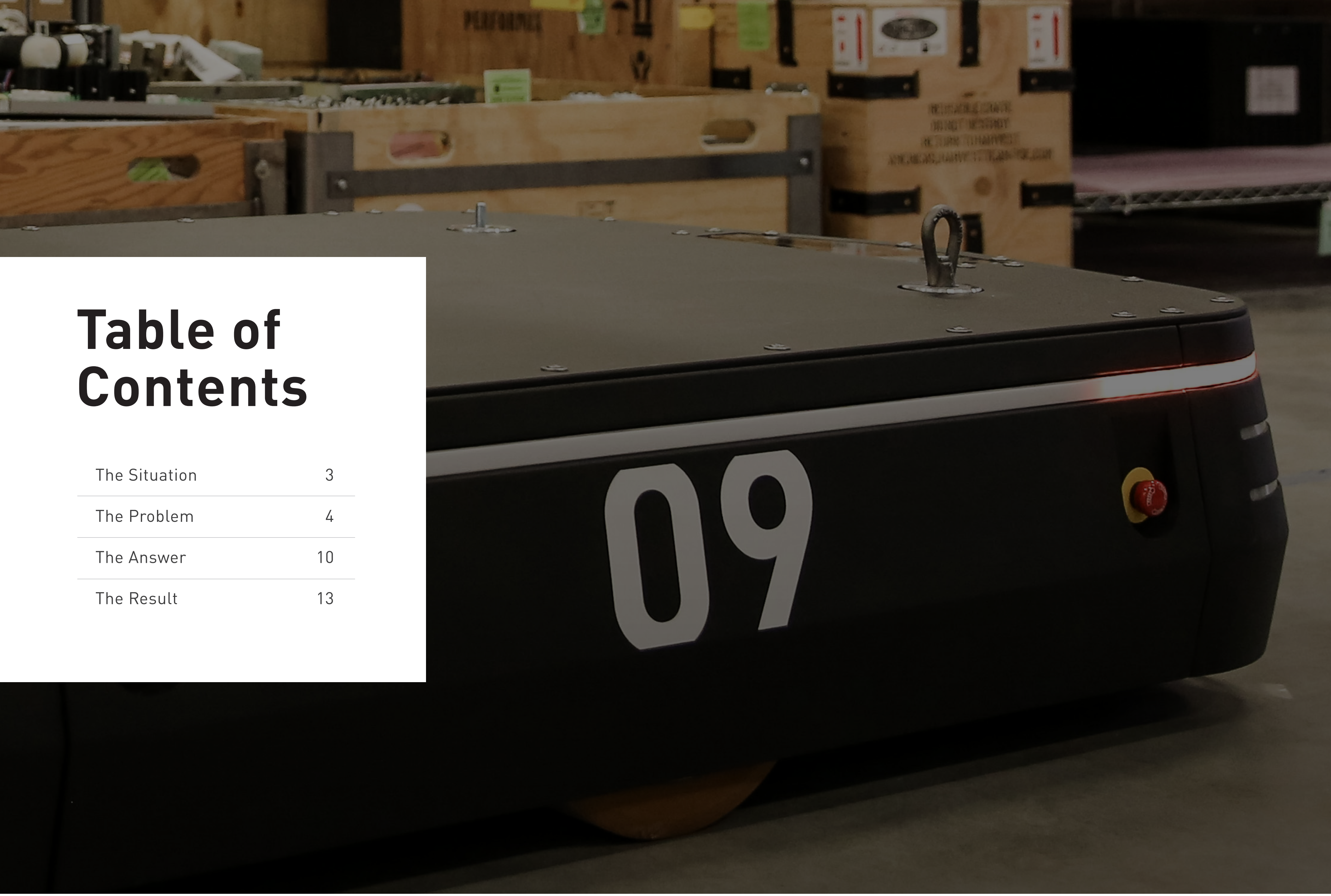
SELF-DRIVING VEHICLES FOR INDUSTRY

Innovation in an Interconnected World

Industry 4.0 and the power and potential of self-driving vehicles

OTTO MOTORS



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OTTO MOTORS

The Situation

Manufacturing is Ripe for the Next Generation of Innovation

Fact:

92% of industrial manufacturing executives say innovation is important to future revenue growth.[3]

Over the last century, innovation in industrial manufacturing has brought our society much benefit. From the automobile, to televisions, to cell phones, to modern-day appliances, the machines and products produced by manufacturers have made our lives simpler, better, and more efficient.

Automation has transformed the way factories work and made it cheaper and faster for manufacturers to produce a wide variety of products. According to industry advisory firm PWC, across industries, there is a clear correlation between innovation and revenue growth, with the most innovative companies growing 38% faster than their stagnating counterparts over the last three years[1]. PWC also notes that while global expansion has been the biggest driver for manufacturing growth over the last few decades, most industrial executives believe they will need to generate the majority of their growth organically going forward[2]. What this means is that innovation — in all aspects of operations — will be critical to a manufacturer's prosperity and survival.

While many other aspects of the manufacturing process have been automated, materials handling remains a hold out, very likely due to the fact that it is a low value, non-revenue generating activity. However, materials handling still costs manufacturers time and money — mostly because of the human-intensive nature of the work. Automation of the materials handling process offers manufacturers yet another way to improve the bottom line by reducing costs and errors. Minimizing human involvement in materials handling can also reduce the risk to worker safety.

In this eBook, we'll take a detailed walk through of some of the business challenges facing manufacturers today, the implications and costs associated with inefficiencies, and how connectivity, automation and game-changing self-driving vehicle advancements can help manufacturers slash labor and support optimization of each island of automation and every movement in between.

1. *PWC, 'Rethinking innovation industrial manufacturing — are you up for the challenge?' Barry Misthal, Steve Eddy.*
2. *IBID*
3. *IBID*

The Problem *The Innovation Dilemma*

To continue to prosper and grow, manufacturers need to embrace innovation to overcome some of the significant challenges they face in the day-to-day operation of their business. Here are just some of the challenges manufacturers are battling today:

> *"There is no waste in the world that equals the waste from needless, ill-directed, and ineffective motions."*
>
> Frank Bunker Gilbreth, Sr.[4]

Challenge #1: Adapting to a new Velocity of Change

From the water they drink to the car they drive, consumers are now demanding more variety in the goods they purchase. This insatiable appetite for choice is putting new pressure on industry to manufacture goods in a different way. To deal with the explosion of SKUs customers want available on store shelves, manufacturing environments need to be far more flexible than they've been in the past. To get there, manufacturers are turning to dynamic manufacturing methods such as mixed-model assembly lines (MMALs) and/or just-in-time (JIT) kit-based delivery to produce smaller batch runs with a greater variety and variation of products.

Lean impacts: overproduction, overprocessing

Challenge #2: Managing rising complexity

Customers may be demanding manufacturers produce a greater variety of product with a higher velocity, but these flexibility demands are creating chaos on the factory floor. As traditional automation and material handling systems are typically built into the infrastructure and cannot be easily or cost-effectively adapted to deal with ongoing change, manufacturers are continually struggling to contend with increasing complexity in the way products are built, the way raw materials are transported, and the way people and machines move through the facility.

Lean impacts: overproduction, overprocessing

4. *Frank Bunker Gilbreth Sr. d. 1924 was an American industrial engineer and an early advocate of scientific management and a pioneer of motion study https://www.asme.org/engineering-topics/articles/construction-and-building/frank-bunker-gilbreth*

"North American manufacturers are constantly under pressure to find new ways to gain an edge against low-cost offshore competition. Traditional automation is saturating. But what about the more complex tasks too difficult or expensive to automate?"

Matt Rendall, CEO and co-founder, Clearpath Robotics

Fact:

The manufacturing sector in the U.S. has not grown as fast as the rest of the economy and, as a result, its share of total output has fallen from 24% in 1970 to 12% currently.[5]

Challenge #3: Remaining competitive on a global playing field

While North American manufacturers continue to wrestle with the complexities created by dynamic manufacturing models, there is yet another large dynamic at play: offshore competition. Manufacturers working in offshore locations such as China, Mexico, Eastern Europe and Africa are able to capitalize on lower local labor costs to produce goods and services for the market more affordably, making them significantly more competitive than their US counterparts. North American factory owners face higher real estate prices, higher labor costs, and more stringent environmental and regulatory compliance requirements than their offshore counterparts. Therefore, in order to be competitive in this global marketplace, a North American industrial center must find ways to be more efficient than its low cost country counterparts. Automation plays a significant role in helping North American manufacturers achieve operational parity. Manufacturing is, and always will be, a tough and highly competitive business.

Lean impacts: transportation, inventory

Challenge #4: Reducing operating costs

In order to successfully compete against offshore rivals, US manufacturers need to reset the bar for production density and re-shore their operations. Automation is the linchpin within this strategy. As more manufacturers introduce automation, including robotics on the factory floor, production efficiency will rise, cost will fall, and the manufacturer will gain greater competitive advantage.

Lean impacts: adds value

5. *Cushman & Wakefield "Manufacturing in North America" August 2015*

The 7 Wastes of Lean

Overproduction
creating too much material or information

Inventory
having more material or information than you need

Transportation
moving material or information

Motion
moving people to access or process material or information

Waiting
waiting for material or information, or material or information waiting to be processed

Defects
Errors or mistakes causing the effort to be redone to correct the problem

Overprocessing
processing more than necessary to produce the desired output

Challenge #5: Inefficient and chaotic materials transportation

> *"I believe that we are at the dawn of an innovation wave that will soon hit the material handling industry. The convergence of big data, faster and cheaper computer power, and the increasing demands of customers will likely accelerate the adoption of innovative products and services."*
>
> Scott Sopher, Principal, Deloitte Consulting LLP [6]

The variety and velocity at which goods must be produced, the increasing level of complexity this creates for manufacturers, and the ongoing cost pressures faced by North American industry become an acutely obvious problem when one looks at the way materials are transported and flow through a manufacturing facility. Three key elements tied to materials movement, transport (moving products that are not actually requiredto perform the processing), motion (people or equipment moving or walking more than is required to perform the processing) and waiting (for the next production step, interruptions of production during shift change) are among the original seven wastes of LEAN.

Yet, despite being the grease for the manufacturing wheel, materials transport remains an untapped opportunity for automation and innovation in most manufacturing establishments.

Simply walk into any manufacturing facility today. Forklifts and AGVs may be in operation serving specific parts of the manufacturing floor, but you'll also see hundreds of people at work, pulling, tugging and pushing goods from point A to point B. So why is it that we are still using humans — our most important asset — for materials transport?

Lean impacts: excess motion, waiting, transportation

The good (old) forklift

The forklift was first introduced into the manufacturing world at the beginning of the 20th century,[7] and these transport vehicles are a defacto standard in any manufacturing environment. They are used to transport pallets of goods in bulk.

6. *Deloitte, "The 2015 MHI Annual Industry Report — Supply Chain Innovation, Making the impossible possible" 2015 http://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/global-supply-mhi-industry-report.html*
7. *Packaging Revolution, Rick Leblanc, "What Came First, The Pallet or the Forklift?" July 2014*

Fact:

According to OSHA, there are roughly 85 forklift fatalities and 34,900 serious injuries a year, with 42 percent of the forklift fatalities related to the operator's being crushed by a tipping vehicle.[8]

Six ways to lower manufacturing costs

1. Optimize production processes
2. Optimize your workforce
3. Monitor and manage your energy consumption
4. Lower the cost of regulatory compliance
5. Consider your inventory costs
6. Focus on freight and trasportation management[10]

8. Occupational Health & Safety, "Death by Forklift is Really the PITs, Chuck Paulausky, September 2013 — https://ohsonline.com/Articles/2013/09/01/Death-by-Forklift-is-Really-the-PITs.aspx

9. HWEC Solid & Hazardous Waste Education Centre "Forklifts: Operational and Environmental Impacts http://www4.uwm.edu/shwec/publications/cabinet/p2/Forklifts1.pdf

10. Cerasis Blog, Author: Adam Robinson '6 Ways to Lower Your Manufacturing Costs to Gain a Competitive Advantage' August 20, 2014

The forklift is a fine and faithful piece of equipment. But it has its limitations. First it needs a human operator. It is cumbersome to drive, and is intended to move more stuff, less frequently. In a MMAL environment, manufacturers end up working around the demands to serve a quick changeover of lines by having forklift drivers make multiple runs, shuttling full pallets of raw materials between the warehouse and line. This approach can be inefficient, chaotic and unsafe.

» Forklifts are costly and drive larger operational footprints.[9]

» Forklifts can be dangerous to operate.

» Forklifts create unneeded traffic on the factory floor.

» The pallets they deliver then clog and crowd the aisles, fill up potential revenue-generating floor space, and create safety issues.

» The tracking and tracing of goods delivered by forklift is difficult, if not impossible.

Are AGVs the Answer?

The first AGV, a form of mobile robot, was brought to market in the early 1950s and used in industrial applications to move materials around a factory or warehouse. The original Barrett Electronics "Guide-O-Matic" tracked a radio signal emitting from a wire mounted in the ceiling. Over the decades, AGV navigation evolved marginally, with today's AGVs now getting their bearings from magnetic tape on the floor, fixed reflective markers installed on the walls, or magnetic plugs and bar code stickers strategically placed along the vehicle's pre-programmed path.

But when it comes to dealing with the complexity of today's dynamic manufacturing environments, AGVs have some notable limitations. Let's take a look at a few of them.

AGV Limitations

Adoptive not adaptive

Since AGV routes need to be simple and unobstructed, most facilities pre-plan layouts with AGVs in mind. Devoted and quarantined AGV paths are purposely designedinto transport aisles, and machines and work areas are positioned to accommodate the vehicles' planned transport route. In other words, most manufacturing operations adapt to the way AGVs work, rather than the AGVs adapting to a factory's existing layout and workflows. For facilities that were not well designed in advance for automation, the prerequisite planning can make it very difficult for operations to adopt AGV technology. This means operations end up resorting back to manual transport methods.

Captured not collaborative

Fixed path AGVs cannot conveniently collaborate and share work. For example, pre-programmed AGVs devoted to loop #1 cannot be easily and rapidly redeployed to loop #2 to perform another job. Unlike human based transport that can shift with the dynamic needs of an operation and dart conveniently between several transport tasks throughout the facility, purposed AGVs are held captive within their pre-programmed task. This lack of flexibility prevents the assets from collaborating on multiple and shifting work tasks.

Reactive not proactive

When faced with an obstruction to their path, AGVs reliably and safely stop. However, unlike human driven vehicles that can easily sidestep these obstructions, fixed path AGVs cannot deviate from their preprogrammed route. As a result, unexpected obstructions in the path (including preoccupied or disabled AGVs) can force a blockage that may bring factory line productivity to an unexpected and unwelcome halt.

Fixed not flexible

AGVs follow a pre-programmed route through the facility, like a train moving on a track or a bus sticking to a route. Although well suited for simple, repeatable point-to-point delivery tasks in rigid facility layouts, a much higher percentage of materials now need to move in the facility in a more dynamic way, from random origin to random destination. Ironically, in most operations that use conventional AGVs, large fleets of manually driven tug vehicles and fork trucks still move other materials in parallel. This is because the routing of these materials is too random and too complex for line following AGVs.

It must be pointed out (for all the reasons above and more) that while AGVs have been available to manufacturers for more than half a century, they have proven to be far from a miracle cure for material transport.

> *"The whole warehouse environment must be adapted in order for the AGV to work efficiently."*
>
> Fathi Tlatli, DHL Customer Solutions and Innovations [11]

So we're back to humans

Today's manufacturing environments are not static. As we have identified, high volume producers are increasingly shifting to a complex, dynamic delivery models, where required parts are frequently delivered to the shop floor in pre-arranged kit containers. In this scenario, where there is no predictable sequence of operations and goods move in random patterns with high frequency, the costly/risky forklift and the rigid format of an AGV do not work.

For lack of innovation and a better option, manufacturers turn back to the most flexible, adaptable and reconfigurable solution available to them for complex, unpredictable and ever-changing materials transport. That solution happens to be human beings, who can think and who can quickly and readily adapt to change.

11. *Automotive Logistics Magazine, Guiding In Motion*

Fact:

In a typical manufacturing facility, materials handling can account for up to 75% of an item's total production cost, occupy 25% of employees, consume 55% of factory space and up to 87% of production time.[12]

But at what cost?

While materials handling is a necessary aspect of the manufacturing process, it is a non-revenue generating activity. This means it has traditionally fallen low on the priority list when it comes for things manufacturers can and should automate.

After all, it is a problem that can be solved with a few more bodies. But at what expense to a manufacturer's operational efficiency?

Inefficient material handling methods drive up factory costs because they create unnecessary motion of employees, unnecessary transport and handling of goods, and increase waiting time. In a LEAN manufacturing scenario, this might be a work cell that is awaiting the delivery of raw materials that are delayed in the warehouse, or a forklift operator who spends valuable time shuttling multiple pallets of raw materials from the warehouse to the front of the line. This kind of waste adds no value to the business. Wages paid to workers engaged in materials transport cannot be directly associated to the cost of the finished product.

12. *http://users.encs.concordia.ca/~andrea/indu421/Presentation%207%20(MH).pdf*

The Answer

Smart & connected materials handling

Welcome to a world of connectivity

Industry 4.0, or the fourth industrial revolution, is an increasingly popular term that encompasses a number of contemporary automation, data exchange and manufacturing technologies[13], aimed at helping manufacturers contend with the operational and complex challenges they face every day. In this 'smart factory,' machines and products communicate with each other cooperatively driving production. Raw materials and machines are interconnected within an industrial 'Internet of Things' to support highly individualized, efficient mass production.

Six design principles of Industry 4.0:

1. Interoperability
2. Virtualization
3. Decentralization
4. Real-time capability
5. Service Orientation
6. Modularity

In this video entitled, "Industrie 4.0," Siemens paints a vision for tomorrow's manufacturing world where intelligent factories, machines, raw materials and products all communicate.

https://www.youtube.com/watch?v=HPRURtORnis

Advancements in self-driving vehicles pave the way

Popularized over the last few years by companies such as Google, self-driving vehicles are defined by the National Highway Traffic Safety Administration as "vehicles in which operation occurs without direct driver input to control the steering, acceleration, and braking."[14]

> *"Imagine a world where advanced robots expertly and inexpensively perform and augment most physical task."*
>
> McKinsey 'Disruptive Technologies', May 2013

13. *Wikipedia, "Industry 4.0" https://en.wikipedia.org/wiki/Industry_4.0*

14. *Wall Street Journal, "Tesla CEO Musk Sees Fully Autonomous Car Ready in Five or Six Years" http://www.wsj.com/articles/tesla-ceo-sees-fully-autonomous-car-ready-in-five-or-six-years-1410990887?mod=WSJ_LatestHeadlines*

The Answer
Smart & connected materials handling

> *Self-driving vehicles will be 'a factor of 10' safer than a person at the wheel in a six year timeframe."*
>
> Elon Musk, CEO Tesla[15]

The self-driving objective: steamlined operations, reduced complexity, and reduced costs

Google's self-driving vehicles (and others) learn and adapt to their environment thanks in large part to Simultaneous Localization and Mapping (SLAM), a class of algorithm whereby a robot or a device uses a variety of sensors to create a map of its surroundings, and locate itself properly within this map in real-time.

Over the next five-to-six years, experts predict the emergence of self-aware vehicles powered by SLAM that can increasingly sense, interpret, decide, act, and communicate with other automobiles, infrastructures, organizations, and people[16]. This kind of capability unleashed on the factory floor has the potential to be a game-changer for manufacturers seeking to streamline operations, reduce complexity and reduce costs.

Proven in prototype to be safe and reliable, from mid-2011 to early 2014, Google self-driving cars have covered a total of 1.25 million kilometers (nearly 700,000 miles), mostly in California, District of Columbia, Florida, Michigan, and Nevada, USA.[17]

Companies building self-driving tech:

- Audi
- Daimler
- Ford
- Tesla
- General Motors
- Volvo
- Nissan
- Google
- Delphi Automotive
- Bosch

Current deployments of self-driving vehicles:

- Military and industry applications
- Minesweeping
- Aerospace (Mars Curiosity)
- Agriculture (tractors)
- Hospitals (food and drug transportation)
- Consumer applications
- Appliances (lawn mowers, vacuum cleaners)
- Public transport applications
- Automated people mover
- ParkShuttle system
- Self-driving shuttle
- People movers
- Automotive applications
- Parking assistant system
- Valet parking
- Highway pilot
- Google self-driving car

15. *Deloitte, "The 2015 MHI Annual Industry Report — Supply Chain Innovation, Making the impossible possible" 2015 http://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/global-supply-mhi-industry-report.html*
16. *DHL, Self Driving Vehicles in Logistics, 2014*
17. *Wall Street Journal, "Tesla CEO Musk Sees Fully Autonomous Car Ready in Five or Six Years" http://www.wsj.com/articles/tesla-ceo-sees-fully-autonomous-car-ready-in-five-or-six-years-1410990887?mod=WSJ_LatestHeadlines*

The Self-Driving Vehicles Revolution for Manufacturing Centres

CLEARPATH

Era 1:

Early Industrial Robotics

1955 – 1980

- Devices capable of transferring objects from one point to another over short distances
- Extremely limited movement
- Unsafe to work near or around people

Application:

- Small-parts assembly jobs
- welding robots

Era 2:

Autonomous Guided Vehicles

1980 – 2015

- Computer-controlled and wheel-based, load carriers that travel along the floor of a facility without an onboard operator or driver
- Moves on a predictable path usng a cable, track or tape
- Cannot move away from designated path
- Travels in dedicated areas or zones to predefined depots
- Does not work directly with people or deliver to users
- Difficult and expernsive to expand or re-map

Application:

- Heavy lifting
- Movement of objects along a predictable path
- connecting islands of automation

Era 3:

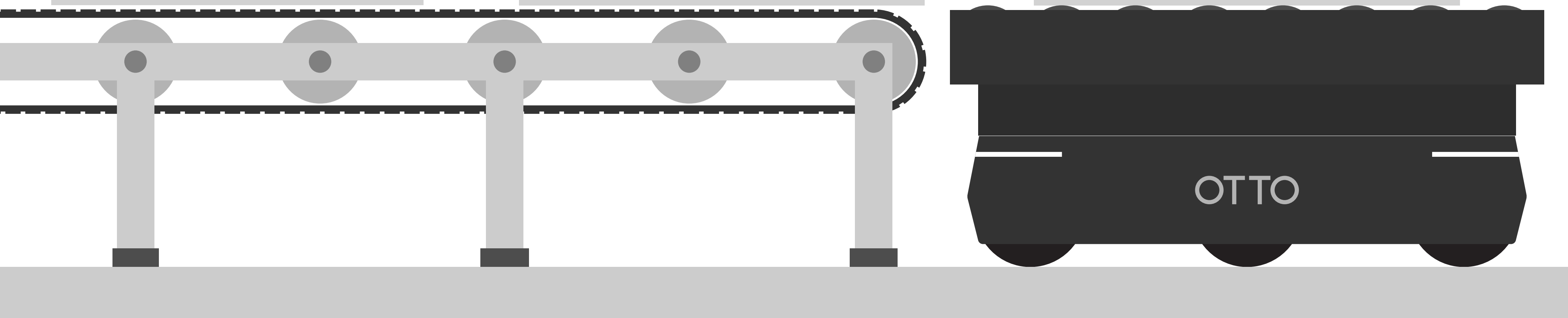
Self-Driving Vehicles

2015 – 2025

- Self-driving autonomous vehicle used in manufacturing centers
- Infrastructure free: simulatneous localization and mapping technology enables dynamic path planning and flexible, adaptable transport of materials
- Safe and collaborative: intelligently detects and avoids obstacles using safety-rated sensors
- Offers perceptive light signals for passerby
- Capable of traveling long distances with loads spanning 100kg to 1500kg
- A centralized system integrates with existing WMS to dispatch jobs to vehicles and track status of self-driving fleet

Application:

- Fully automated use in line side delivery
- Virtual conveyance
- Other self-driving applications



The Result

Smarter material transport = smarter factories

"Over the next five-to-six years, self-aware vehicles will likely emerge that are increasingly able to sense, interpret, decide, act and communicate with other automobiles, infrastructures, organizations and people."

Deloitte[18]

Outdoor versus indoor driving environments

While the prospect of self-driving vehicles entering our roadways is capturing consumer and media attention, widespread use of autonomous cars on commercial highways is likely a good five or ten years away due to legal, insurance and infrastructure hurdles. It will also require a significant behavioral mind shift among drivers accustomed to having control behind the wheel.

The more immediate potential for self-driving technology actually lies within indoor driving environments found in the manufacturing sector, where there is greater opportunity to deploy self-driving vehicles under conditions that can be (mostly) controlled.

Over the last few decades, industrial robots have taken on a variety of manufacturing tasks — those that are difficult, dangerous or impractical for humans — welding, spray-painting, and handling of heavy materials. Robots are also now capable of delicate and intricate tasks, such as picking and packing, or manipulating small electronic parts. They have become adaptable, capable of operating in chaotic conditions and working safely alongside humans.[19]

"Autonomous vehicle (AV) technologies could help to optimize the industry supply chains and logistics operations of the future, as players employ automation to increase efficiency and flexibility. AVs, in combination with smart technologies, could reduce labor costs while boosting equipment and facility productivity. What's more, a fully automated and lean supply chain can help reduce load sizes and stocks by leveraging smart distribution technologies and smaller AVs."

McKinsey & Company

18. *Deloitte, "The 2015 MHI Annual Industry Report — Supply Chain Innovation, Making the impossible possible" 2015 — http://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/global-supply-mhi-industry-report.html*

19. *McKinsey & Company 'Disruptive Technologies: Advances that will transform life, business and the global economy,' May 2013*

The Result

Smarter material transport = smarter factories

> *"Manufacturers can see a return-on-investment in less than 18 months."*
>
> Clearpath Robotics

Manufacturing's need for flexibility, pressures to improve operational efficiency in order to compete, and its inefficient, inflexible materials transport technologies make it a perfect test bed for self-driving vehicles. Cognitive and capable of delivering dynamic and efficient transport in increasingly congested industrial operations, self-driving vehicles present a viable and cost-effective alternative to traditional material handling systems. Here's why:

- Unlike AGVs, self-driving vehicles do not require costly and rigid changes to infrastructure.
- Unlike AGVs, self-driving vehicles readily and intelligently adapt to changing environments.
- Unlike AGVs, self-driving vehicles do not require external infrastructure for navigation, making implementation hassle-free and highly scalable.
- Self-driving vehicles are proven to be safe for collaboration with warehouse personnel.
- Self-driving vehicles in a manufacturing setting have been demonstrated capable of carrying up to 3300 lb loads at speeds up to 4.5 mph, while tracking along optimal paths and safely avoiding collisions.

The ROI benefits of self-driving vehicles for manufacturers:

- Higher throughput
- Lower labor costs
- Increased production density
- Less worker compensation incidents
- Reduced infrastructure costs
- Reduced training expenses
- Reduced maintenance costs (self-driving vehicles travel using optimal paths at optimal speeds)
- Reduced inventory needs through access to real-time data

Industry 4.0, self-driving vehicles and the factory of the future

In a traditional factory setting, it is not uncommon for a manufacturer to employ 50 forklift drivers to transport raw materials to an assembly line. At some point during the day, a skid falls in an aisle, obstructing the drivers' path. At a bare minimum, it is going to take minutes to communicate this news to all 50 drivers. And even if all workers receive the news of the blocked route, habit will inevitably take over and a few forklifts will need to turn back.

Now imagine the factory of the future, populated by robotic work cells served by self-driving vehicles handling materials transport to and from the assembly line. A skid falls in the aisle. But in this interconnected system, information is transmitted instantly, including the most optimal path to take, or how to avoid congestion because you know all the happenings in the industrial center in real time.

Better yet, picture a manufacturing process where every machine at every step is connected and constantly communicating. Each machine is operating autonomously within the network but knows where the others are located. These machines are continually sharing information on how work should be performed to maximize efficiency. And this interconnected, intelligent 'system' is now able to deliver the right amount of goods to the line exactly when needed, produce the exact quantity required with no waste, and do so with maximum transport efficiency.

Do people exist in this fully automated interconnected world? Of course they do. But workers are now performing task in collaboration with robots and self-driving vehicles. And these human beings are focused on doing what they are best suited to do — performing intricate, complex, cognitive-based tasks, leaving complicated but mundane materials transport jobs to the machines.

The Result
Smarter material transport = smarter factories

Your roadmap to self-driving vehicle success

We're on the brink of a self-driving vehicle revolution — not only on our roads, but also in our factories. These self-driving vehicles have immense potential to help manufacturers combat complexity and automate materials handling processes allowing them to realize new efficiencies, reduce costs and improve production density.

To the right is a roadmap aimed at helping manufacturers overcome objections and the status quo, prove the benefits of self-driving vehicles, and build a strong business case for self-driving vehicle adoption.

1. Understand your current operations and the potential of what your operation could be

Will your factory of the future be highly profitable and your automation investments provide the anticipated returns?

Are you able to simulate the benefits of self-driving vehicles to paint for your leadership a picture of productivity, demonstrate the impact and prove that production density goals can be achieved?

2. Audit the costs of your current operations

Identify low hanging fruit and longer-term opportunities for cost savings to be realized through the use of self-driving vehicles. through the use of self-driving vehicles.

3. Build trust and confidence in the technology

Identify an application within the facility that is non-mission-critical and embark on a proof of concept (POC) to build faith in the technology. There are many random tasks within a manufacturing facility that could be turned over to a self-driving vehicle, for instance, track collection, or picking up of non-compliant items, or quality assurance samples.

Build and prove Key Performance Indicators (KPIs).

4. Deploy the self-driving vehicle technology to a production task

Find a suitable production task where self-driving vehicle technology can be applied in a controlled way.

5. Find the most valuable use cases within the facility and expand

Identify opportunities where self-driving vehicles can facilitate rapid growth objectives, offer competitive advantage, maximize production density, or can be deployed with minimal friction (for instance in a greenfield scenario).

It’s your turn to drive the discussion

Manufacturers everywhere are looking to reduce complexity and to realize operational gains in order to compete effectively and to serve a consumer audience that increasingly expects a wide variety of quality goods at a fair price. While most manufacturers have adapted to dynamic production methods such as mixed-model assembly and JIT kit-based delivery, these more nimble, flexible processes have not yet spilled over to material transport.

Within the Industry 4.0 paradigm, technological advancements from embedded data sensors, to artificial intelligence, to wireless communications protocols are becoming increasingly available and affordable to manufacturers, allowing them to embrace automation in every corner of the factory enterprise. We can now readily envision a manufacturing reality where devices and self-driving vehicles can be interconnected to allow significant amounts of data to flow through the manufacturing process; where we are able to build an interconnected web of technology where machines ‘think,’ adapt to changing business conditions, perform complex tasks and connect to other automation systems to optimize manufacturing processes. And best of all, this revolutionary technology is proven for industry, available and ready to deploy today.

It’s time for you to drive the discussion on how self-driving vehicles can benefit your manufacturing environment. Seize the potential of Industry 4.0 today and connect with our industrial sector experts. Email us at info@clearpathrobotics.com or share your thoughts with us on Twitter (@clearpathrobots) using the hashtag #selfdrivingfutures

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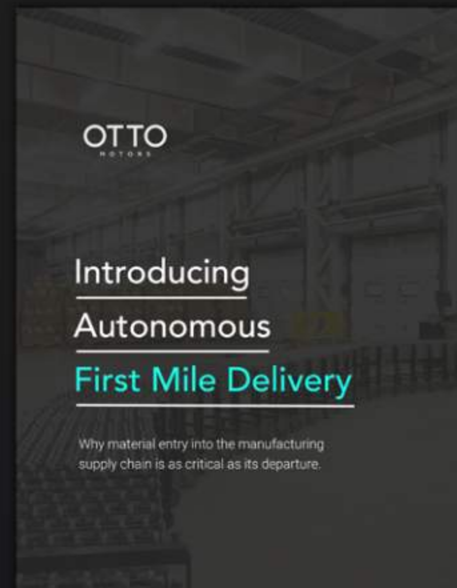

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Learn why material entry into the manufacturing supply chain is as critical as its departure.