



A LILEE Systems White Paper

# Why we're bullish on buses too

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# Introduction

Thriving communities depend on transportation to access jobs, education and conduct trade. Collectively, [U.S. urban transit systems move more than 27 million passengers a day](#)<sup>1</sup>. As transportation systems grow, safety, reliability and even customer satisfaction are becoming technology-dependent. With 5G and other technologies ramping up, we can expect to see tangible advances in intelligent transportation, including systems and business models supporting automation and mobility-as-a-service (MaaS).

Recent reports indicate that buses will be a [growing component](#)<sup>2</sup> of modern urban transportation systems. Global market size, growth and demand for buses are [forecast](#)<sup>3</sup> to increase through 2025, and electric buses constitute the fastest-growing segment of the EV market with an annual compound growth rate of more than 100 percent as compared to 60 percent for [passenger cars](#)<sup>4</sup>. Despite these predictions, buses lag behind other modes in respect to modern technology applications.

In this paper, we address how technology can work in buses, shuttles and similar vehicles to advance safety, efficiency and passenger experience as society redefines modern transportation systems.



# Universal Challenges

Why focus on buses? With autonomous vehicles and MAAS in pilot phases, buses, vans and shuttles solve problems for transportation systems **now**. Here are 3 major factors driving their growth as the urban mobility equation evolves.



## 1. Continuing Urbanization

The world population continues to migrate toward urban centers where there are more commercial opportunities, jobs and resources. Already, 55% of the world's population lives in cities as compared to 30% in 1950, and 82% of the North American population already [resides in cities](#)<sup>5</sup>. As cities continue to absorb more residents, increased population density is stressing urban transport systems, causing congestion, noise, pollution and heat. Technology-enabled solutions have appeared, but the jury is still out in respect to long-term efficacy.

For example, two-sided transportation marketplaces, in part aimed at reducing the number of privately owned vehicles on urban roads may, in fact, be having the opposite effect. For example, in San Francisco, studies indicate that over a six-year period, Uber and Lyft accounted for two-thirds of a 62% [rise in congestion](#)<sup>6</sup>. In addition, their current

[business models may not work well enough](#)<sup>7</sup> to prevent drivers from [gaming the system](#)<sup>8</sup>, for example, canceling rides until higher fares are available, reducing reliability for consumers and exacerbating congestion. Urban residents, municipal leaders and corporations are now looking for other solutions to offset pressure on existing transportation resources.

Buses are one of the most viable options for safe, reliable transport, and according to some studies, adding buses to transportation fleets represents one of the [best cost structures for urban systems](#)<sup>9</sup>. Buses can utilize existing infrastructure, providing immediate relief to already congested roadways, causing minimal disruption to residents and corporate tenants. Bus and shuttle fleets can also adapt availability as demand flexes seasonally, during commuting hours as well as for first- and last-mile needs, using either traditional or MAAS business models.



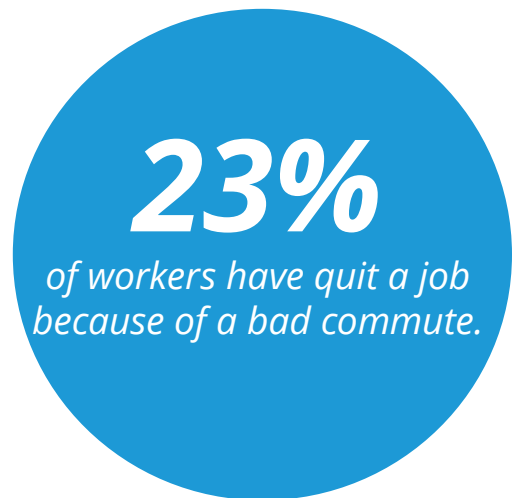
## 2. Emphasis on Experience

Today, passengers expect more than a way to get from Point A to Point B. Technology has changed expectations around “passenger experience,” but implemented intelligently, also reduces risk, improves efficiency and streamlines operations.

More and more, people expect to stay connected to personal devices for entertainment and work, wherever they are. For some transportation solution providers, reliable, cost-effective connectivity can increase ridership and reduce customer churn. For others, it is more than a “nice to have.”

Increased congestion and urban sprawl have contributed to a steady [rise in average commuting times](#)<sup>10</sup>, materially affecting businesses in terms of productivity and talent retention.

In heavily urbanized areas, 23% of workers have quit a job because of a [bad commute](#)<sup>11</sup>. Leading corporations are now partnering with private bus operators to offer commuter benefits that help them attract and retain talent. Bus operators offering onboard Wi-Fi with enterprise-class capacity, security and controls can help improve employee productivity while reducing commute stress (see Customer Story).



“Connected transportation,” however, means much more than offering passenger Wi-Fi. Downtime, accidents and fleet inefficiency are major cost centers for bus operators, both in hard costs and lost revenue. Lifecycle costs, including maintenance and are reported to exceed initial investments when calculating total cost of ownership. Operators also need to keep reserve vehicles to assure availability but may not know how many units are needed to balance cost and availability. Liability is also an issue. In 2016, it was reported that [NYC Transit had paid \\$431M](#)<sup>12</sup> over five years to settle lawsuits from people injured by MTA trains or buses.


As wireless connectivity improves, digital solutions can also help operators lower operating costs and mitigate risk through driver- and asset-monitoring solutions, helping to increase ridership by keeping costs low.

## Customer Story

WeDriveU® is a leading provider of corporate transportation. Moving 5 million passengers annually, WeDriveU's Commute Alternative solutions eliminate 15,000 single-passenger vehicles daily and generate \$250 million in annual productivity value. WeDriveU's secure, always-on passenger Wi-Fi ensure that thousands of employees can be productive while commuting.

In addition to connectivity, customers also wanted to track and monitor their fleet, authenticate passengers, and remotely monitor onboard networks and mobile gateways. LILEE Systems worked with WeDriveU to deliver a fully managed connectivity-as-a-service solution that provided highly reliable, high-bandwidth passenger Wi-Fi as well as the ability to manage their fleet.

So far, every passenger has taken advantage of the high-speed Wi-Fi to connect to their corporate VPN and applications. Operators also use LILEE Systems solution to boost operational efficiency and to keep cellular costs low. LILEE's subscription-based service has allowed WeDriveU to scale as its customer base grows, deploy premium connectivity to a wider fleet, and extend its lead in the marketplace.



"Superior connectivity is integral to offering the best commute experience for passengers. We're thrilled to team with LILEE Systems and see the real-world results that they provide."

- Erick VanWagenen, President and Chief Operating Officer at WeDriveU, Inc.





### 3. Paths to Autonomy

Some transportation modes are well on the way toward being fully or semi-autonomous. In 2008, the U.S. Government [introduced legislation](#)<sup>13</sup> that required the implementation of improved safety measures in the rail sector. Known as the Rail Safety Improvement Act (RSIA), this legislation required all Class I railroads and passenger rail operators to implement mandatory Positive Train Control (PTC) technology to enable remote collision avoidance systems. Elsewhere, [China introduced a driverless bus-train hybrid](#)<sup>14</sup> in 2017 which is operated electrically and uses sensors to follow “virtual rails” on the road. Finally, Caterpillar’s [fully autonomous mining vehicles](#)<sup>15</sup> are being used to improve safety and productivity.

In urban settings, some are promising self-driving cars, or [robotaxis, will be in available by 2020](#)<sup>16</sup>;

however, inserting fully autonomous cars into the urban mobility equation will be far more complex for municipalities and technology providers. Operating parameters for cars and taxis have a higher degree of variability in respect to route selection, environment and driver behavior as compared to rail and even mining vehicles which have fixed or more predictable routes. Higher degrees of complexity mean greater dependence on computing power, continuous connectivity and bandwidth thus making total autonomy less feasible for cars and taxis in the near term.

As cities, corporations and commuters grapple with congestion, buses and shuttles taking fixed routes may be the next mode to go semi- or fully autonomous to become safer and more cost-effective.



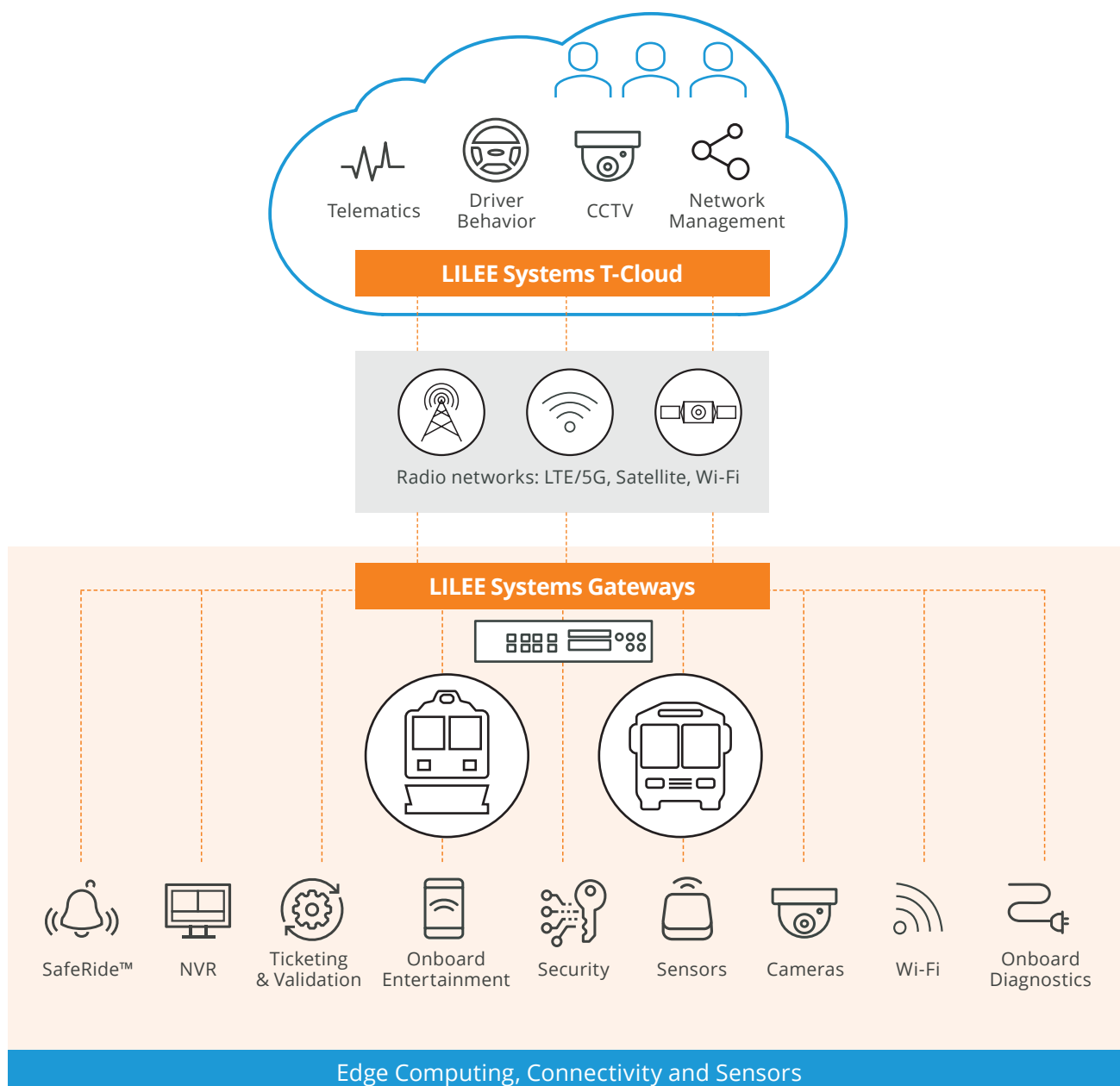
## So, what now?

In today's climate, no industry, including transportation, is immune to digital transformation. Certainly, (I)IoT, Big Data and AI are already influencing operations, but they do not change fundamental business objectives. Whether it's for public or private transportation providers, technology has the capacity to improve safety, customer satisfaction and keep services cost-effective.

## Solution Approach

LILEE Systems was founded in 2009 by industry leaders with extensive backgrounds in wireless communications, network routing and switching, and software-defined radio (SDR). Founded with the main purpose of providing communication networks to enhance safety in the railroad industry, we have recently applied this expertise and "lessons learned" to create digital solutions for the broader transportation market, including buses, motor coaches and shuttles.

LILEE Systems offers the following and other solutions to transportation owners, operators and municipal managers.





## SafeRide™

Drivers and operators all take on a huge responsibility when transporting passengers. They expect to reach their destination safely, and there can be significant consequences if they do not.

Compared to cars and other transport, the number of bus accidents is extremely low; however, buses do not always have the same [level of protection](#)<sup>17</sup> (e.g. seat belts) that passenger cars do. If a serious accident does occur, injuries are often more severe and can trigger liability suits for transportation companies.

There are many variables that can contribute to a bus accident or onboard injuries. When something does go wrong, it can often be difficult to determine cause and fault. Some of the most common causes of bus accidents include:

- Drivers either drowsy or distracted
- Bad road conditions and weather
- Defective or malfunctioning bus equipment
- Disruptions in cabin
- Improper weight distribution

To date, there has not been an effective, data-driven way for operators to understand conditions affecting the safety and efficiency of their fleets, either in real time or when investigating the causes of accidents or injuries.

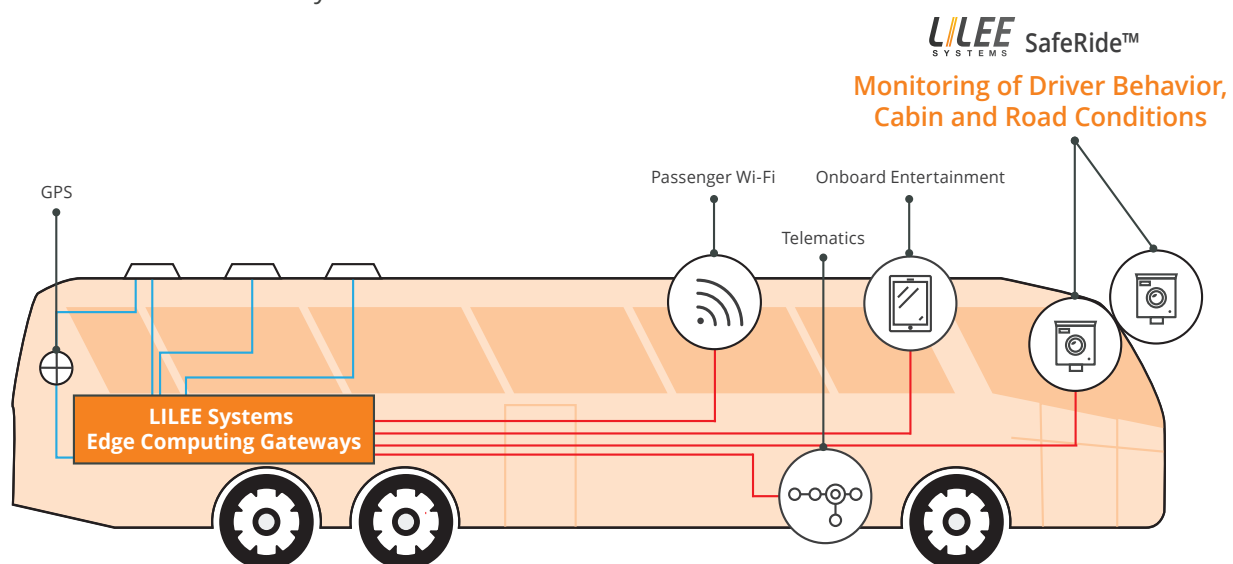
LILEE Systems SafeRide is an event-based data and video monitoring solution. It combines digital “black box” data with time-synchronized video

feeds to enhance data with operational contexts. Visual and audio records of driver, cabin and road conditions combined with events enable operators to see, record and understand all factors correlated with potential safety breaches and incidents.

How does it work? Onboard sensors detect and memorialize events such as hard braking and cornering, speeding, vehicle fault codes and when a “panic” button signaling dangerous conditions is depressed. Simultaneously, up to eight onboard cameras create and store video and audio records of road conditions, passenger and driver behavior. Discrete events are synchronized with and bookmark video records, effectively integrating operational events and contexts.

SafeRide video feeds are viewable in real time so operators can remotely monitor driver behavior as well as cabin and road conditions. When needed, bookmarked videos are available on-demand, and if stored, create a comprehensive record base that can be re-used for training, asset lifecycle management or exposed to AI to understand causes of accidents, safety breaches and breakdowns.

Finally, defined or driver-defined events such as mechanical fault codes or onboard emergencies, can be shared through text or email with operations and emergency personnel to trigger quick and effective incident or crisis management.



For more information, please visit [www.lileesystems.com/saferide](http://www.lileesystems.com/saferide).



## Passenger Wi-Fi and Onboard Entertainment

In today's on-demand society, reliance on mobile devices for work, school and entertainment is only growing. For today's transportation providers, passengers have come to expect and even rely upon the same digital service they have in their homes, no matter where they are. Differentiating transportation services often means ensuring that customers have seamless connectivity and/or entertainment options, no matter where they are.

LILEE Systems delivers premium Connectivity-as-a-Service that offers highly reliable connectivity on buses, shuttles and vans. With high-bandwidth Wi-Fi, passengers can do more than just check email. Corporate riders can rely on Wi-Fi to access office applications behind firewalls as they would in the office, transforming their commute into productive time (see Customer Story). With Onboard Entertainment, long-haul passengers can access popular content, even as they travel through remote areas.

With both Wi-Fi and Entertainment solutions, LILEE Cloud Services alleviate IT administration through zero-touch device and network management.

Modular solutions reduce risk of adoption by enabling:

- Ability to scale up or down rapidly
- No upfront hardware and software investment
- Cloud-based infrastructure management
- Flexible data rate plans (40GB to 400GB+/month)
- 24x7 customer support



For more information, please visit [www.lileesystems.com/smart-connectivity](http://www.lileesystems.com/smart-connectivity).

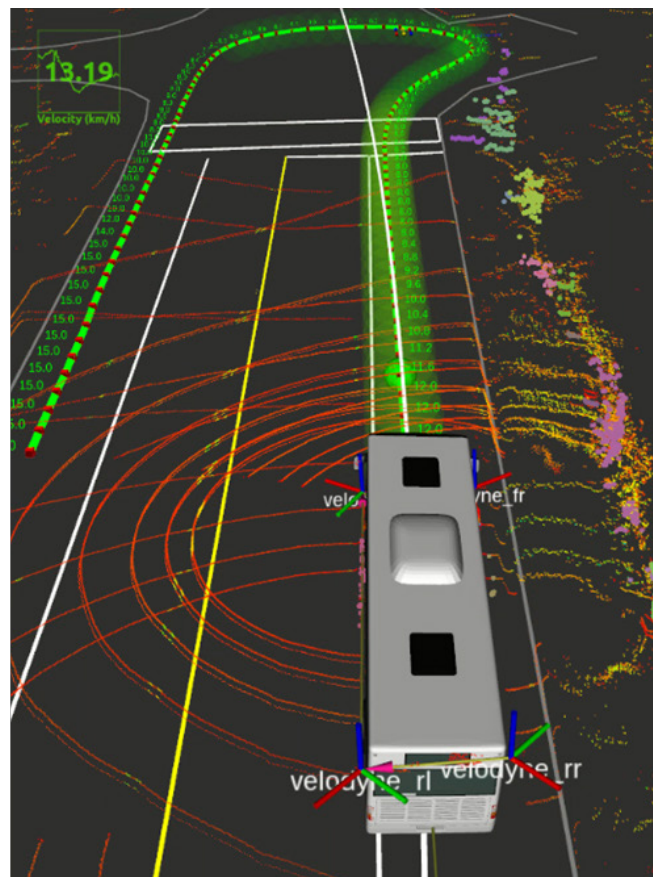
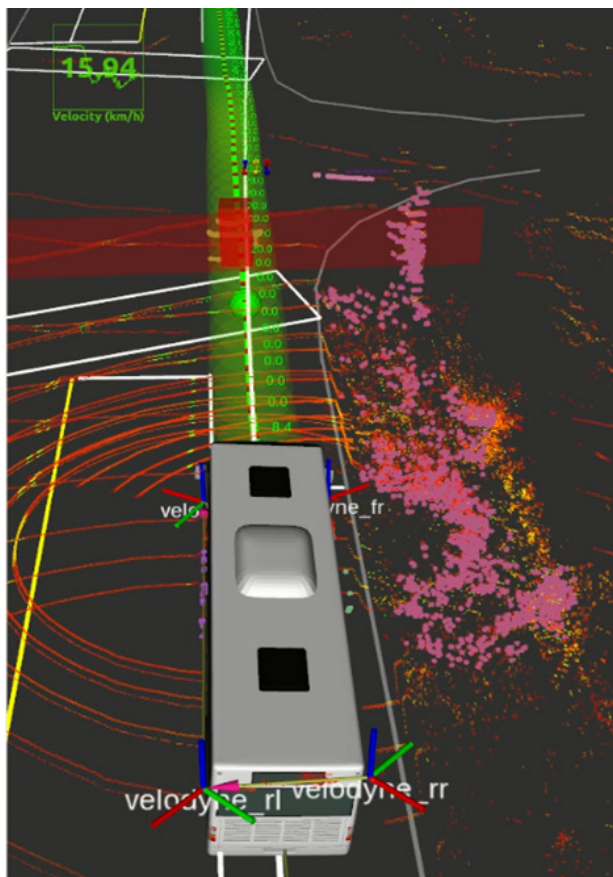
## Virtual Tracks, Autonomous Buses

Why buses? Buses do not need massive infrastructure investments and can eliminate risk associated with robo-taxis and autonomous cars. When buses travel on defined routes, engineers and city planners can map these routes like ‘virtual tracks’ for communications-based control. There are already successful pilots in play. In 2017, China released a driverless Smart Bus, dubbed Autonomous Rail Transit, which is operated electrically and uses sensors to follow “virtual rails” on the road.

In Taiwan, LILEE Systems leveraged years of experience in Communications-Based Train Control (CBTC), a proven rail safety technology, to make autonomous buses a reality in Taichung City. After retrofitting a city bus with sensors and communication, the LILEE Systems Autonomous Bus carried more than 5 thousand people safely over its 3-mile course.

Looking forward, technology enabling autonomous buses can facilitate more productive operations, faster than other modes. For example, dynamic dispatching can be implemented based on ridership, and cities would not need to wait for new technology. LILEE Systems enables stakeholders to retrofit existing city buses and shuttles with Drive-By-Wire (DBW) controls, smart sensors, cameras, GPS and LiDAR, offering a reliable and cost-effective strategy to modernize transit systems.

Other groups could benefit from the same approach. With a reasonable infrastructure investment, transportation providers with fixed routes including first- and last-mile delivery services, airports, as well as theme and corporate parks can all benefit from virtual-track technology to improve safety, availability and cost.



Global waypoints of the LILEE Systems autonomous bus for route decision-making

To see LILEE's autonomous bus, please visit [www.lileesystems.com/autonomous-buses](http://www.lileesystems.com/autonomous-buses).



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## Summary

No matter which industry you find yourself in, digital technologies are changing operations, business models and customer experience. For some, advances in IoT technology are sharpening operational visibility and insight. For others, digital technologies are helping companies improve customer experience either by gaining holistic views of the customer or enhancing existing products with digital capabilities.

In transportation, the benefits of intelligent, or “digital,” transportation systems are well characterized. While some modes, like rail and aviation, are well on the way to being fully autonomous, passenger cars have lagged behind, in part, because of challenges of scale associated with full autonomy.

While some are predicting that robo-taxis will be next to hit the streets, we believe that “smart” buses will come first. Buses reduce congestion and have advantageous cost structures for cities. Driver, passenger and operational monitoring systems purpose-built for buses are now available and can help operators improve safety, protect against risk and build operational transparency.

When investing in technology, transportation can learn from other industries including energy, manufacturing and construction. Under-investing in technology or treating each application (e.g. Wi-Fi, Safety, Telematics) as an isolated “project” together creates cost, solution rigidity, data silos and IT complexity at best. At worst, creating system complexity or ignoring technology known to improve safety can damage license to operate.

LILEE Systems was founded with the main purpose of providing IoT technology robust and scalable enough to enhance safety in the US railroad market. Our technology for buses leverages the expertise gained in this market and is designed to simplify “digital transformation.” LILEE solutions create **a unified operational console** to enhance safety, passenger experience and operational efficiency and ensure that operators can deliver services that modern customers have come to expect now and as technology and business models change.



## References

1. Productivity in transit: a new measure of labor productivity for urban transit systems. Aug 2018 [www.bls.gov](http://www.bls.gov)
2. Global Bus Market Report 2019 – Market Size, Share, trend and forecast. May 2019 [360marketupdates.com](http://360marketupdates.com)
3. Global bus market by Application, By Length, By Seating Capacity, By Fuel Type, By Body Type, By Region, Competition Forecast & Opportunities, 2012 – 2022 [www.techsciresearch.com2541`](http://www.techsciresearch.com2541)
4. Fast transit: Why urban e-buses lead electric vehicle growth. October 2018 [www.mckinsey.com](http://www.mckinsey.com)
5. World Urbanization Prospects: The 2018 Revision. [population.un.org](http://population.un.org)
6. Uber, Lyft account for two-thirds of traffic increase in SF over six years, study shows. May 8, 2019 SF Chronicle [www.sfchronicle.com](http://www.sfchronicle.com)
7. Lanctot, R.C. Uber, Lyft & the Price of Greed. May 12, 2019 LinkedIn Pulse [www.linkedin.com](http://www.linkedin.com)
8. Dear Uber, It's over and it's definitely your fault... March 4 2019 [www.godsavethepoints.com](http://www.godsavethepoints.com)
9. Bosch, P. Becker, F., Becker H. Axhausen, K.W. Cost-based analysis of autonomous mobility services Transport Policy 64:76-91 Elsevier May 2018
10. Commuting times, median rents and language other than English Use in the Home on the Rise, Dec 2017 [www.census.gov](http://www.census.gov)
11. Nearly one-quarter of workers have left a job due to a bad commute, according to a Robert Half survey Sept 2018 <http://rh-us.mediaroom.com>
12. NYC Transit shelled out \$431M in last five years to settle lawsuits from people injured by MTA trains or buses. September 2016 NY Daily News [www.nydailynews.com](http://www.nydailynews.com)
13. Statement on Positive Train Control Implementation. Updated Dec 31, 2018 Dept. of Transportation [www.transportation.gov](http://www.transportation.gov)
14. China Unwraps World's first Driverless Rail Transit System with Autonomous Technology. Engineers Garage blog. [www.engineersgarage.com/blogs](http://www.engineersgarage.com/blogs)
15. The future is autonomous, the future is now. [www.cat.com/en\\_US/articles/customer-stories/built-for-it/autonomous-vehicles.html](http://www.cat.com/en_US/articles/customer-stories/built-for-it/autonomous-vehicles.html)
16. Tesla's Elon Musk expects "robotaxis" to start in the US next year April 2019 BBC [www.bbc.com](http://www.bbc.com)
17. Buses and Trains lack safety features that are standard elsewhere. New York Times April 4, 2019.

## About LILEE Systems

LILEE Systems was founded in 2009 by industry leaders with extensive backgrounds in wireless communications, network routing and switching, and software-defined radio (SDR). LILEE's initial mission was to build technology enhancing safety in the railroad industry. We have recently adapted these capabilities to serve the broader transportation market.

LILEE Systems technology merges multiple wireless connections into a predictable, stable and manageable network, bringing new capabilities defining safety, efficiency and modern passenger experiences in the growing software-defined transportation market.

LILEE Systems is headquartered in San Jose, California and operates in three continents. Our solutions monitor over \$20B assets for rail, bus companies, and five of the seven Class 1 railroads in the U.S. use our solutions for mandated safety applications.

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