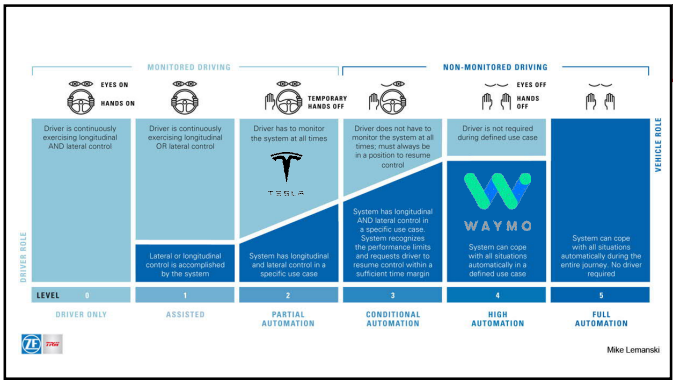
Automated Trucking: Current State and Near Term Outlook

Richard Bishop
Principal, Automated Driving Strategy & Partnerships

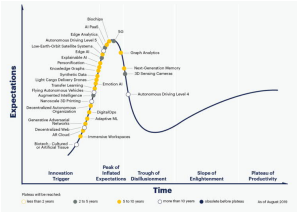
NCHRP 20-24(128) Freight AV Conversation with State DOT Leaders
March 22, 2021

BISHOP CONSULTING

Macro Trends: Big Picture

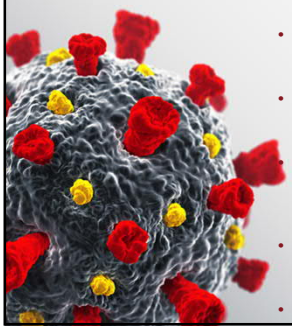


Gartner Hype Curve



- Gartner: Automated Driving Level 4 past the peak and heading for the trough.
  - but driverless has now launched!
  - Automated Trucking near launch.
- Gartner: Automated Driving Level 5 ascendent.
  - ….but no point in discussing Level 5;
  - there are endless business cases within Level 4!
- The "Trough of Disillusionment" in reality is an in-depth engineering phase focused on deployment.

COVID's Effects on Automated Mobility



- COVID's effects have been a mixed bag but are generally positive, with some areas like robo-delivery accelerating.
- Therefore street-level AV has significant momentum even if robo-taxi moves more slowly due to less ride-hailing demand generally.
- Development
  - Pandemic curtailed on-road testing of developmental AV's, while engineering staff made progress via simulations
- Deployment
  - Vastly different customer behavior (B2C and B2B) and limitations created delays
- Pandemic accelerated consolidation

Consolidation / Partnerships

- People Transport
  - VW invests $2.6 billion into Ford Argo AI
  - Honda invests $2B into GM Cruise
  - Hyundai-Aptiv: "Motional"
  - Amazon-Zoox
  - Waymo-Daimler supplier agreement
- Goods Transport
  - now moving past the point of AV startups working alone to prove themselves
  - Key indicators of sector maturity appearing:
    - partnering across OEMs-suppliers-startups
    - integration of ADS by OEMs.
  - Factory Built Level 4 Trucks:
    - TuSimple-Navistar partnership
    - Daimler
  - VW Traton full acquisition of Navistar Trucks (~$3B) highly significant to US market

Where Does Connectivity Fit in the ADS Ecosystem?

- ADS safety case must rely fully on on-board equipment.
  - cannot rely on external communications (including GNSS)
- ADS will be connected via cellular / cloud for purposes of efficiency/monitoring.
- ADS explicitly using low-latency V2V as a "niche":
  - truck platooning: data integrity via radio is fully under control of system provider, i.e. closed system
  - Cooperative Adaptive Cruise Control in ADS light vehicles? Robo-taxi's?
- Low latency V2X provided by infrastructure
  - highway: public agency data valued but can be provided via cellular
  - street: traffic light data valuable as additional data source, but not essential

Deployment of ADS Products & Services

Highly Automated Driving: Fleets First! Robo-delivery, Robo-taxis, Robo-trucks.

- Operations area selected for best fit with tech capability.
- Cost pressure much less than retail model: all about Return on Investment!
- Hands-on, skilled staff provides software upgrades, system safety certification, maintenance, etc.

People Transport
Privately Owned Vehicles

Examples of Level 2 (Hands-Off, Eyes-On)

- GM / Cadillac CT6 “Super Cruise”
- BMW (low speed range)
- Ford Mach-E
- Nissan “ProPilot 2.0”
- Subaru

GM Super Cruise on Cadillac CT6

- Super Cruise used in 70% of miles driven by CT6 owners on divided highways.
- Automated lane changes coming 2021
- Next generation “Ultra Cruise” functionality may include street operations.



Examples of Level 3 Offerings (Hands-Off, Eyes-Off, Brain-On)

- Honda Legend (Japan)
  - low speed range
  - ~$8000 option
  - March 2021
- Mercedes S-Class
  - low speed range
  - Germany only
  - late 2021
- BMW iX
  - full speed range
  - late 2021

People Transport Robo-Taxi

Robotaxi Developments: USA

- Waymo
  - 600 autonomous vehicles
  - Fully driverless operations in Phoenix, Arizona
  - driverless testing in San Francisco
- Cruise
  - Traverses 20,500 San Francisco intersections daily
  - testing driverless now
  - no public use yet
- Lyft
  - Lyft platform supporting Lyft, Aptiv, and Waymo vehicles
  - 2023 launching driverless services with Motional
- Voyage
  - Chrysler will supply Voyage with purpose-built Pacifica Hybrid minivans
  - transitioning to driverless soon
- Ford
  - robo-delivery launch 2022

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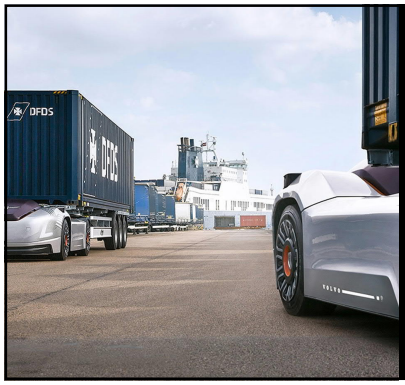
Goods Transport

Controlled Environments

Streets

Resource Roads

Highway



Controlled Environments

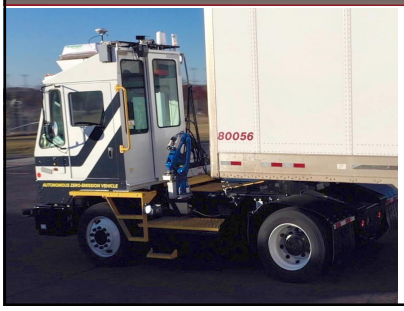
- Low speeds; dirty, dusty
- Specialized, high user need
- Small market

Controlled Environments

Outrider

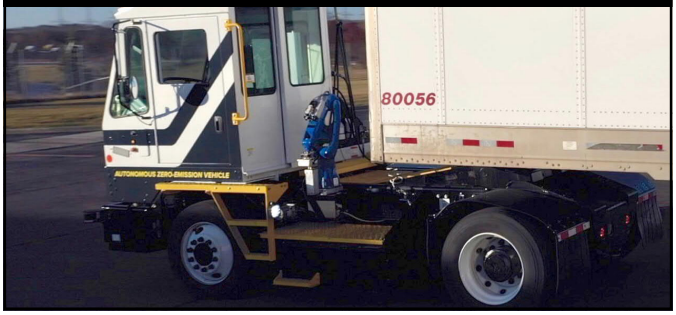
- Announced customers:
  - Georgia Pacific
- $65M in new funding

Outrider.ai: Distribution Yards



- Distribution yard ideal for automation:
  - well-defined environments
  - complexity constrained
  - discrete repetitive tasks
- Automates all aspects of the yard including connecting and disconnecting the brake lines to the trailers.

Robotic Manipulation of Air Line Connections



Street

- Complex environment
- Low speed
- Customer-facing
- Strong market, growing

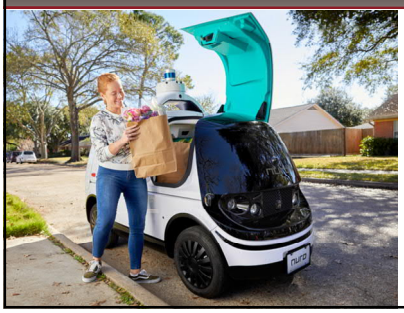
Streets: Parcel Delivery Business-to-Business

Waymo
- Announced customers:
  - UPS

Gatik
- Announced customers:
  - Walmart
  - Loblaw
- 2021: fully driverless operations in Arkansas
- $25M in new funding

Einride
- Announced customers:
  - Oatly
  - Lidl
  - Coca-Cola
- $10M in new funding

Streets: Parcel Delivery Business-to-Consumer



nuro
- Announced customers:
  - Fry's Food
  - Kroger
  - CVS
- $500M new funding

Resource Roads

- Unpaved roads
- Remote areas
- Medium speed
- Modest market

Resource Roads

FPInnovations

- A major Canadian not-for-profit research center.
- Driver shortage is a key pain point! Automated Follower platooning of interest.
- Launching project in 2021 to adapt commercial systems for rural public roads.

Forest Product Innovations

FPInnovations

- Challenges
  - unpaved roads
  - all-weather conditions (dust, snow)
  - complex truck configurations
- During 2018-2019, FPInnovations hosted the first-ever truck platooning trials on resource roads in snow and rain, with vehicles from Auburn University's GPS and Vehicle Dynamics Laboratory
- Video's
  - A Canadian First: Truck Platooning on Forest Roads:https://www.youtube.com/watch?v=OdhzRJQ7Qfw&t=139s
  - Truck Platooning Initiative Launch: https://www.youtube.com/watch?v=BYoF0n8sw9E&list=WL

Highway

- Well ordered environment
- High speed
- Huge market
- Platooning L1 / L4
- Stand-alone L4 driverless

Truck Platooning Basics

- Close Drafting done safely, reducing fuel use
  - 4% for leader, 10% for follower at 60 ft at 60 mph
- Close Following via "connected braking" between trucks, using low-latency vehicle-to-vehicle communications (DSRC)
- Commercial systems focus on multi-lane, divided, limited access highways
- Properly handling cut-in's by other vehicles a key part of safety case.

Platooning: Two Generations

1st Generation

Level 1 Platooning

- front driver drives normally
- rear driver(s) steer, monitor the road, respond to traffic

2nd Generation

Level 4 Following

- front driver drives normally
- no driver in follower truck(s)

Current Active Truck Platooning Players

Peloton

LOCOMATION

ROBOTIC RESEARCH

TRATON GROUP

VOLVO TRUCKS

DAIMLER TRUCKS

FHWA's Field Test Of Truck Platooning Launches 2021

- FHWA awarded $3M platooning Field Operational Test program to UC-Berkeley
  - 150,000 miles of operations on route California to Texas (I-10).
  - Running 4 trucks at SAE Level 1, one as a control/baseline truck plus either two- or three-truck platoon.
  - Assessing driver issues as well as interactions with other traffic.
- Most interesting results: evaluating interactions between platooning trucks and surrounding traffic.
- Other research goals of assessing fuel economy and driver experience have been thoroughly examined by the private sector.
- Estimate results being published in 2023 at the earliest.

Level 1 Platooning

Initial Major Use Case: Same-Fleet, Hub-to-Hub Routes

Peloton Technology Customer Trials

- PlatoonPro commercial Level 1 system
- Major customer trials with multiple leading fleets since 2018
- Driver feedback: consistently positive
- No hard braking or safety incidents
- Cut-ins:
  - averaging once per 620 miles
  - smooth dissolves
- Team fuel savings: ~ 7%

Level 4 Platooning: Automated Following

Locomation

- Testing with Wilson Logistics last summer, carrying freight between Oregon and Idaho.
- Wilson Logistics agreed to equip 1,120 of their trucks with Locomation's platooning technology; initial deliveries in 2022.

Peloton Technology: AutoFollow

- Doubles the amount of freight one driver can haul in a single trip.
- Human driver in lead vehicle simplifies technical design
  - allows operations across a wider set of complex operating scenarios for more deployable miles.
  - allows interactions with public safety officials
- Market launch builds upon Level 1 platooning customer base.

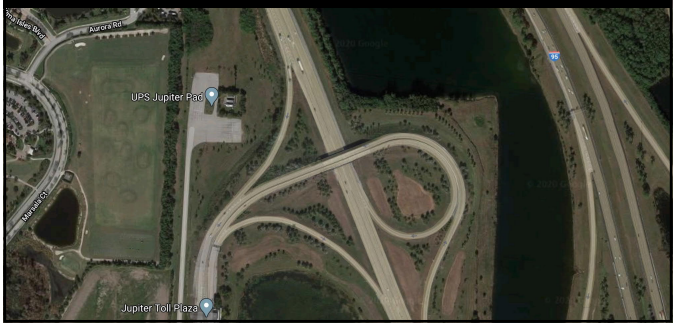
U.S. Army Procuring "Leader-Follower" Kits

- Different functional specification
  - short to long gaps
  - Level 1 and Level 4
- 100 systems being evaluated at an Army base.
- Army RFP for thousands of systems expected in 2021.

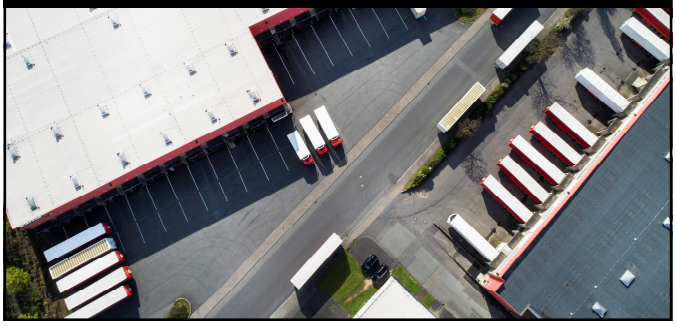
ROBOTIC RESEARCH

Level 4 “Solo Driverless”

Ramp-to-Ramp



Dock-to-Dock



Solo Driverless Players

AUTOBON · Ike · WAYMO · tusimple · EMBARK · PRONTO · Kodiak · Aurora · E/NRIDE · pony.ai · plus.ai · TESLA · VOLVO TRUCKS · PACCAR · NAVISTAR · TRATON GROUP · DAIMLER TRUCKS

Solo Driverless Trucking

- Development and Testing
  - Truck ADS startups are operating L4-intent systems on public roads, backed up by safety drivers.
  - Kodiak:
    - recently made its 250th commercial delivery in Texas
    - just announced 800 miles of continuous disengagement-free driving over multiple runs in Texas
  - TuSimple: running 3 to 5 commercialized trips per day.
  - Plus
    - Safety testing program across 17 states includes winter testing on MnROAD.
    - Ohio's Transportation Research Center contracted to provide independent track-based validation.
  - OEMs Daimler and Volvo have initiated large programs for automated operations.

Solo Driverless Trucking

- Efficiency
  - Developers note significant fuel savings from "solo" automated driving.
- Deployment
  - Redundancy is critical to driver-out operations
    - TuSimple asserts first driver-out operations in 2021, based on retrofit
  - Factory built Level 4 trucks coming 2023-2025
    - TuSimple partnership with Navistar
    - Waymo sourcing L4-ready trucks from Daimler
  - Plus:
    - PlusDrive driver-involved "supervised Level 4" product: can be installed on an existing truck or as an upfit option on new trucks
    - Deliveries underway: 10,000 pre-orders for PlusDrive in 2021

Case Study

Plus: A Unique Statistical Validation Approach

- "Billions of real-road miles are needed to statistically prove the safety of the system before making fully driverless trucks commercially available."

Plus: A Unique Statistical Validation Approach

- 2021 product introduction: intelligent trucks powered by Plus's self-driving system
- Jointly developed with the world's and China's largest heavy-duty truck maker (FAW).
- Initial driver-in product (2021)…
- … incrementally validate and transition to full driverless product.

Plus: A Unique Statistical Validation Approach

- FAW J7+ models average 100,000 miles per year or more.
- Only 5000 trucks running for two years = 1B miles.
- L4 deployment expected ~2024 as truck OEMs bring L4-ready tractors to market.

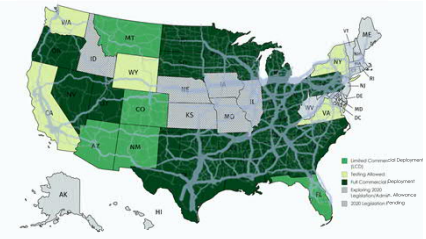
A Harbinger of Things to Come: Plus "Butter Run"

- Land O'Lakes partnered with Plus to complete a hub-to-hub trip from Tulare, CA to Quakertown, PA — 2,800 miles — in less than three days.
- First cross-country automated freight run with refrigerated cargo.
- What are the implications for a sustainable supply chain?

Regulatory Snapshot

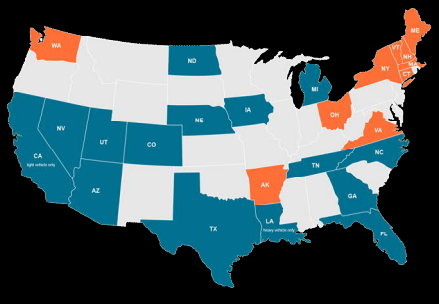
U.S. State Allowance for Truck Platooning

Commercial deployment now widely allowed



- **Level 1 Commercial Deployment now allowed in 27 States**
- **Approved States now Encompass over 80% of Annual US Freight Truck Traffic**
- **AutoFollow allowed in Arizona, Texas, Utah thus far**

U.S. State Government: State Regulations on Driverless Vehicles



Allows Testing Only
- Can be considered as precursor to allowing deployment.

Allows Deployment
- States allowing deployment may need to put additional measures in place for police and traffic enforcement.
- For highways, AV truck advocates are pushing hard for definitive and clear state regulations.
- For urban operations, city governments may play an important role.

Deployment Geography

USA fo[illegible]ets comprise~160,000 trucks.

EU exemption process allows for limited deployment now.

California Bill: "all AV's to be EV's by 2025"

California Bill: "all AV's to be EV's by 2025"

Automated Vehicles Are Not A Monolith!

- Early years of AV discussion and Federal guidance focused on AV generically: appropriate for the time
- Now entering era of deployment
- AV's span vast array of Use Cases: differences must be understood and taken into account.

Automated Trucking and Labor: Gradual Rather Than Disruptive

- Securing America's Energy Future
  - "America's Workforce and the Self-Driving Future" June 2018
  - Positive economic impacts
  - Negative economic impacts
    - Slow evolution: order of magnitude less impact than 2003 recession
    - Can easily be absorbed by market via existing tools such as re-training
  - "SAFE believes that society does not have to choose between the compelling benefits of AVs and the stable evolution of the workforce. The totality of evidence generated by this study strongly supports the conclusion that the best pathway to broad American prosperity is through the adoption of policies supporting AV deployment while simultaneously laying the groundwork for the workforce of the future."

Automated Trucking and Labor: Gradual Rather Than Disruptive

- USDOT Volpe Center 2021
  - analysis of the potential macroeconomic impacts resulting from the adoption of higher level automated driving systems (ADS) of the long-haul trucking industry in the United States.
  - Three time profiles for the adoption of automation are explored.
  - The results show that automation of the long-haul trucking industry is expected to bring welfare enhancing productivity enhancements to the economy.
  - Assuming that occupational turnover rates remain as they are, these positive economic impacts would not be accompanied by forced-lay-offs under the slow and medium adoption scenarios. Only under the fast adoption scenario are there short-lived, small magnitude lay-offs.

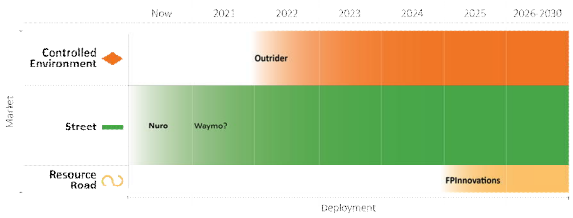
USDOT FMCSA Administrator Meera Joshi

- "The truth is there's a huge workforce that today travels all across the nation and performs the duties of a professional driver, and it's been a mainstay of American employment for a long time. Automated vehicles will certainly make in-roads into that workforce."
- "…hard question to answer empirically as we just don't yet have the data to be able to predict when or how significant that impact will be."
- "It is certainly a priority of this administration, this DOT, and the Department of Labor, understanding that there are real and broad impacts to automation on peoples' livelihoods."
- "The administration needs to think about opportunities to where that workforce can be shifted, what training opportunities there are to allow displaced drivers to prepare for new careers, and what additional jobs may actually be created through automation."
- "We can argue about the scope and the timeline, but we can't argue that there will be a major shift in workforce. [We are working to] best prepare the workforce for this change regardless of the timeline and the size of the disruption."

Pulling It All Together

Goods Transport: Driverless Deployment

Size of Market and
Extent of Deployment Over Time



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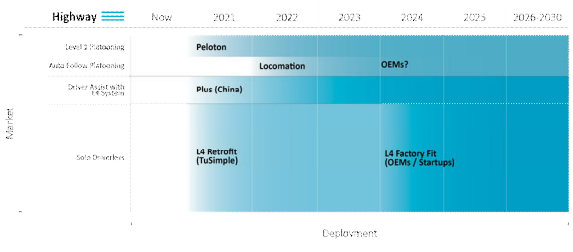

Thank You

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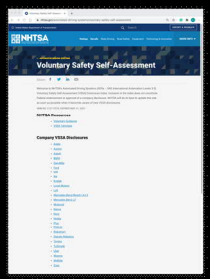
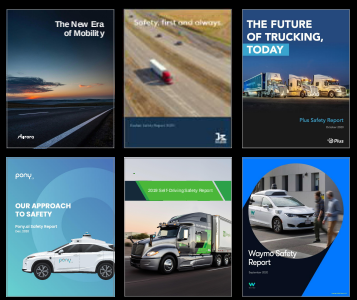
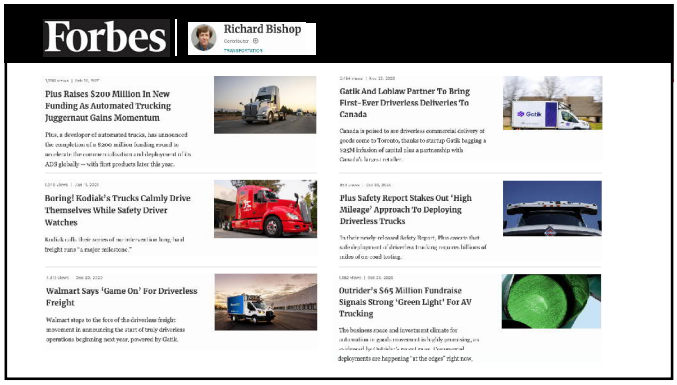
Voluntary Safety Self Assessment (VSSA)



https://www.nhtsa.gov/automated-driving-systems/voluntary-safety-self-assessment





Forbes | Richard Bishop

Plus Raises $200 Million In New Funding As Automated Trucking Juggernaut Gains Momentum

Plus, a developer of automated trucks, has announced the completion of a $200 million funding round to accelerate the commercialization and deployment of its ADS globally—with first products later this year.

Gatik And Loblaw Partner To Bring First-Ever Driverless Deliveries To Canada

Canada is poised to see driverless commercial delivery of goods come to Toronto, thanks to startup Gatik logging a $25M infusion of capital into a partnership with Canada's largest retailer.

Boring! Kodiak's Trucks Calmly Drive Themselves While Safety Driver Watches

Kodiak calls their automated operation boring, but freight runs "a major milestone."

Plus Safety Report Stakes Out 'High Mileage' Approach To Deploying Driverless Trucks

In their newly released Safety Report, Plus asserts that safely deployment of driverless trucking requires billions of miles of on-road testing.

Walmart Says 'Game On' For Driverless Freight

Walmart steps to the fore of the driverless freight movement in announcing the start of truly driverless operations beginning next year, powered by Gatik.

Outrider's $65 Million Fundraise Signals Strong 'Green Light' For AV Trucking

The business space and investment climate for automation in goods movement is highly promising, as evidenced by Outrider's recent raise. Commercial deployments are happening "at the edges" right now.