Informa Tech Automotive Group

Automotive

WARDS INTELLIGENCE™

WARDSAUTO™

Dell Survey Report

Exploring the impact of the overlapping universe

November 2020

informatech

Executive Summary of Overall Survey Results

- **Vehicle Technology**
  - Future electric/electronic (E/E) and software architectures that have longevity assured by over the air updates are key to leveraging emerging vehicle technology and sensor-fusion capability. Although the auto industry remains focused on feature and function driven architectures, rather than service-oriented architectures (SOAs), there is a determination to deploy SOAs in vehicle software architectures. However, there are challenges to be overcome, and there appears to be skepticism concerning deployment timelines.

- **Vehicle, Infrastructure and Data Interaction**
  - OEMs prefer full control over product development and the technology employed in that process, and that is manifested in how the auto industry views private cloud and service-provider data-storage solutions. Although there is clarity on over-the-air updating requirements and why SOAs will play a key role in the future, without partnerships and an open approach to development, change will come slowly. The good news: OEMs see ease of data management as critical to their data storage strategy, so the pace of change could accelerate.

- **Technologies to Design, Develop, Manufacture and Deliver Vehicles**
  - The supply chain will contract in part because of forces outside the auto industry. But further pressure will come from OEMs and Tier 1s increasing their efforts toward critical software and connectivity technology development, potentially driving away smaller players and start-ups.
  - Predictive maintenance and cost diagnostics will be key application focus areas for the automotive industry.
  - The growth in data is a given, and the industry expects artificial intelligence to play a role along the data continuum – with near-term AI applications focused mostly on algorithm training. The No.1 concern in employing AI directly in onboard vehicle systems is security, followed by the ability to keep the technology current.
  - Automotive OEMs are bullish on their progress to Industry 4.0, but suppliers, Tier 1 and below, report poor implementation thus far.

Exploring The Impact Of The Overlapping Universe

Context for the Survey

A broader concept of mobility is developing from a complex eco-system that comprises a variety of domains vehicles interact with.

Public cloud and on-premise datacenters are needed to support OEM back-end operations, R&D efforts and manufacturing facilities. ITS, Smart Grid, Smart City or Smart Home are just few of the domains that will overlap in both function and market application with the auto industry's future concepts of mobility and connected services.

Data represents where these various domains and IoT industry segments intersect. Data is the new gold, representing a huge revenue-generating opportunity for the automotive sector. Data will be collected, structured, elaborated and shared to create additional value in a non-linear manner across domains.

Inside the vehicle

To achieve this, new architectural approaches are required inside and outside the vehicle. As highlighted by the results of a Wards Intelligence/Dell survey on future vehicle architectures, the automotive supply chain – and, in particular, vehicle manufacturers – are focusing efforts on developing future-proof and flexible E/E system architectures that can easily accommodate the new features and requirements of next-generation vehicles. Future-proofing of these architectures at the design stage will allow OEMs to perform updates during a vehicle's lifetime, avoiding obsolesce and ensuring a relevant user experience that keeps pace with faster-moving adjacent markets such as Information Technology and Consumer Electronics. In future-proofing vehicle architectures, automakers will likely prioritize a shift away from traditional monolithic software approaches, where programs can contain tens of millions of lines of code. SOA's are expected to be the basis of future software-defined vehicles, providing substantial abstraction layers to services and applications. Analogous to microservices and cloud compute this should result in deployment speed, application reliability and faster time to market for services.

Exploring The Impact Of The Overlapping Universe

Context for the Survey

Beyond the vehicle

In-vehicle system architectures are not the only aspect to consider. A well-geared and designed back-end infrastructure is also essential for OEMs to take full advantage of digitalization. Vehicle manufactures aim to control – end-to-end – the entire automotive business, from design, manufacturing, testing, validation, final assembly and certification to maintenance, software updating, app development and deployment and mobility services during the lifetime of a vehicle.

Consequently, a separate and secure back-end environment is essential to maintain the control and ownership of the most important elements of the automotive business sector in the future: DATA and SOFTWARE.

An extremely expanded ecosystem, new SOAs and broadly deployed connectivity, as well as the ability to identify and monetize data, are impacting the OEM business model and profit pool in a big way. The automotive market beyond 2030 will appear quite different from today, as will the business strategies of vehicle manufacturers.

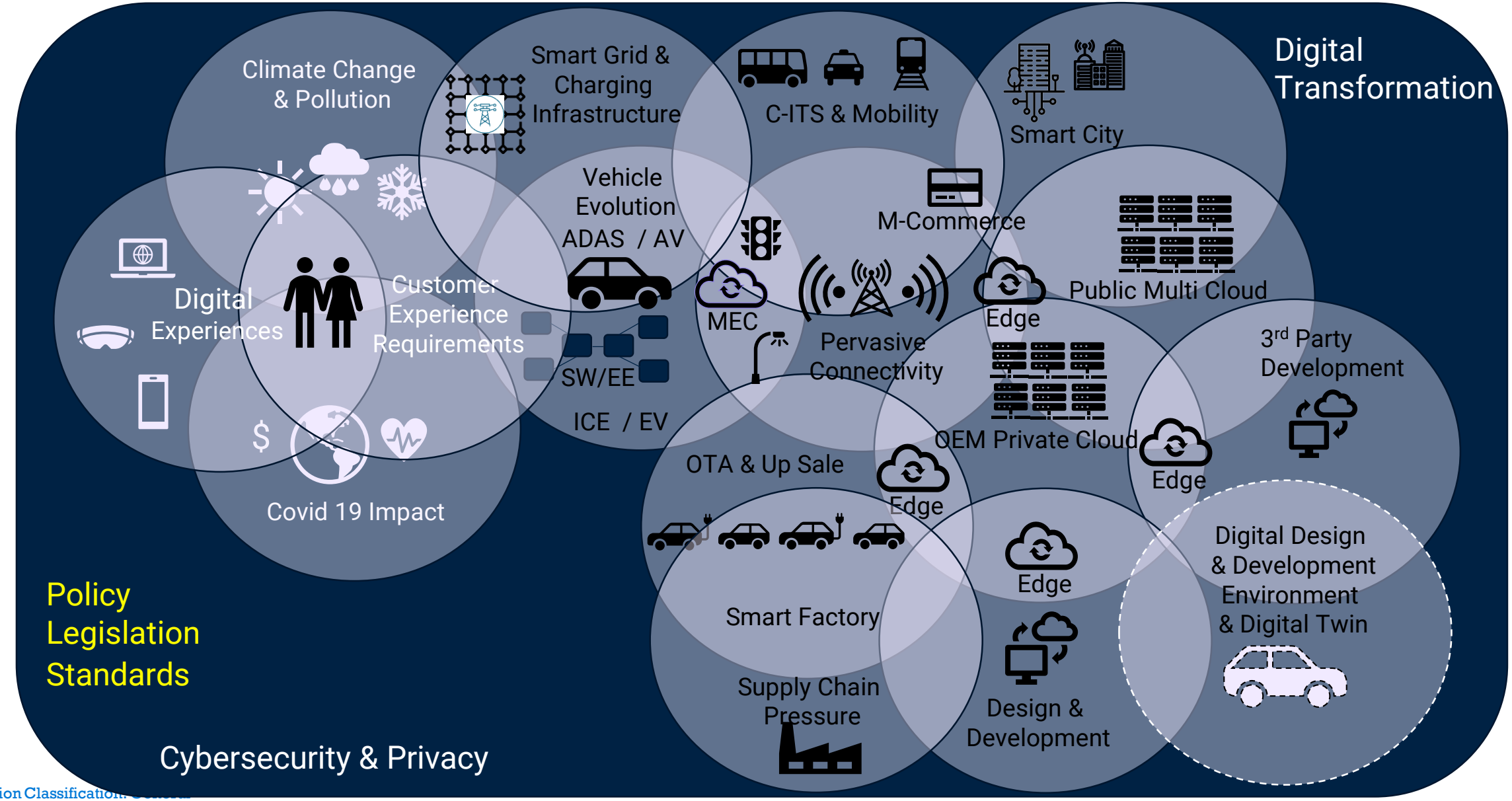
But to achieve real agility in the vehicle-design cycle, manufacturers also will need to change their mindset and promote flexibility and speed of innovation. Beyond physical hardware, OEMs need to build software development and data analytics competence quickly by cultivating skills in-house and/or securing reliable partners.

Exploring The Impact Of The Overlapping Universe

Covid-19 Context

- The global pandemic has increased dependence on digital services. Working from home and providing online schooling for children has become a reality for many. Online shopping for groceries and the reliance on mobile applications to prevent isolation, as well as entertainment, have pushed many people to try new digital services.
- For the auto industry, the virus has changed consumer behaviors and attitudes in ways that are significantly impacting a business model that hasn't evolved much over the past 100 years.
- Many companies now are eliminating or downsizing their offices as employees work mostly from home. This fundamental shift in working practices, together with the fear of infection via public transportation, could have a negative impact on commuting and urbanization.
- Studies of how Covid-19 has altered transportation behaviors in many of the world's largest cities have shown improved air quality, resulting from fewer vehicles on city streets. The diminished traffic is allowing communities to rethink urban planning and how streets are used.
- All this change has intensified the pressure on an already stressed automotive industry, reeling from the impact of the crisis on vehicle demand and production, as well as automaker and supplier liquidity. In Q2 2020, according to the Original Equipment Suppliers Association's (OESA's) Automotive Supplier Barometer index, Covid-19 has driven North American suppliers to their most pessimistic level in the history of the series.
- Digital transformation has been an industry buzzword for many years. However, despite an automotive sector that has embraced aspects related to its information-technology systems, the way the industry operates has not changed significantly.
- Traditional industries often show a hesitancy and unwillingness to experiment, but the pandemic has demonstrated that everything from shopping to education, entertainment and social interaction is possible via digital channels. Those same digital technologies are key to ensuring survival by eliminating engineering silos, creating new operating and business models and building a culture that embraces innovation.
- The automotive industry does not stand alone. It is subject to the influence of multiple overlapping industries and domains…each with their own technology and commercial timeline but all subject to the same disruptive forces identified above. The challenge is to assess the degree of influence each will have on the mindset and direction of the automotive industry.

The Overlapping Automotive Universe



Survey Demographics

Geography

Q1 Where is your company located?	
North America	66%
Europe & Russia	17%
Asia Pacific	7%
India	4%
Middle East & Central Asia	3%
Central/South America (including Mexico & the Caribbean)	2%
China	1%
Africa	-
Respondent Count	318

Job Function

Q4 Which of the following best describes your primary job function?	
Advanced Research	18%
Marketing and Sales	17%
Corporate Management	13%
Software Engineering	9%
Hardware Engineering	7%
IT	7%
Data analyst or scientist	5%
Manufacturing Engineering	5%
Quality & reliability assurance	4%
Manufacturing Operations	3%
Supply Chain Logistics	2%
Purchasing	1%
Security	0%
Other	9%
Respondent Count	318

Organization

Q2 What type of organization do you work for?	
Analyst/Consultant	20%
Tier 1 automotive supplier	20%
Automaker	18%
Tier 2 automotive supplier	8%
Software developer/provider	7%
Electronics / IT Hardware Supplier	5%
Government	4%
Wireless carrier/Mobile network operator	3%
Mobility/Telematics service provider	3%
Semiconductor supplier	3%
Cloud provider	1%
Trade association	1%
Security supplier	1%
Battery supplier	0%
Other	7%
Respondent Count	318

Revenue

Q3 What is your company's annual revenue?	
Less than $50 million	34%
$50 million to $199 million	15%
$200 million to $499 million	9%
$500 million to $999 million	6%
$1 billion to $4.9 billion	9%
$5 billion to $10 billion	6%
More than $10 billion	22%
Respondent Count	315

Observations

- 46% (145) were OEM, tier 1 or tier 2 suppliers.
- 22% (69) of respondents were associated with manufacturing engineering, operations, quality, supply chain or purchasing.
- 20% are analyst / consultants that can provide an alternative perspective with an outside in view of the industry situation.
- N. America was 66% and Rest of the world 34%.
- Good cross section of company sizes .
- The job functions indicate technically literate respondents.

Vehicle Technology– Enabling the Revolution

Current State

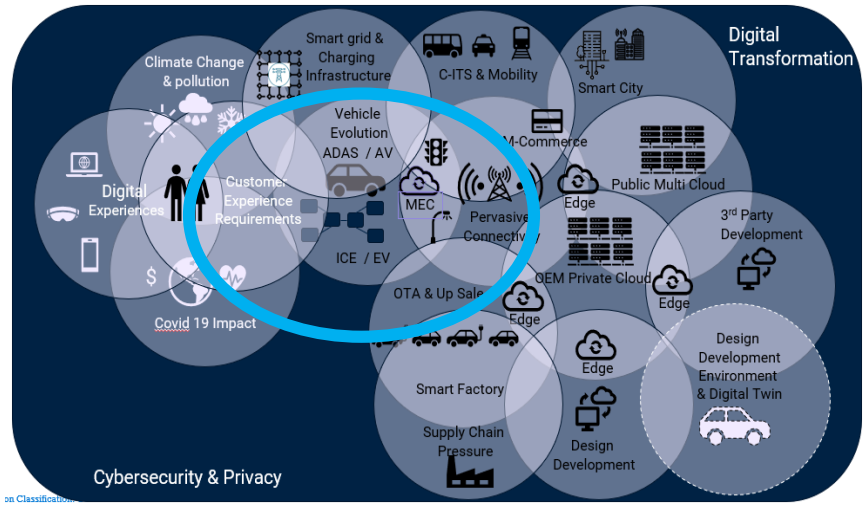
In the past 10 years, vehicle complexity has increased exponentially. The factors below are just a few of the concerns facing strategists and development engineers along the entire automotive supply chain:

- Lack of knowledge to master and take advantage of transformative technologies such as Artificial Intelligence, Data Analytics, Cloud and Datacenter, IoT.
- Huge costs associated with the development of high-performance semiconductor components needed to meet the demands of future vehicles.
- Proliferation of in-vehicle features expected to meet comfort, user experience and safety requirements.
- Complexities of networked ECUs: cross-communication, data exchange and interaction among several electronic control units in vehicle.
- Regulations and mandates driving sustainability and safety.
- Increasing maintenance and development costs.
- Need for frequent and secure system/software updates and functional upgrades.
- Pressure to optimize cost throughout the entire development and manufacturing process.
- Need to reduce time to market and product lifecycles to better keep pace with the consumer-electronics sector.
- Gaps in “in-house competencies” due to the shift in focus from hardware to software components.
- Security and cybersecurity concerns, as consequences of a highly connected world.
- New business models driven by data analytics and connectivity technologies.

The above factors are forcing a rethink of the entire in-vehicle architecture, and development and manufacturing processes and business models.

Technology on Vehicles

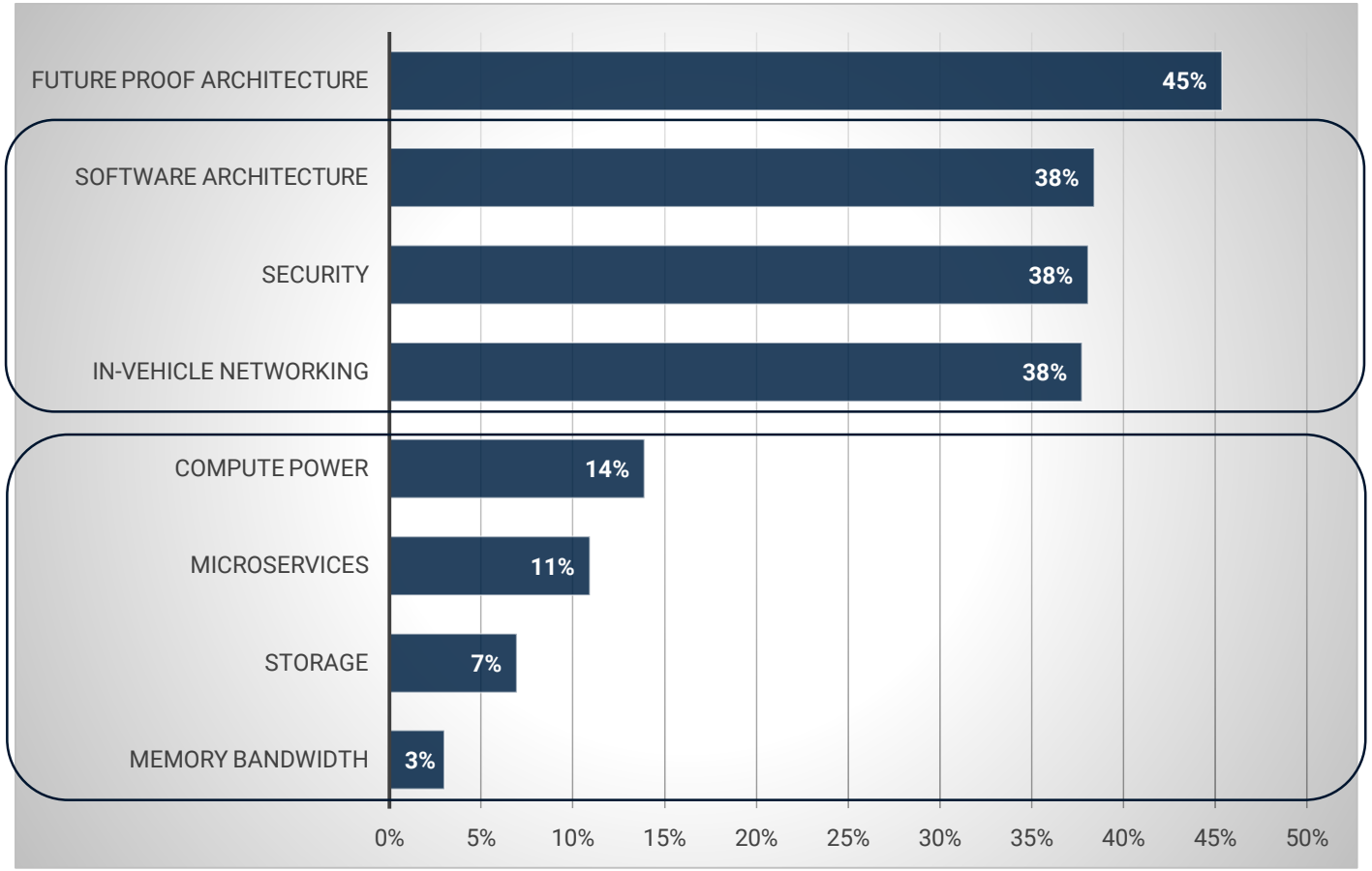
Summary Points



Future electric/electronic and software architectures that have longevity assured by over the air updates are key to leveraging emerging vehicle technology and sensor-fusion capability. Although the auto industry remains focused on feature and function driven architectures, rather than service-oriented architectures (SOAs), there is a determination to deploy SOAs in vehicle software architectures. However, there are challenges to be overcome, and there appears to be skepticism concerning deployment timelines.

Key Area	Findings
Major vehicle electrical and electronic system challenges.	Clear concerns about creating an architecture that has longevity. Dimensions of concern are at a fundamental level: Software, security and networking. Less concern with technical capabilities.
Essential enabling technologies for vehicles in the next 10 years.	Top focus is on sensor fusion, which is safety and AV related. Yet C-V2X is perceived among the least important technologies. External technologies are rated very important, while component technology is considered important. Blockchain is not viewed as important.
Software development areas for vehicles.	Features and functionality dominate industry thinking rather than services and apps. Security, user experience and safety are the primary focus.
Appearance of Service Oriented Architecture (SOA) in vehicle software architectures.	Software architecture is seen as a challenge, and yet 46% believe an SOA will appear by 2025 and 39% believe it will be in the market by 2030.
Timing for Electronic Data Recorder (EDR /Blackbox) mandate.	Seventy percent believe this will happen, but not before 2030. Deployment will likely be similar to the e-Call development experience.
Deploying a new in-vehicle architecture.	The deployment of a future-proofed architecture is not considered a priority for overall ecosystem respondents with 55% believing it will be deployed after 2025. However, automotive OEMs are more bullish, with 50% indicating they will deploy a new in-vehicle architecture by 2025.

Major Vehicle Electrical & Electronic System Challenges



Observations:

The results from the survey clearly confirm the need for future-proof and flexible E/E system architectures that can easily adjust to new features and requirements of next-generation vehicles. Future-proof architectures will allow OEMs to run updates during a vehicle´s lifetime and maintain a relevant user-experience when compared with adjacent markets such as IT and Consumer Electronics.

Moreover, the updates in functionality are also essential to coping with fast-developing technologies such as Artificial Intelligence and Cybersecurity.

A point of note: In the vehicle's electronics, and along the automotive infrastructure, hardware building blocks such as memory, processing power and storage are of less concern to respondents.

In fact, the speed of progress in the semiconductor industry, also driven by other domains such as IT and Consumer Electronics, make hardware components less critical, although still important.

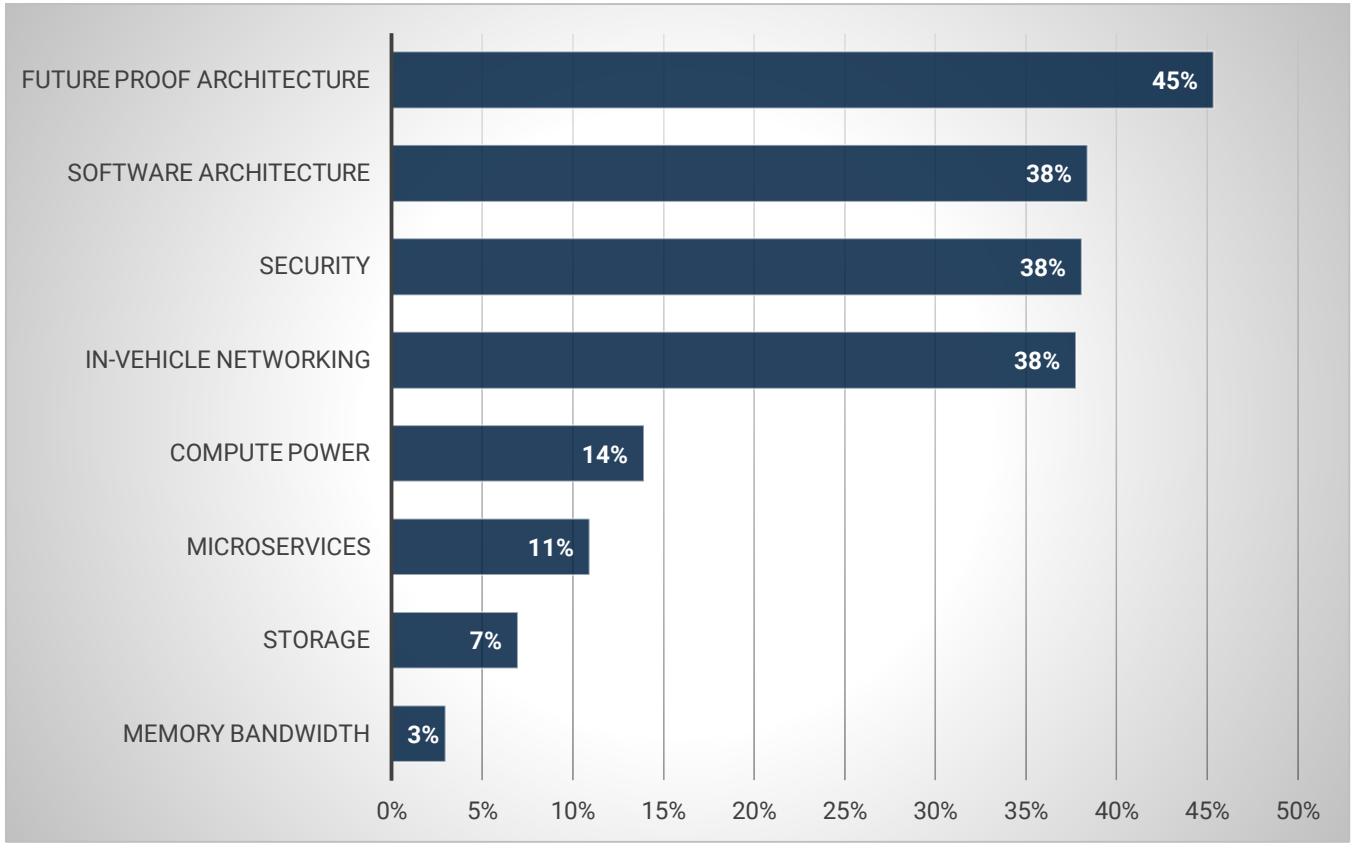
Takeaway

There are clear concerns about creating an architecture that has longevity. Main hurdles appear around the fundamental levels of software , security and networking. There is less concern with technical capabilities.

Percent of Respondents: N=318 Q5: What are the major vehicle electrical and electronic system challenges for your company? (Limited to three choices)

Major Vehicle Electrical & Electronic System Challenges - Deep Dive

All Respondents



Percent of Respondents: N=318 Q5: What are the major vehicle electrical and electronic system challenges for your company? (Limited to three choices)

Automaker, Tier 1 Suppliers & Tier Suppliers	Rank
Future proof architecture	46%
In-vehicle networking	41%
Software Architecture	38%
Security	36%
Compute power	16%
Microservices	7%
Storage	7%
Memory Bandwidth	2%

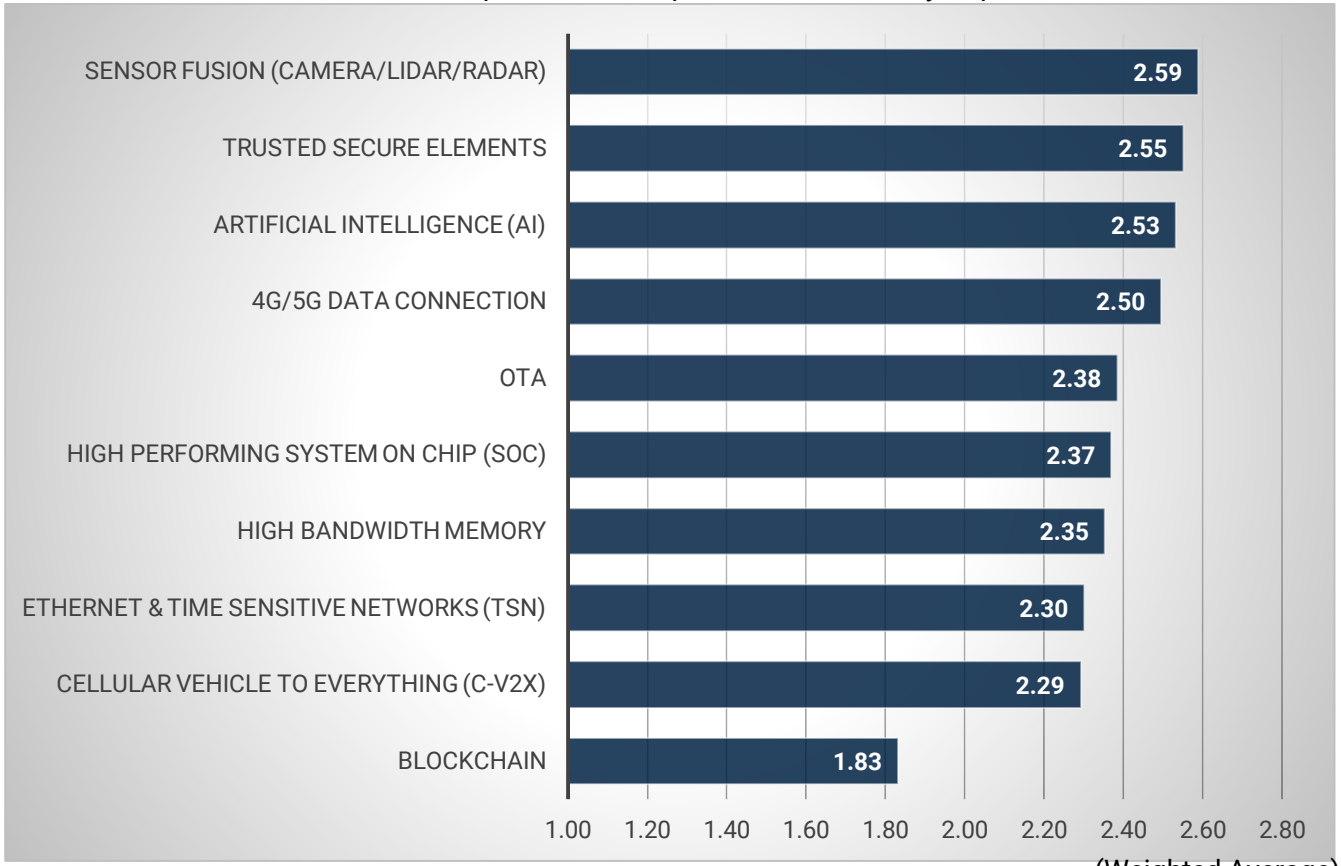
Automakers, Tier 1 & Tier 2 suppliers rank in-vehicle networking more of a challenge than software architecture.

Analysts/Consultants ONLY	Rank
Security	50%
Future proof architecture	47%
Software Architecture	38%
In-vehicle networking	24%
Microservices	16%
Storage	9%
Compute power	7%
Memory Bandwidth	3%

Analysts see security as the highest challenge while Automakers, Tier 1 & Tier 2 suppliers rank it 4th.

Future Essential Enabling Technologies

Based on 1-3 scale, where 1 = Not important, 2 = Important, and 3 = Very important



Takeaway
Top focus is sensor fusion. which is safety and AV related. Yet C-V2X is among the least important technologies. External technologies are rated very important while component technology is considered important. Blockchain is not considered important.

Percent of Respondents: N=318 Q6: What are the essential enabling technologies for vehicles in the next 10 years?

Observations:

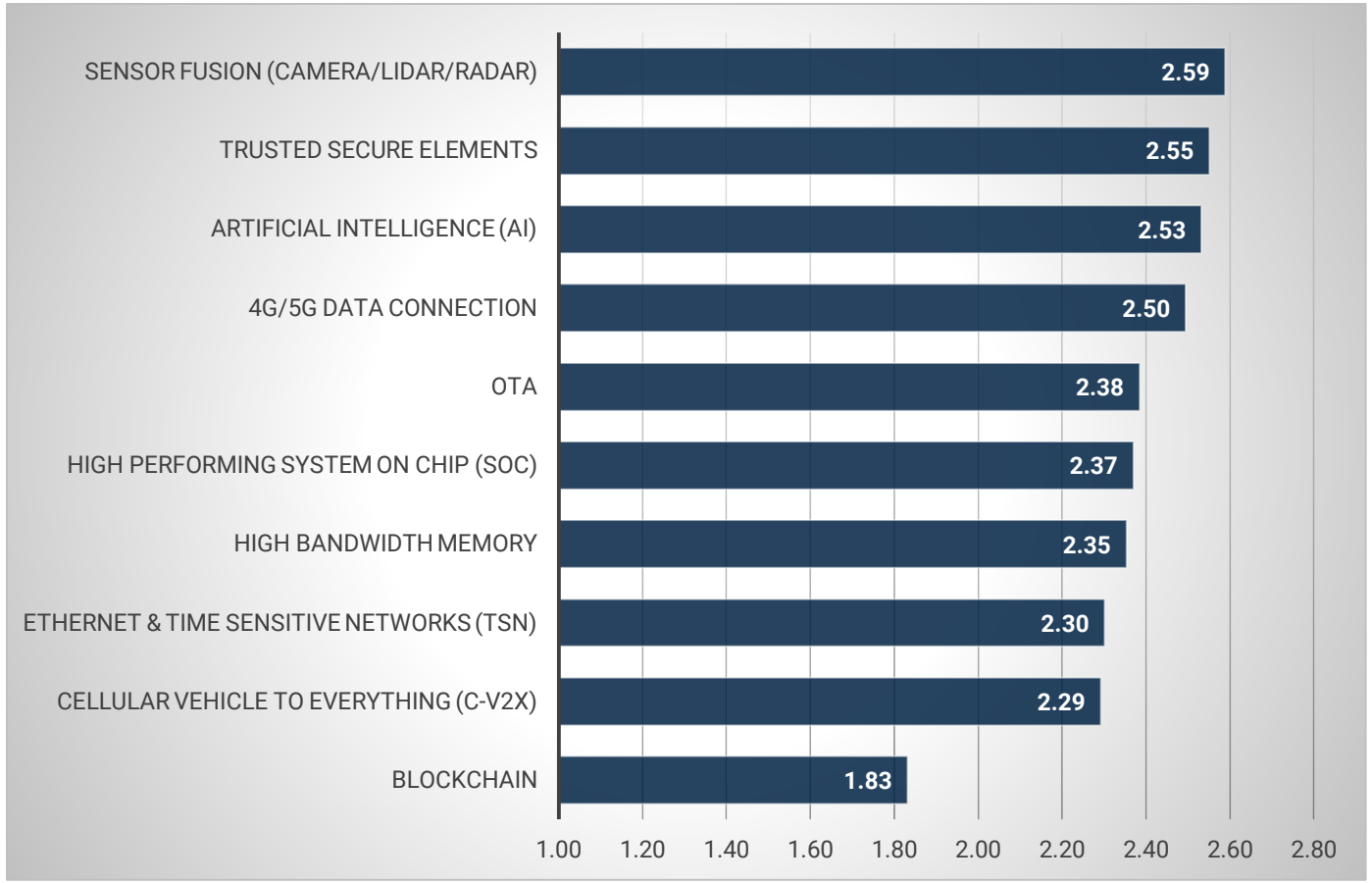
Survey respondents have highlighted four crucial technologies required to achieve the right level of safety in autonomous vehicles:

- A reliable **sensor fusion** of input from different sensors is fundamental to achieving an accurate perception of the vehicle driving environment, under all circumstances: traffic, weather, speed and time of day.
- **Secure elements** that can be trusted are an essential aspect of end-to-end trust architectures.
- **Artificial Intelligence** is widely accepted as the technology that can deliver the required performance for perception and sensor fusion necessary for AVs.
- **4G/5G** broadband technologies are also essential to achieving reliable communication among vehicles and infrastructure for data exchange, reducing autonomous-driving algorithms and ensuring real-time operation in safety critical applications.
- Blockchain is not yet considered mature or essential in the development of connected and autonomous vehicles.
- However, Blockchain is used in the supply chain to track and ensure source of origin and could add more value in the expanding automotive data-centric eco-system.

Future Essential Enabling Technologies - Deep Dive

All Respondents

Based on 1-3 scale, where 1 = Not important, 2 = Important, and 3 = Very important



(Weighted Average)

Automaker, Tier 1 Suppliers & Tier Suppliers	Rank
Sensor fusion (Camera/Lidar/radar)	2.61
Trusted secure elements	2.52
4G/5G data connection	2.44
Artificial Intelligence (AI)	2.44
OTA	2.42
High Performing System on Chip (SoC)	2.31
High Bandwidth Memory	2.28
Cellular Vehicle to Everything (C-V2X)	2.26
Ethernet & Time Sensitive Networks (TSN)	2.21
Blockchain	1.79

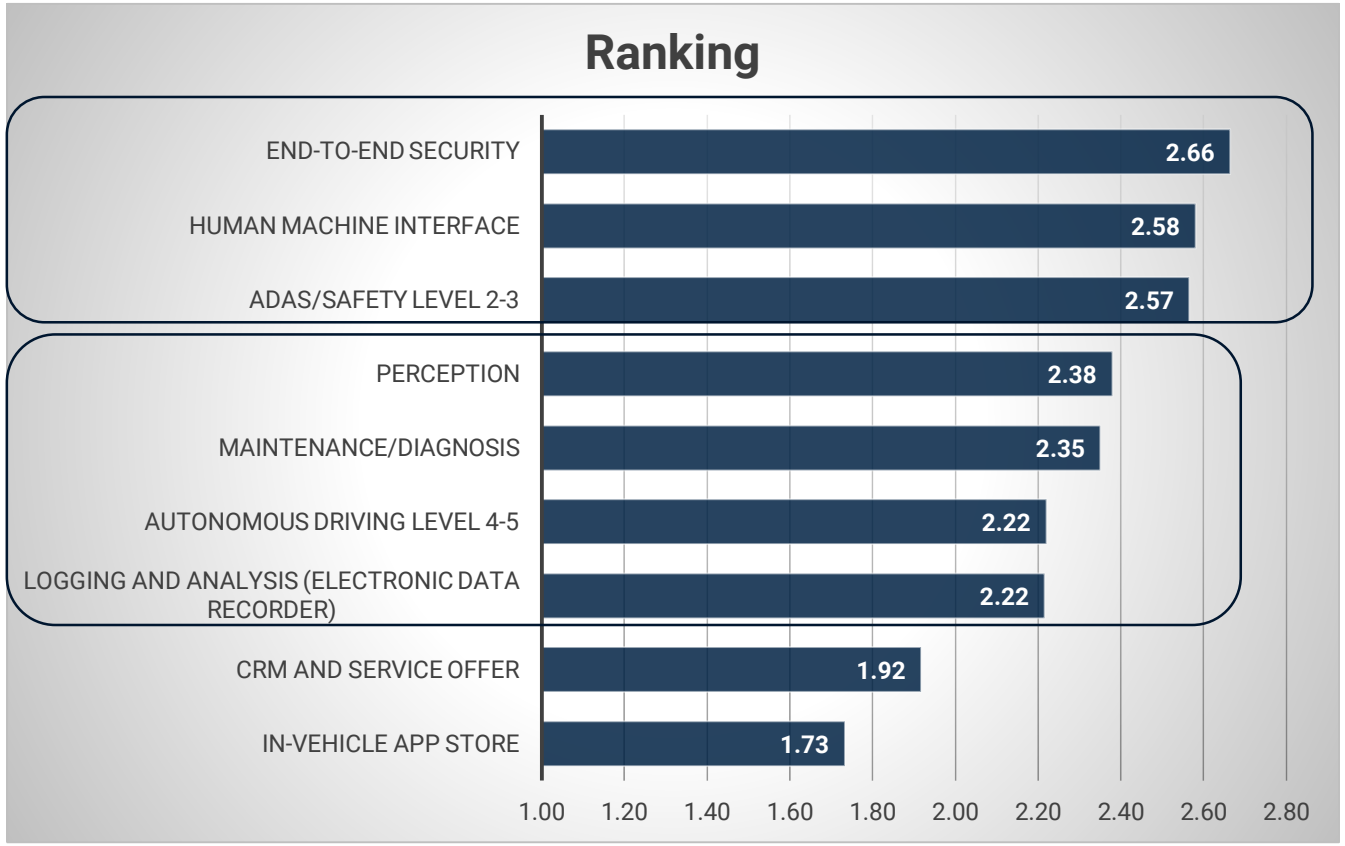
Note again that analysts rate security in the form of trusted secure elements higher than Automakers.

Analysts/Consultants ONLY	Rank
Trusted secure elements	2.66
Sensor fusion (Camera/Lidar/radar)	2.60
4G/5G data connection	2.59
Artificial Intelligence (AI)	2.58
High Bandwidth Memory	2.49
Ethernet & Time Sensitive Networks (TSN)	2.46
Cellular Vehicle to Everything (C-V2X)	2.44
High Performing System on Chip (SoC)	2.43
OTA	2.36
Blockchain	2.03

Percent of Respondents: N=318 Q6: What are the essential enabling technologies for vehicles in the next 10

Top Software Development Areas for Vehicles

Based on 1-3 scale, where 1 =Not important , 2 = Important, and 3 = Very important



(Weighted Average)

Observations

Safety-related items are ranked as top software-development areas, reflecting the absolute priority of the industry.

Security is a critical topic, as deficiencies could jeopardize functional safety systems.

ADAS and safety-critical functions are ranked close to security in priority, including Level 2-3 type of functions and perception systems, followed by the highly challenging Level 4-5 software development.

Human-machine interface (HMI) maintains a solid position in second place. HMI is central to every interaction between the driver and vehicle, from entertainment functions to more safety-critical engagement. Such safety-critical functionality includes driver monitoring and warning indicators (e.g., lane-keep warning-LKW, blindspot detection-BSD), as well as the highly critical task of alerting the driver to take over control in the case of Level 3 autonomous vehicles.

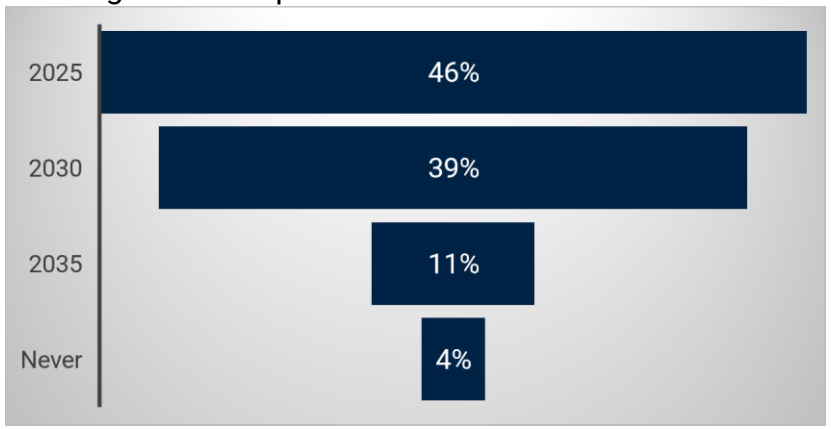
Of note, the in-vehicle "App Store" is not ranked as a key feature. Considering the importance seen for HMI as a brand differentiator, and the relevance given to in-vehicle applications and feature upgrades (Q18, Q13), Wards Intelligence believes respondents rank "App Store" low because the focus is more directly on onboard content and the user experience.

Takeaway
Features and functionality dominate thinking, rather than services and apps. Security, user experience and safety are primary focuses.

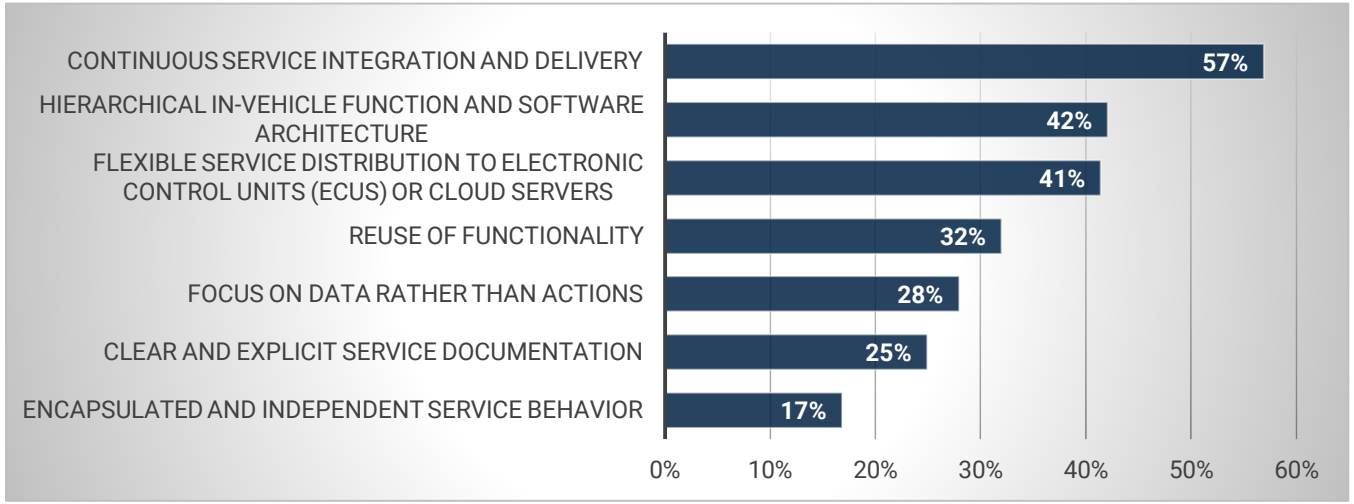
Percent of Respondents: N=303 – 310 Q7: What are the top software development areas for vehicles?

The Role of SOA in Software-Defined Architectures

Timing of SOA Implementation



Top Drivers of SOA & MSA Implementation



Observations

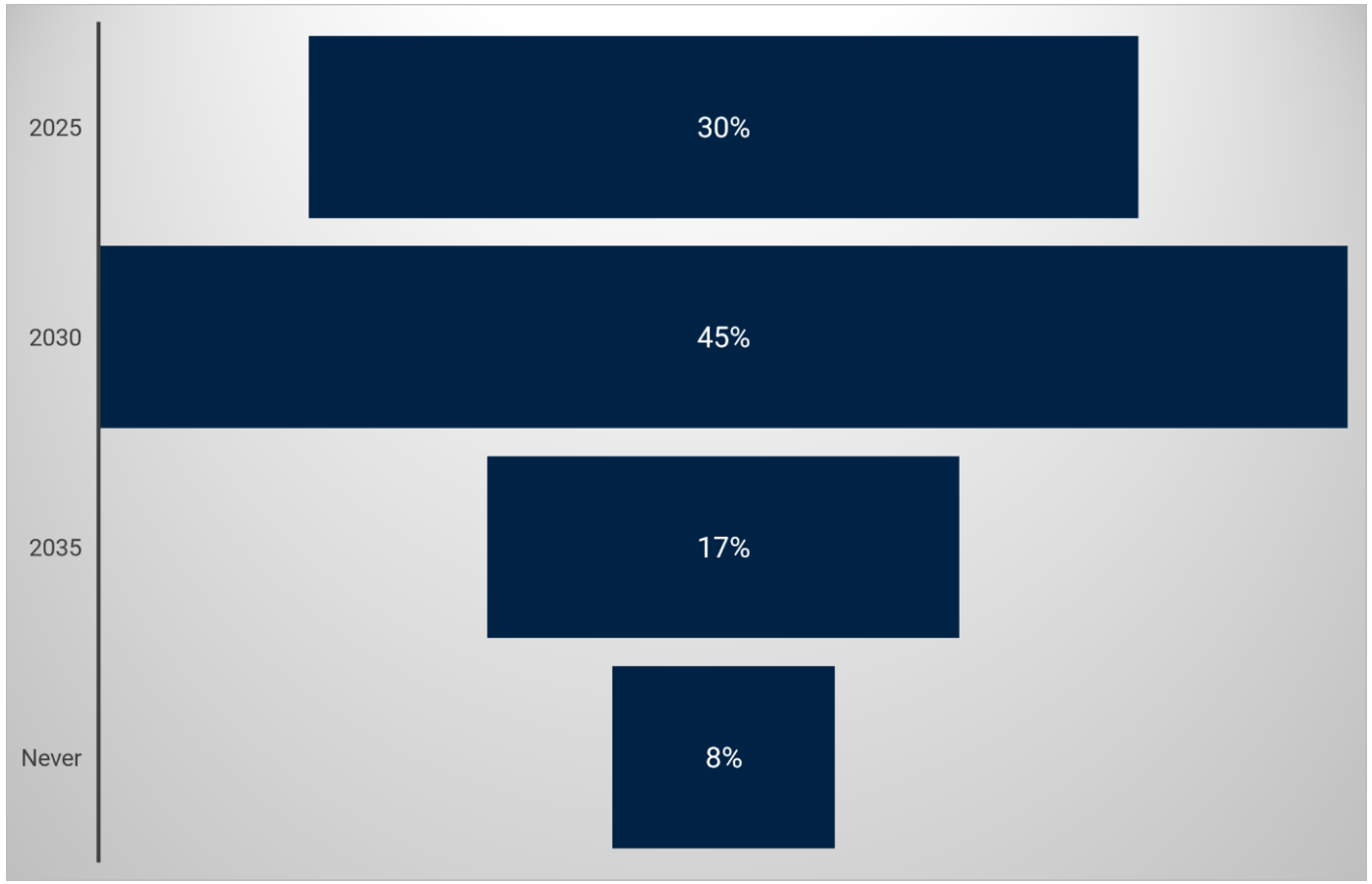
The importance of Service Oriented Architectures (SOAs) is apparent in the survey results, with 46% of respondents predicting deployment on next-generation vehicles by 2025.

Wards Intelligence confirms such expectations. SOA is a cornerstone for substantially higher levels of vehicle capability in the future and is consequently considered an essential step to:

- Delivering continuous Integration of services and applications. (57%, see Q14).
- Minimizing lines of SW code.
- Ensuring faster development cycles and time to market.
- Optimizing updates, quality enhancements, and lifecycle management.
- Enabling software reusability.
- Simplifying safety systems certification (ISO26262).
- Enhancing HW utilization, especially on legacy ECUs.

Q8: When will SOA (Service Oriented Architecture) appear in vehicle software architectures?
Q14: What are the top drivers paving the way for the implementation of Service-oriented architectures (SOA) and micro service architectures (MSA). (Limited to three choices)

EDR/Blackbox Mandates



Observations

There is a reasonable level of confidence among respondents that implementation of Electronic Data Recorders (EDR), sometimes referred to as “black boxes”, will be mandated in 2025-2030.

Wards Intelligence considers that a reasonable timeframe in relation to the increased number of autonomous functions and their widespread deployment across each OEM’s vehicle lineup, from premium to economy models.

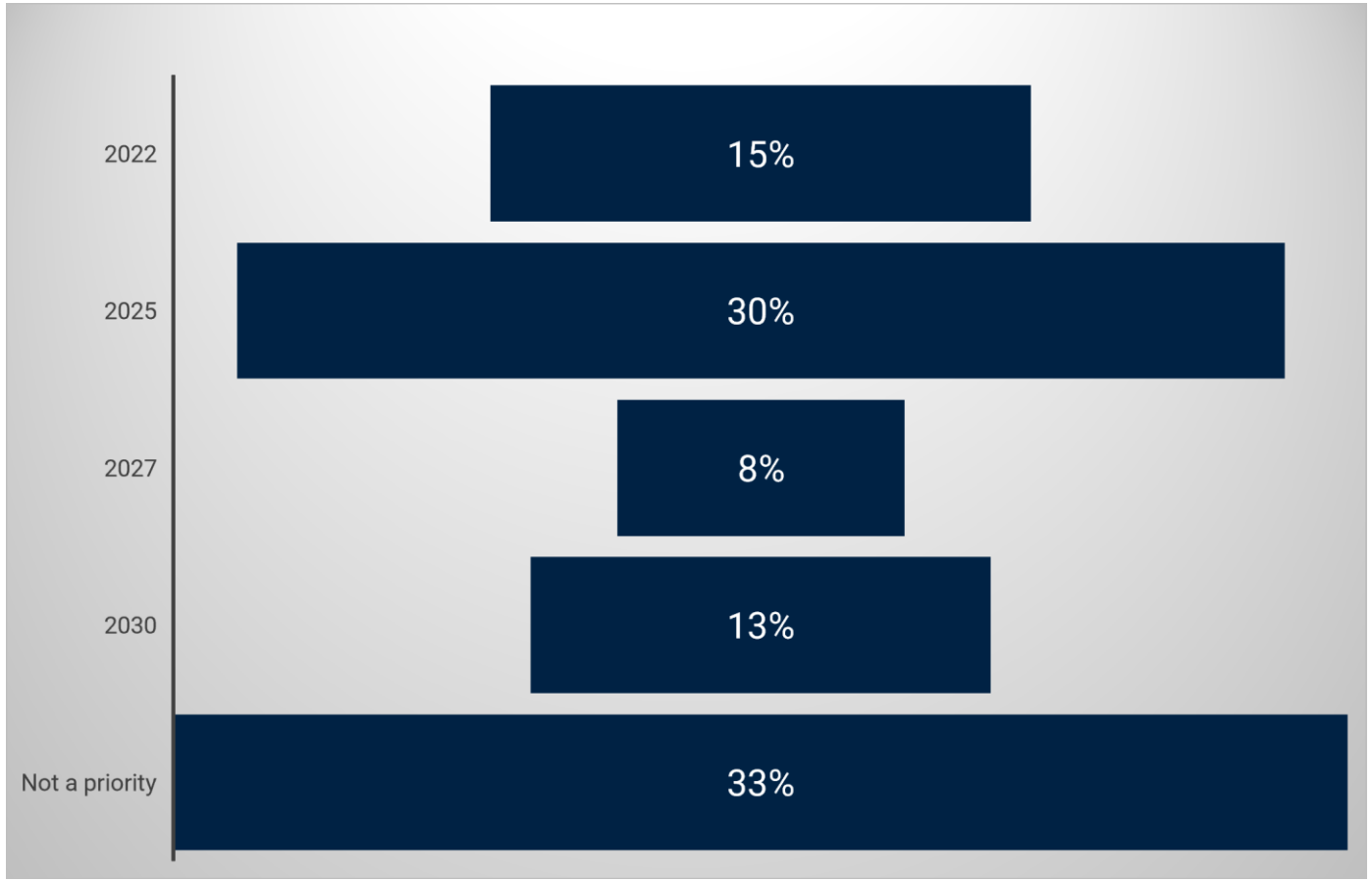
OEM liability increases exponentially relative to autonomous vehicles. EDRs offer a complete record of vehicle operations and environmental conditions in real time, providing valuable data that can help reconstruct the scene in detail in case of an accident or other significant event.

Together with other European Union initiatives such as e-Call, EDRs will be able to support additional services and safety functions, including the opportunity to match a driver´s insurance protection and premium to his driving habits.

Takeaway
EDR will happen. but is not a near-term priority. Deployment will be similar to the e-Call experience.

Percent of Respondents: N=318 Q9: When do you believe In-vehicle Electronic Data Recorders (EDR / black box) will be mandated?

Deployment Timing for New In-Vehicle Architecture



Observations

In an apparent contradiction with Q8, just 30% of respondents expect deployment of new in-vehicle architectures by 2025; moreover, 33% of them do not consider that to be a priority.

Wards Intelligence's believes the respondents took a holistic view in answering this question, with "systems architecture" addressing not only the software portion (SOA) but also the impact on hardware components and networking (e.g., Centralized Domain Control and Zonal Architecture).

When averaged across OEMs around the world (both premium and mass-market manufacturers), a cautious outlook is in line with the feedback Wards Intelligence received from various players within the supply chain.

Although a common concept for new modular and optimized electric/electronic (E/E) system architectures has developed organically in automotive, the industry is focusing more narrowly on achieving the first key milestone: enabling software-defined cars.

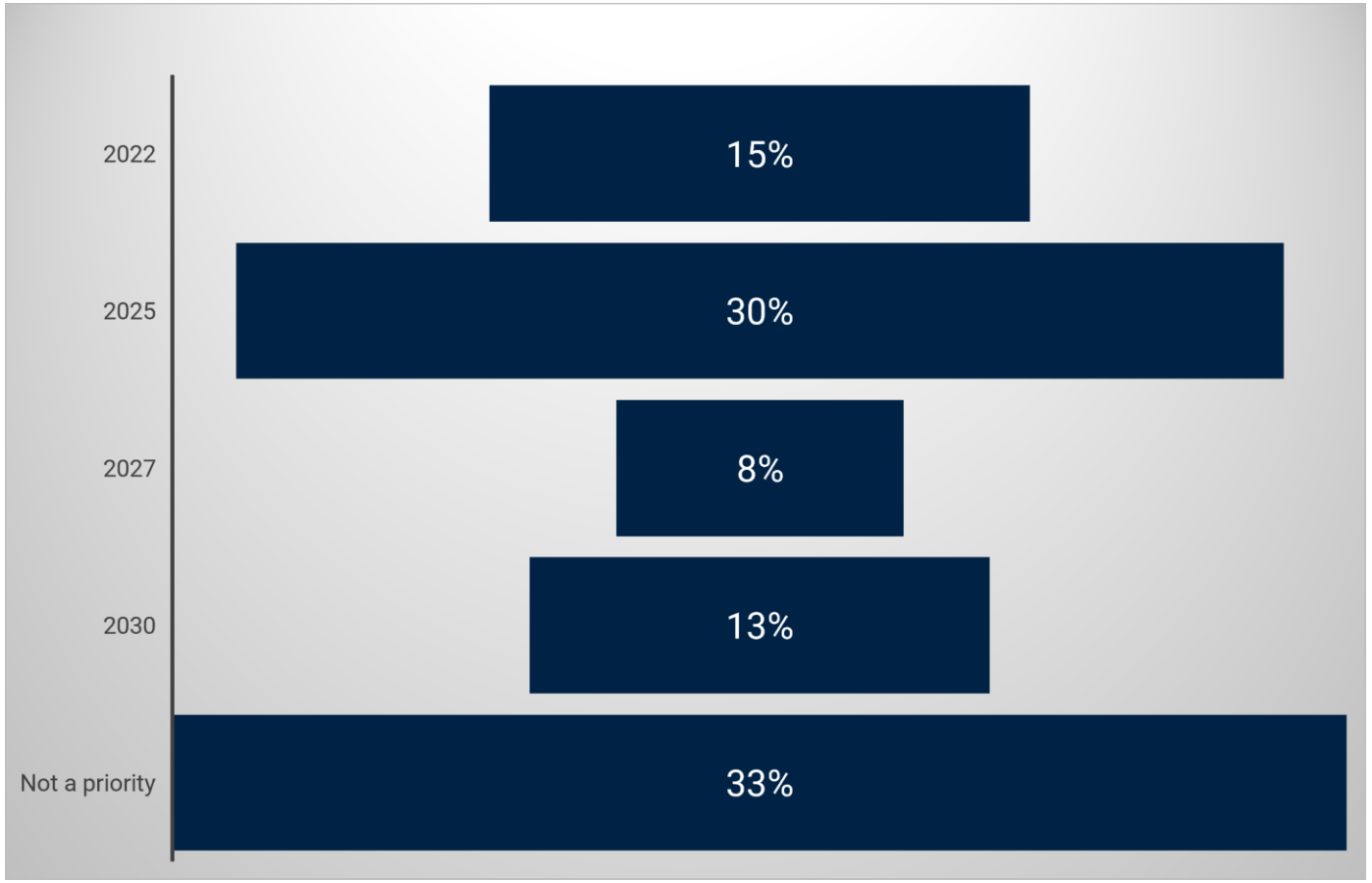
As a result, software architectures, such as SOAs, have much higher priority levels.

Takeaway
The challenge of a future-proof architecture is not considered a priority by 55% of ecosystem respondents.

Percent of Respondents: N=318 Q10: When will you deploy a new in-vehicle architecture?

Deployment Timing for New In-Vehicle Architecture - Deep Dive

All Respondents



Automakers, Tier 1 Suppliers & Tier Suppliers

2022	15%
2025	29%
2027	11%
2030	11%
Not a priority	33%
Respondent Count	141

Analysts/Consultants

Q10 When will you deploy a new in-vehicle architecture?	
2022	9%
2025	25%
2027	7%
2030	19%
Not a priority	40%
Respondent Count	57

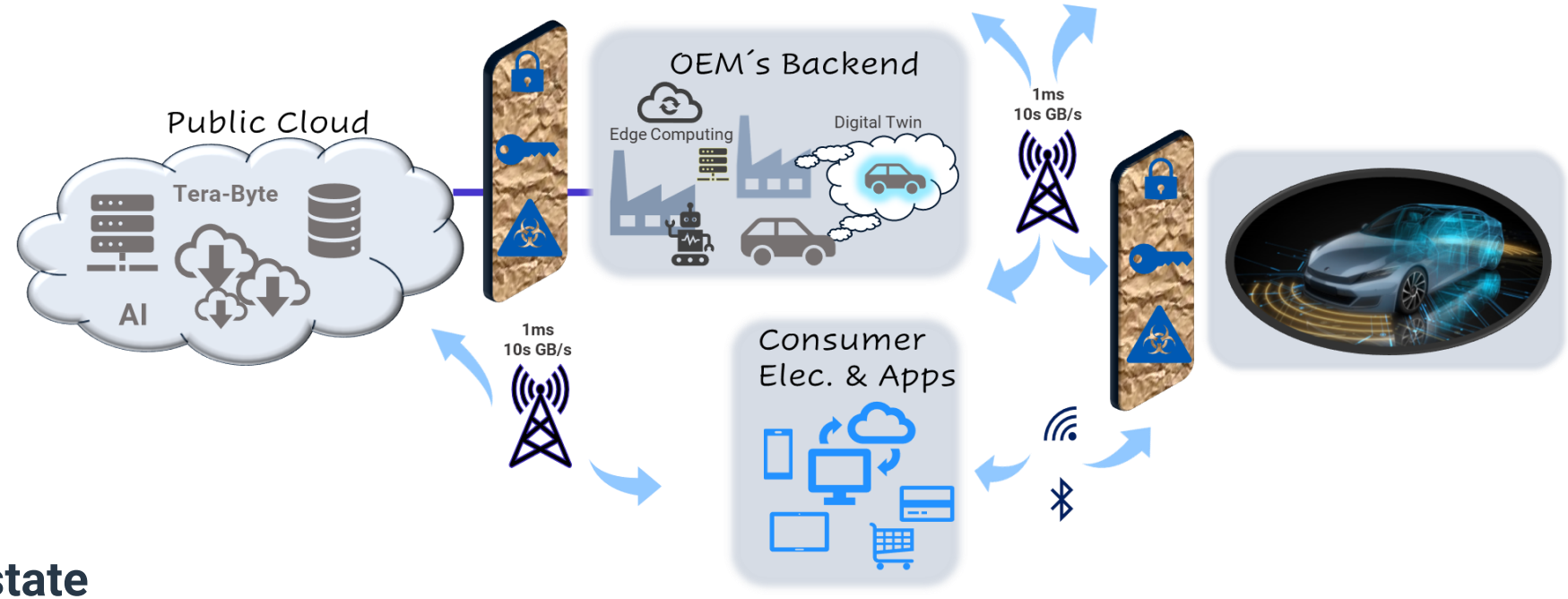
Automakers

Q10 When will you deploy a new in-vehicle architecture?	
2022	20%
2025	30%
2027	13%
2030	19%
Not a priority	19%
Respondent Count	54

Takeaway
Fifty percent of automotive OEM respondents indicate they will deploy a new in-vehicle architecture by 2025 while the rest of the ecosystem is more skeptical.

Percent of Respondents: N=318 Q10: When will you deploy a new in-vehicle architecture?

Vehicle, Infrastructure and Data Interaction



Current state

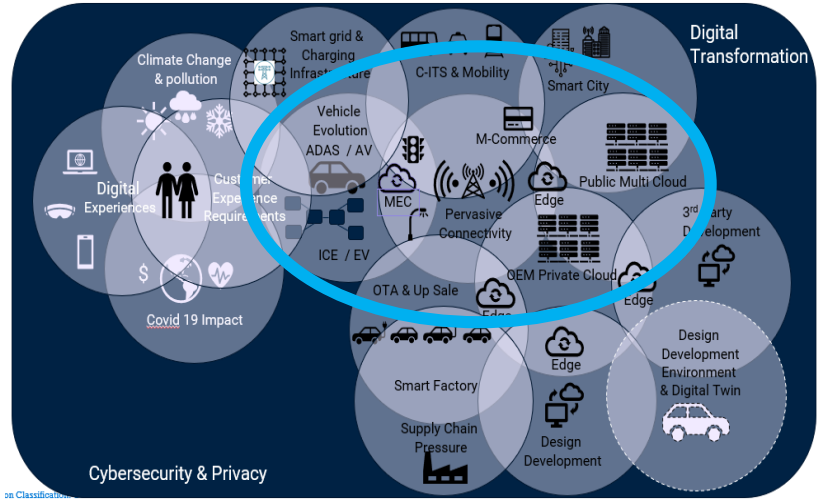
The above graphic depicts the threemajor independent domains beyond the car that OEMs need to clearly identify. They then need to secure and control data interaction to ensure functionality and efficiency in and outside the vehicle; new business opportunities and revenue streams; cost control and optimization.

Three major forms of monetization can be extracted from the above setup:

- Direct Revenue: a) B2C: Selling products, features, upgrades to customers; b) B2B: Selling vehicle/driver data for tailored advertising/product recommendations.
- Cost Reduction: a) Predictive maintenance; b) Diagnosis and feedback to R&D for optimization; c) Cost of repair; d) Optimization of fleet operations; e) Insurance and warranty; f) Retailer Footprint and Inventory.
- Brand Differentiation and Added Value services: a) CRM and loyalty programs; b) Optimized HMI and Settings; c) Security and Safety; d) eCall, bCall; e) e-commerce.

Vehicle, Infrastructure and Data Interaction

Summary Points

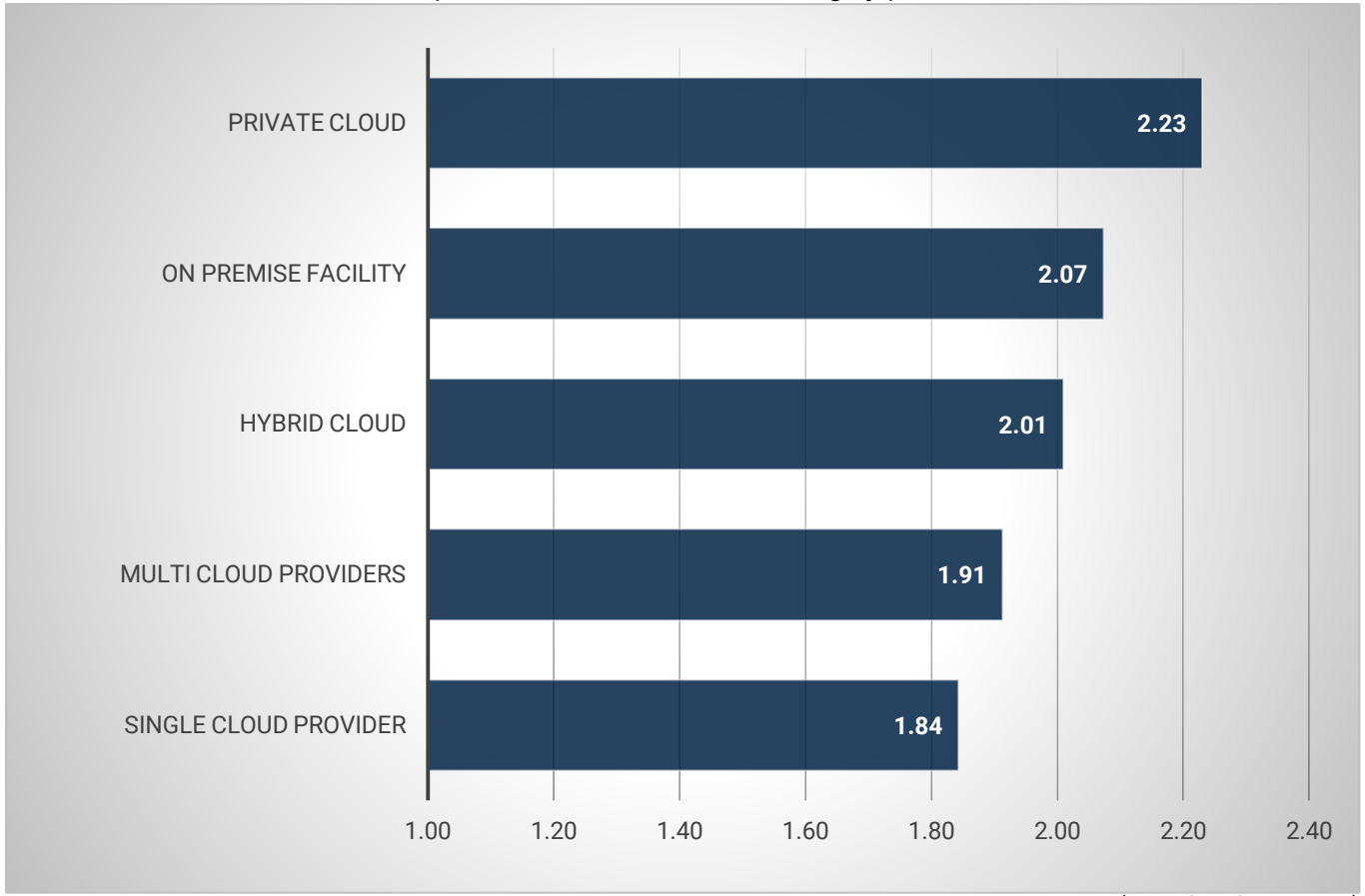


OEMs prefer full control over product development and the technology employed in that process, and that is manifested in how the auto industry views private cloud and service-provider data-storage solutions. Although there is clarity on over-the-air updating requirements and why SOAs will play a key role in the future, without partnerships and an open approach to development, change will come slowly. The good news: OEMs see ease of data management as critical to their data storage strategy, so the pace of change could accelerate.

Key Area	Finding
Cloud/IT service provider solutions .	Control is still a key driver. Private cloud and on-premises storage are preferred solutions and reliance on a single cloud is least preferred.
Current data strategy implementation.	Average to slightly better than average gives little comfort to those anticipating digitization and transformation to occur rapidly. A deep dive reveals more. Automotive OEMS rate their data strategy more strongly than Tier 1 & 2 players, especially in vehicle development, assessing it as above average and approaching excellent.
Applications offering top data monetization opportunities for OEMs.	Automotive OEMs see the OTA feature upgrade capability as key to monetization. Suppliers and consultants see smart city services as the key.
Top drivers for the implementation of Service-Oriented Architectures (SOA) and Micro Service Architectures (MSA).	Clear alignment of OEM and Tier 1 & 2 suppliers on the top three drivers. Continuous service integration and delivery is No.1, followed by hierarchical in-vehicle function and software architecture. Analysts agree on No.1 but believe reuse of functionality is second highest.
Critical elements for a future-proof storage strategy.	OEMs consider ease of management very important. The ecosystem is more concerned with performance that scales, which could reflect the existing size and scale of the OEMs.

Rating Cloud/IT Service Provider Solutions

Based on 1-3 scale, where 1 =Not preferred , 2 = Preferred, 3 = highly preferred



(Weighted Average)

Takeaway
Control remains a key driver. Private cloud and on-premises are preferred storage solutions and reliance on a single cloud least preferred.

Observations

Software-defined vehicles and “functionality as a service” are driving and will continue to drive new revenue streams even more so in the future, as well as provide cost-reduction opportunities along the entire automotive value chain.

But such essential new roles for software components also demand the development of a more-efficient and flexible infrastructure within the automotive industry, impacting servers, storage equipment and connectivity, both in R&D and manufacturing.

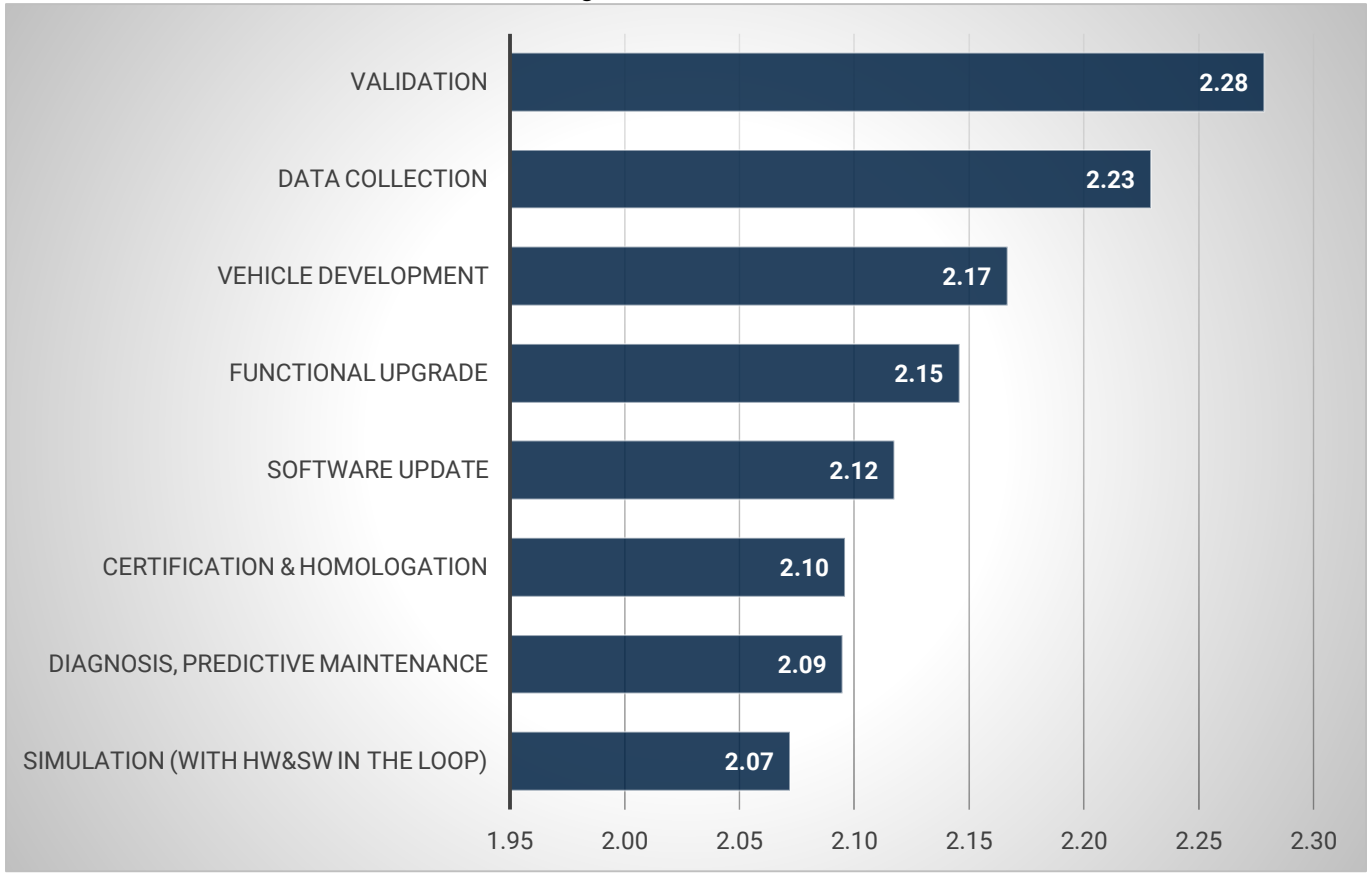
The preference for private cloud and on-premises storage reflects OEMs’ desire to control and secure vehicle data and software along several key phases of the vehicle lifecycle: R&D, Manufacturing, Testing and Validation, Maintenance, Certification, Services, CRM, System Upgrade and Update.

The way industrial products are designed, manufactured and maintained is evolving because of changes brought on by both macroeconomic trends and emerging technologies. Efforts to reign in skyrocketing cost increases through innovation also play a role in the design and manufacturing evolution.

Percent of Respondents: N=318 Q11: Rate the following Cloud/IT service provider solutions based on your company's compute, storage and security requirements

Rating Company's Current Data Strategy

Based on 1-3 scale, where 1 =Poor, 2 = Average, 3 = Excellent



(Weighted Average)

Takeaway
Average to slightly better than average ratings don't provide much comfort to those anticipating digitization and transformation will occur rapidly.

Percent of Respondents: N=318 Q12: Rate your company's current data strategy in implementing:

Observations

Responses to Q12 vary considerably when looking at respondent demographics. This indicates various members of the supply chain identify different priorities and business opportunities when implementing their data strategies.

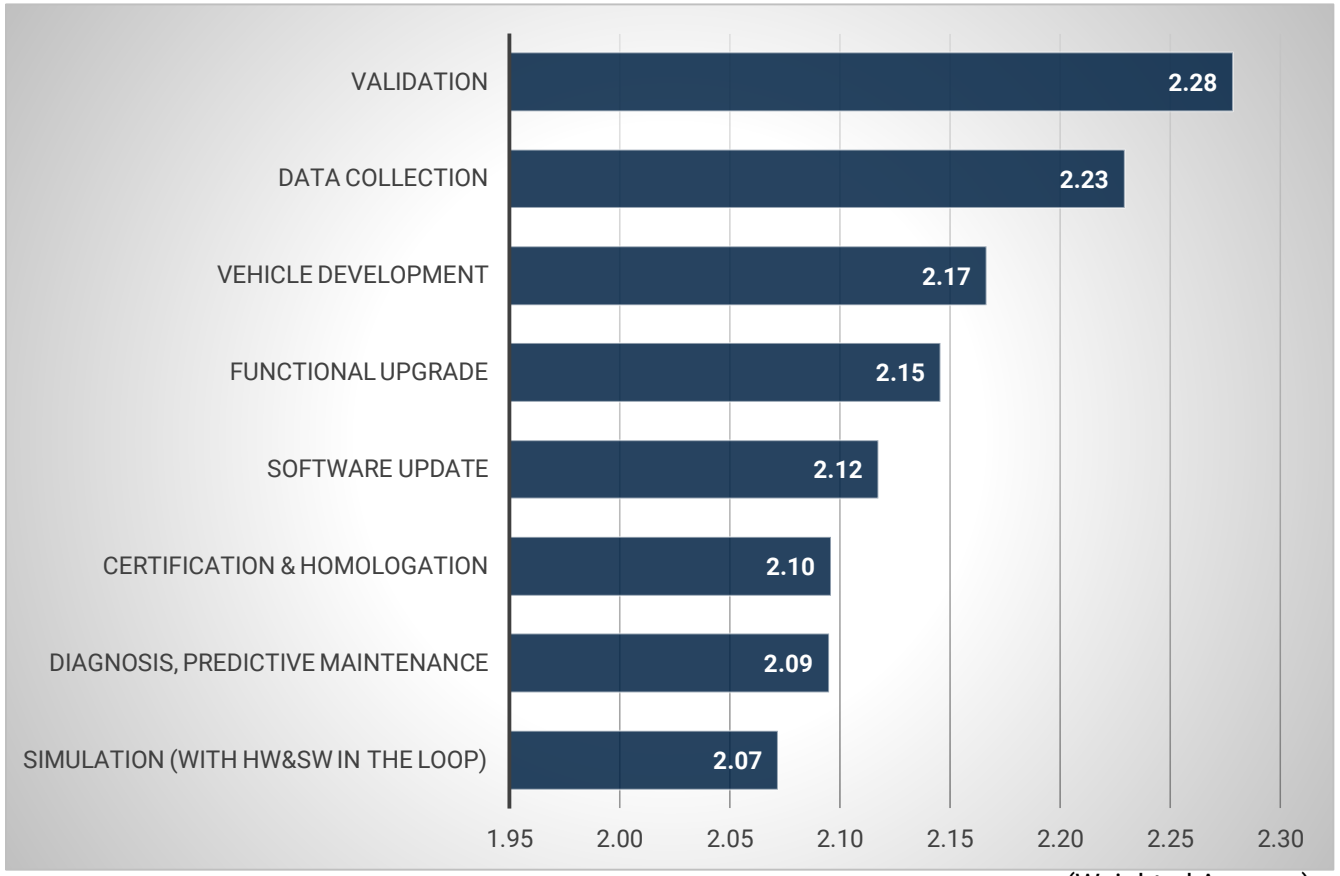
Analyzing the response by type of organization, we note OEMs rate themselves closer to excellent on several items. They have a high weighted average score of 2.57 for vehicle development followed by 2.55 for validation. They also give a higher score for certification & homologation (2.38) and for diagnosis, predictive maintenance (2.31) than the overall industry results.

Alternatively Tier 1 and Tier Suppliers rated their engagement in data-strategy implementation low; with only validation scoring higher than average

The results could hint at a more favorable position for the OEMs in controlling and monetizing data, rather than other automotive suppliers.

Rating Company's Current Data Strategy - Deep Dive

Based on 1-3 scale, where 1 =Poor, 2 = Average, 3 = Excellent



Automakers ONLY

Vehicle development	2.57
Validation	2.55
Certification & homologation	2.38
Diagnosis, predictive maintenance	2.31
Simulation (with HW&SW in the loop)	2.30
Data collection	2.28
Software update	2.19
Functional upgrade	2.13

N=54

Tier 1 Suppliers & Tier Suppliers ONLY

Validation	2.32
Vehicle development	2.14
Data collection	2.10
Functional upgrade	2.09
Certification & homologation	2.04
Diagnosis, predictive maintenance	2.00
Simulation (with HW&SW in the loop)	1.98
Software update	1.94

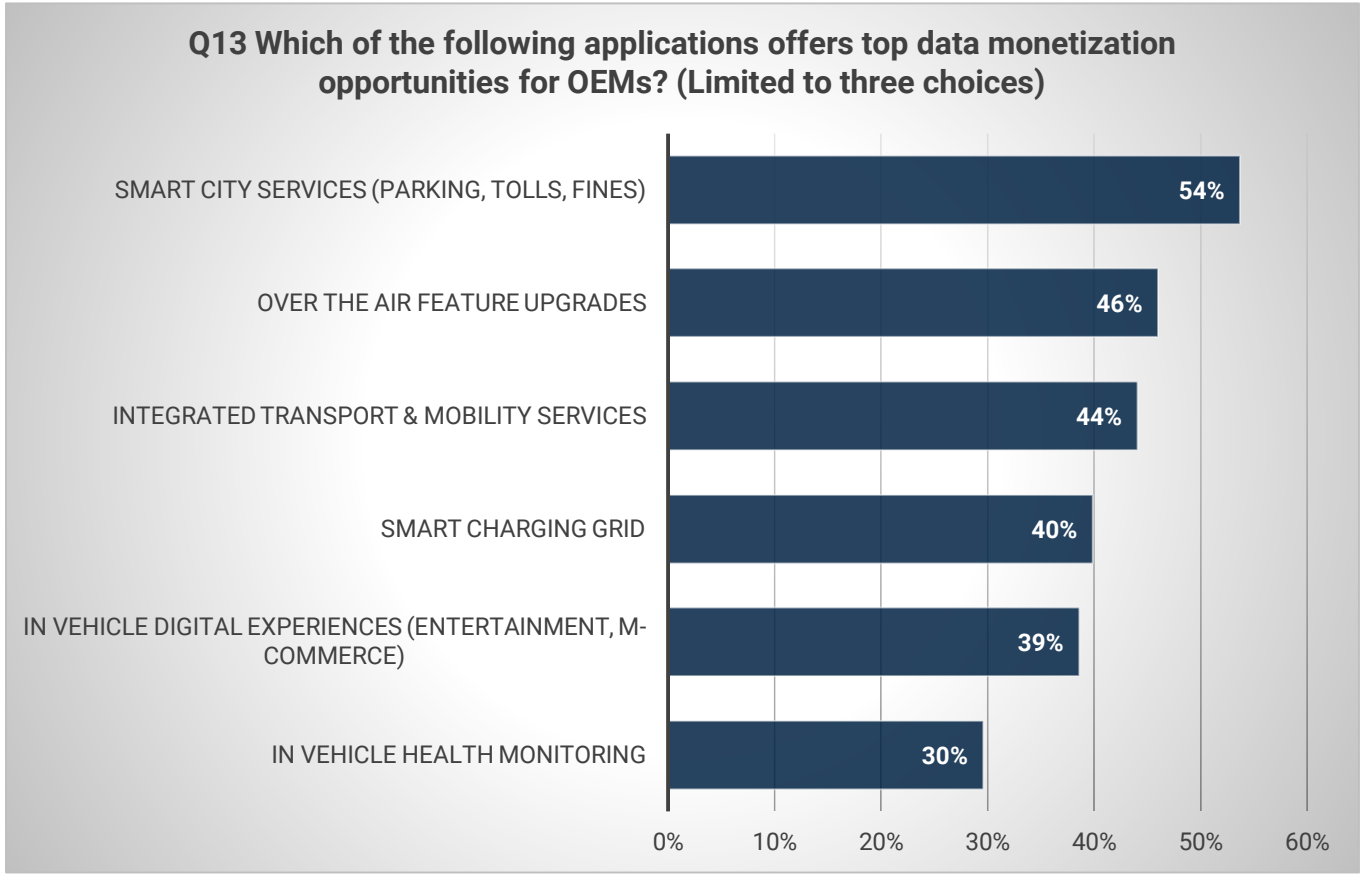
N=83

Takeaway

Average to slightly better than average ratings don't provide much comfort to those anticipating digitization and transformation will occur rapidly. However, a deep dive reveals more. OEMs rate their data strategy more strongly than Tier 1 & 2 players, especially in vehicle development, rating it above average and approaching excellent.

Percent of Respondents: N=318 Q12: Rate your company's current data strategy in implementing:

Top Data Monetization Application Opportunities for OEMs



Percent of Respondents: N=318 Q13: Which of the following applications offers top data monetization opportunities for OEMs? (Limited to three choices)

Observations

The automotive industry believes data is a potential gold mine that will trigger new revenue streams and high-margin business models.

Technology and infrastructure are available, or on their way, to take advantage of the “hidden” value embedded in the huge amount of data compiled by each member of the automotive eco-system. In particular:

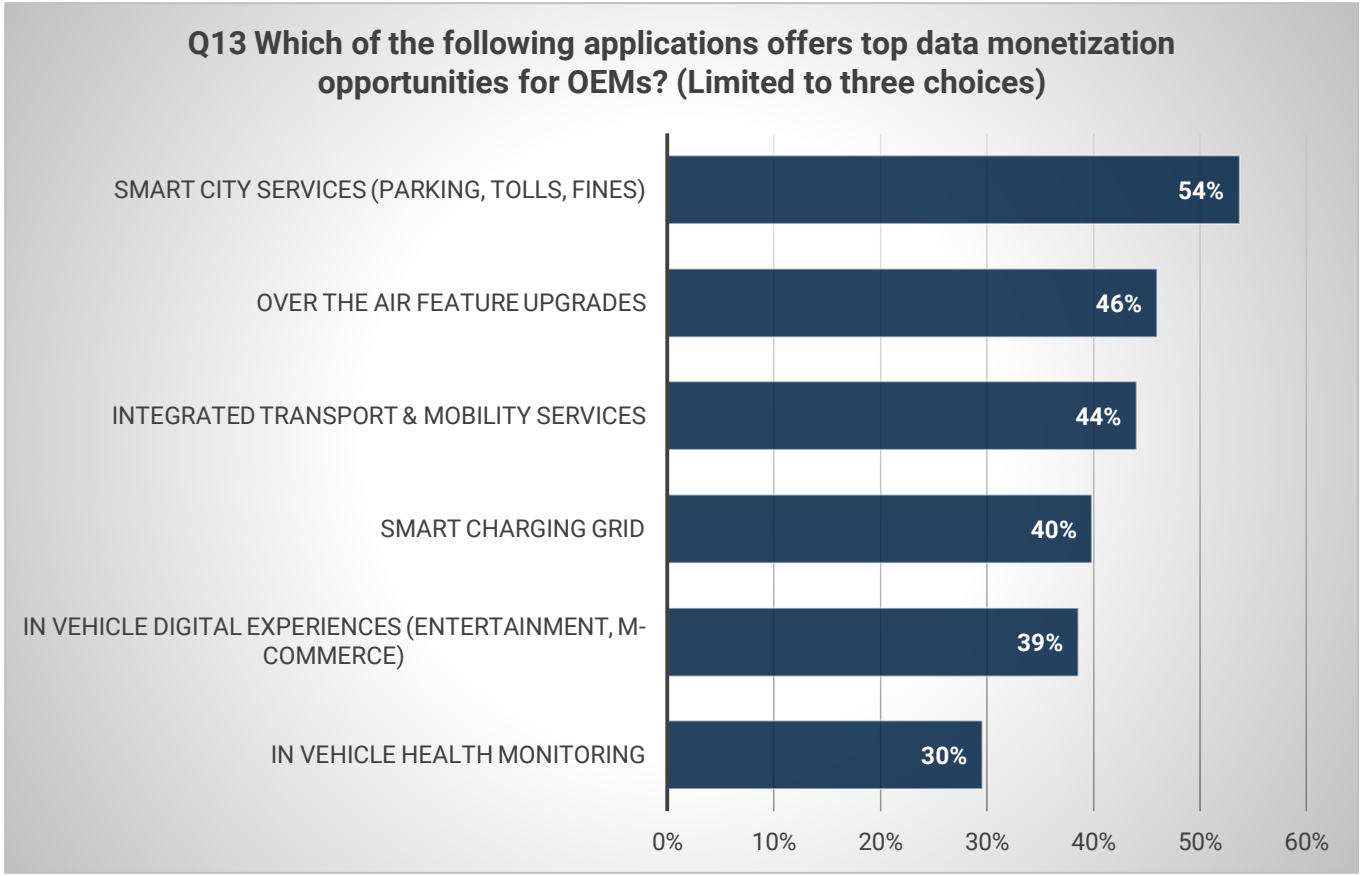
- Connectivity: the basic precondition.
- HMI and Software platform: the enabler to data collection.
- Artificial Intelligence: the "gold sniffer.“
- Cloud and Datacenter: the required infrastructure.

As highlighted in Q12 and Q13, responses vary between members of the supply chain that identify different priorities in data monetization.

The result corresponds with the best opportunity OEMs or suppliers identify in controlling the data, as well as in addressing the low hanging fruit that best fits their business model.

While both OEMs and suppliers believe the highest priority is “OTA Feature Upgrade” (OEM 56%, Tiers 46%), the top opportunity for suppliers (58%) was Smart City Services, selected just by 35% of the OEMs. OEMs mainly are focused instead on Mobility Service and In-vehicle User Experience both at 44%.

Top Data Monetization Application Opportunities for OEMs - Deep Dive



Takeaway
Automotive OEMs see the OTA feature upgrade capability as key to monetization. Suppliers and consultants see smart city services as the prime opportunity.

Percent of Respondents: N=318 Q13: Which of the following applications offers top data monetization opportunities for OEMs? (Limited to three choices)

Automaker OEMs

Over the air feature upgrades	56%
In-vehicle digital experiences (entertainment, m-commerce)	44%
Integrated transport & mobility services	44%
Smart charging grid	39%
Smart city services (parking, tolls, fines)	35%
In-vehicle health monitoring	21%

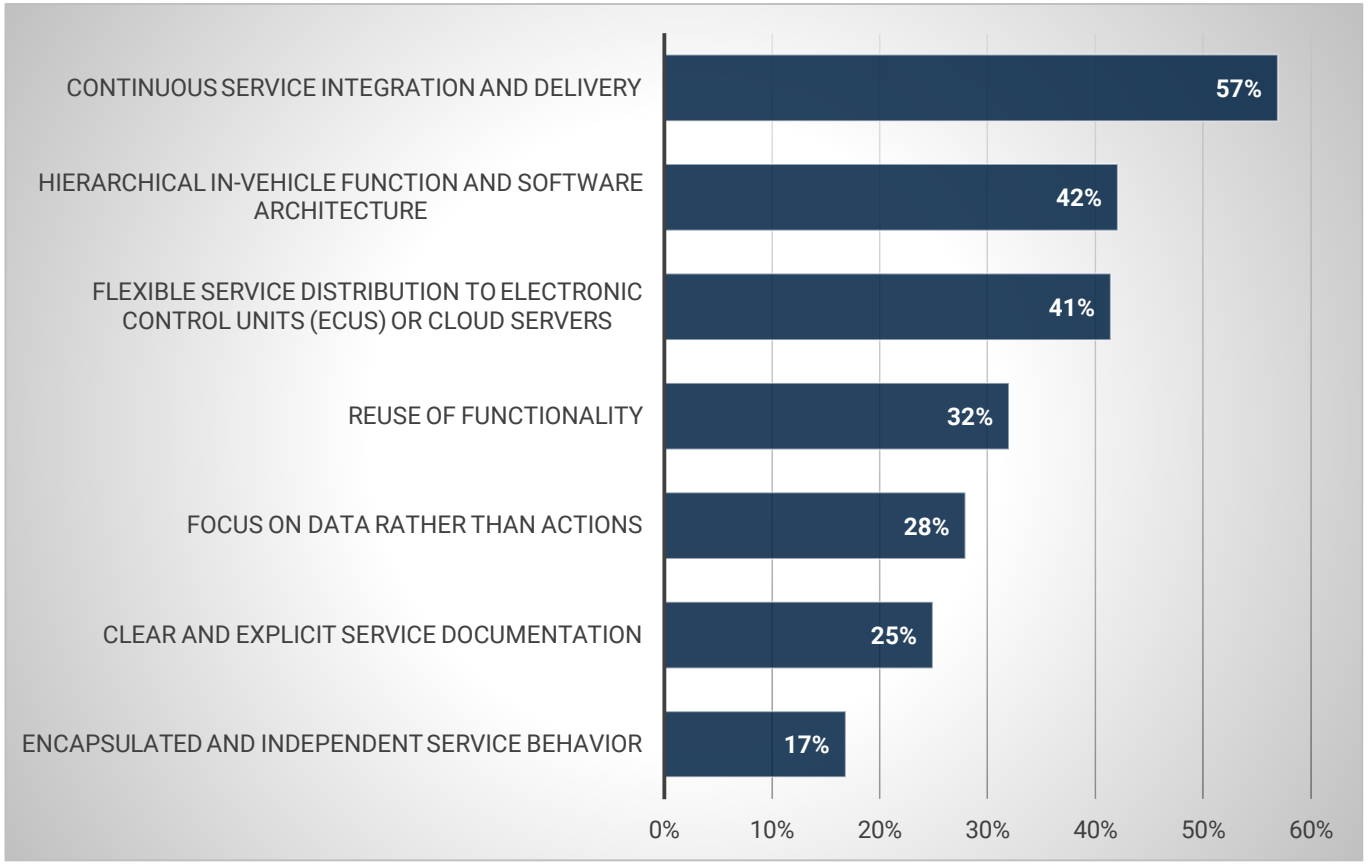
Tier 1 & Tier Suppliers

Smart city services (parking, tolls, fines)	58%
Over the air feature upgrades	47%
Integrated transport & mobility services	38%
Smart charging grid	37%
In-vehicle digital experiences (entertainment, m-commerce)	37%
In-vehicle health monitoring	34%

Analysts/Consultants

Smart city services (parking, tolls, fines)	50%
Smart charging grid	47%
Integrated transport & mobility services	45%
In-vehicle digital experiences (entertainment, m-commerce)	42%
Over the air feature upgrades	42%
In-vehicle health monitoring	18%

Top Drivers of SOA & MSA Implementation - Deep Dive



Automaker OEMs

Continuous service integration and delivery	60%
Hierarchical in-vehicle function and software architecture	43%
Flexible service distribution to electronic control units (ecus) or cloud servers	42%
Clear and explicit service documentation	26%
Focus on data rather than actions	25%
Reuse of functionality	21%
Encapsulated and independent service behavior	8%

Tier 1 & Tier Suppliers

Continuous service integration and delivery	60%
Hierarchical in-vehicle function and software architecture	43%
Flexible service distribution to electronic control units (ecus) or cloud servers	35%
Reuse of functionality	33%
Clear and explicit service documentation	30%
Focus on data rather than actions	29%
Encapsulated and independent service behavior	13%

Analysts/Consultants

Continuous service integration and delivery	59%
Reuse of functionality	46%
Hierarchical in-vehicle function and software architecture	41%
Flexible service distribution to electronic control units (ecus) or cloud servers	41%
Focus on data rather than actions	29%
Clear and explicit service documentation	16%
Encapsulated and independent service behavior	14%

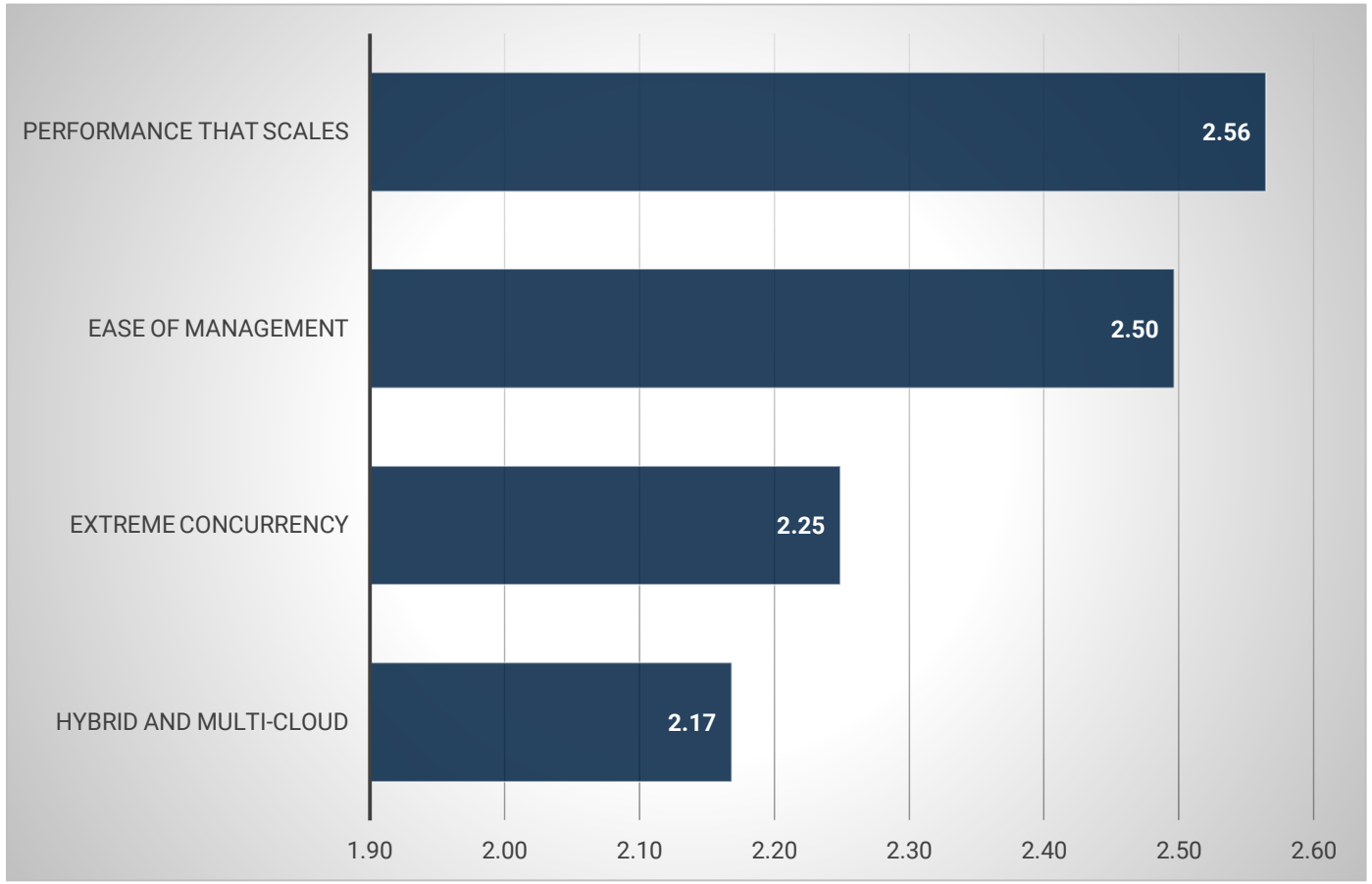
Takeaway

Auto OEM and Tier 1 & 2 suppliers are aligned on the top three drivers. Continuous service integration and delivery is No.1, followed by hierarchical in-vehicle function and software architecture. Analysts agree on No.1, but rate reuse of functionality second highest.

Percent of Respondents: N=318 Q14 What are the top drivers paving the way for the implementation of Service-oriented architectures (SOA) and micro service architectures (MSA). (Limited to three choices)

Important Features of a Future-Proof Storage Strategy

Based on 1-3 scale, where 1 =Not important , 2 = Important, 3 = Very important



Percent of Respondents: N=318 Q15: Which of the following is critical for a future-proof storage strategy?

Observations

Storage is an essential asset, because automotive is software-defined but data driven.

The survey also confirms storage solutions must provide performance that can be scaled and adapted easily to various application requirements. As in other industries, there is not a one-size-fits-all scenario for automotive. Consequently, storage solutions must provide flexibility around performance, reliability and cost. Diversified applications such as AI training/AI Inference and data structuring/data elaboration must be able to run in parallel from the same datacenter,.

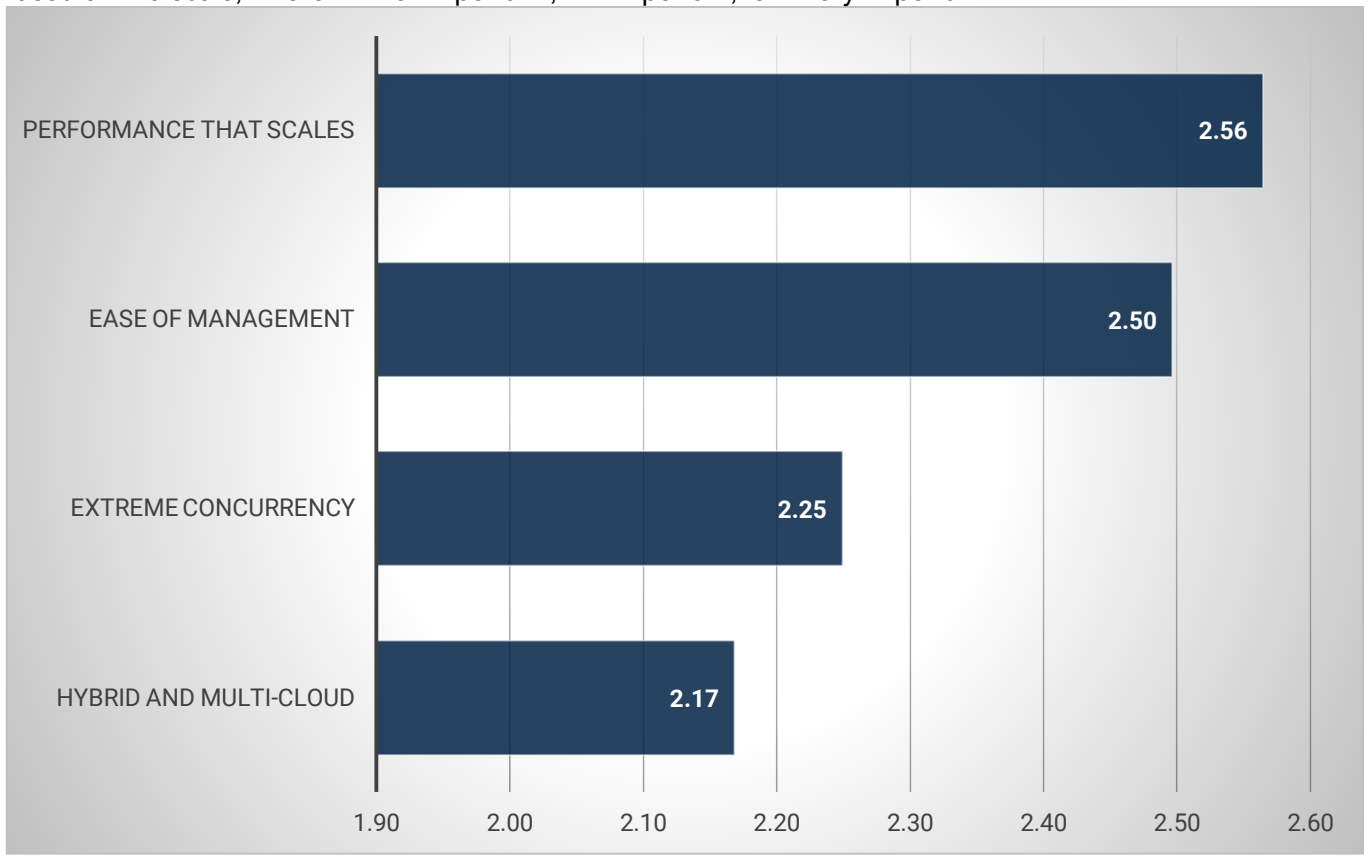
The rapidly increasing demands of data analytics and artificial intelligence across a wide variety of applications requires data-storage systems to adjust to changing objectives and be able to off-load data processing when required.

The automotive industry will generate tens of tera-byte of data per day from autonomous vehicles and through ADAS sensors and applications, as well as EDR control units already implemented on most new U.S. vehicles.

NHTSA reports 91.6% of all 2010 vehicles and 96.0% of all 2013 vehicles were equipped with EDRs in the U.S.

Important Features of a Future-Proof Storage Strategy

Based on 1-3 scale, where 1 =Not important , 2 = Important, 3 = Very important



(Weighted Average)

Takeaway
OEMs consider ease of data management very important. The ecosystem is more concerned with performance that scales. The disparity could reflect the existing size and scale of the OEMs.

Percent of Respondents: N=318 Q15: Which of the following is critical for a future-proof storage strategy?

Automaker OEMs

Ease of management	2.64
Performance that scales	2.54
Extreme concurrency	2.26
Hybrid and multi-cloud	2.17

Tier 1 & Tier Suppliers

Performance that scales	2.55
Ease of management	2.43
Extreme concurrency	2.11
Hybrid and multi-cloud	2.02

Analysts/Consultants

Performance that scales	2.67
Ease of management	2.48
Extreme concurrency	2.44
Hybrid and multi-cloud	2.29

Technologies to Design, Develop, Manufacture and Deliver Vehicles

Current State

The way industrial products are designed and manufactured is evolving because of both macroeconomic trends and emerging technologies. The following are the macro-trends identified as strongly impacting engineering design and manufacturing companies, including automotive:

Globalization:

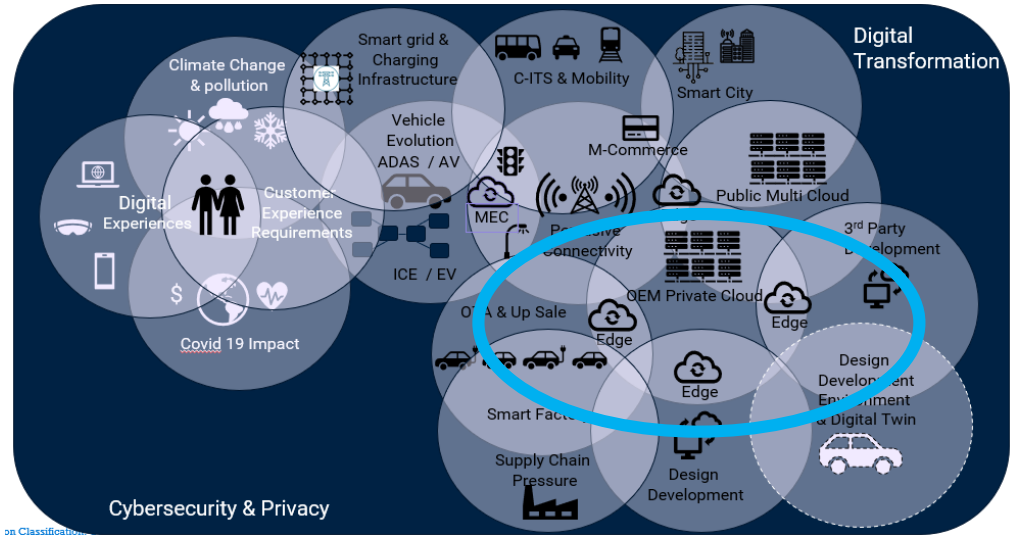
- Firms can more easily operate from geographically distributed locations.
- Mergers and acquisitions (M&As) are creating new, larger competitors and increasing the footprint of previously smaller firms; thus, widening the competitive landscape.

Worker shortage:

- Despite the number of engineers entering the labor market, the number of those employed at engineering design firms is decreasing. This is due in part to the appeal of high tech, venture capitalist (VC) firms to graduating engineers.
- Similarly, subject matter experts who have been in the industry for decades are reaching the age of retirement. Their domain knowledge is at risk of being lost as the gap between new hires and retirees widens.
- Highly competent resources in data analytics and software are limited and in high demand.

Productivity:

The manufacturing industry at large has come in slightly below target in terms of productivity for the past several years. This has a direct impact on GDP. At the individual firm level, there is a need not only to be more



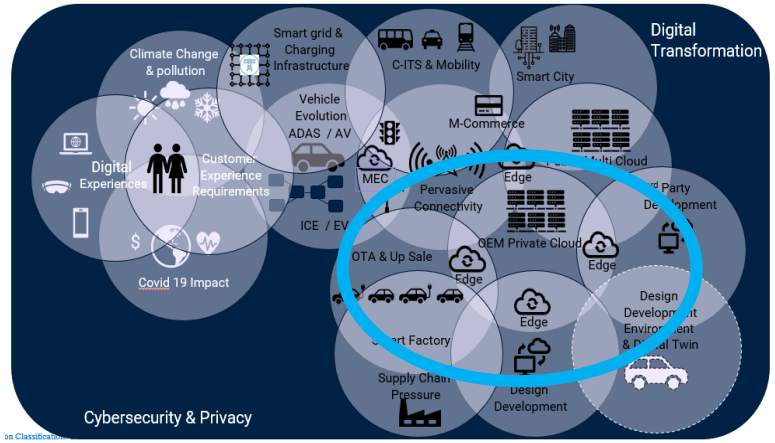
productive as part of a go-to-market acceleration but also a need to continue ensuring total manufacturing output meets industry expectations.

Availability of transformative technologies:

The combinations of multiple technologies could disrupt the market much more than the sum of the effect of every single technology, having an impact on the engineering process and changing the way industrial products are designed and manufactured. These technologies include 3D printing, AI, digital design, simulation and integration, high-performance computing and cloud, IoT, HMI- Augmented Reality, VR and Mixed Reality.

Technologies to Design, Develop, Manufacture and Deliver Vehicles

Summary Points

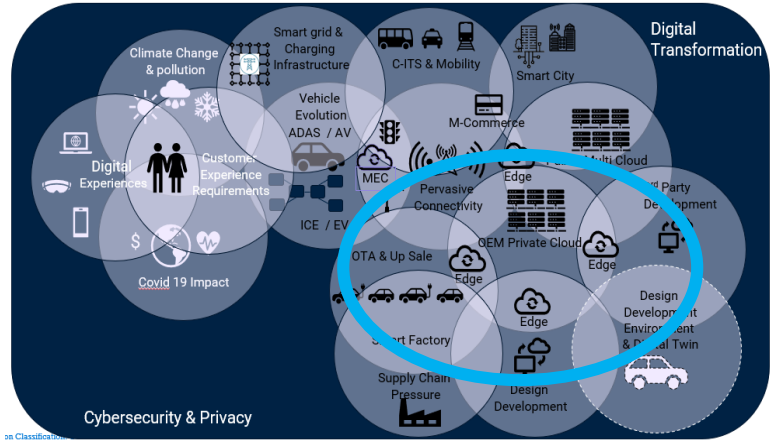


The supply chain will contract in part because of forces outside the auto industry. But further pressure will come from OEMs and Tier 1s increasing their efforts toward critical software and connectivity technology development, potentially driving away smaller players and start-ups.

Key Area	Finding
Supply Chain Evolution.	Increased concentration driven by OEM acquisitions and partnering with Tier 1 vendors and start-ups. Tier 1 vendors likely to form partnerships both up and down the supply chain, as well as expand their ecosystems via acquisition and collaboration.
Technologies In Automotive.	Connectivity is seen as an important underpinning technology. Edge computing, robotics and AR/VR are considered important enabling technologies. Quantum computing and blockchain are not perceived as critical at this time.
Application Areas.	Differences in degrees of importance in terms of weighted average are limited across the application areas. Predictive maintenance is leading the pack, followed by in-vehicle applications and diagnostics for cost savings and efficiencies. Suppliers rate in-vehicle applications the highest priority along with predictive maintenance. OEMs favor predictive maintenance, but diagnostics on cost savings and in-vehicle applications are only a 0.1 weighted-average point behind and tied for second most important.

Technologies to Design, Develop, Manufacture and Deliver Vehicles

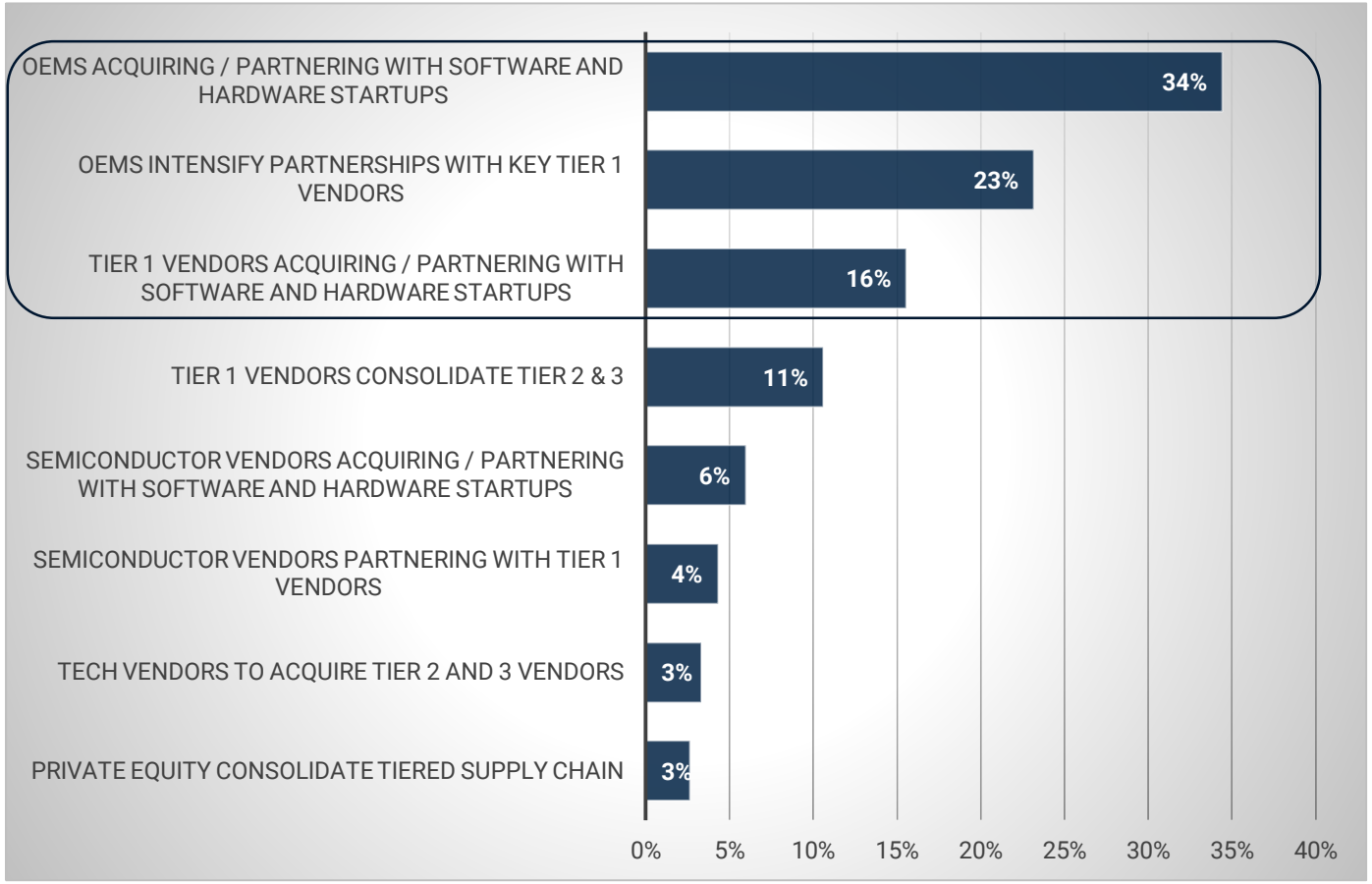
Summary Points



The growth in data is a given, and the industry expects artificial intelligence to play a role along the data continuum – with near-term AI applications focused mostly on algorithm training. The No.1 concern in employing AI directly in onboard vehicle systems is security, followed by the ability to keep the technology current. Automotive OEMs are bullish on their progress to Industry 4.0, but suppliers report poor implementation thus far.

Key Area	Finding
AI Influence On Data Continuum.	The application of AI at various stages of data processing, from collecting to monetization, reveals AI currently has the highest impact at the use stage (training and evaluating algorithms). Overall AI has medium to high impact on all stages of the data continuum.
Industry 4.0 /Smart Factory Implementation.	The overall assessment is the industry is maintaining a good situation regarding implementation. However, OEMs are more bullish about their progress toward Industry 4.0, with robot-assisted production rated “excellent,” followed closely by production-line simulation, big data quality control and autonomous logistics vehicles. Suppliers rate themselves “poor” to “good” overall.
Implementing AI in the vehicle and production process.	Security is the biggest concern, followed by the ability to upgrade and maintain safety and performance during the vehicle's lifecycle and as the production process evolves. Ability to upgrade is seen as the second most important challenge across different groups, but data bandwidth and scalability are close contenders.

Primary Means of Supply Chain Evolution



Observations

The findings on the future of the supply chain are not unexpected. The top three results account for more than 70% of the total responses, reflecting exactly what has been witnessed in the automotive industry during the past 5-10 years.

Vehicle manufacturers continue to fill competency voids, add essential assets and capacity and reposition themselves overall through acquisition.

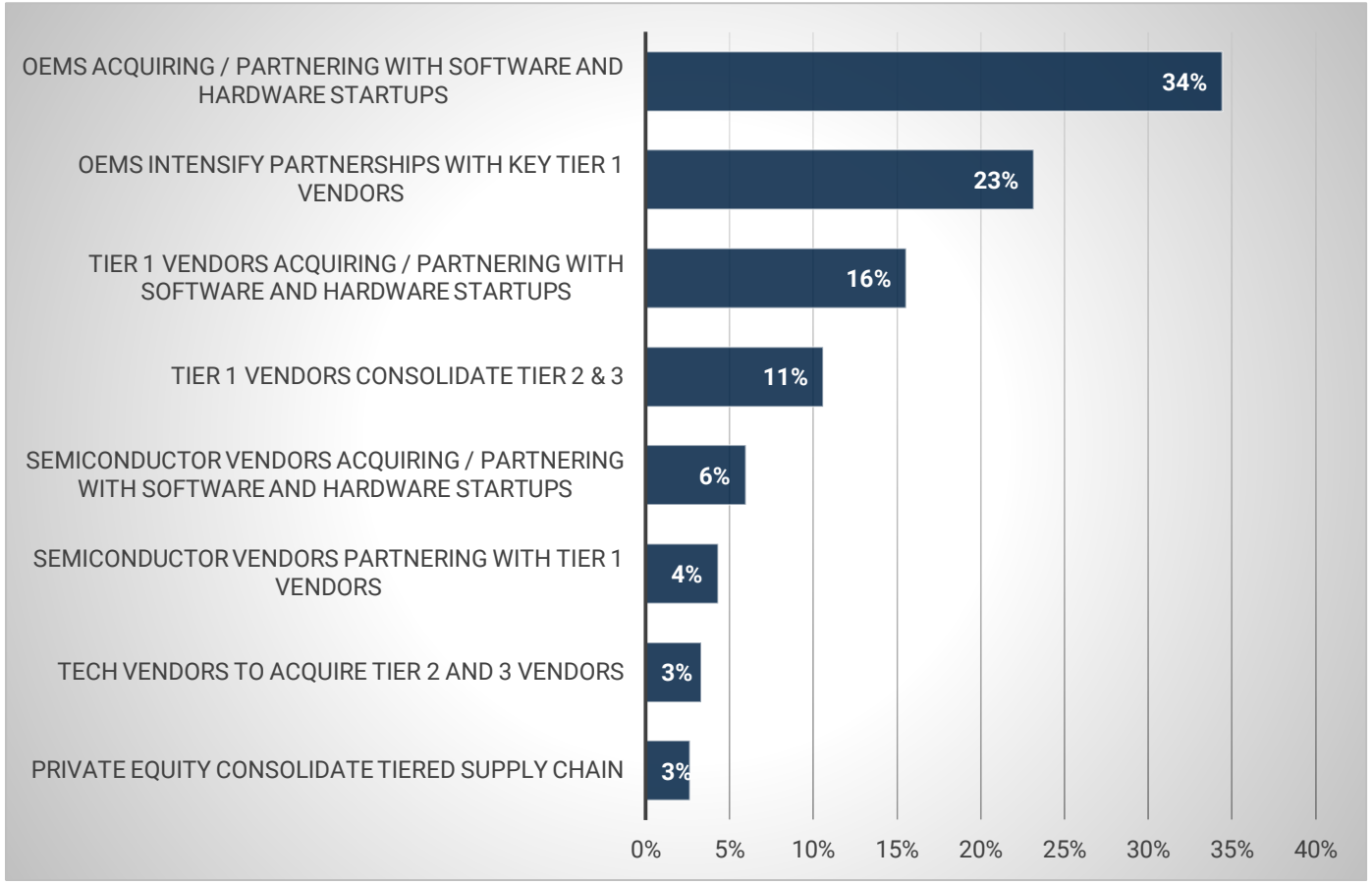
Tier 1s in particular are finding themselves pressed from above by OEMs and from below by the technology and semiconductor suppliers that are gaining relevance by promoting themselves as system integrators and roadmap partners for OEMs.

Unlike suppliers, automakers responding to the survey emphasize much more strongly the role of OEMs and their efforts to acquire essential competencies such as software development capability. OEMs rank this option highest (45%), while “Partnership with Tier 1 vendors” is chosen by just 22%.

Takeaway
Increased concentration of the ecosystem, driven by OEM acquisitions and partnering with Tier 1 vendors and start-ups.

Percent of Respondents: N=318 Q16: What are the top ways the supply chain will evolve?

Primary Means of Supply Chain Evolution - Deep Dive



Automaker OEMs

OEMs acquiring / partnering with software and hardware start-ups	45%
OEMs enhance partnerships with key tier 1 vendors	22%
Tier 1 vendors acquiring / partnering with software and hardware start-ups	15%
Tier 1 vendors consolidate Tiers 2 and 3	15%
Semiconductor vendors acquiring / partnering with software and hardware start-ups	2%
Semiconductor vendors partnering with Tier 1 vendors	2%
Tech vendors to acquire Tier 2 and 3 vendors	-
Private equity consolidates tiered supply chain	-

Tier 1 & Tier Suppliers

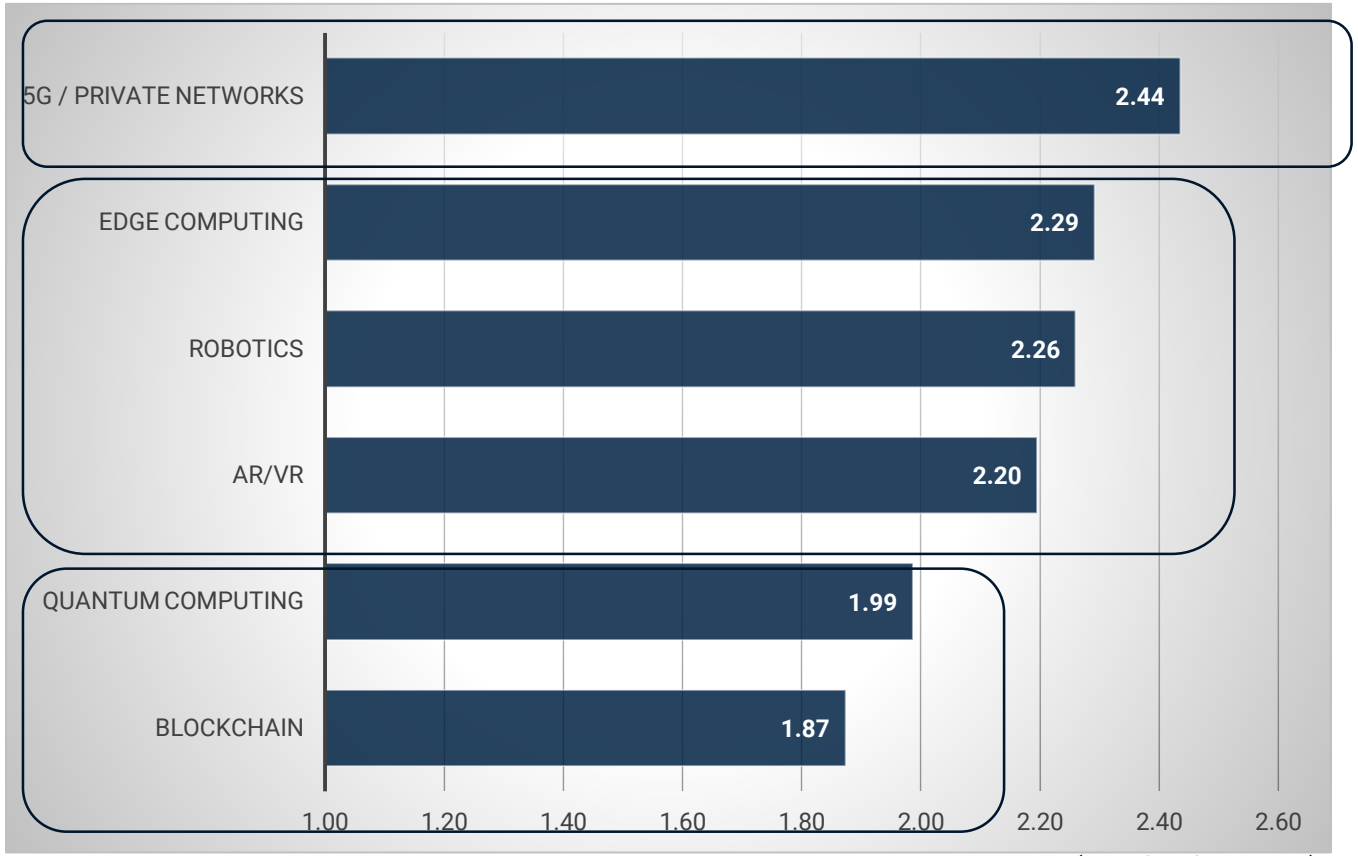
OEMs intensify partnerships with key tier 1 vendors	27%
OEMs acquiring / partnering with software and hardware start-ups	26%
Tier 1 vendors acquiring / partnering with software and hardware start-ups	15%
Tier 1 vendors consolidate tier 2 & 3	11%
Semiconductor vendors partnering with Tier 1 vendors	9%
Tech vendors to acquire tier 2 and 3 vendors	6%
Semiconductor vendors acquiring / partnering with software and hardware start-ups	5%
Private equity consolidate tiered supply chain	1%

Takeaway
Tier 1 vendors appear to be considering both up and down partnerships and ecosystem expansion via acquisitions and collaboration.

Percent of Respondents: N=318 Q16: What are the top ways the supply chain will evolve?

Importance of Select Technologies in Automotive

Based on 1-3 scale, where 1 =Not important , 2 = Important, 3 = Very important



(Weighted Average)

Takeaway

Connectivity is seen as a critical underpinning technology. Edge computing, robotics and AR/VR are considered important enabling technologies. Quantum computing and blockchain are not perceived as important at this time.

Percent of Respondents: N=318 Q17: Rate the importance of the following technologies in automotive.

Observations

Most respondents generally agree as to the importance of transformative technologies such as 5G, edge computing and robotics.

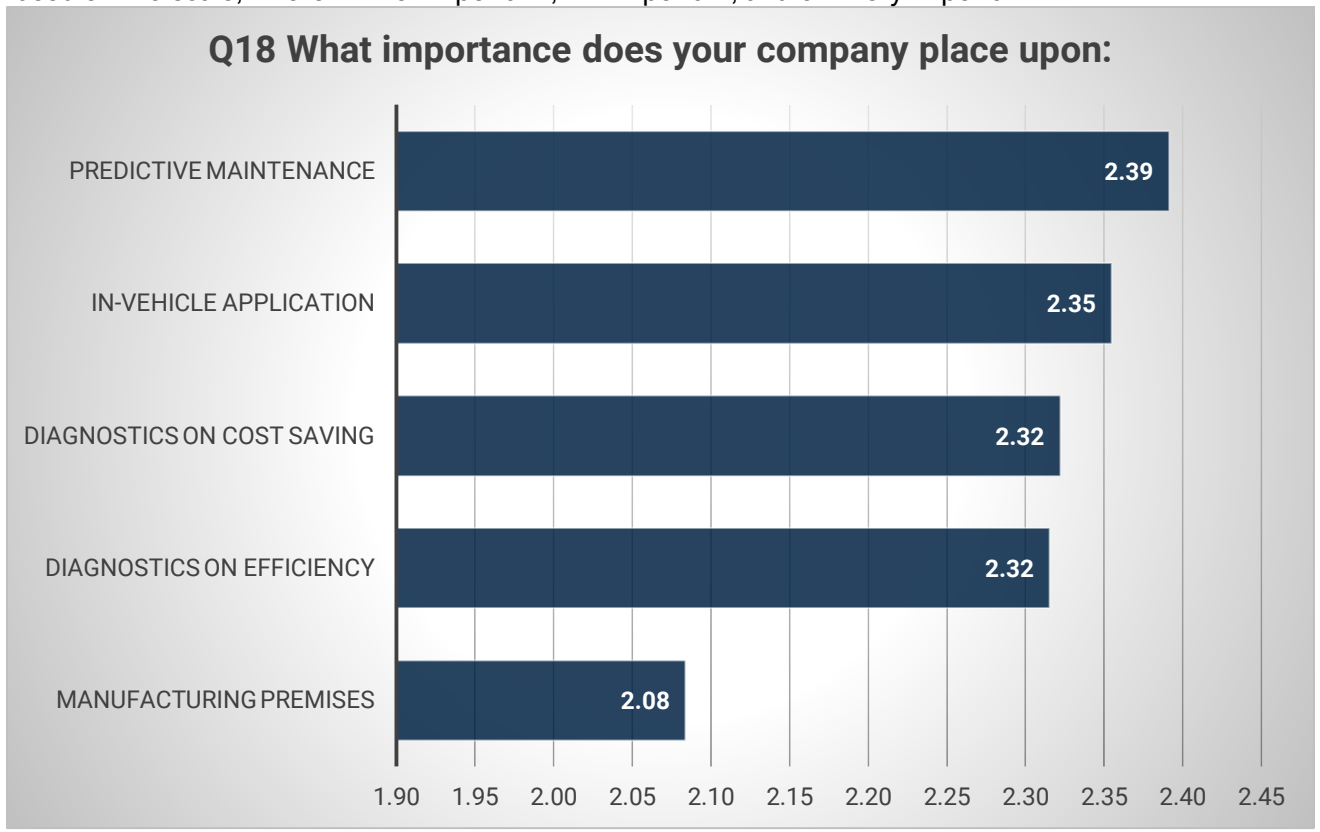
The lower relevance given to quantum computing and, to an even lesser extent, blockchain in the survey results, likely reflects the lack of priority for the supply chain, rather than the overall importance of the technology to the industry.

The complexity and effort associated with the evolution of the automotive industry is driving OEMs and suppliers from Tier 1 and below toward individual paths, where priorities are determined by opportunity.

Wards Intelligence believes the survey results align perfectly with the need to address critical business areas that will lead to a future-proof environment for the development of new mobility. Connectivity, processing power and automation guarantee automotive manufacturers will have the ability to manage costs and in-vehicle applications, as well as optimize processes and ensure full control of data. This positions them to best utilize data from vehicles, backend operations and the infrastructure.

Importance of Select Applications & Considerations

Based on 1-3 scale, where 1 =Not important , 2 = Important, and 3 = Very important



(Weighted Average)

Takeaway
Differences in degrees of importance in terms of weighted average are limited across the application areas. Predictive maintenance leads, followed by in- vehicle applications and diagnostics for cost savings and efficiencies.

Percent of Respondents: N=318 Q18: What importance does your company place upon:

Observations

In direct connection with the prior question, respondents confirm great interest in applications that tend to add value but also optimize costs and increase efficiencies.

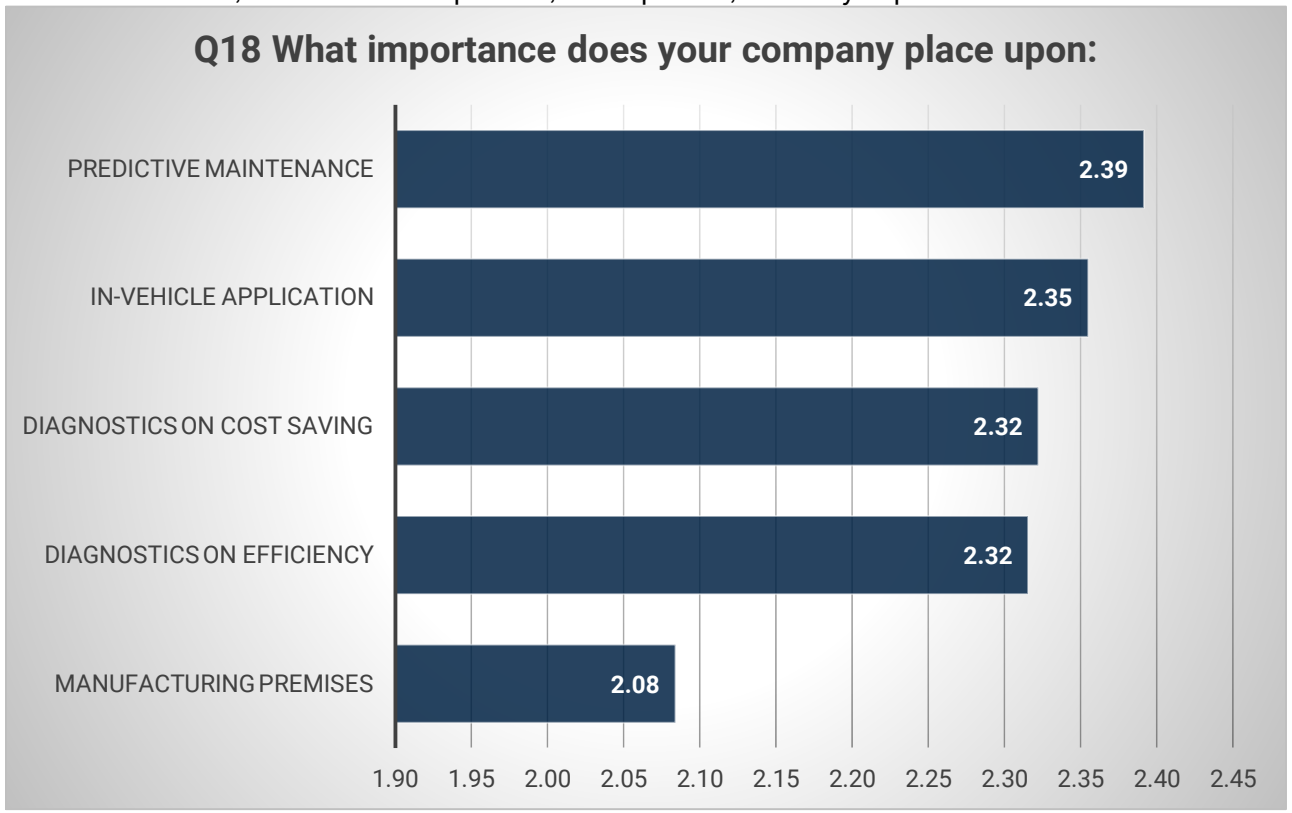
As noted, development costs are skyrocketing, and the use of software, data and advanced AI algorithms are essential to optimizing processes and controlling costs.

Although App Store was ranked low in importance in question 7, question 18 confirms the relevance of In-vehicle Applications to the industry.

A rich offering of applications and services adds value for customers. But it will be in the form of software apps, which will ensure higher margins and ROI.

Importance of Select Applications & Considerations - Deep Dive

Based on 1-3 scale, where 1 =Not important , 2 = Important, 3 = Very important



(Weighted Average)

Takeaway
Suppliers rate in-vehicle applications the highest priority along with predictive maintenance. Auto OEMs favor predictive maintenance, but diagnostics on cost savings and in-vehicle applications are only a 0.1 weighted average point behind and tie for second most important.

Percent of Respondents: N=318 Q18: What importance does your company place upon

Automaker OEMs

Predictive maintenance	2.47
Diagnostics on cost saving	2.46
In-vehicle application	2.46
Diagnostics on efficiency	2.40
Manufacturing premises	2.24

Tier 1 & Tier Suppliers

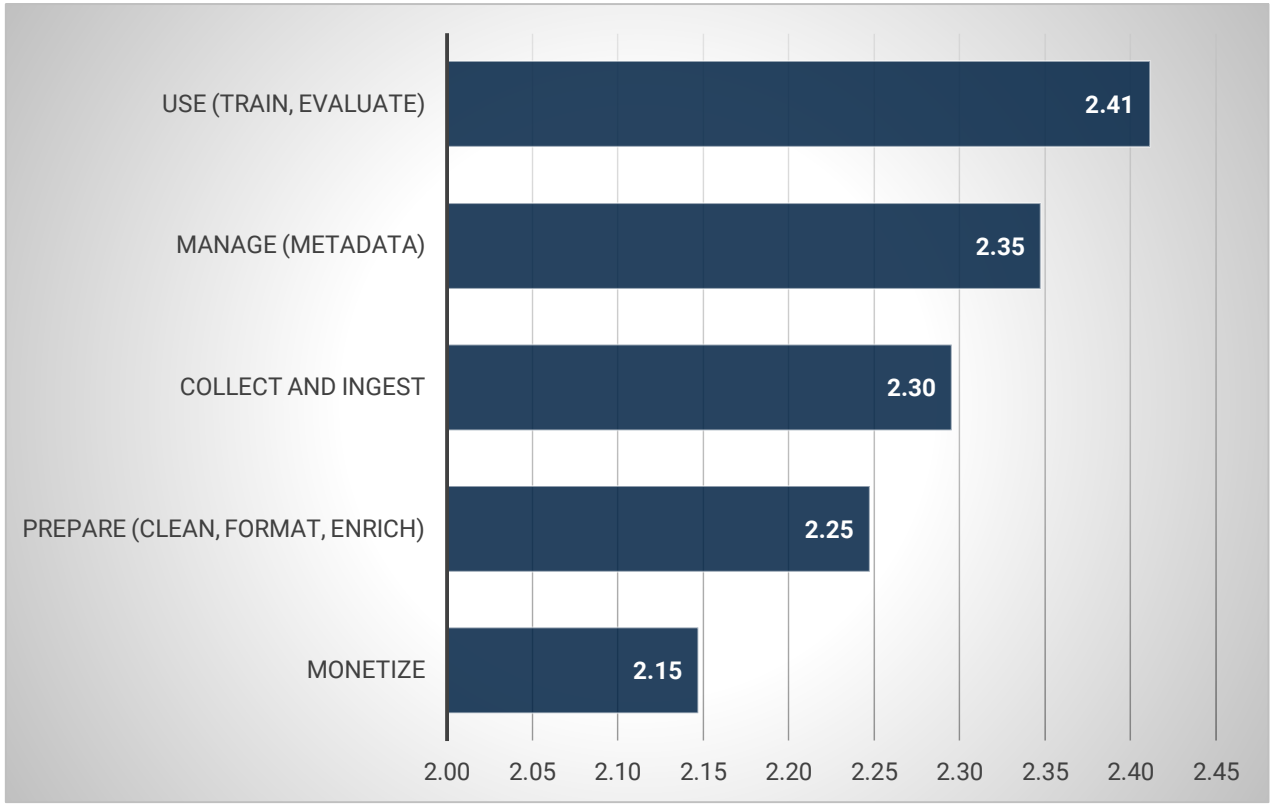
In-vehicle application	2.28
Predictive maintenance	2.28
Diagnostics on efficiency	2.23
Manufacturing premises	2.18
Diagnostics on cost saving	2.17

Analysts/Consultants

Predictive maintenance	2.47
Diagnostics on cost saving	2.32
Diagnostics on efficiency	2.30
In-vehicle application	2.28
Manufacturing premises	1.98

Strongest Impacts of AI in the Data Continuum

Based on 1-3 scale, where 1 = Low impact, 2 = Medium Impact , 3 = High Impact



(Weighted Average)

Takeaway
The application of AI on the data at various stages in the process currently has the highest impact at the use stage (training and evaluating algorithms). Overall AI has medium to high impact on all stages of the data continuum

Observations

A successful application of artificial intelligence imposes different requirements at various stages of data-processing, from collection to monetization.

The survey reveals that the highest impact when implementing AI algorithms will be at the stage of "training and evaluating" the AI-based application.

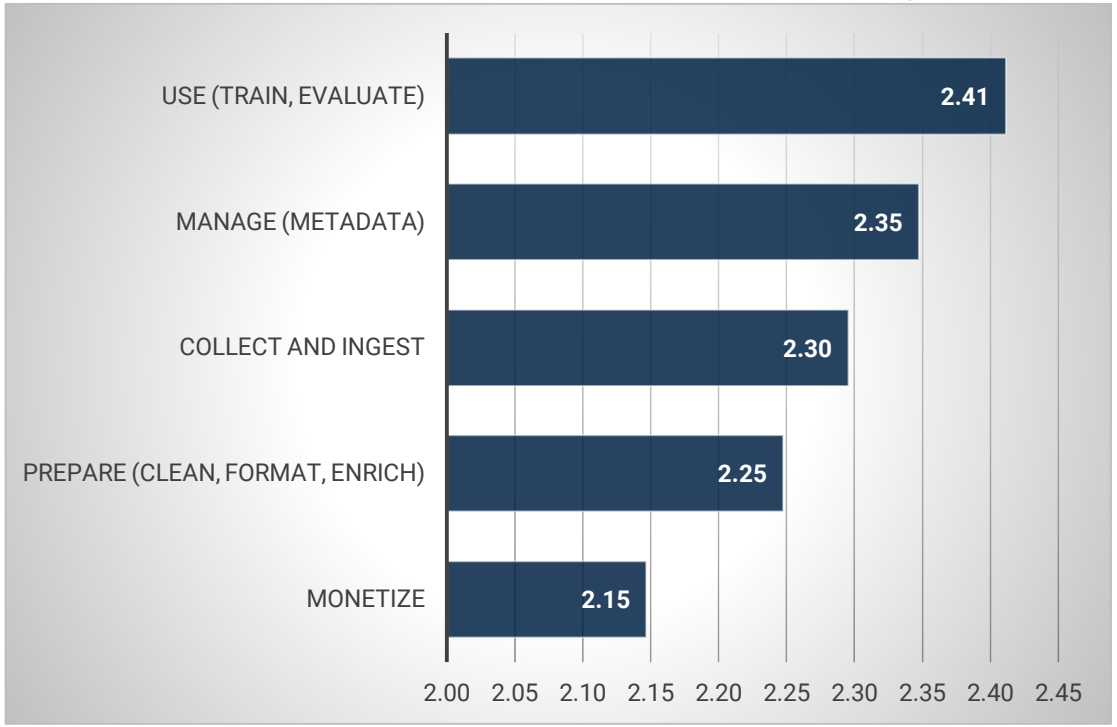
However, the implementation of AI algorithms has medium to high overall impact along all points of the data continuum.

Particularly for automotive safety-critical applications, each of the stages plays a crucial role in avoiding the introduction of bias into AI algorithm decision making. This could have significant consequences in terms of hardware needed and development time.

Percent of Respondents: N=318 Q19: Where in your data continuum do you expect the strongest impact of AI?

Strongest Impacts of AI in the Data Continuum - Deep Dive

Based on 1-3 scale, where 1 = Low impact, 2 = Medium Impact , 3 = High Impact



(Weighted Average)

Takeaway

Automotive OEMs and analysts indicate collecting and ingesting is the next highest impact stage for AI application, but Tier 1 suppliers think it is managing meta data. This may reflect a different state of maturity in the AI journey for OEMs and suppliers.

Percent of Respondents: N=318 Q19: Where in your data continuum do you expect the strongest impact of AI?

Automaker OEMs

Use (train, evaluate)	2.46
Collect and ingest	2.32
Manage (metadata)	2.32
Prepare (clean, format, enrich)	2.31
Monetize	2.20

Tier 1 & Tier Suppliers

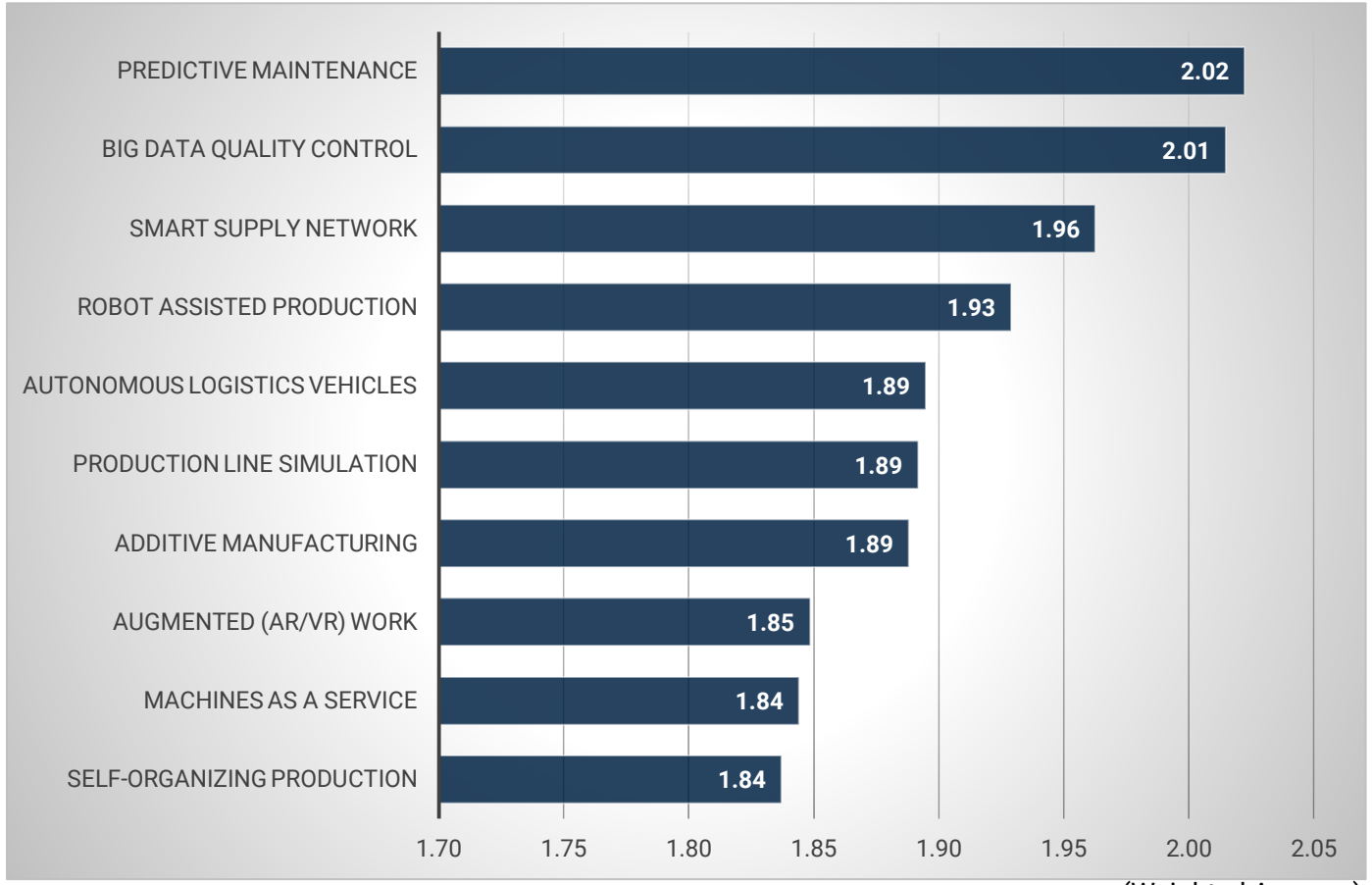
Use (train, evaluate)	2.33
Manage (metadata)	2.30
Collect and ingest	2.27
Prepare (clean, format, enrich)	2.14
Monetize	2.04

Analysts/Consultants

Use (train, evaluate)	2.44
Collect and ingest	2.43
Manage (metadata)	2.36
Prepare (clean, format, enrich)	2.30
Monetize	2.28

Progress Implementing Industry 4.0/Smart Factory Projects

Based on 1-3 scale, where 1 =Poor, 2 = Good, 3 =Excellent



(Weighted Average)

Observations

Predictive maintenance as well as Big Data quality and control are the obvious areas in which the automotive industry is making significant investment, along with robotics and the supply chain. The era of data analytics and AI will bring about quantum leaps in efficiency and throughput across several areas and applications and move the industry toward full digitalization.

Predictive maintenance, testing and simulation, quality control, autonomous machines/robotics, inventory management, equipment inspection and process control are affecting the automotive industry as well as every other domain, striving for higher efficiency and cost reduction.

Unlike in the past, the enormous amount of data available today passes through a lengthy process of labeling and tagging, data structuring, processing and data orchestration.

An essential component of future industrial and automation domains is the integration of all data-based functionalities into a digital replica of manufacturing premises and systems to enable data-driven engineering, production and maintenance decisions – the digital twin.

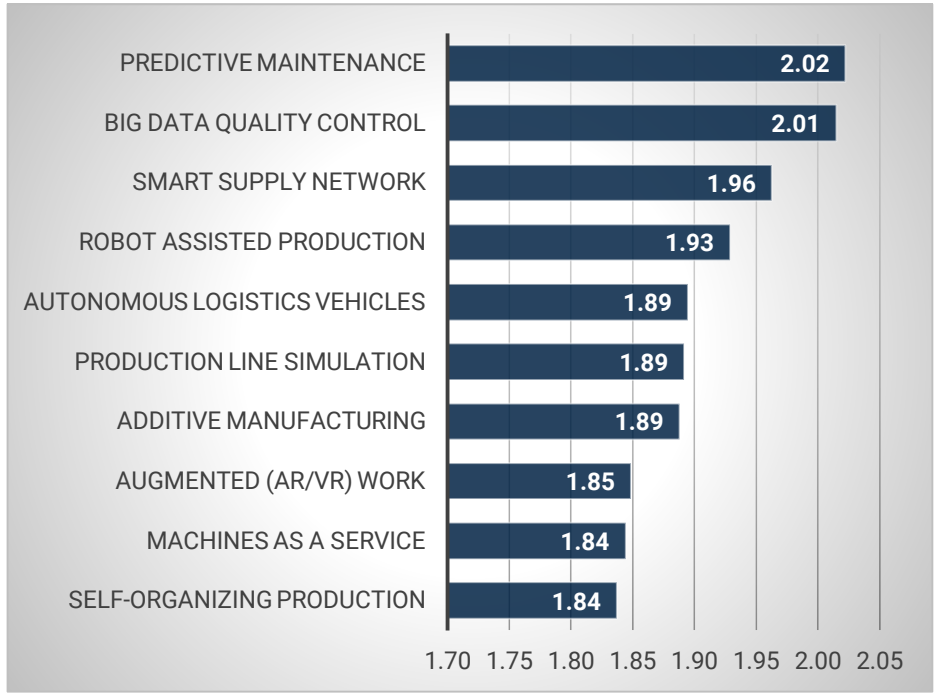
Takeaway

Overall respondents indicate the industry is well-positioned regarding implementation.

Percent of Respondents: N=318 Q20: Rate your progress on implementing Industry 4.0 /smart factory projects?

Progress Implementing Industry 4.0/Smart Factory Projects - Deep Dive

Based on 1-3 scale, where 1 =Poor, 2 = Good, 3 =Excellent



(Weighted Average)

Automaker OEMs

Robot assisted production	2.30
Production line simulation	2.19
Big data quality control	2.17
Autonomous logistics vehicles	2.17
Predictive maintenance	2.13
Smart supply network	2.02
Self-organizing production	1.96
Additive manufacturing	1.91
Augmented (AR/VR) work	1.87
Machines as a service	1.87

Analysts/Consultants

Robot assisted production	2.08
Autonomous logistics vehicles	2.08
Big data quality control	2.04
Machines as a service	2.02
Additive manufacturing	1.98
Augmented (AR/VR) work	1.98
Predictive maintenance	1.94
Production line simulation	1.92
Self-organizing production	1.92
Smart supply network	1.92

Tier 1 & Tier Suppliers

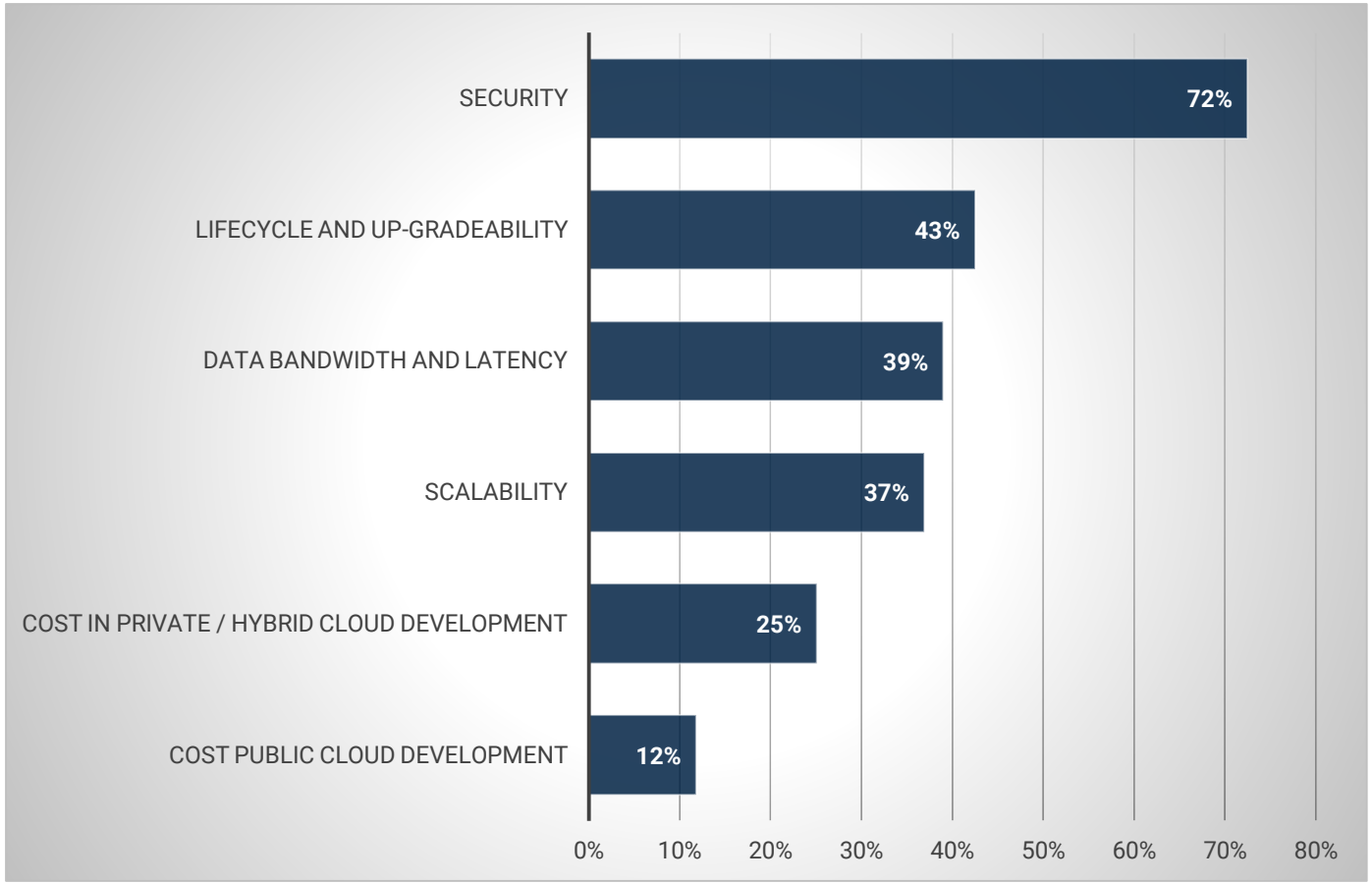
Predictive maintenance	2.01
Big data quality control	1.91
Robot assisted production	1.87
Smart supply network	1.84
Additive manufacturing	1.82
Production line simulation	1.79
Self-organizing production	1.70
Machines as a service	1.68
Autonomous logistics vehicles	1.64
Augmented (AR/VR) work	1.64

Takeaway

OEMs are more bullish on their progress toward Industry 4.0, with robot- assisted production scoring “excellent,” followed closely by production-line simulation, big data quality control and autonomous logistics vehicles. Suppliers overall rate themselves “poor” to “good.”

Percent of Respondents: N=318 Q20: Rate your progress on implementing Industry 4.0 /smart factory projects?

Challenges in Implementing AI in the Vehicle & Production Process



Takeaway
Security is the biggest concern, followed by the ability to upgrade and maintain safety and performance during the vehicle's lifecycle and as the production process evolves.

Percent of Respondents: N=318 Q21: What are the top challenges to implementing AI in the vehicle and production process? (Limited to three choices)

Observations

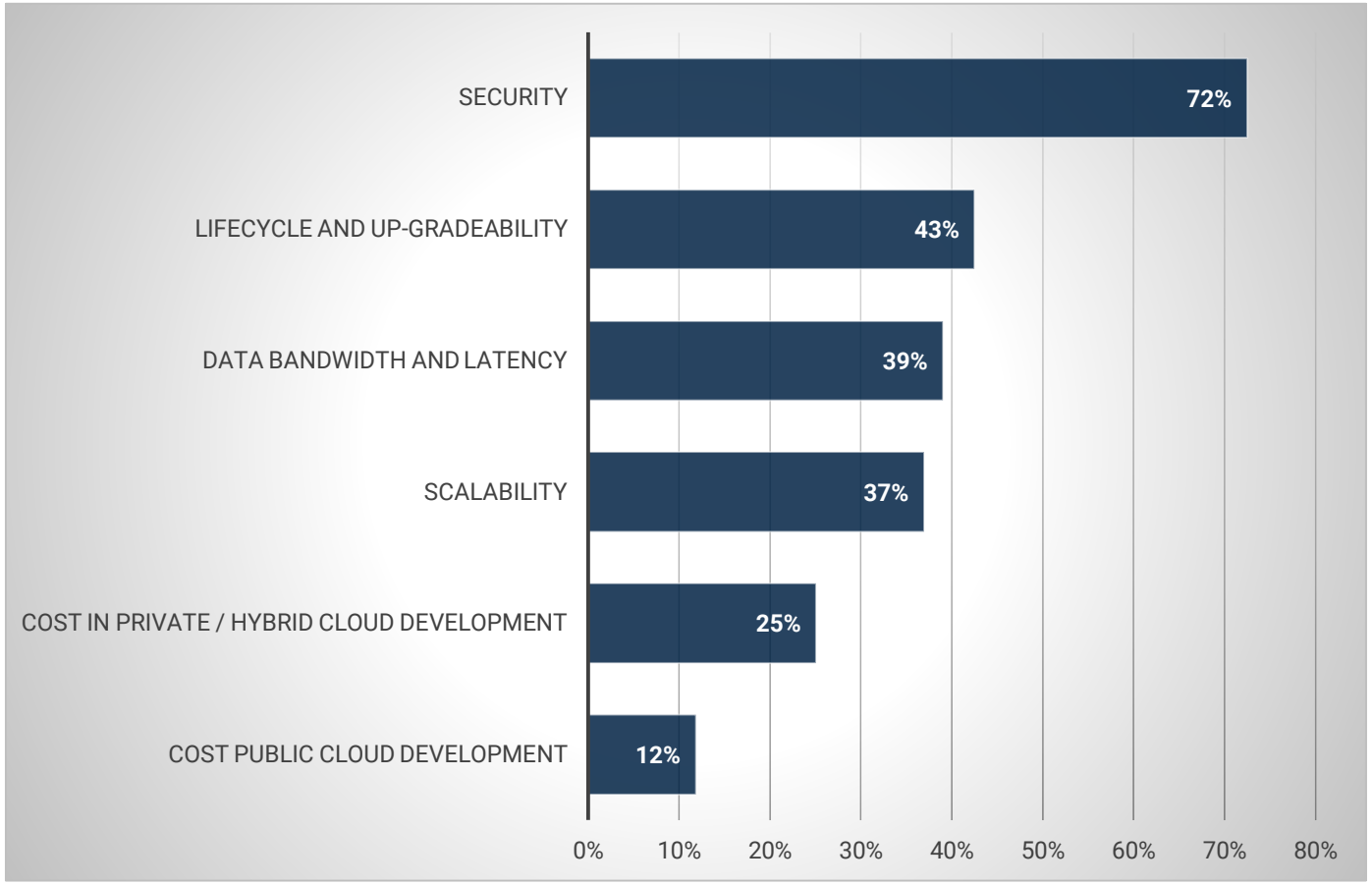
Although AI is widely considered an essential technology for self-driving vehicles, Artificial Neural Networks (ANNs) and Deep Learning (DL) need further development.

Survey statistics clearly show security is of upmost concern.

Deterministic behavior and related safety certification is an issue for machine-learning, data-based algorithms. Functional safety (ISO26262) is the biggest challenge for DL-based systems, because it is not clear how to validate and certify to ISO26262 in the case of a "virtual" brain. The sequence of events and actions executed by the algorithms are, as of today, not deterministic and not traceable. The automotive industry will likely need to set clear standardized procedures for validating and testing DL systems, which also would partly address the certification for functional safety.

Performance and cost also are of concern. Today, the hardware for embedding DL in safety-critical and high-performance automotive applications is not available, or it is not available at adequate and reasonable cost for volume production, considering the need to update and upgrade such algorithms during the vehicle's entire lifecycle.

Challenges in Implementing AI in the Vehicle & Production Process - Deep Dive



Security	76%
Lifecycle and up-gradeability	45%
Data bandwidth and latency	37%
Scalability	31%
Cost in Private / Hybrid Cloud development	27%
Cost Public Cloud development	8%

Security	71%
Lifecycle and up-gradeability	40%
Scalability	34%
Data bandwidth and latency	33%
Cost in Private / Hybrid Cloud development	33%
Cost Public Cloud development	15%

Security	81%
Data bandwidth and latency	45%
Lifecycle and up-gradeability	45%
Scalability	42%
Cost in Private / Hybrid Cloud development	15%
Cost Public Cloud development	8%

Takeaway
Upgradeability is seen as the second most important challenge across different groups, but data bandwidth and scalability are close challengers.

Percent of Respondents: N=318 Q21: What are the top challenges to implementing AI in the vehicle and production process? (Limited to three choices)