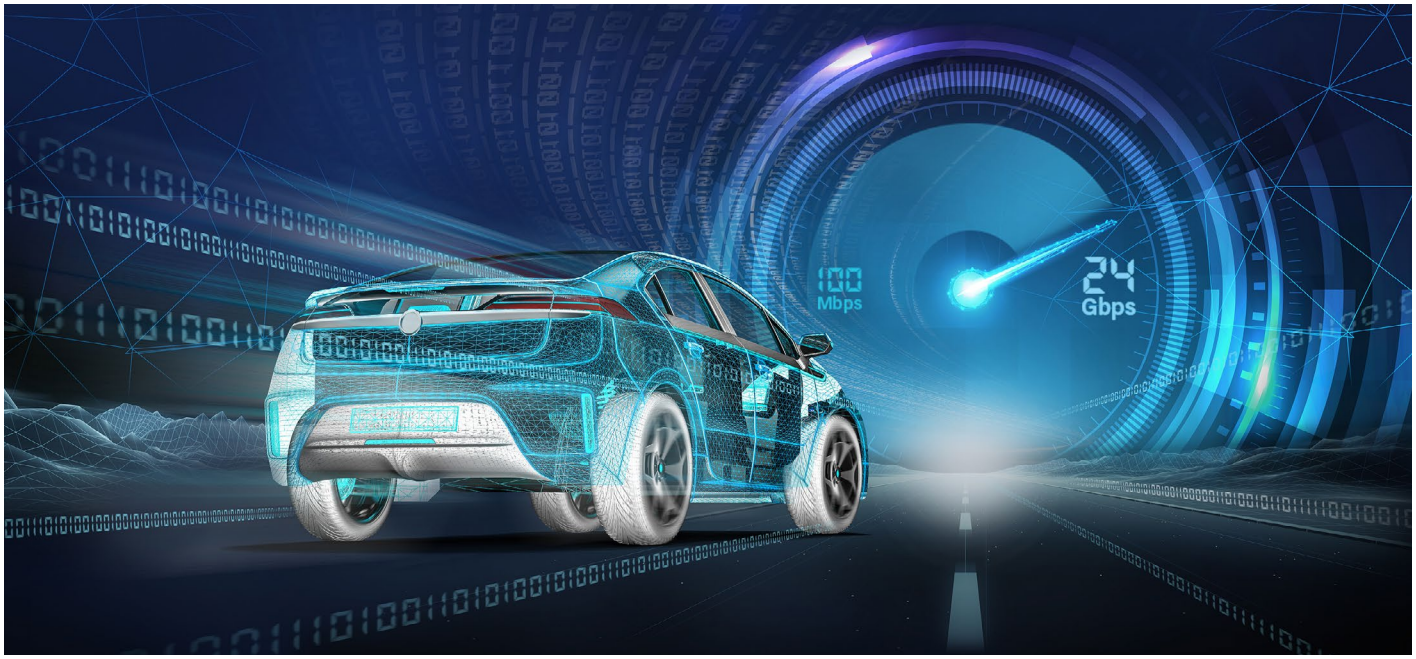
TE CONNECTIVITY TREND PAPER

DRIVING THE DATA-FUELED FUTURE

Automotive Trends, Challenges, and Solutions for Data Connectivity



Vehicles are getting smarter, providing ever-increasing levels of safety, security, convenience, and efficiency. At the core of this improved level of intelligence is complex decision making based upon information generated and gathered both inside and external to the vehicle. Decisions based upon data can be as simple as initiating an audible chime if a door is opened while the vehicle is moving, or as complex as an automated evasive maneuver when a threatening in-path object on a mountain pass is detected.

Add to these extremes the traffic management scenarios, with vehicles communicating to roadside signs as well as to each other. And all of this while streaming the latest movies from the cloud to a rear seat infotainment display.

While petrol and diesel have been the fuels of the first century of transportation, electricity and data are clearly the catalysts propelling us to the future. Now more than ever, data must move from its source to intended destination flawlessly, seamlessly, quickly, and in volumes and environments once unimaginable.

These data connectivity challenges are not trivial, and TE Connectivity (TE) is collaborating with customers and suppliers, across various industries, to address these challenges.

AUTOMOTIVE MEGATRENDS ARE ALL ABOUT THE ACES

The acronym **ACES** is gaining momentum as the moniker that summarizes the four key trends in mobility. ***Automated. Connected. Electrified. Shared Mobility.*** Much has been written on these subjects, and exciting technical developments are progressing at breakneck speed.

The automated, or assisted, trend is all about the balance of decision-making and control between the driver and his or her automobile. Increased data availability and processing power in a vehicle enables advanced driver assistance (ADAS) features including anti-lock brakes (ABS), collision alert, lane keeping, pedestrian detection, and automatic parallel parking. Additional ADAS features are continually being introduced. Adaptive body height control, for example, utilizes lateral motion sensors to detect an imminent side collision and increase the car's body height ride by as much as 10 cm or more. More assistance from the vehicle means more automated functionality as we travel on the road to, potentially, 100 per cent assistance (full autonomous driving).

The connected trend is related to society's ever-increasing desire to stay engaged. Given recent worldwide events, personal and business travel by automobile is expected to climb as individuals feel more comfortable and in-control of their personal space. Consumers expect the ability to stream infotainment content (music, movies), shop online, navigate journeys, and conduct business (professional and personal) directly from their cars. Gone are the days when one must be home or in the office for optimal connection.

The electrification trend is the migration from internal combustion engines to electric motors (e-motors) as the primary method of propulsion. This trend is driven by a desire to reduce reliance on fossil fuels, reduce (even eliminate) tailpipe emissions, and improve energy usage efficiency. Suites of sensors and complex control algorithms are employed to optimize e-motor performance, reduce maintenance costs, safely charge batteries, and maximize distance travelled per charge. Along with battery electric vehicle (BEV) introduction comes the needs to think about when and where to charge one's car when on a trip. By automatically processing range, location, and route information, cars are addressing this range anxiety head on because they are able to navigate to conveniently located charging stations.

The shared mobility trend is driven by the demand for shared transportation services and the potential to reduce personal vehicle ownership in exchange for easy access to

vehicles. The vehicle experience needs to be personalized for each user. Eventually, each shared vehicle will have the ability to be personalized for the driver or rider, just like one's phone, tablet, pc, and home television deliver tailored experiences.

Whether a livery service like Uber or Lyft, or a car-sharing vehicle rental like ZipCar or Turo, readily-available access to mobility applications (apps) as well as data from the cloud makes this all possible.

DATA IS THE FUEL TRANSPORTING US TO THE ACES FUTURE

What do these four ACES megatrends have in common? The answer is that they are all heavily reliant upon data as the key enabler for successful execution. For these trends to reach their full potential, decisions made from vast amounts of information generated by sensors must be processed and executed in fractions of a second. Some of these decisions, although important, are rather benign. Finding the closest ice cream parlor, while an important use of data, is not a safety-critical task (although not all will be in agreement).

Detecting a pedestrian in-path of a vehicle and automatically applying brakes, however, is an action that must take place within milliseconds and where failure is not an option. As time rolls on, each of the ACES megatrends will rely on increasing amounts of information. This requires decisions to be made in shorter amounts of time for outcomes that are more critical for safety, reliability, and efficiency. It is imperative that any data that is generated at its source makes it to its intended destination swiftly and flawlessly.

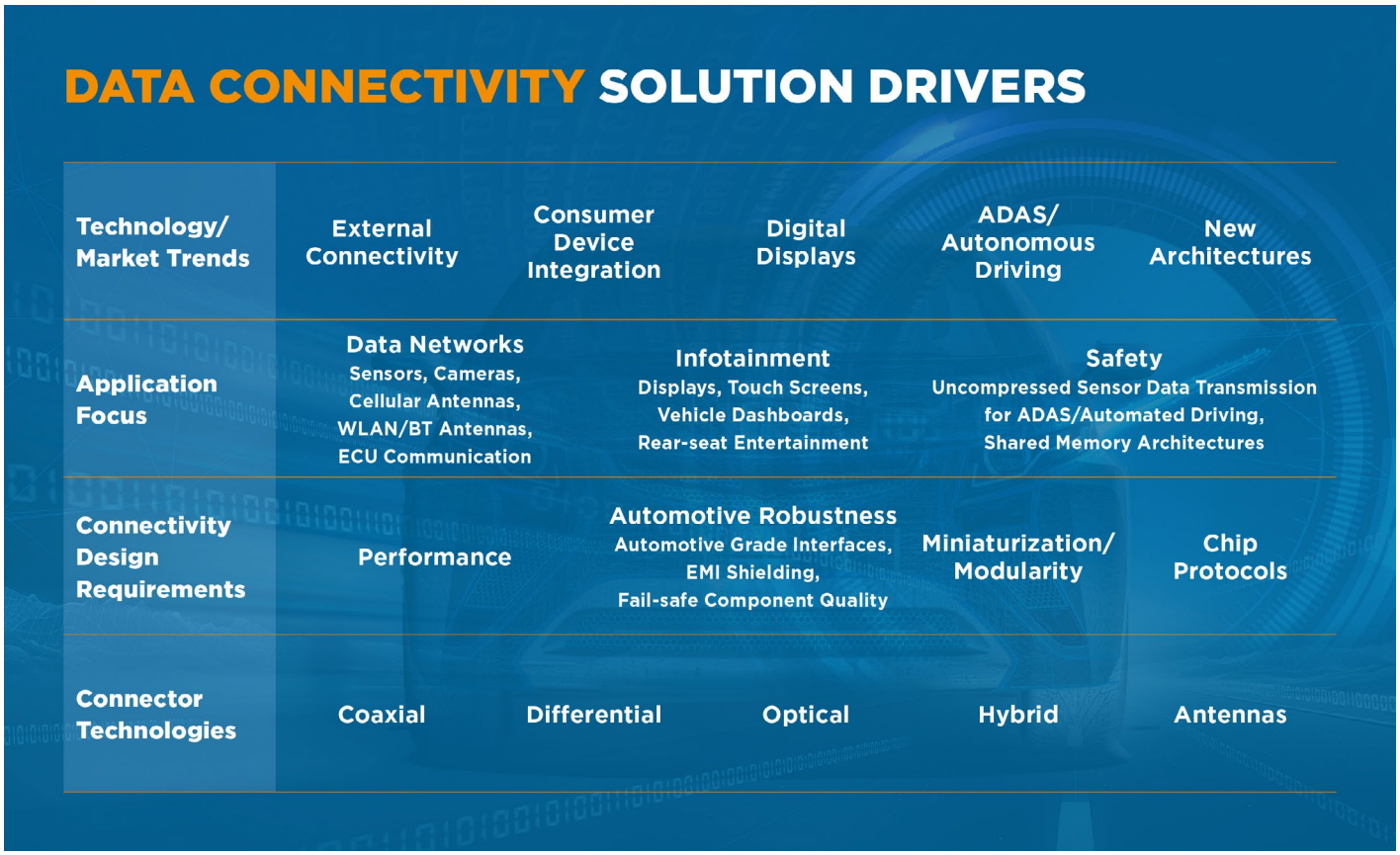
IF DATA IS THE FUEL OF THE FUTURE, THEN DATA CONNECTIVITY IS THE FUEL DELIVERY SYSTEM

Data connectivity is fast becoming the most important technology enabler in the automotive industry. It all started with connecting the control units within the vehicle. Then smartphones were connected to the vehicle. Today, many cars are able to autonomously collect information from the web. The next logical step will be connecting cars with each other and the environment, using V2X (vehicle to everything) technology. Data connectivity for automotive applications is multi-faceted, serving a plethora of applications via shared data networks.

tions that all fit within the ACES trends. Some examples of these wireless communications paths, utilizing antennas to connect the car to the world, include:

- AM/FM/DAB/TV
- LTE/5G
- GPS/GNSS
- V2X

V2X is short for "vehicle to everything". The term describes a vehicle's communication with surrounding or interacting road users and structures which include other vehicles (V2V), roadside infrastructure (V2I), pedestrians (V2P),



Applications typically fit into one of three distinct functional categories: safety and security, convenience, efficiency. Automotive data connectivity is usually thought of along three physical categories: vehicle-to-world; in-vehicle; vehicle-to-occupant. Information may be generated by and drawn from any of the physical data connectivity paths and utilized by any of the functional applications.

Vehicle-to-world connections. For years, wireless communications for transportation had been primarily one-way paths for radio broadcasts. Today, vehicles have essentially become highly mobile sensors and rolling computer platforms. Two-way communications between one's vehicle and the rest of the world is a function which enables safe, secure, convenient, and efficient applica-

and so on. The trend towards relying on information making its way into and out of a vehicle means, more than ever, that data must be received flawlessly and from a trusted source.

In-vehicle connections. In-car networking has been a part of vehicle architectures for the past 40 years. Examples of some of the more commonly employed wired networks found in vehicles include:

- CAN
- LIN
- FlexRay
- MOST
- Camera video
- Automotive ethernet

With the evolution towards advanced driver assist safety systems and the greater number of automated driving functions within the vehicle, high-speed data transmission lanes in vehicles are becoming increasingly relevant to the safety of the vehicle. This means that new design features for vehicle components are required and that vehicle OEMs must consider the limitations of physical channel properties during the definition of the architecture and the selection of the communication protocol.

Vehicle-to-occupant connections. An important connection to consider is the connection between human and machine. Whether providing information to the driver, entertainment to a passenger, or seamless integration with personal devices, the connection between occupants and the vehicle itself is becoming essential. Via tomorrow's digital cockpit, drivers and occupants alike will be provided experiences specifically tailored for them. Seat and mirror settings, music presets, navigation settings, and address book information, for example, can automatically follow the driver from one vehicle to the next. For passengers, streaming service accounts and wi-fi settings can be at the ready from car to car. Some examples of vehicle-to-occupant connections include:

- WLAN
- Bluetooth
- USB
- WiFi
- Displays

AUTOMOTIVE DATA CONNECTIVITY CHALLENGES AND REQUIREMENTS

Evolving data connectivity specifications and requirements are challenging, and automotive OEMs and suppliers are working together to address these vehicle challenges.

There is a high variety of data messaging strategies (functional layer) and transmission protocols (physical layer) not only between vehicle manufacturers, but even in a single vehicle. Wireless connections (antennas) come in many varieties depending upon the frequency and protocol of the interface. Wired connections can be differential twisted pair, coaxial, shielded, unshielded, etc. They can even be optical.

Connections must be fast. In-vehicle communications architectures are driving towards speeds up to 12 GB per second. ACES-driven applications, with their ever-increasing computing speeds needed for critical decision-making, are demanding high bandwidth, high volume, and low latency communication channels.

Connections must be robust and reliable. Data communication must be flawless, even in an all-electric high-power environment. Data links must meet rigorous electromagnetic compatibility (EMC) requirements, ensuring they do not inadvertently radiate unwanted emissions nor are susceptible to inadvertent electromagnetic fields. In-vehicle communication channels will be subjected to temperature and vibration extremes.

Connections must be small and fit the communications architecture. They must support miniaturization and weight reduction approaches approaches driven by car manufacturers and system suppliers. As electronics continue to shrink while functionality grows, connectors cannot and should not dictate the package size of the electronics. Whether for a distributed architecture approach or for a centralized one, the connectivity solution must fit the approach. New architectures incorporating high-speed computing clusters supporting signal processing for applications based on sensor fusion will have increasingly challenging requirements for data communications within vehicles.

TE CONECTIVITY AS THE SUPPLIER OF CHOICE

TE Connectivity (TE) is a system-knowledgeable data connectivity component supplier with electronics architecture and physical integration expertise, enabling us to speak our customers' technical language. We work with customers, providing application support to optimize their systems by providing optimized integrated component solutions. As our customers develop new and improved vehicle architectures, we are teaming to provide optimized design of scalable sub-systems and components for them.

To connect with us click here

From the point at which information is digitized to the point at which it is received, TE works in collaboration with its customers to develop and deliver tailored solutions to meet their data connectivity requirements. We support our customers with a comprehensive product portfolio, technical design expertise and know-how, manufacturing and application tooling prowess, and leveraging the power of TE – our depth and breadth of industries and markets served by our engineers, scientists, and global presence.

Product Portfolio. As a global leader in connectivity solutions, we collaborate with our customers and other industry technology leaders to create engineered solutions that address these physical and wireless automotive connectivity challenges of the data-fueled future. Based on all major media (differential, coaxial and optical) and transmission technologies, our comprehensive portfolio of powerful data connectivity solutions offers high-speed data interconnection products developed to meet the increasing performance demands of automotive vehicle-to-world, in-vehicle and vehicle-to-occupant connections.

Our portfolio achieves high channel performance aligned with multiple chip manufacturer physical layer specifications. This includes our new solution for multi-gigabit ethernet connectors which support speeds up to 10 Gbps and, with other protocols, in excess of 20Gbps addressing the needs of next-generation safety and autonomous driving applications. Moreover, TE's data connectivity products have been designed specifically to meet the requirements of harsh automotive environments and are compliant with standards such as LV214 and USCAR, meeting the most stringent of environmental requirements. They are also tested against the most stringent specifications for signal integrity and electromagnetic compatibility, such as the One-Pair Ethernet (OPEN) Alliance Technical Committee.

Technical design expertise and know-how. Drawing upon more than 75 years of physical connection systems expertise, TE Connectivity's team of engineers, contact physicists, and material scientists work closely with customers to develop optimized solutions to ever-increasing connectivity demands and challenges. With design centers around the world, all the simulation, modeling, prototyping, and testing can be done close to where our customers are located. Additional technical capability includes: RF design and EMC expertise; design, manufacturing, and application tooling expertise in miniaturized and compliant interconnect technology enabling small, robust packaging; seamless electronics integration; tailored antenna systems for optimized signal reception and transmission; robust connector interfaces for in-vehicle data transmission; PHY-to-PHY channel analysis, including component limit specifications and complete link performance.

We provide simulation models for our components to calculate the channel performance based on link requirements while supporting miniaturized and modular designs which enable optimum integration into both legacy and next-generation architectures. For example, TE's miniaturized coaxial connector system (MATE-AX) can reduce connector footprint on a PCB by up to 75% compared to a traditional FAKRA component while offering higher bandwidth.

TE's miniaturized automotive ethernet connector system (MATEnet) addresses the need for efficient cabling solutions for physical link technologies that can be seamlessly integrated into existing ECU interfaces in more complex high-speed data networking architectures. Additionally, our portfolio of antennas and wireless connectivity technologies, offer external communication solutions for broadcast, cellular and next generation telematics and V2X services. Here, we are also developing integrated solutions that combine antennas and transceivers to reduce complexity and space and performance.

Depth and breadth of industries served and global presence. TE Connectivity serves a vast array of customers representing diverse industries and markets including consumer electronics, aerospace and defense, industrial, appliances, transportation, to name a few. By linking and leveraging across our company, our automotive-focused engineers can draw upon the knowledge and experience of colleagues across the globe to solve automotive industry challenges. We participate in various standards committees and industry consortia, enabling us to address

problem solutions early in the process. We invest extensively in upfront R&D, seeking to collaborate on solving tough industry challenges before they become problems for our customers.

Manufacturing and application tooling. As a global manufacturer of connectivity solutions with an in-house application tooling business unit, we not only practice world-class manufacturing processes for our products, but also confirm that our product designs align with specific customers' manufacturing methods and practices. We have the tools and equipment to optimize designs to customers' ever-evolving operating environment needs. We work with the complete supply chain, from chip makers to module makers to system suppliers, to provide optimized system-level performance for data integrity and signal quality. We provide the right data connectivity solution for the specific application and need.

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ABOUT TE CONNECTIVITY

TE Connectivity is a $13 billion global industrial technology leader creating a safer, sustainable, productive, and connected future. Our broad range of connectivity and sensor solutions, proven in the harshest environments, enable advancements in transportation, industrial applications, medical technology, energy, data communications, and the home. With nearly 80,000 employees, including more than 8,000 engineers, working alongside customers in approximately 150 countries, TE ensures that EVERY CONNECTION COUNTS. Learn more at **www.te.com** and on LinkedIn, Facebook, WeChat and Twitter.

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