50 Years of Growth, Innovation and Leadership

Intelligent Connected Mobility Is Reaching an Inflection Point—A Data-centric Future Requires a Platform Approach

Executive Research Highlights IT, Business and Engineering Opportunities

A Frost & Sullivan White Paper
In Partnership with Dell Technologies

FROST & SULLIVAN

D&LL Technologies

INTRODUCTION

The rapidly changing mobility landscape and the increasing complexity of the technology infrastructure pose a formidable challenge to the transport vehicle makers, mobility providers and Tier 1 suppliers that are committed to the transformation of long-established business models by harnessing the diverse types of data generated across the transport ecosystems. This is one of the main findings from recent Frost & Sullivan research targeting top mobility executives.

The business, technology and engineering leaders interviewed by Frost & Sullivan are acutely aware of the decisive change facing them. Tried and tested business processes and models are being placed under increasing strain by converging market forces. Pressures include strict emission and safety regulations; increasing expectations of the in-car experience; and the saturation of sales in developed markets.
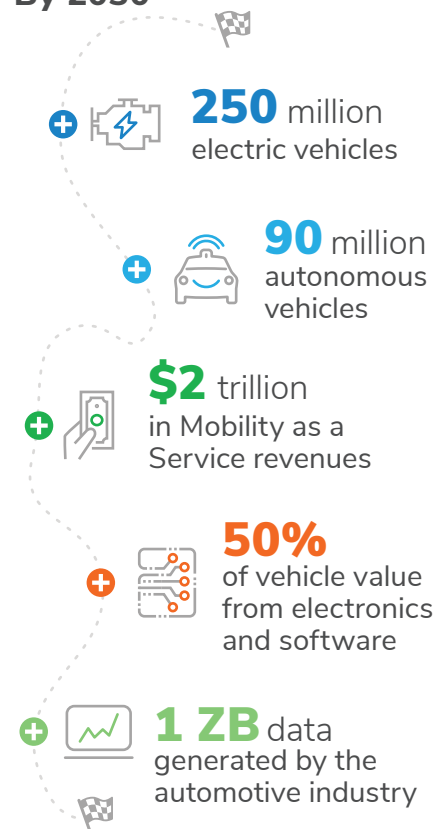
In response to the eroding and shifting profit margins, the mobility industry is reinventing its core products and introducing new service models. This requires significant investment in new technology and talent pipelines as well as a certain amount of perseverance, as the return on that investment will only materialize in the long term.

These are just a few of the changes already happening. Industry business, technology, and engineering executives agree on a future that is connected and autonomous. All forms of vehicular transport (passenger, commercial and industrial) will be intelligent and self-driving along smart routes in digital cities, offering new value creation models based on innovative products and services. In Frost & Sullivan's opinion, the pursuit of data-centric value creation models will require the industry to embrace almost revolutionary change that will affect engineering, operations, marketing, sales, legal, and the supplier eco-system. That said, the time-honored revenue streams from vehicle sales will continue and should not be lost to view.

However, what stands out from interviews conducted by Frost & Sullivan is that many executives are unsure of how to move from their industrial present to the lucrative, digitally-connected and autonomous future.

MOBILE INDUSTRY DISRUPTION
By 2030

250 million electric vehicles

90 million autonomous vehicles

$2 trillion in Mobility as a Service revenues

50% of vehicle value from electronics and software

1 ZB data generated by the automotive industry

Source: Frost & Sullivan

DEFINITIONS

Transport vehicle makers refer to manufacturers of cars, trucks, buses, tractors, mining equipment, etc.

Mobility providers refer to mobility service providers; e.g., Lyft, Uber, Didi, Avis, Hertz, etc.

Tier 1 suppliers refer to system integrators and component suppliers; e.g., Bosch, Magna, ZF, Aptiv, etc.

In Frost & Sullivan's view, the greatest opportunity will be found in harnessing the enormous volume and variety of automobile, customer, and third-party data that will be generated throughout the life cycle of each vehicle.

When managed and utilized effectively, this data represents a powerful tool for transport vehicle makers to inform and drive new revenue growth via service delivery, while also creating competitive differentiation and business diversification beyond traditional design and engineering capabilities. However, more guidance from technology providers on how to capitalize on the opportunity would be opportune.

In this report, key research and analysis reveal:

- How global business, IT and engineering leaders in the world's leading transport vehicle makers, mobility providers, and Tier 1 suppliers are currently addressing digital transformation challenges; and navigating the disruption that connected and autonomous fleets and services pose today; as well as planning for their impact over the coming two decades.

- That leaders are experiencing a lack of consensus and a high degree of caution and concern over next steps required to prepare them to become data-centric

- That some decision-makers are starting to build toward a robust and holistic technology infrastructure and data management strategy to support their future connected and autonomous fleets.

- How a platform solution strategy is necessary for managing future intelligent fleets and deriving value from accelerating volumes of data that are created and leveraged to drive new revenue.

- A checklist of critical questions and pragmatic recommendations to help jump-start your transformation.

Frost & Sullivan Research:
Many Views on How to Move Forward

In July 2019, Frost & Sullivan interviewed 17 executives (including CIOs, CTOs, and Heads of Connected and Autonomous) who lead the business, product, and technology transformation initiatives for transport vehicle makers, mobility providers, and Tier 1 suppliers. As they lay the groundwork for the connected and autonomous future, these executives are eager to drive their companies forward and aspire to become disruptors and market leaders. The interviewees agree that generated data (i.e. vehicle, customer, and third-party data and insights) will be at the heart of these sweeping changes. Many executives have expressed the expectation that daunting volumes of data will be generated by vehicles, leveraged for connected and autonomous fleet operations, and, ideally, aggregated for future monetization. One executive expected the data volume to rival or exceed what Facebook and possibly AWS currently possess. For transport vehicle makers, Tier 1 suppliers, and mobility providers, this is an entirely new paradigm to work within.

> " As a carmaker, we have to be able to offer similar experiences to a customer inside the car as to a customer outside the car. This is a big challenge since we cannot just copy all the digitalization into the vehicle.
>
> Head of Connected Services, European OEM

At the same time, the leaders revealed a lack of consensus and a high degree of caution and concern over next steps required to prepare them to become data-centric. A few vehicle makers, such as Tesla, are following a 'best-of-breed' strategy, investing in technologies to support their own unique data management roadmap. Similarly, to solve the challenges around managing data ingestion to implement their SAE L0 to L3 ADAS roadmaps, other companies are trialing a range of point solutions and applications that have entered the market to support their current test and development initiatives.
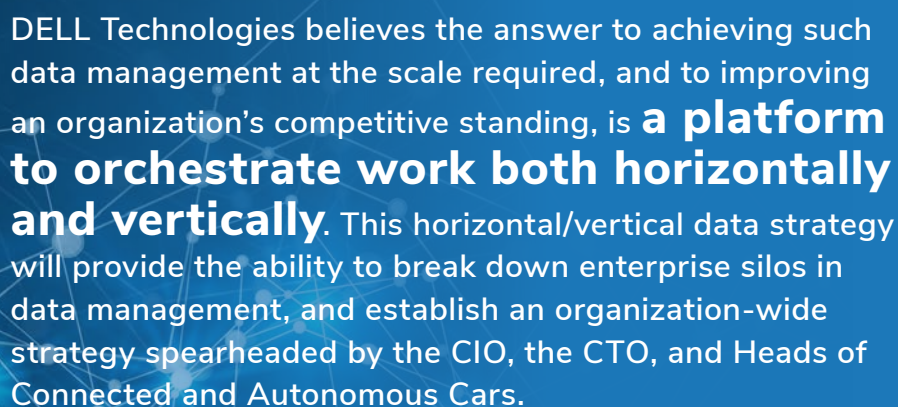
Such point solutions may help in addressing specific challenges in the short term. However, they will fall well short of delivering the scale and next-generation capabilities required to manage the cascade of data and analysis that are essential to the higher levels of connected and autonomous driving and related services.

> " One of the biggest challenges a carmaker currently has is how to manage vehicle-to-cloud connections at scale.
>
> Head of Connected Services, European OEM

Frost & Sullivan notes that the current data strategies of the transport vehicle makers remain focused on data ingest, as they have yet to broaden their scope to include innovative solutions for orchestration, movement, and compute that would cater to dynamic access needs in the future. Moreover, transport vehicle makers will need the help of the technology industry to better manage and monetize data.

DELL Technologies believes the answer to achieving such data management at the scale required, and to improving an organization's competitive standing, is **a platform to orchestrate work both horizontally and vertically**. This horizontal/vertical data strategy will provide the ability to break down enterprise silos in data management, and establish an organization-wide strategy spearheaded by the CIO, the CTO, and Heads of Connected and Autonomous Cars.

4

Today, the considerable internal R&D expenditure and external investment by transport vehicle makers indicate their priority is the design and testing of new, connected and autonomous products and services. Unfortunately, the industry suffers from a shortage of talent with sufficient functional expertise to create the differentiating algorithms needed to run the workloads and manage the data to safely and securely operate the new vehicles.

Beyond vehicle development and partnerships, many (but not all) incumbents and start-ups are in the early stages of building toward a robust and holistic technology infrastructure and data management strategy to support their future connected and autonomous fleets. Many recognize that the management, movement, and monetization of the vehicle and ecosystem data generated with their new products will be overwhelming.

Frost & Sullivan interviewed numerous technology and R&D executives who face a conundrum. They are cautious about placing a stake in the ground today and then risking "getting caught in a mousetrap solution" that could adversely affect their strategic and digital agility in the future. However, waiting to take action until an industry-proven standard emerges is also a sure path to competitive failure.

> " Key to handling data processing, management, and storage will be to shift from current 'purpose-driven' models to more horizontal, organization-wide approaches.
>
> Head of Autonomous Driving, European Premium OEM

> " What we have seen from Waymo, Uber, Lyft and many [other leaders] in this space, is a strong understanding of cloud platforms and in building a stack that can scale from day one.
>
> VP, Autonomous Driving, North American Mobility Service Provider

Designing and implementing an effective, forward-looking data strategy will be challenging especially given the lack of consensus from the technology providers that would have provided robust guidance to the mobility industry. In Frost & Sullivan's opinion, transport vehicle makers and mobility providers would benefit from technology partners with a solution strategy that removes barriers to innovation and propels them over the finishing line to achieve competitive advantage. In the following section, IT leaders interviewed by Frost & Sullivan identify their top hurdles.

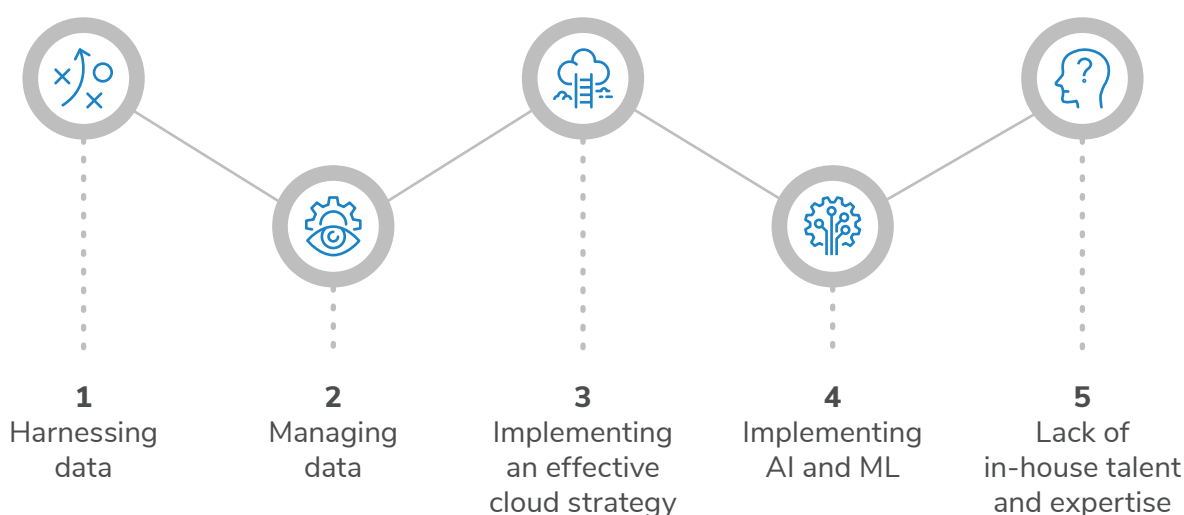# IMPLEMENTING AN EFFECTIVE DATA STRATEGY: BARRIERS TO SUCCESS

As we have discussed, beyond developing their next generation of connected and autonomous vehicles, C-level business and IT leaders recognize that mastering their data strategies—and therefore the potential to unlock monetization—is the only way to differentiate and win in a highly competitive market. The main challenges are: where to focus investments, understanding which data is valuable, and developing the infrastructure and ecosystem for scale.

The connected and autonomous future begins with data management: specifically, with an integrated, software-defined and agile cloud infrastructure capable of managing accelerating data volumes securely and cost-effectively.

> " The challenge is to understand how much data and how many services will be required. Future connected services will require proprietary cloud applications with third-party layers in the public cloud, where processing is done exclusively in the cloud.
>
> Head Autonomous Driving, European Premium OEM

TOP FIVE CHALLENGES

1	2	3	4	5
Harnessing data	Managing data	Implementing an effective cloud strategy	Implementing AI and ML	Lack of in-house talent and expertise

According to Frost & Sullivan analysis, transport vehicle makers, mobility providers, and Tier 1 suppliers need to overcome the top five challenges analyzed on the following pages.

1. **Harnessing data to future-proof vehicle design, development, and deployment**—To meet rapidly changing consumer and customer demands, transport vehicle maker and mobility providers must become more agile, reducing time-to-market and decreasing costs. Data from vehicle usage and driving patterns should enable vehicle makers to rectify any future faults by providing on-time OTA updates, as well as feed into design and development of next-generation vehicles. A data-centric approach to process improvement will require identifying and aggregating relevant data from multiple sources, exposing it to analytics software and applications, and storing it securely and cost-effectively.

    > The horizontal approach to data management will result in the integration of supply chain, product development and manufacturing, sales, and services until the end-of-life of the vehicle—with the customer firmly at the epicenter.
    >
    > Head of Connected Services, European OEM

2. **Managing the volumes of data associated with connected and autonomous functionality**, next-generation vehicles require the ability to support, capture, catalog, move, store, secure, and index massive volumes of data (structured and unstructured) from mobile sources, to cloud- and/or edge-based resources. There is no shared view on how to achieve this, as mentioned in the earlier section.

    > The automotive industry currently monetizes only about 300 MB of connected vehicle data per day. However, identifying and harnessing the true kinetic potential of autonomous vehicle data, which could be over 10TB generated per vehicle per day, is still an opportunity that remains unaddressed by major players.
    >
    > Head of Connected Vehicles—China, European OEM

3. **Implementing an effective cloud strategy**—Scalable, flexible cloud deployment will be the foundation for the future of the mobility industry. A host of new and yet-to-be-created cloud-native applications will be developed to leverage the model's accessibility and scalability. Data can be stored cost-effectively in the public cloud, and exposed to next-generation AI and ML functionality. The challenge for automotive technology executives is to design, deploy, and manage an effective, agile infrastructure that integrates multiple clouds, on-premise data centers, and vehicle and edge infrastructure.

" The current approach of top-down integration of service platforms could compromise the ability to scale, as workload management will need to be implemented bottom-up, at a foundational platform level. For automakers, achieving this long term vision while addressing these challenges will require an IT partner more than a vendor

Head Connected Services, Japanese OEM

4. Implementing AI and ML across the organization—AI and ML are powerful capabilities that should be embedded into the IT fabric of the organization. To optimize the use of data for future services, transport vehicle makers and mobility providers must ensure that all data (regardless of format, source, or age) remains accessible and can be readily exposed to AI/ML functionality across various departments within the organization.

" An integrated data approach provides the highest visibility to AI/ML compute power. This, in turn, enables [firms] to shorten hardware and software test cycles, which is essential to fast-tracking the development of multiple projects in parallel.

Head of Autonomous Driving, Chinese Premium OEM

5. Lack of in-house talent and expertise—Underlying many of the challenges is the lack of in-house experience and expertise in essential new technologies, including cloud strategy, AI/ML, and data science. Resource-constrained IT leaders continue to have a limited budget to hire and attract skilled talent available in the market, despite knowing the competencies and skills required for their team. As a result, firms are actively exploring partnerships with technology experts.

" Addressing challenges with regards to data management is not the automakers' strength. It is best to rely on the expertise of IT vendors who already tackle these issues in other industries.

Former CTO, North America, Asian Tier 1 Supplier

> ❝ The [necessary] expertise is unlikely to reside with automakers and Tier 1 suppliers in the future, but with their infrastructure partners instead. [Automakers] will require the expertise of IT partners who can develop, implement, and manage the entire infrastructure.
>
> Head of Digital Products, European Tier 1 Supplier

Overall, Frost & Sullivan observes that the industry today is heavily focused on the challenges of ingesting the data generated from their current test and development vehicles. The priority is the development and production of these next-generation vehicles. There is less emphasis on harnessing data to create value beyond deployment, although several vehicle makers recognize the opportunity. They are only just beginning to address the technology infrastructure necessary to effectively master the data management and movement strategy needed to build business models that can monetize their data future, and ultimately drive innovation and progress.

One solution the transport industry could adopt would be to develop mutually beneficial partnerships with technology providers to gain additional expertise and promote a specific solution strategy. Frost & Sullivan believes the inflection point has been reached and smart decisions regarding data strategies must be made.

In the next section, Frost & Sullivan offers its view of how transport vehicle makers and mobility providers could move forward with a specific, effective solution strategy that addresses barriers to success; introduces new opportunities; and institutes the long-term strategic consistency required for any organization to realize its vision for the autonomous and connected future.

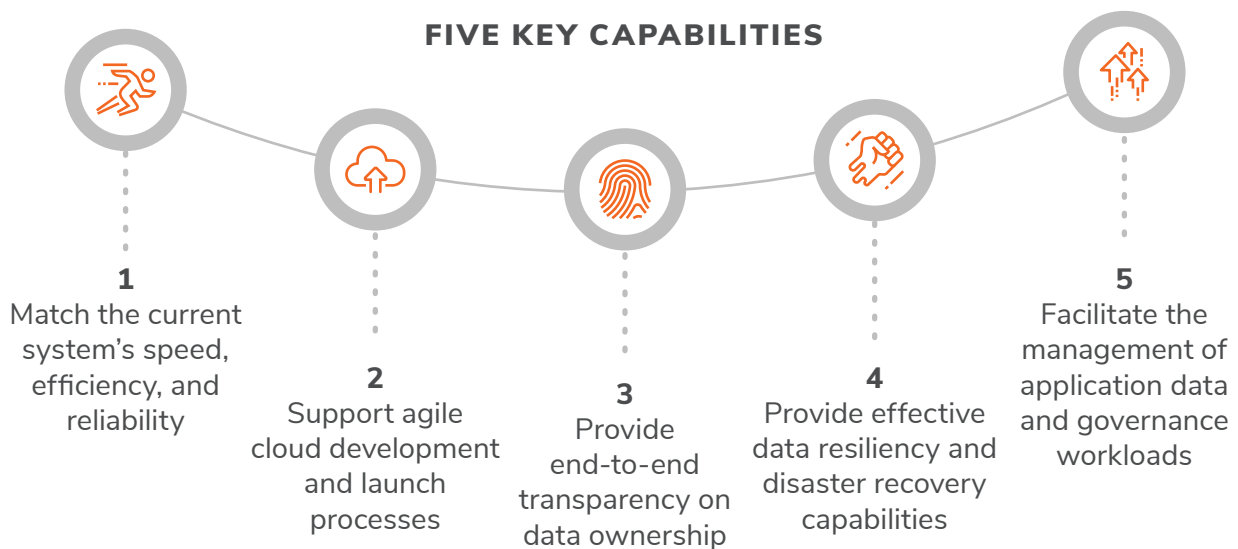## A PLATFORM-BASED SOLUTION STRATEGY TO ENABLE TRANSFORMATION

The scope of industry and mobility transformation is broad, complex, and evolving. If organizations approach each new opportunity or challenge in a vacuum, they will quickly become overwhelmed by hundreds of disparate point solutions, data sets, and management systems.

A more effective method is to implement a platform solution strategy that is cost-effective and flexible enough to address today's immediate needs, and that enables vehicle makers and Tier 1 suppliers to rapidly integrate new technologies, services, and ecosystem partners. This platform-centric mindset addresses both 'the now' and future business scenarios. The core principle of the platform or grouping of technologies must support critical data management functions—including data ingest, orchestration, movement, data protection, and availability—and embed AI and ML process and storage capabilities. As previously noted, it should also be multi-cloud in nature, and make it easy to integrate disparate data sets and multiple infrastructure deployment options.

"
Achieving the required level of integration between services will, however, require automakers to develop a unified cloud platform approach, with decisions around storage, compute and application development standardized with an integrated service management tool."

Director, Connected Cars, Japanese OEM

FIVE KEY CAPABILITIES

1
Match the current system's speed, efficiency, and reliability

2
Support agile cloud development and launch processes

3
Provide end-to-end transparency on data ownership

4
Provide effective data resiliency and disaster recovery capabilities

5
Facilitate the management of application data and governance workloads

Frost & Sullivan has identified five key capabilities that a platform-based, horizontal and vertical approach to data management would bring to vehicle makers, strengthening their competitive position:

1. Match the speed, efficiency, and reliability of their current purpose-built data management systems.
   - This will be critical for future autonomous driving services that require edge-based, low-latency processing, such as centimeter-level precise localization that relies on instant availability of ML resources via edge clouds.

2. **Support agile development and launch processes** for cloud-native applications and workloads.

   - Today, most data is moved from its source to wherever the application is hosted. In the future, thanks to exponential data volumes and the zettascale challenge, moving the data will be more difficult. This new method moves the application code to where the data resides; and shortens hardware-in-loop (HIL) and software-in-loop (SIL) simulation testing, especially for services like OTA updates. The on-demand addition of new ML instances will improve management of simulation training databases; for instance, platforms that can help fast-track the transition from test and development to production of future connected and autonomous vehicles.

3. **Provide the necessary end-to-end transparency on data ownership** that is required to address current business concerns central to data privacy and security.

   - Not surprisingly, our interviews highlighted that maintaining security and privacy of customer data is critical.

> " Security of customer data is paramount for the automotive industry; hence complete anonymization and encryption of data will be required throughout its lifecycle.
>
> Head of Autonomous Driving, German Premium Automaker

   - With the ability to integrate future platforms like consent management and third-party Application Programming Interfaces (APIs) for external services such as payment and authentication, a platform-based approach will equip transport vehicle makers with the necessary tools to act as the central gateway for various digital services, offering an unobstructed view of vehicle and customer data.

4. **Provide effective data resiliency and disaster recovery capabilities** required to geographically scale connected and autonomous services—cost-effectively and with minimal downtime.

   - The complexity of regional data sovereignty and privacy regulation continues to increase (e.g. GDPR in Europe), creating challenges and risk as firms expand globally. A unified platform will give transport vehicle makers the capability to easily migrate between cloud deployment models in multiple geographies while ensuring a seamless customer experience for their connected and autonomous services.

5. **Facilitate the management of application data and governance workloads** that require responsibility splicing between vehicle and cloud.

   - Aspects of information management such as meta-tagging and anonymously namespacing data will need to be integrated into the overall process of data management for future services. A platform solution strategy will enable transport vehicle makers to improve

services in real time by navigating the data generated at the service layer to the relevant data management layer, where the workloads can be assigned instantaneously.

While the platform solution strategy continues to evolve, critical core components can be identified.

CORE COMPONENTS OF A FUTURE PLATFORM

For optimal performance and scale, the platform solution strategy should be architected to utilize data reduction, ingest and movement strategies, intelligent infrastructure solutions, and industry-leading and proprietary AI/ML technologies. To be successful, transport vehicle makers need to consider the following components:

- **AI Science**—Core to the foundation of an integrated platform, embedded artificial intelligence science is designed to both govern and ensure there are continuous improvements in lower computational and storage requirements. This underlying component will augment and enable overall platform capabilities, whether they are built from within or added from another ecosystem partner. This component intelligently automates functionality across the entire platform and deployment environments (e.g., in-vehicle, edge, cloud, core). This is the brain of the platform that ultimately governs the horizontal and vertical layers within the platform, as well as the integration of purpose-built OEM, ecosystem, or 3rd party platforms.

- **Software & application services**—The applications component is horizontally designed to support all connected and future autonomous services—training, simulation, HD maps, infotainment, analytics, events, training, simulation, and future workloads and service capabilities.

- **Workload and services orchestration**—This layer is designed to operate service managers and schedules for multiple workloads and services, for connected and autonomous scenarios, at scale.

- **Information and data management**—This highly intelligent component is designed to take the raw data from the vehicles that will be ingested, prepared (meta-tagged/name spaced), moved, stored and then leveraged for training & simulation. Additionally, the functionality may include creating extra value by leveraging the anonymized data that will be made available for further monetization with others.

- **Infrastructure management & services**—Designed to maximize utilization of infrastructure to deliver optimal application execution. This component intelligently, horizontally manages the placement of computational and infrastructure resources within the vehicle HW (sensors), across the network, within the storage tiers, and across heterogeneous computing environments (e.g., in-vehicle, edge, regional/core HPC).

- **Security & privacy**—A vertical, flexible and scalable layer designed to manage and orchestrate services including identity & access, security operation, threat modeling, security test and development, regulation and standards, and overall privacy.

- **Policy control, automation, and orchestration**—A vertically integrated component designed to serve the end-user needs (e.g., mobility provider or fleet manager), and deploy governance policies down through the horizontal layers of the platform.

KEY CONSIDERATIONS TO ADDRESS

Developing and producing the future connected and autonomous vehicles and services is the biggest challenge global transport vehicle makers and mobility service providers will face in their lifetime. Closely behind that challenge will be the funding, design, and build-out of the supporting technology infrastructure needed to operate and manage the data, use cases, and functionality needed to support their future vehicles and services. The interviewees mainly agree that there is currently no roadmap and that each company and joint venture will forge their paths differently to protect their differentiation.

Today, a fully-functional platform to support vehicle fleets and services does not exist, but a solution strategy could be the answer and promote the consensus needed by industry. The current industry approach of improving and adding service platforms via top-down and bottom-up integration will inevitably restrict scale, as workload management will need to be implemented ground-up at a foundational platform level.

Vehicle makers currently developing their own platforms for autonomous driving are likely to experience that their integration into existing connected car or mobility services platforms will lead to unforeseen complexities with data integrity and workload availability.

For IT and engineering leaders, finding the right path toward a platform requires asking some challenging questions—first internally, and then to potential technology partners. Questions such as:

1. How can we optimally manage the exponentially growing volumes of data generated and leveraged by connected and autonomous vehicles and services?

2. What is the best infrastructure and workload configuration for our hybrid or multi-cloud environment? How can we ensure optimal price-performance for workloads and data?

3. What is the best way to support and automate ML and AI on a massive scale, across the organization?

4. What advances in storage media and heterogeneous compute should we consider, to lower implementation and maintenance costs without performance degradation?

5. How can we cost-effectively support the functional requirements of the production vehicle fleets?

6. What is the optimal platform architecture and design that can address the scale and performance requirements for future connected and autonomous vehicle and services?

Frost & Sullivan research indicates that the leading transport vehicle makers, mobility providers, and Tier 1 suppliers perceive such a unified platform to exist only in concept form today. However, this actually represents a solution strategy they can begin formulating today by investing in the right building blocks for this future foundation.

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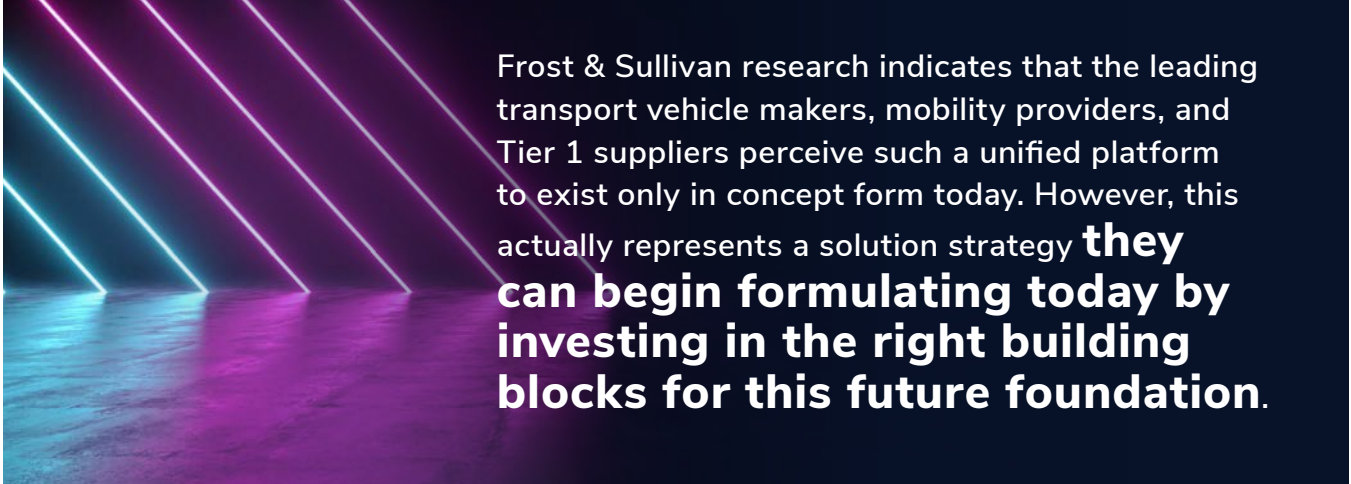
CONCLUSION—THE TIME FOR CONSENSUS IS NOW

Mobility leaders are highly aware that their industry fundamentals are shifting. Against a backdrop of changing customer preferences and expectations, the convergence of autonomous, connected, electric and shared mobility technologies is radically altering the way people and goods move.

Data is at the center of this shift—and more importantly, the insights derived from it. By efficiently collecting, processing, analyzing, and storing valuable data assets, industry participants will be able to achieve differentiating business outcomes:

- Streamlining product design and development processes, speeding time to market and cutting costs

- Launching autonomous vehicles that safely interact with their environment, whether it be a city street, highway, port, farm, or mine

- Identifying, predicting, and automatically fixing mechanical or electrical problems in vehicles, thus making passengers and environments safer

- Optimizing ride-sharing and e-hailing services, lowering personal transportation costs

- Delivering a host of new customer services and capabilities

- Increasing revenue, based on the ability to monetize the right data for trusted ecosystem partners, both public and private

- Fund and support new business models and operations

Over the next few years, not all incumbents, start-ups, suppliers and other ecosystem participants will survive the shift from old-world industrial to next-gen connected mobility. The path they take is critical to their success, and solution strategies are emerging from IT vendors that will underpin that success.

Those that succeed in the coming years will not only build new and beautifully designed vehicles and services for their customers. They will have a long-term vision, clear roadmap, and set of expert technology partners who can help them create an enterprise data-centric platform that intelligently manages the complexity and vastness of the data required to operate fleets of connected and autonomous vehicles and services.

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