AUTONOMOUS TRUCKING: WHO'S IN THE DRIVER'S SEAT?

UPNEXT

DRIVING TRANSPORTATION FORWARD

INTRODUCTION

Piggybacking off the buzz around driverless passenger cars, the trucking industry has seen its share of headlines on autonomous trucks. Several truck manufacturers have already added to the speculation, announcing self-driving rigs that are years away from commercial release. Some third-party entities have even garnered press from test runs on closed or low-traveled routes.

Of course, any new and exciting technology tends to create a lot of speculation, but how can you tell what is mainly hype and what is truly the future? The answer to that question will eventually manifest itself in time, as OEMs and start-ups alike prove the safety and effectiveness of their product on actual routes and trucking scenarios. In the near-term, congested roadways, construction zones, pedestrian traffic, intricate docking procedures, and other technical challenges make human drivers the best option for most applications.
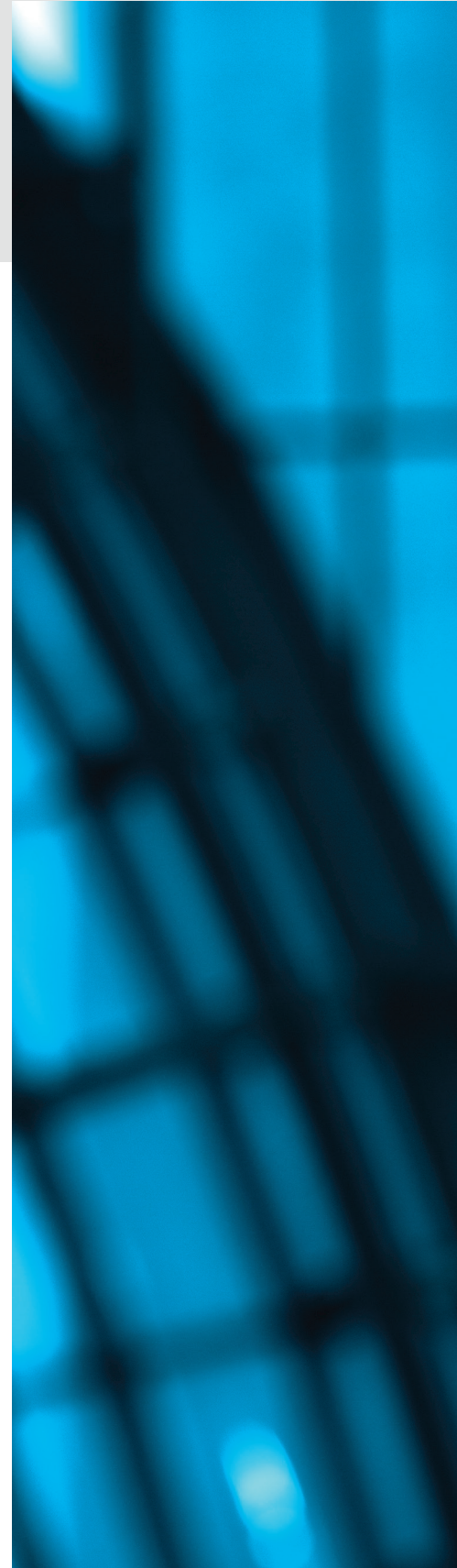
FOR THE TRUCKING INDUSTRY, AUTONOMOUS DRIVING TECHNOLOGY POSES OTHER SIGNIFICANT QUESTIONS:

- What must be true for autonomous trucks to become a reality?

- Will society accept autonomous trucks?

- What's the role of the driver?

- How will this technology be integrated into trucking?

- How will autonomous vehicles be regulated?

- What will it do to our industry?

These are legitimate questions and concerns for all those invested in this industry, as well as our own company stakeholders. We'll attempt to answer these questions and other related concerns in this point-of-view (POV) document.

Beside addressing these issues and separating out the hype from the reality, we'll provide a view of the International Truck roadmap to autonomous trucking, including what we're doing with our partners and suppliers to lead the industry into the future.
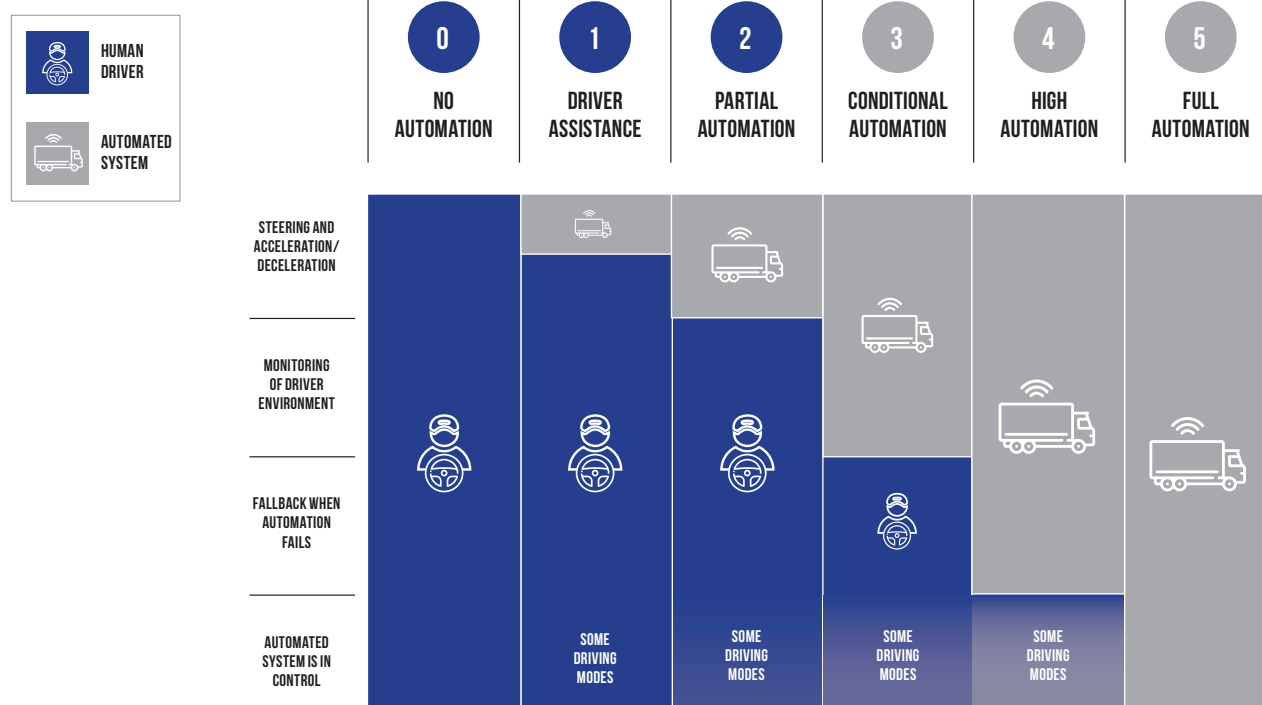
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UNDERSTANDING AUTONOMOUS TECHNOLOGY

Before any further discussion of autonomous trucks, it's important to understand exactly what we are talking about when we refer to "autonomous," "self-driving vehicles" or "driverless technology."

1 FIVE LEVELS OF AUTOMATION

Regardless of what you call it, a simpler way to look at autonomous driving technology is in terms of levels of automation. The Society of Automotive Engineers (SAE) and the US National Highway Traffic Safety Administration (NHTSA) have both issued guidelines for what the various levels of autonomy mean in cars. Although the guidelines for the SAE and NHTSA differ, these same general guidelines can be a useful tool in understanding what autonomy means in trucking.

THE 5 LEVELS OF DRIVING AUTOMATION

HUMAN DRIVER

AUTOMATED SYSTEM

	HUMAN DRIVER MONITORS THE ROAD			AUTOMATED DRIVING SYSTEM MONITORS THE ROAD		
	0 NO AUTOMATION	**1** DRIVER ASSISTANCE	**2** PARTIAL AUTOMATION	**3** CONDITIONAL AUTOMATION	**4** HIGH AUTOMATION	**5** FULL AUTOMATION
STEERING AND ACCELERATION/ DECELERATION						
MONITORING OF DRIVER ENVIRONMENT						
FALLBACK WHEN AUTOMATION FAILS						
AUTOMATED SYSTEM IS IN CONTROL		SOME DRIVING MODES	SOME DRIVING MODES	SOME DRIVING MODES	SOME DRIVING MODES	

2 AUTONOMOUS TECHNOLOGIES

It's important to understand the technology that enables vehicle automation is comprised of several different types of technologies and innovations working together. As we've seen with ADAS innovations, these are complex systems. Depending on the exact features, autonomous driving technology can be a mix of many advanced technologies, such as onboard computers, sensors, lasers, radar, video cameras, cloud computing services, satellites, GPS, and even artificial intelligence.

We've already seen the many benefits of today's ADAS systems, such as collision mitigation and lane departure warnings. The net impact of these proven safety systems further supports uptime, as well as lowers the cost of ownership

FOR EXAMPLE

Studies show that forward collision mitigation systems have the potential to:

PREVENT UP TO
20%
of the total 5.8 million reported crashes in the U.S. per year

INCLUDING
66K
serious and moderate injury crashes

AND
879
fatal crashes[1]

Another study shows that lane departure warning systems could prevent or mitigate:

UP TO
3%
of all crashes

AND
37K
injury accidents per year[2]

INCLUDING
7,529
fatal crashes

At a minimum level ADAS technology is integrated into Level 1 Driver Assistance (shown in the previous graphic), but comprises a greater portion of each automation level through full automation (Level 5). Besides the different levels of automation, a simpler way to look at the potential of autonomous trucking is to explore the different types and uses of this technology.

3 PLATOONING

You've probably heard of platooning, and for good reason. Next to the continuing improvements and advancements in ADAS systems, it represents a near-term viable step toward autonomous trucking. International Truck is currently evaluating multiple options for bringing this technology to market. In our view, this is a technology that holds a lot of promise and potential for trucking as a means of reducing cost of ownership.

A truck platooning system allows several partially automated trucks to follow closely to each other – usually 40 to 50 feet apart – enabled by state-of-the-art driver support systems. Cloud-based connectivity can also be an integral part of platooning, such as OnCommand® Connection (OCC) by International Truck. OCC can enable bi-directional and secure communication between platooning trucks, as well as aid with alerts, traffic, weather, logistics, and GPS data.

With the most widely-accepted platooning model, the front driver has full control of the vehicle. For vehicles that are following, each driver has partial control of the truck – they can steer, but the braking and acceleration are automated in order to keep a precise distance behind the truck ahead, as well as ensure safety.

PLATOONING OFFERS SEVERAL ADVANTAGES:

FUEL CONSUMPTION SAVINGS
Trucks that are following behind another truck benefit from an average of 10 percent reduced drag. Constant speed also contributes to fuel savings.

INCREASED SAFETY
Systems feature virtually instant braking time (ten milliseconds), so platooning can improve traffic safety and cut down on accidents.

HELP TRAFFIC FLOW
Platooning can reduce tail-back, vehicles move at continuous speed for better traffic flow, and the shorter distance between vehicles takes up less space on the road.

HOW TRUCK PLATOONING WORKS

1) The driver in the first container truck leads the three driverless trucks. The lead vehicle is linked to a platoon via wireless communications.

2) The vehicles can be coupled and decoupled to allow other road users to cross between the vehicles in the convoy.

3) Vehicle detection, anti-collision and lateral control technologies are incorporated for safety reasons.
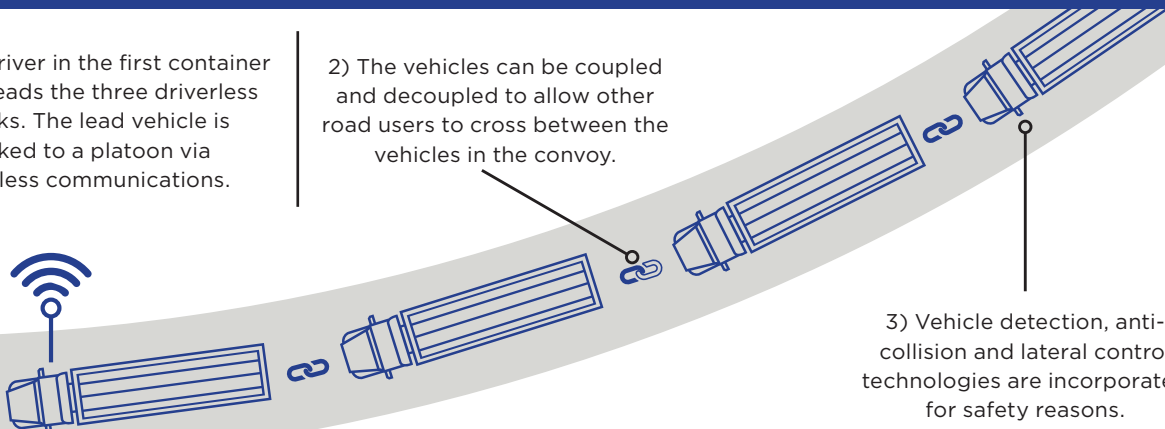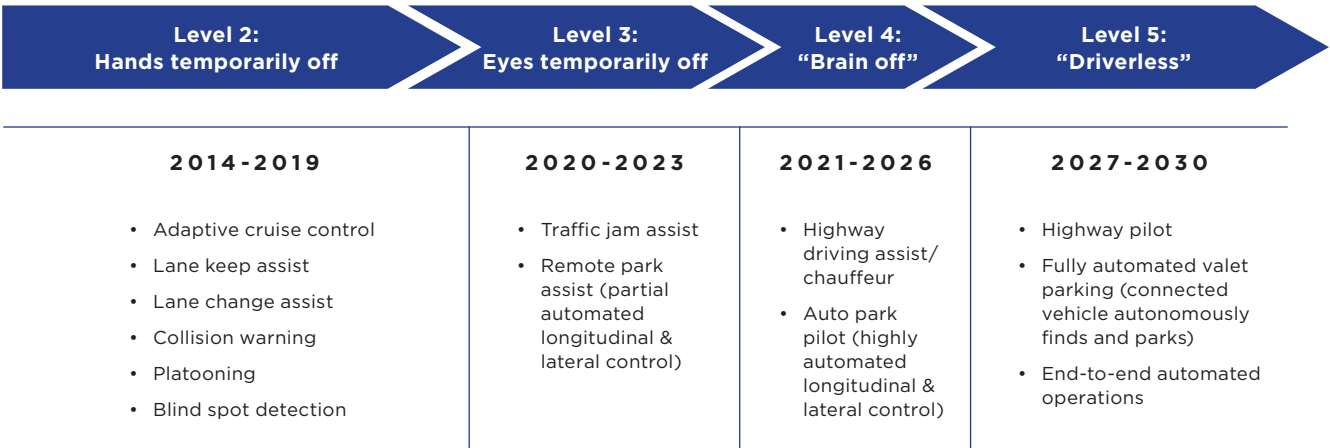
International Truck is committed to leading the industry by providing technology advancements with platooning that will deliver tangible benefits to their customers. The platooning model for International Truck, integrated with OCC vehicle-to-cloud connectivity currently being tested, has several incremental advantages:

- Improved visibility with video and over-the-horizon alerts
- Active safety and collision mitigation system
- Active braking system linked with platooning
- Safety monitoring and forensic control
- Enhanced maintenance standards and monitoring
- Vehicle-to-vehicle communications

4 OTHER AUTONOMOUS TECHNOLOGIES

Although platooning is taking center stage for the moment, there are several other innovations in development with planned releases over the next few years. Besides the many driving automations, these soon-to-come features include various levels of parking and docking assistance and range from partially automated to fully-automated operations.

POTENTIAL TIMELINE FOR AUTONOMOUS COMMERCIAL TRUCKING

Level 2: Hands temporarily off	Level 3: Eyes temporarily off	Level 4: "Brain off"	Level 5: "Driverless"
2014-2019	**2020-2023**	**2021-2026**	**2027-2030**
• Adaptive cruise control • Lane keep assist • Lane change assist • Collision warning • Platooning • Blind spot detection	• Traffic jam assist • Remote park assist (partial automated longitudinal & lateral control)	• Highway driving assist/ chauffeur • Auto park pilot (highly automated longitudinal & lateral control)	• Highway pilot • Fully automated valet parking (connected vehicle autonomously finds and parks) • End-to-end automated operations

02 THE INTERNATIONAL TRUCK POV ON AUTONOMOUS TRUCKS

In our view, autonomous driving technology has the potential to transform the industry. We believe autonomous trucking is really about two things: safety and efficiency.

We anticipate automated driving will boost both safety and efficiency to levels our industry has never seen before. Like electric trucks, it's not a question of "if," it's a question of "when" autonomous driving technology will be the dominant force in our industry.

That's why International Truck embraces this technology, with a pragmatic approach. We are working to develop, test, and launch autonomous trucking in a smart and methodical way. To us, that means a product development roadmap that rolls out this technology one automation level at a time. This approach doesn't expose our customers, suppliers, and stockholders to unnecessary risk, while still unleashing the technology's potential to bring tremendous benefits to fleet owners.

1 AUTONOMOUS AND ADAS

It's important to note that many in the industry take issue with the terminology being used. For example, the term "autonomous trucks" implies the absence of a driver. We'll discuss the new role of the driver later, but a term that we prefer is advanced driver assistance systems, or ADAS. We believe the role of the driver will change and increase efficiency for fleet owners.
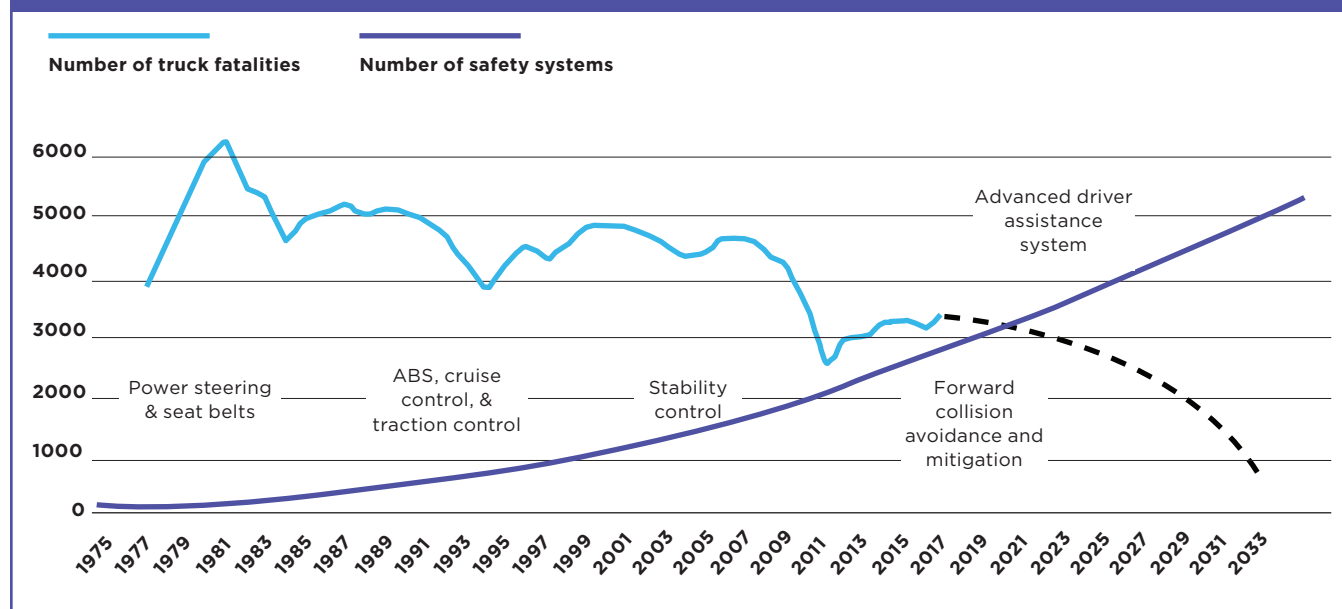
Although the term "autonomous" is widespread and perhaps can't be avoided in a discussion of automated vehicles, we certainly don't want to minimize or diminish the role of the driver as we discuss these technologies.

Consider how much ADAS safety systems have already had an impact on creating safer roads, which bodes well for autonomous technology. In fact, it's easy to argue that ADAS systems are the technology that has laid a foundation for autonomous driving, helping people around the world become more comfortable, little by little, with passenger vehicles performing certain functions. And as safety requirements tighten, there will be a bigger push for more ADAS systems. This will likely boost overall confidence in vehicle automation, and drive faster acceptance and adoption of automated trucks.

ADAS systems began with power steering and seat belts in their infancy, and progressed to ABS, cruise control, and traction control. Today, they offer advanced features like stability control, forward collision avoidance, automated distance-controlled cruise, blind spot detection, lane departure alerts, and other highly automated safety features. Not coincidentally, if you look at a two-line chart that tracks and forecasts the evolution of ADAS systems with truck fatalities, you see a clear inverse correlation.

THE EVOLUTION OF ADAS

Number of truck fatalities   Number of safety systems

Advanced driver assistance system

Power steering & seat belts

ABS, cruise control, & traction control

Stability control

Forward collision avoidance and mitigation

2 A PRAGMATIC APPROACH

Using the SAE five levels of driving automation previously outlined as a reference point, International Truck is committed to advancing this technology with thorough product and road testing. Our view is that each progression in the evolution of autonomous trucking must be thoroughly tested and proven on roadways.

We are committed to ensuring that each new automation or advanced ADAS feature that is integrated into our rigs advances the safety and efficiency of trucking, without posing unneeded risks to fleet owners. This pragmatic approach ensures our customers and stakeholders receive the value they've come to expect from us.

3 IT'S ABOUT SAFETY

For many in mainstream society, the prospect of an automated behemoth traveling at high speed on a highway may seem dangerous. But, for those of us that understand the technology and the sophistication of the systems, it's quite the opposite.

CONSIDER THAT 90 PERCENT OF ROAD ACCIDENTS ARE CAUSED BY HUMAN ERROR[3]

THE POTENTIAL IMPACT OF AUTOMATED TRUCKS ON SAFETY

Trucks involved in crashes
(per 100m vehicle-miles)

2000 = 222 crashes

2020 = 42 anticipated crashes

70%

2040 = 8 anticipated crashes

10%

1 = 10 trucks

Base year 2000

Projected development w/o automated trucks

Potential development with automated trucks

Source: EIA; NHTSA: BLS; Roland Berger[5]

Autonomous technology and artificial intelligence have the potential to take human error entirely out of the equation for a real possibility of crashes becoming a thing of the past. While fleet operators may be hesitant to invest in automated trucks due to costs or perceived slow payback, many in the industry feel that safety regulations may be the driving force leading to adoption of automated trucks.[4]

A human driver also has limited visibility, senses, and knowledge of what's down the road. With an autonomous truck equipped with sensors around the entire perimeter of a vehicle, visibility can be unlimited. Video, laser, and radar add the ability to sense other vehicles, objects and road conditions in instantaneous and precise ways that no human could ever achieve. At level 4, autonomous vehicles may have upwards up 10 radars, 10 cameras, 5 lidars, and so on. The technology behind it is spatial imaging. The truck's onboard computer instantly processes various sensor data and "models" the environment in real time, recognizing surrounding objects faster than humanly possible.

Finally, no one can see around a highway bend, let alone miles down the road. But trucks that wirelessly receive cloud-based mapping data based on crowd-sourcing, like Waze, can receive data that tells them there's a stalled car in the right lane two miles down the highway. Based on that data, a cloud-based truck has plenty of time to maneuver to safety. In the not-so-distant future, vehicle-to-vehicle and vehicle-to-infrastructure give drivers visibility to the road ahead. In comparison, a human may only have a fraction of a second to react to a stalled car in front of them as they clear a bend, having to execute tricky emergency maneuvers with unpredictable results.

4 IT'S ABOUT EFFICIENCY

The value of efficiency improvements industry-wide that could be brought about from autonomous level 4 and level 5 penetration in the trucking industry is forecasted to save the industry $59 billion dollars. These potential gains in efficiency cover a wide range of areas within trucking – everything from driver time efficiencies to operational improvements to transport time savings and more.

AREAS OF EFFICIENCY IMPACTED BY AUTONOMY

EFFICIENCIES WITH AUTONOMOUS TRUCKS

- Optimized driver resting times
- Less traffic congestion
- Reduced accidents
- Faster automated short-haul transfers
- Optimized routing
- Maximixed vehicle utilization
- Reduced vehicle complexities
- Optimized speed
- Weight efficiencies

5 WHAT HAS TO HAPPEN

Like any disruptive technology, autonomous trucks have certain hurdles to overcome to move forward toward full adoption.

REGULATIONS

Currently, the regulatory environment is fluid, and technologies like platooning are being addressed legislatively state-by-state. The good news is that policy makers appear to understand the benefits of autonomous technology, with several states already cleared for testing. In addition, a legal driving framework needs updating, and liability issues must be identified as well.

DRIVER ACCEPTANCE

There's a prevalent skepticism with many drivers about autonomy, as well as an understandable concern that their jobs will be replaced by technology. We believe those worries are largely unfounded, and that education is the key to drivers accepting systems and qualifications.

SOCIAL ACCEPTANCE

As with all autonomous vehicles, the public has yet to fully embrace the concept of autonomy, and trucking may experience the same resistance, if not more. ADAS systems and testing on dedicated roads will help pave the way to greater acceptance, but the responsibility is on product developers and testers to ensure all safety measures are taken. We must tread carefully – one single accident could set progress back and tighten the regulatory environment, as evidenced by recent fatalities involving both Uber and Tesla autonomous passenger vehicles.

DIGITIZED SUPPLY CHAIN AND CONNECTIVITY

Although this is the subject of another International Truck POV, it's important to note that technology communications platforms, like OnCommand® Connection (OCC), will be a key component that must be integrated with autonomous trucks. Digital supply chain technology will have to continue to develop and align with autonomous technologies.

03 THE ROLE OF THE DRIVER

International Truck values the role of the driver going forward into the autonomous future. We believe it's a role that will evolve, not be eliminated. When we look at the airline industry and how autopilot technology was integrated in airplanes, it was – and still is – considered an assistive innovation that allows pilots to do their jobs better and safer. While we can't rule out the possibility of driverless trucks years from now, we believe that autonomous technology will follow a similar path for the foreseeable future.

1 IMPROVING THE DRIVER EXPERIENCE

All partially or highly-automated levels can greatly assist drivers in what has historically been a difficult and even grueling job on the road. Automation can make the job easier in several ways and help improve driver wellness.

- **Fewer accidents due to distraction:** Nobody's perfect, but autonomous technology can compensate for any lapses in attention.

- **Better hours-of-service:** Trailing platooning truck drivers experience optimized resting times. Automation can also save time in completing manual tasks.

- **Reduced stress and greater comfort:** Drivers can relax more in the cabin. As automation takes over cumbersome tasks from drivers.

- **Greater engagement:** Drivers can engage in other operational and communication activities that can make the job more stimulating.

- **Less time sitting in traffic:** Autonomous technologies like platooning take up less road, potentially leading to less congestion.

In our view, autonomous trucks will be a boon for the wellness of drivers with the open mind to embrace this exciting new technology. And, with the median age of truck drivers at 55 and rising, these technology-based innovations have the potential to attract a younger generation of haulers that will not only help solve the current driver shortage, but infuse new energy into our industry too.

2 AREAS OF FOCUS FOR FULL AUTOMATION

Again, while we can't eliminate the possibility of fully automated trucks in the future, we do believe that there are some ideal applications for Level 5 Full Automation. These applications are being widely tested in Europe. International Truck is evaluating a wide range of applications for autonomous vehicles. For example, in the Port of Rotterdam in the Netherlands, autonomous trucks move containers from crane and ship areas into loading areas.[6] Short-haul, (less than a mile) repetitive movement of goods at distribution centers and ports is an area where full automation makes sense.

In fact, the mining industry is a good case study for the potential short-haul applications of autonomous technology. Many global mining companies have already had great success with driverless "robot" trucks designed specifically for hauling iron ore short distances. These vehicles run 24/7, completing arduous and sometimes dangerous human tasks without risks to life, while cutting operational costs by double digits in the process.[7]

It should also be noted that, even with Level 5 Full Automation, operational support from humans is still needed. In fact, for self-driving mining haulers, "drivers" control the vehicles remotely from a command center. So, even with fully autonomous trucks, the concept of a "driver" may evolve to include operational support or control of multiple vehicles outside the cabin.

04 THE INTERNATIONAL TRUCK APPROACH TO AUTONOMOUS VEHICLES

A t International Truck, we have a positive view on autonomous trucks, particularly in the area of platooning. The continued development of ADAS systems that allow for partial or high levels of automation is also part of our roadmap. An example of this includes our predictive cruise controls in our LT line that "looks" ahead of the truck to calculate the most efficient speed and gear for optimal fuel efficiency.

Best of all, we are in a strong position to lead the industry with our advanced and widely-adopted OCC connectivity platform, as well as our alliance partnerships.

1 PARTNERSHIP IS THE KEY

In 2017, Navistar finalized a strategic alliance with Volkswagen Truck & Bus to allow us to move much more quickly into several industry disruptive areas, including electric propulsion, autonomous vehicles and digital supply chain technology. The agreement included Volkswagen Truck & Bus acquisition of a 16.6 percent stake in Navistar. Other collaborations include connected vehicle platforms with the potential to be included in 650,000 vehicles worldwide.

VOLKSWAGEN TRUCK & BUS The Volkswagen Truck & Bus Alliance helps International Truck to leverage their substantial technology innovations and components in segments of the market where International Truck is already a leader. In addition, it facilitates an increase in global scale, strengthens competitiveness, and provide customers with expanded access to cutting-edge product, technology, and services.

The technology sharing element of the alliance will help the brands to move forward faster with commercial vehicle development, including areas like advanced driver assistance systems, connected vehicle solutions, platooning, and autonomous technologies.

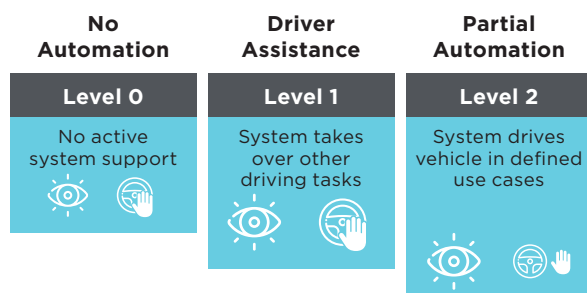# 2 KEY TO SUCCESS: VIEW IT AS STEP-BY-STEP PROCESS

If we look at autonomous trucking in terms of the SAE and NHTSA levels of automation, we believe in a path that takes us from where we are now with most modern rigs (roughly level 1 Driver Assistance to Level 2 Partial Automation) to the imminent launch of platooning.

Along the way, ADAS systems will continue to see advancements that bring us closer to a Level 3 of Conditional Automation, and clear a path to High Automation, or Level 4. Along the way, fleet owners will see increasing improvements in efficiency, bringing with them increasing levels of savings.
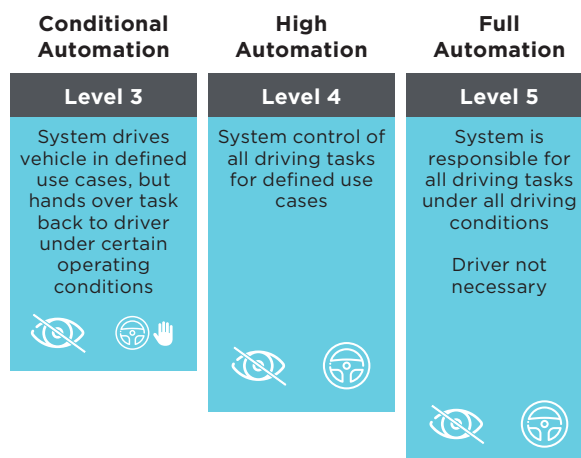
THE JOURNEY TO AUTOMATION

Driver - System

DRIVER "IN THE LOOP"

No Automation	Driver Assistance	Partial Automation
Level 0	**Level 1**	**Level 2**
No active system support	System takes over other driving tasks	System drives vehicle in defined use cases

DRIVER "OUT OF THE LOOP"

Conditional Automation	High Automation	Full Automation
Level 3	**Level 4**	**Level 5**
System drives vehicle in defined use cases, but hands over task back to driver under certain operating conditions	System control of all driving tasks for defined use cases	System is responsible for all driving tasks under all driving conditions. Driver not necessary

TCO Savings

| ~ 0% | ~ 0% | ~ 0% - 2.5% | ~ 2.5% - 5% | ~ 5% - 20% | ~ 30% - 40% |

Increasing level of automation and efficiency →

A SENSIBLE AUTONOMOUS PROCESS

A simpler way to look at our autonomous path is through the lens of the technologies. Breaking down into these four categories reflect our intent to progress toward higher and higher levels of automation and assistance, with the driver still in the cabin.

ADAS SAFETY SYSTEMS

- Collision mitigation
- Lane departure
- Auto emergency braking

PLATOONING

- OCC integration
- Digital supply chain
- Fully integrated and tested platooning solution

ADAS SAFETY EFFECIENCY

- Adaptive technologies
- Auto park
- Optimized routing

HIGHLY AUTOMATED FEATURES

- Automated docking
- High driver assistance
- Highway pilot
- Fully connected vehicles

05 CONCLUSION

At International Truck, we take the long-range view on autonomous trucks. We're excited about our initial trials and the imminent launch of our platooning technology, supported by OCC. Once state laws are amended, we believe the capability to deploy platooning intra-state will expand rapidly.

We also intend to continue to lead the way in ADAS and autonomous technology, one level at a time. Our aim is to bring autonomous trucks to market that can help the entire industry achieve unprecedented levels of safety and efficiency.

However, unlike some of the hype you may have heard recently that claims driverless trucks are imminent, we believe these technologies will serve drivers, not strip them of their livelihoods. Autonomous technology will make the trucking experience more comfortable, safer and engaging, improving overall driver wellness. Yes, the driver will have to embrace autonomy and evolve, but, those who do will reap these rewards and more.

And, by leveraging our OCC platform, platooning partnerships, and our strategic alliance with Volkswagen Truck & Bus, we intend to continue to approach autonomy in a way that brings greater opportunities and profits to our customers and stakeholders.

SOURCES

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3/4) Source: Roland Berger

5) EIA; NHTSA: BLS; Roland Berger

6) https://www.naiop.org/en/Magazine/2015/Summer-2015/Business-Trends/Driverless-Trucks.aspx

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