Z built with his company, it works the same way. We did it totally in parallel. IRobot does have a simulator on their website.

Patty: I can attest to being able to program without having any experience programming, not coming from a STEM background. It was very easy when I started working with waypoint to learn using those tools and start doing my own programs. The ease of it.

Mary: Sort of related question. Is it really that easy to set up and operate your robots for the end-user?

Jason: We think it is.

Patty: It really is. There is a big green button that takes you through. There is a lot of visual cues showing what is happening when the map is being created. The big green button will guide you to the next step in the process. It is very easy to get it to where it is moving from point-to-point fully autonomous and the ability to navigate around objects.

Jason: As an anecdote, when we go out to do demos I always ask who is moving the materials now? Can we get them to come in for the demo and presentation? I involve them. I have them looking over my shoulder. I will hand off the tablet to them. They can start using it. At the end of a demo, they are in the room with us and whatever automation engineers who may have brought us in and I always asked them -- does this make sense? Do you feel you know how to use it? In the course of 20 minute set up and a one hour demo, the answer has always been yes.

Mary: Interesting. Couple other questions coming up around safety. Before we do that, I want to ask this, which someone posted, I am scrolling -- do you know any techniques HR offices can use to help employees feel comfortable working around these AMR's? Speaking back to the integration of these guys showing up on the floor with actual humans.

Patty: Going back to what we were talking about, the earlier you can get people, the workers on the front lines to have exposure to that -- that is why we very much recommend even in the evaluation process, not after the robot has been chosen and purchased, but bring them in, let them know, explain why you are bringing in these tools. How it will help them. Invite them to the vendor meetings and have them ask questions. They really are going to be the best person to get that perspective of how it is going to be used in their world, even more than the operations manager, we believe anyway. We hear that from people we work with.

Mary: Gotcha. Let's address the safety questions from the chap. -- chat. Are there different safety regulations for these as opposed -- someone posted the robotic arms used to be housed in caged areas -- that was one question related. More about the loawness to the ground. Can they be a tripping hazard? Can you give us more on safety?

Jason: The safety industrial robots, that phrase usually applies to huge arms bolted to the floor that are incredibly powerful. They need a cage around them, although some are trying to change that but that is another conversation. They are very powerful. They do need to be separated. In recent years, starting with collaborative arms, which are smaller, slower, less powerful arms with torque sensing and the ability to detect and prevent impacts or reduce effects of impact, the arms were kind of first to go in the space of exploring the idea of this is a robot that is working with people in the same place and space, even one handing or holding for another. AMR's have really turned into collaborative robots of a different sort. Especially when you look at vector, it is a relatively small robot and it is built specifically to operate in the places people are operating. We have built a bunch of safety features into it as well as specific tools to really amplify the collaborative capabilities of it. The mobile manipulation robot with the collaborative arm on the collaborative mobile robot -- one of the cool things as we built in, we integrated the three stage safety system with the arm. So, if the robot docs to machinery or shelf, the robot can set up a portable safety fence, basically. It sets up a safety laser zone and in the same way our three stage system will slow down and stop if someone or something gets too close, if someone approaches the mobile manipulator, from behind, the arm will stop

moving and wait for them to get out of the way before it continues its job. That is something already built in. That is part of what makes it easy to set up.

Mary: I think that answers most of the safety questions. One last set of questions. Those Omni wheels, directional wheels, how do they handle debris or uneven floors? Do they require extra maintenance? What happens when it goes down? Who does repairs?

Jason: I would encourage everybody to go to our website and check out the videos from our garbage patch. We built one and filled it full of garbage out of the trashcan. Soda cans, wires, packing materials. We have done tests with plastic pellets such as feedstock for injection molding. These are ball bearings basically on the floor. We put them in the garbage patch and made a video of the robot navigating in, around, over that stuff. The wheels do great. They actually do better than other types of propulsion systems and the why of that is a long conversation I am happy to have with anybody. They are actually incredibly good at rejecting debris. I do not want to say perfect. There is always the magic grain of sand that is just the right size to get stuck somewhere but we have been pleasantly surprised how well the wheels do with spitting out debris that one would think would get ingested in. Because it floats over the top of debris, we find that it is really easy for the robot to maintain localization. We did design those wheels to be consumables. Anybody who has anything with a wheel that doesn't design it to be consumable is crazy. They will eventually wear out. With the HD Vector, there is one bowl per wheel. -- blot per wheel. You can change them like a pit star in a race -- like a pitstop in a race.

Patty: And who does repair, one is encouraging that maintenance the workers can be involved with. If they are brought in from the start, they can help with preventative maintenance. There are other higher-level repairs it might escalate up but there is basic preventative maintenance, you can really avoid a lot of these high-level repairs.

Jason: That is exactly the kind of thing we see future technicians and robot wranglers doing. If there is somebody who was pushing a cart yesterday, then they can be keeping track of 3, 4 AMR's in addition to whatever high skill thing they would rather be doing. You just have to keep an eye on the wheels, the dust on the lenses, that kind of thing and do basic maintenance. We did build it so the

same user, the shipping receiving clerk, the assembly line workers, those of the people that can do that kind of maintenance.

Mary: That is awesome. Unfortunately, that hour flew by . We have to say goodbye to y'all. Thank you, Jason and Patty both for that inspiring and interesting session. Lots of food for thought.

Patty: Thank you. We are happy to answer any other questions. If you want to send them to us, we will get back to people.

Mary: You can look in the chat now that you are not in the hot seat.

Jason: Thanks.