João P. Trovão
Senior Editor

Future Vehicles May Arrive Soon

The 2022 IEEE Vehicle Power and Propulsion Conference

After the two last virtual conferences in 2019 and 2020 run by Prof. Pablo Arboleya from the University of Oviedo (Spain), the IEEE Vehicle Power and Propulsion Conference (VPPC) was held for the first time in Merced, California, USA, last November. The conference was organized by a very motivated team from the University of California, Merced, led by Prof. Ricardo De Castro. With the motto "connect green e-motion" worldwide in a complete network, the four-day conference delivered insight and intelligence from several key players at the forefront of hybrid and electric vehicle (EV) development. A very attractive program was prepared, including four outstanding keynote speeches, three tutorial lectures, and the in person or virtual presentation of 143 papers. During the last conference day, attendees had the opportunity to visit two technical sites: TRC California and the University of California, Berkeley. VPPC 2022 was the first VPPC after the COVID-19 lockdowns and was run in hybrid mode, with in-person and online attendees. VPPC 2022 continues to be the venue for researchers, educators, and engineers to share the latest results in research, teaching, and development of EV and hybrid vehicles and related technologies, as shown in Figure 1. It was an important forum where the academic and industrial communities and policymakers discussed new technology trends and collaboration for mutual development at a crucial time just before the 2022 United Nations Climate Change Conference.

Digital Object Identifier 10.1109/MVT.2022.3232274
Date of current version: 2 March 2023

The VPPC, one of the IEEE Vehicular Technology Society's flagship conferences, is annually organized on a rotating basis among America, Asia-Pacific, and Europe-Africa. VPPC 2023 will be held in Milano, Italy, (see Figure 2) from the 23rd to 27th of October 2023, where Prof. Giambattista Gruosso will be the general chair and responsible for its organization. The venue will be Politecnico di Milano, a technical university that belongs to the 10% of the excellent universities in the world. The Milano area is rich with transportation enterprises, from automobiles to airplanes, including railway and other land transportation systems.

The conference will bring together practicing engineers, researchers, and other professionals for interactive, multidisciplinary discussions on power, propulsion, and related technologies of electrified vehicles. Our main goal is to connect mobility worldwide into a comprehensive network.

The conference program will include, together with technical sessions, interesting tutorial sessions, some industrial forums, and an exhibition. Some technical visits to enterprises in the transportation sector will enrich the program, which can be seen at https://events.vtsociety.org/vppc2023//.

After All, What Will the Vehicles of the Future Look Like?

This is a very common and recurring question because the automotive industry has always been present, and functional machines are in a large part of the modern era development. Therefore, among speculations of automation, large electrification, and even flying cars, an analysis of the main trends for the automotive industry and understanding how the identified trends can impact the future of the people's mobility is discussed.

The future of the automotive sector will be centered on four pillars: sustainability, safety, economy, and comfort. These will be the most important aspects shaping the future of the automotive industry. Over time, these factors will gain strength in the market, especially sustainability, which is leveraged by consumer awareness.

In addition, an increase in the sophistication of vehicles, which will be designed to simplify everyday dilemmas in the lives of owners, should be highlighted. The ultimate anticipation is that these vehicles

1556-6072/23©2023IEEE

FIGURE 1 The VPPC 2022 opening ceremony. (Source: IEEE Vehicular Technology Society.)

will provide safe entertainment or a productivity hub while commuting. Finally, the possible gains and innovations in urban mobility should also be emphasized. With a smarter and more connected automotive fleet, current challenges like congestion and delays can become a thing of the past.

The main trends for 2023 in the automotive industry are automation, electrification, artificial intelligence (AI), connectivity, a sharing economy, and, ultimately, flying car concepts. These are the six main trends that should lead the future of the automotive market in the next 10 years.

Automation

As the name suggests, automation is a concept that aims to employ contextual, sensorial, and decisive intelligence in vehicle decisions. Figure 3 presents conditional automation in driving for level-3, linking sensorial, decisive intelligence, and driving supports. The aim of this technology is to completely replace human intervention in driving a car. Until then, the industry is going through a transition period toward this trend as no automaker has reached full automation, in which the vehicle safely replaces the driver in 100% of traffic scenarios.

FIGURE 2 Milano: a transportation history. (Source: Giambattista Grusso; used with permission.)

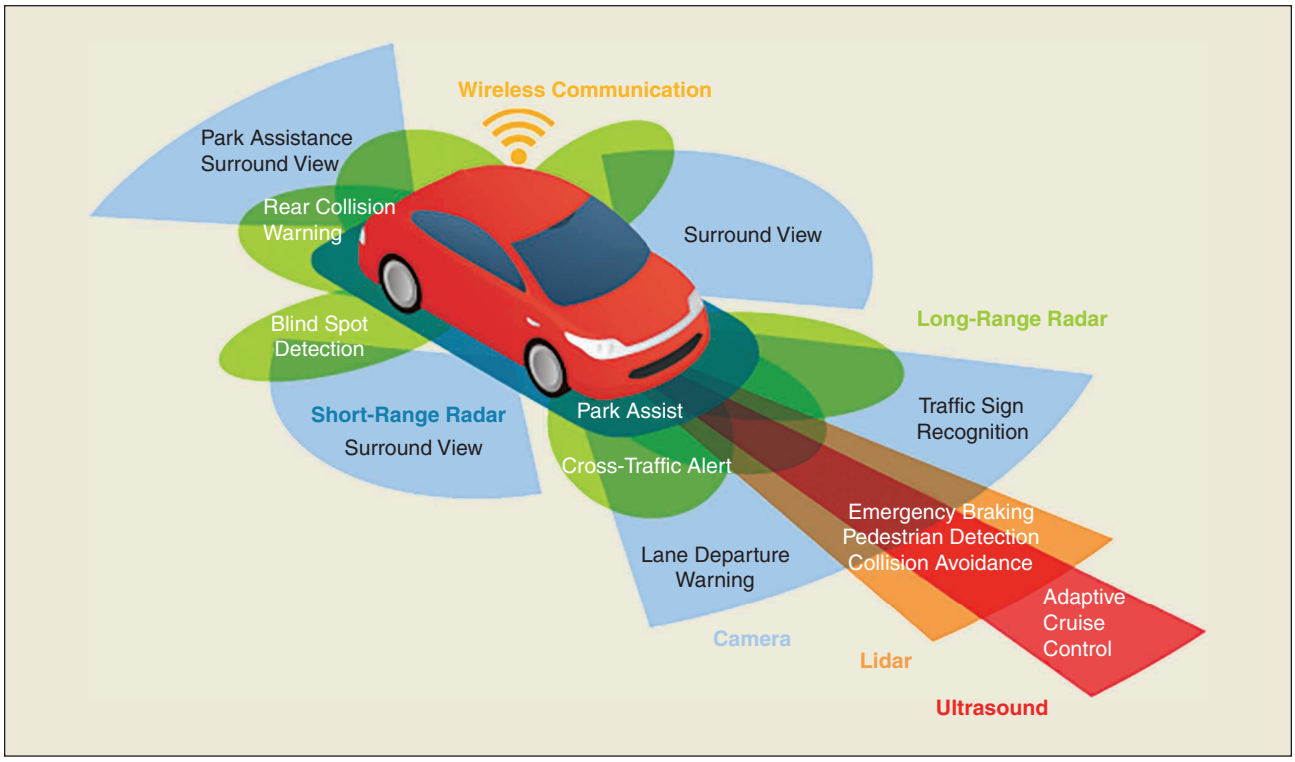

Figure 3 Conditional automation in driving—level-3 autonomous cars. (Source: https://www.landmarkdividend.com/; used with permission.)

However, it is possible to assess that the main global automakers, for instance, Hyundai [1], as well as several technology companies such as Uber, Google, and so on already dedicate enormous efforts and resources to research and improvements in the area. Figure 4 presents an example of what can be a robotaxi based in Hyundai's IONIQ 5 equipped with the hardware and software needed for level-4 self-driving capabilities.

Figure 4 Hyundai's IONIQ 5-based autonous robotaxi. (Source: https://www.hyundai.com/; used with permission.)

The following are the six autonomous levels in driving:

- *Level 0*: No automation—In this level, the car does not have the technological capabilities that enhance self-driving. The car is controlled by a human driver.
- *Level 1*: Driver-assist—The driver does most of the operations. There is automation of some individual controls. For example, electronic stability control can enhance stability of the vehicle.
- *Level 2*: Partial automation—In this level, two or more controls can be automated simultaneously. There is higher automation than in level 1.
- *Level 3*: Conditional automation—There is higher automation than in level 2. The car can control a significant number of operations.
- *Level 4*: High automation—All the critical functions are automated. The driver does not control the car at any time.
- *Level 5*: Full automation—This is the highest level of automation.

All functions are automated, and the car can carry human passengers with no human interaction.

In a future in which vehicular automation reaches its fullness, automobiles will be revolutionized in their way of use so that people will be able to use vehicles as a living, study, or work room while commuting in complete safety and comfort.

For instance, as a fundamental key for this automation development, Incredibuild for Automotive significantly accelerates automakers' software development cycles on-prem, in the cloud, on Linux and Windows for a new generation of software-defined vehicles [2]. The proposed product includes notable features that enhance productivity and offer the quality consumers expect integrated with industry-leading virtualized parallel distribution, newly launched patent-pending Build Cache technology lets development teams store previous build data, considerably reducing build times and improving performance; and flexible licensing allows for better resource management, resulting in cost and time savings with zero waste. Another key result is that consumers will experience quicker updates to advanced driver assistance systems (ADASs) and other real-time operating systems with no compromise on quality or safety.

Also, the HUBER+SUHNER 3D antenna is the first long-range 3D metallized plastic radar antenna designed for ADASs, offering ultralow losses for the most accurate object detection while meeting automotive standards [3]. Based on injection molding, the HUBER+SUHNER 3D waveguide antenna creates an air-filled waveguide to achieve very low insertion loss, and an overwhelmingly higher performance compared to printed circuit board antennas. Its increased size allows the antenna to read objects from more than 300-m away, offering broad bandwidth and excellent signal to noise ratio. With major original equipment manufacturers (OEMs) requesting sensors containing 3D antenna components for this heightened performance, HUBER+SUHNER is leading the way in this space as the only supplier to offer 3D antennas for long-range use cases. HUBER+SUHNER develops antennas for all automotive radars; in addition to long-range radar, it also includes mid-, short-range, and corner radar.

Electrification

This is a major trend in the automotive industry, defined by the large mainstream as the electric car revolution era. But before that, it is essential to highlight what is motivating carmakers in this electrification race. We are talking about concepts such as sustainability and socioenvironmental responsibility.

With the deepening of climate issues accelerating at the same speed as consumer awareness, it is increasingly important to make the transition from fossil fuels to renewable energy sources precisely because it results in zero emissions and greater savings. Currently, electrification is still a relatively expensive technology, essentially due to battery or fuel-cell fabrication costs, even in more consolidated markets such as North America and Europe. However, as EV adoption increases, and EV technology becomes the norm, there is a normal trend for price decreases to be harmonized and promote the mass adoption of EVs.

The next years will be driven by a large electrification in fleets and more integration of renewables, and battery storage with EV-charging infrastructure advances.

Electrification of fleets (buses and light and semi- and heavy commercial vehicles) continues to evolve. The boom in home deliveries during the COVID-19 pandemic has encouraged plans to electrify "midclass" trucks and vans over the next two years. The major players, Amazon, FedEx, United Parcel Service, and DHL, already have electric vans on the streets, with orders in for more.

For instance, Amazon invests more than €1 billion to electrify its European transportation network and reduce carbon emissions [4]. Also, Volvo Trucks and Deutsche Post DHL Group have signed a cooperation agreement to accelerate the shift to zero-exhaust emission vehicles [5]. DHL intends to intensify its transition to heavy electric trucks by deploying a total of 44 new electric Volvo trucks on routes in Europe, as presented in Figure 5. Volvo Trucks is leading the market for heavy all-electric trucks in Europe, with a market share of 42% in 2021. Already in 2019, Volvo Trucks started serial production of electric trucks, as one of the very first truck brands in the world to do so. The company has delivered electric trucks to a wide range of customers in Europe, North America, and Australia.

These last-kilometers vehicles are particularly suited to electrification because they serve predictable routes and travel fewer than 80 km a day, well within current battery range. Early adopters of EV fleets have already achieved savings of 20–25% through greater efficiency, more affordable "refueling," and reduced maintenance.

School and public transit buses have similar profiles, placing them at the top of the government's priority lists for electrification. For instance, Lion Electric delivers its first bus (see Figure 6) funded by a grant under the U.S. Environmenal Protection Agency's Clean School Bus program [6]. In addition to last-kilometers vehicles, buses can be recharged overnight to be ready to go in the morning. But this will require building smart EV-charging depots that can manage charging and energy consumption, for example, by overwhelming charging and balancing loads to avoid overloading the local grid.

On one hand, the electrification of heavy-duty freight trucks

(HFTs) is a long-term undertaking. The effort will require development of high-capacity batteries and the charging infrastructure to support them, both at depots and along the highway. Efforts involving the CHArge de MOve (CHAdeMo) association and Charging Interface Initiative e.V. (CharIN) are underway to develop standards for megachargers (above 1 MW), with other industry players working on harmonizing standards at scale to facilitate HFT deployment. On the other hand, clean, renewable energy sources of solar and wind energy are increasingly being integrated into the grid by utilities around the world. Utilities are also allocating green energy to e-mobility service providers to charge EVs, further reducing the impact of hydrocarbon-based energy sources on the world.

As the rate of EV adoption increases, public charging networks, fleet operators, and campuses will need to meet energy demands without incurring high-demand charges or undue strain on the electrical grid. Intelligent power management that balances power distribution between chargers is an alternative. Integrating on-site renewable energy generation, typically from solar panels, into the point-of-load power supply can supplement energy drawn from the grid. Another approach is to integrate battery storage systems into charging stations. EVgo Inc., the largest fast-charging network in the United States, pioneered the use of batteries and intelligent power management to provide a stable EV-charging service. A full-service logistics operator in California was recently announced, providing a unique transload and transportation service that partners in moving products via truck, rail, or ocean vessel to support MHX's first-ever fleet-electrification project. The collaboration will begin with the deployment of EVgo's fast-charging infrastructure at MHX's location in Fontana, California, which will be backed by 24/7 customer support as well as innovative fleet charging and management capabilities through EVgo Optima and EVgold solutions. The project will feature high-power 350-kW fast chargers, capable of serving six vehicles simultaneously (see Figure 7) [7]. Power is injected into grid batteries during low demand and low-cost periods or from on-site renewable sources and then released to charge EVs during peak hours. It is the same principle as vehicle-to-grid charging, where the batteries, in this case, in the EVs themselves, store energy during idle time and return it to the grid during peak demand.

Figure 5 DHL's light distribution electric truck. (Source: https://www.dhl.com/; used with permission.)

Figure 6 Lion Electric's buses plugged into recharging stations. (Source: https://www.thelionelectric.com/; used with permission.)

These are just some of the major trends that are already gaining momentum in the automotive electrification industry as key players such as charging station operators, e-mobility service providers, utilities, and governments are working together to drive the adoption of EVs. The benefits will be realized by the public and the environment as the industry develops.

AI

AI is a concept closely linked to vehicle automation, being technical and practically impossible to imagine one technology in the absence of the other. However, AI deserves a special

focus due to vehicular connectivity's natural growth. Idealistically, it is possible that the vehicles of the future will be connected to the same shared network according to their positioning. With this, the vehicles will be able to communicate with each other's different parameters such as speed, distance, and so on. This constant communication, complemented by autonomous driving, could revolutionize traffic as we know it, drastically reducing the number of accidents to almost zero, eliminating congestion, increasing traffic speed, and reducing travel times.

For instance, Infineon just launched its 32-bit TriCore AURIX-TC4x (see Figure 8) family of microcontroller units (MCUs) for next-generation e-mobility, ADASs, automotive electrical/electronic (E/E) architecture and affordable AI applications [8]. The new scalable family provides an upward migration path from Infineon's leading AURIX TC3x family of MCUs. Performance is boosted by the next-generation TriCore 1.8 and scalable AURIX accelerator suite, including the new parallel processing unit and multiple smart accelerators. Support for high-speed communication interfaces like 5-Gbit Ethernet and peripheral component interconnect express, along with new interfaces such as CAN-XL and 10BASE T1S Ethernet, gives customers the performance, throughput, and flexibility needed to implement new E/E architectures. The scalable family concept enables a common software architecture, providing a significant platform software savings, and the feature-rich concept gives plenty of headroom to grow for both Tier 1s and OEMs.

Connectivity

To enable all this communication and collective intelligence of cars, the automotive future is invariably linked to full Internet connectivity, including, this is where vector technologies like 5G come in, providing high-quality signals for vehicles everywhere.

In addition, the Internet on board will be used by occupants, who will be able to connect their electronic devices to consume media, work, study, play, and so on. In some ways, the automotive future is more about in-flight entertainment than the driving experience.

In June 2022, STMicroelectronics, the global semiconductor manufacturer, introduced a new platform to accelerate the introduction of digital car keys, providing consumers keyless access through their mobile devices. Such supportive factors are expected to benefit industry growth in the coming period. For instance, STMicroelectronics' automotive audio power amplifiers bring digital flexibility to eCall, telematics, and Acoustic Vehicle Alerting System [9].

According to a report on the automotive near-field communication market by Future Market Insights, the global market is anticipated to grow at a compound annual growth rate of 30.2% from 2022 to 2032, reaching US$35 billion. In 2022, the market is expected to be valued at US$3.26 billion, up from US$2.5 billion in 2021 [10]. The government's increasing rules requiring the use of ADASs are anticipated to have a favorable impact on the market.

Recently, semiconductor designer and manufacturer NXP has announced an automotive-grade development platform that integrates a wide variety of NXP wireless technologies, from broadcast radio, Wi-Fi 6, and Bluetooth, to secure car access with ultrawideband and Bluetooth Low Energy, and IEEE 802.11p-based vehicle to everything. Designed as a modular platform, the OrangeBox (see Figure 9) is a single, security-enhanced, modular development platform that provides a unified interface between the vehicle's gateway and its wired and wireless technologies [11].

FIGURE 7 EVgo and MHX are limited liability company partners working together to electrify high-power electric truck charging sites. (Source: https://www.evgo.com/; used with permission.)

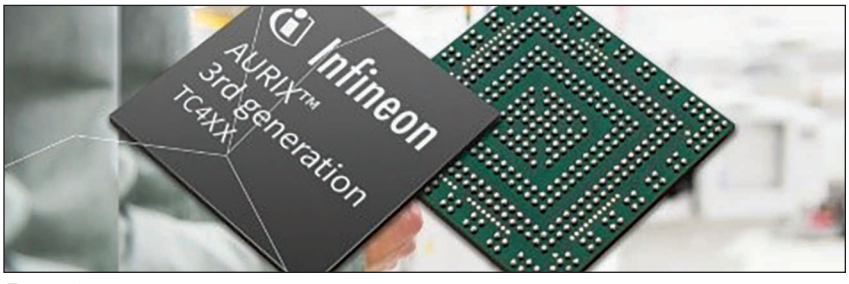

FIGURE 8 The Infineon AURITC4x family. (Source: https://www.infineon.com/; used with permission.)

Following the BlueBox (sensor fusion, high-performance computing), GreenBox (electric powertrains), and GoldBox (in-vehicle network gateway), NXP is now continuing its series of color-associated automotive development platforms with the OrangeBox. The theme of the OrangeBox is solutions and technologies for connecting the vehicle to the outside world.

Shared Economy

One of the most striking transformations of the new generation is taking place in consumer behavior. For the last two generations of consumers, experience is valued more than ownership. It is with this in mind that shared economy solutions have gained such success in recent years.

Therefore, the future of the market will be able to present increasingly flexible solutions for the use of cars without requiring purchase of the vehicle. Here we talk about leasing modalities or even urban mobility requested by application.

Roughly 96% of the time, a car is standing still during its lifetime. Between its construction and its end, only 4% of its time is spent on the road. This means that out of 168 h in a week, a car is used for just 6 h and 43 min. In a full year of 365 days, a car is running for 14.6 days in total [12]. With this framework, Airbnb for cars was born. Purchasing is generally expensive, which is why the car rental industry is flourishing today. One of the privileged emblems on the block is Airbnb for Cars. Not to blame for today's shattered economy, but with the success of ride-sharing companies like Uber, Lyft, Didi, and Grab, Airbnb for Cars is becoming more popular among all entrepreneurs than traditional car rental businesses.

Airbnb has contributed significantly to the burgeoning interest in the sharing economy. It enables numerous rental business owners to expand in their industry as also being an investor renting a car is preferable to owning one.

Figure 9 OrangeBox automotive connectivity domain controller development platform. (Source: https://www.nxp.com/; used with permission.)

Figure 10 The Hyundai Supernal S-A1. (Source: https://www.supernal.aero; used with permission.)

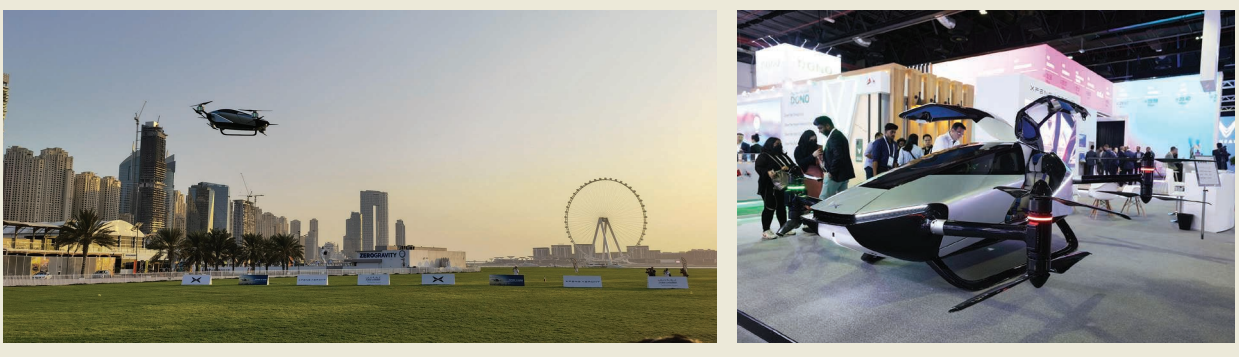

Figure 11 The XPENG X2 electric flying car. (Source: https://www.aeroht.com/; used with permission.)

FIGURE 12 SKAI is the first hydrogen electric vertical take off and landing aircraft. (Source: https://www.alakai.com/; used with permission.)

Flying Car

Finally, we discuss flying cars, an ancient dream of modern civilization. We can even speak with absolute authority because together with Uber, Hyundai is developing the Supernal S-A1 (see Figure 10), an air taxi for speeding up travel in large cities. In some ways, the flying car is closer to a drone than a conventional automobile. However, that does not change the fact that we are getting closer to popularizing this technology that has always been revered by pop culture.

For instance, last October brought the first public presentation of the XPENG X2 (see Figure 11) in Dubai after completing a specific operations risk assessment and achieving a special flying permit from the Dubai Civil Aviation Authority (DCAA). This first flight was witnessed by more than 150 attendees, including representatives from the Chinese Consulate in Dubai, Dubai International Chamber of Commerce, DCAA, Dubai Department of Economy and Tourism, Dubai World Trade Center, and global media [13].

Also, an electric vertical take off and landing vehicle called *SKAI* (see Figure 12), from Alaka'i Technologies, runs entirely on hydrogen fuel cells. The flying car is poised to be one of the safest, cleanest, and most versatile air mobility solutions introduced to the world. SKAI offers practical, real-life solutions to everything from relieving traffic congestion to delivering supplies during natural disasters. SKAI is set to offer affordable, realistic applications in the commercial, private, freight, and personal air mobility markets. The system offers a clean environmental solution from end to end, with the advantage of being 95% reusable and the remaining (99%) recyclable. The hydrogen fuel cells offer reliable, safe, and environmentally clean emissions composed solely of heat and water and allow SKAI to travel farther distances, for up to 4 hr, ~650 km, and carry a greater payload [14].

The future of the automotive industry will be full of news, launches, technologies, and curiosities. Ultimately, vehicles will become even more competent at doing what they have always done, in addition to offering more features that will free up a lot of people's time for other activities.

References

[1] "Inspired by humans: Introducing the IONIQ 5-based robotaxi." Hyundai Motor Company. Accessed: Dec. 7, 2022. [Online]. Available: https://www.hyundai.com/worldwide/en/brand-journal/mobility-solution/ioniq-5-based-robotaxi

[2] "Incredibuild launches new automotive solution, revving up industry software development at unrivaled speeds." Incredibuild. Accessed: Dec. 10, 2022. [Online]. Available: https://www.incredibuild.com/news/incredibuild-launches-new-automotive-solution-revving-up-industry-software-development-at-unrivaled-speeds

[3] "Accelerating adas with the first long-range 3D antenna from Huber+Suhner." Huber+Suhner. Accessed: Dec. 5, 2022. [Online]. Available: https://www.hubersuhner.com/en/company/media/news/2022/2022-06-14-accelerating-adas-with-the-first-long-range-3d-antenna-from-huber-suhner-en

[4] "Amazon to invest more than €1 billion to electrify its European transportation network and reduce carbon emissions." Amazon. Accessed: Dec. 10, 2022. [Online]. Available: https://www.aboutamazon.eu/news/transportation/amazon-to-invest-more-than-1-billion-to-electrify-its-european-transportation-network-and-reduce-carbon-emissions

[5] "Deutsche post DHL group and volvo trucks kick-off new zero emission cooperation with order for up to 44 electric trucks." DHL. Accessed: Dec. 8, 2022. [Online]. Available: https://www.dhl.com/global-en/home/press/press-archive/2022/dpdhl-group-and-volvo-trucks-kick-off-new-zero-emission-cooperation-with-order-for-up-to-44-electric-trucks.html

[6] "Lion Electric delivers its first bus funded by a grant under the U.S. environmental protection agency's clean school bus program." Lion Electric. Accessed: Dec. 22, 2022. [Online]. Available: https://thelionelectric.com/documents/en/Lion_Electric_First_EPA_Delivery_Press%20Final_EN.pdf

[7] "EVgo and MHX, LLC partner to power class 8 electric truck fleet." EVgo. Accessed: Dec. 19, 2022. [Online]. Available: https://www.evgo.com/press-release/evgo-and-mhx-llc-partner-to-power-class-8-electric-truck-fleet/

[8] "32-bit TriCore™ AURIX™–TC4x." Infineon. Accessed: Dec. 10, 2022. [Online]. Available: https://www.infineon.com/cms/en/product/microcontroller/32-bit-tricore-microcontroller/32-bit-tricore-aurix-tc4x/?redirId=166557

[9] "STMicroelectronics' automotive audio power amplifiers bring digital flexibility to eCall, telematics and AVAS." Infineon. Accessed: Dec. 12, 2022. [Online]. Available: hhttps://www.infineon.com/cms/en/product/microcontroller/32-bit-tricore-microcontroller/32-bit-tricore-aurix-tc4x/?redirId=166557

[10] "Automotive NFC market snapshot (2022-2032)." Future Market Insights. Accessed: Dec. 12, 2022. [Online]. Available: https://www.futuremarketinsights.com/reports/automotive-nfc-market

[11] "NXP OrangeBox unifies automotive wireless connectivity into a single domain controller to simplify development and security." Future Market Insights. Accessed: Dec. 12, 2022. [Online]. Available: https://www.futuremarketinsights.com/reports/automotive-nfc-market

[12] "Sharing economy: The road to a sustainable future via digitalization." Capgemini. Accessed: Dec. 12, 2022. [Online]. Available: https://www.capgemini.com/insights/expert-perspectives/sharing-economy-the-road-to-a-sustainable-future-via-digitalization/

[13] "XPENG X2 completes first global public flight in Dubai." XPENG AEROHT. Accessed: Dec. 19, 2022. [Online]. Available: https://www.aeroht.com/article/article?id=126

[14] "Alaka'i Technologies is proud to announce the launch of Skai: Our first hydrogen eVTOL aircraft." Alaka'i Technologies. Accessed: Dec. 19, 2022. [Online]. Available: https://www.alakai.com/skai

VT