WHITE PAPER

Make It Work! Key Aspects for Successful Operations of Autonomous Mobility and Logistics Services

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The mobility and logistics industries along with many other business sectors are on the cusp of revolution as highly automated and fully autonomous vehicles are poised to disrupt long-standing hierarchies and supply chains. In the midst of these changes, safety becomes a primary differentiator among the new purveyors of mobility concepts, promising to transport people and goods and provide services in more efficient, innovative ways.

When Is the Future and What Does It Look Like?

Analysts project that at some point over the next 10 years mobility will reach a critical milestone: the costs of employing a human driver to operate a conventional vehicle will have risen while the costs of Autonomous Vehicles (AVs) will have fallen, so that the two modes are on an equal economic footing. Thereafter, the trend is expected to continue, meaning that AVs will increasingly become the more financially viable option. Large companies are already positioning themselves for this new reality, as are a wide variety of entrepreneurs and start-ups. At the same time, their potential clients, including governments and municipalities, are exploring how to reap the benefits while prioritizing safety.

It is essential to understand that the first generation of AVs and autonomous mobility solutions are on course to make their impact as part of cutting-edge business models, not through sales to private citizens—the costs of purchasing an AV for purely private use will remain far beyond the reach of most individuals, initially. Far more likely is a scenario in which organizations set themselves up as service providers or system integrators that feature an AV fleet. The groundwork for these business models has already been laid by companies from different industry sectors, such as AV technology, vehicle manufacturer, logistic or mobility providers, mapping and navigation, fleet management specialists and others. Among them, some organizations are already experienced in the integration of multiple technology products such as automated or autonomous logistics or mobility vehicles. Typical scenarios are long distance and last mile logistics solutions, or on-demand, dynamic mobility solutions such as shuttle and bus services. But new players will probably come from other sectors, too: home food delivery, mobile laboratories and workshops, hotel room pods, or mobile service

pods are just a few of the hundreds of existing cross-sector concepts currently being developed.

An equally important feature of the coming revolution, especially as it impacts safety, is the relative position of vehicle manufacturers in the supply chain. Since the birth of the automobile industry, OEMs and their products have been the focal point. Clients, both individuals and organizations, relied on these companies to provide safe, dependable vehicles, and a framework of regulations arose to ensure not only that the automobiles met current safety standards but also that drivers were properly trained and licensed and suitable infrastructure was built and maintained.

Autonomous mobility and logistics concepts involve new players situated between the OEMs and the end users (e.g. consumers and the public): they are the systems integrators, dedicated to assembling the tech solutions necessary for a given service, and service providers, the client-facing companies who operate the technology. Moreover, an AV is usually the product of more than one company. Currently, a traditional OEM may manufacture the vehicle while another enterprise produces the Self-Driving System that automates it. Neither of these two companies, however, design, plan, test or sell the various other components involved in a complete automated or autonomous logistics or mobility service concept. It is rather the systems integrators and service providers who are responsible for coordinating tasks such as remote operations and handling incidents, maintenance and infrastructure, cyber security and fleet control connectivity, and many more. Franchising models, which are gaining traction in this field, widen the gap even further, encouraging small-scale entrepreneurs without any specialized training or relevant background to assume oversight of highly complex operations.

The implications for safety are substantial. In many cases, OEMs, mobility and logistics providers have more than a century of experience ensuring the safety of their products and services and work with authorities and standardization bodies to establish standards to protect human health and the environment. But both the long established organizations and the new crop of service providers hoping to capitalize on the promise of AVs by developing innovative services generally lack the kind of experience and expertise you need to operate automated or autonomous fleets. They may even come from a different sector or be entirely new players, focused on the benefits of the emerging technologies and not fully aware of their risks. This can lead to a disconnect between the service providers and their customers, since the former tend to highlight the positive potential of autonomous mobility or logistics while the latter wonder, "Is it safe?".

In a nutshell: the individual parts or aspects of upcoming automated and autonomous vehicles may be "safe," but integrating them into a service-oriented product and operating automated or autonomous fleets require additional safety concepts with a special focus on the interfaces and those situations which are currently controlled by physically present humans.

The Unique Interplay Supporting Successful Autonomous Mobility Concepts

The bulk of media attention on the topic of autonomous mobility is focused on technology. This is understandable, since the new capabilities are exciting and excellent fodder for the entrepreneurial imagination. Technological advances have opened up broad vistas of possibility, and it is fun to speculate how they can make our lives easier, our air cleaner and our cities less congested. However, our collective experience has made abundantly clear that technology also has a challenging side, and logistics and mobility concepts need to take the risks into account with a robust approach to safety, reliability and performance. Furthermore, technology is only one of four equally important and interconnected aspects of a successful operational concept for automated or autonomous mobility and logistics.

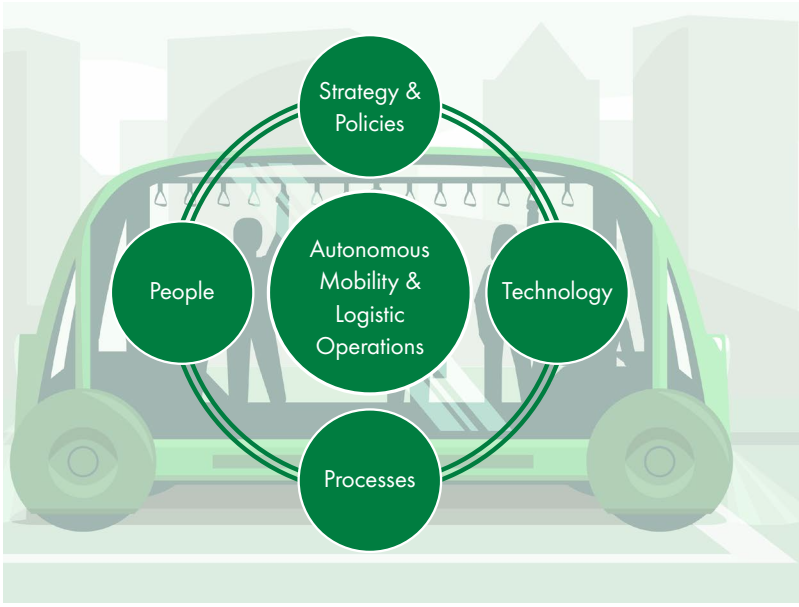


Figure 1: Interconnection of strategy & policies, processes, people and technology forming the safety net

Without a well-developed strategy, appropriate and efficient processes and the right people in the right positions, AV technology cannot deliver on its promises. On the other hand, when technology, strategy, processes and people are given equal attention and appreciated in terms of how they are

interconnected, they form a "safety net" where risks are sufficiently managed and services are safely and efficiently rendered. A strong safety net requires a thorough understanding of potential risks, which is reflected in IT systems, fleet management, cybersecurity measures and operational processes. Risk awareness has to permeate strategy development, procedures, organization, personnel and leadership.

All of these elements are on the shoulders of the future automated or autonomous mobility and logistics service providers since they are the ones—not the OEMs—operating the technologies and driving developments. The result is an international need for expertise and solutions to address the challenges of autonomous mobility and logistics, especially in the realm of operational safety and reliability, and to support service providers as they chart a course forward. The ones that master the interplay among technology, strategy & policies, processes and people will have the competitive edge.

They Say Mobility, We Say Safety: Autonomous Mobility From a Safety Expert's Perspective

Big tech companies and groundbreaking start-up ventures as well as organizations rooted in industries such as food, hospitality, event planning, health sciences and more naturally focus on technology potential and innovation when considering autonomous mobility. Safety experts see risk. To understand their perspective, it is instructive to consider a simple example.

A human driver is at the wheel of a conventional delivery truck. That person is trained not only to operate the vehicle and take care of routine maintenance, they are also versed in a variety of protocols to follow should unforeseen circumstances arise. They know what kind of cargo they are carrying, they can recognize hazardous materials or fragile items by the markings on the packages and have been instructed how to handle them. If they detect a leakage or notice a parcel smoking, for example, they know what to do. They are entrusted with decisions about where to park, how long to wait for a customer, if necessary, how to navigate

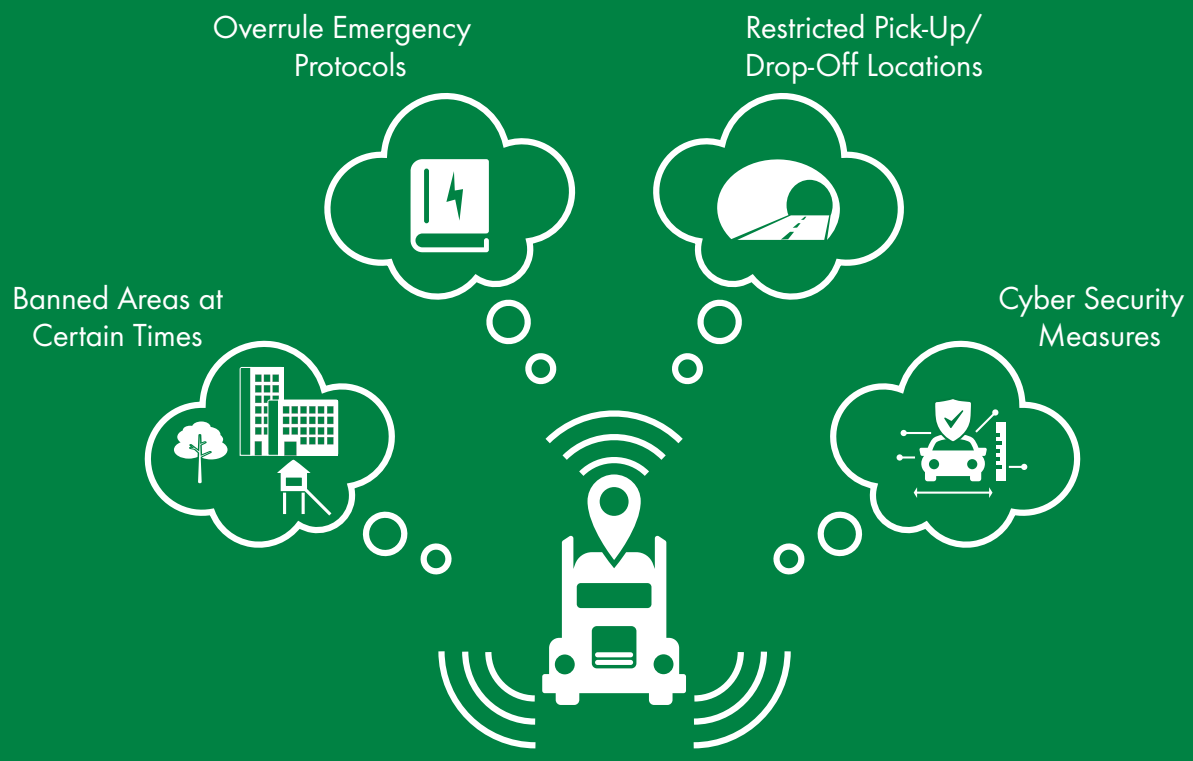


Figure 2: A selection of safety issues needed to be addressed

unusual traffic patterns and more. In other words, their job description extends beyond merely operating a motor vehicle and is integral to ensuring the safety of the entire undertaking. If that human driver is no longer behind the wheel, their delivery and safety expertise is missing too, and will have to be compensated through other means. If not, the risks multiply. Imagine being notified that a package has arrived, opening the corresponding compartment on the autonomous delivery truck, and finding the item in flames!

Another relatable example is the autonomous shuttle. As long as a human driver is present, the unpredictability of traffic, of passenger needs and the potential for mechanical breakdowns can be

managed in familiar ways. Absent the human, whether the primary operator or a back-up to partial automation, what happens when the shuttle comes to an unexpected stop in the middle of a 5-lane motorway? What are the passengers expected to do if the doors open and the AV encourages them to get out? How can the AV react appropriately to passengers dependent on a wheelchair, requiring special equipment, etc.?

In each of these examples, companies are tasked with finding ways to integrate person-to-person communication in the absence of a human operator. Today's OEMs and their partners are proposing various solutions to diverse situations. For example, human drivers often communicate with pedestrians, cyclists and other drivers through eye contact. One AV model features large humanoid eyes that scan its environment and can "lock in" on a pedestrian or other traveler to mimic this form of communication and relate the message that the other party can take the right of way. Other models feature prominent message screens and use language to communicate with the world around them. When selecting from among options such as these there is much to consider, and each choice has far-reaching consequences. Making the best decision is easier with the support of a knowledgeable partner.

When new types of mobility meet inexperience, other risks arise. An enterprise offering e-scooters as a fast, clean and fun alternative to traditional transport, for example, needs to store its fleet somewhere and leases a warehouse for the purpose. If the service provider doesn't fully understand the **potential fire risks** posed by lithium batteries, this could be a destructive or even fatal decision. The complexity of the world will require service providers who rely on AV to make countless decisions related to keeping their customers, employees and the public safe, the majority of which do not depend on the design and manufacture of the AV itself. For instance, they will need to hire remote operators. Who is best suited to this job? Former drivers? Video gaming experts? Will the leadership in these companies prioritize public safety or profits when planning routes and scheduling recharging? This may mean the difference between AVs avoiding the areas and hours when children are likely to be on their way to and from school, or disregarding the potential risks in favor of saving time, mileage and costs. In this context, expertise in operational safety can prevent serious consequences both to people and the **environment**.

What Elements Are Involved in Autonomous Mobility and Logistics Operations?

When analyzing the various elements that make up an autonomous mobility service concept, it is helpful to consider 10 areas that require careful decision-making, strategizing and planning, starting with the vehicle itself. OEMs play a central role in developing and manufacturing vehicles all along the automation spectrum, from those with driver assistance features through full automation. These enhanced vehicles, like their conventional cousins, must be tested and certified to safety standards, which in turn are sure to evolve in response to technological advances.

These vehicles incorporate a Self-Driving System (SDS) comprising cameras, braking and acceleration functions, signaling and more. This is the heart of their autonomy, but as mentioned above, the SDS is often produced by a second company partnering with the OEM that manufactures the vehicle.

Businesses providing a service via AV will require both a fleet and a fleet intelligence center to guide and keep track of the vehicles. Companies like Didi Chuxing, Uber or Lyft already employ a version of this, guiding directions and driving behavior and influencing operational decisions, such as breaks, maintenance return or recharging stops. In the context of full automation, the fleet intelligence center will coordinate vehicles minus the human operators.

Even when people are no longer behind the wheel, there will still be remote operations and incident handling to consider. Companies will have to decide what remote operations looks like, what skillset best matches the function, what incidents might arise and how each should be addressed. If a vehicle breaks down, for example, will another AV arrive, operated remotely, to tow it away? Or in case of an obstacle blocking the vehicle's path, will an operator remotely access the vehicle, override controls and drive manually around the obstacle, perhaps disregarding traffic rules – legitimately, in this case?

The operational design domain governs a broad range of functionalities, such as where and when vehicles are in operation, how and where they may park, the length of wait times for goods and passengers, where they recharge batteries under which conditions, etc. The settings in the operational

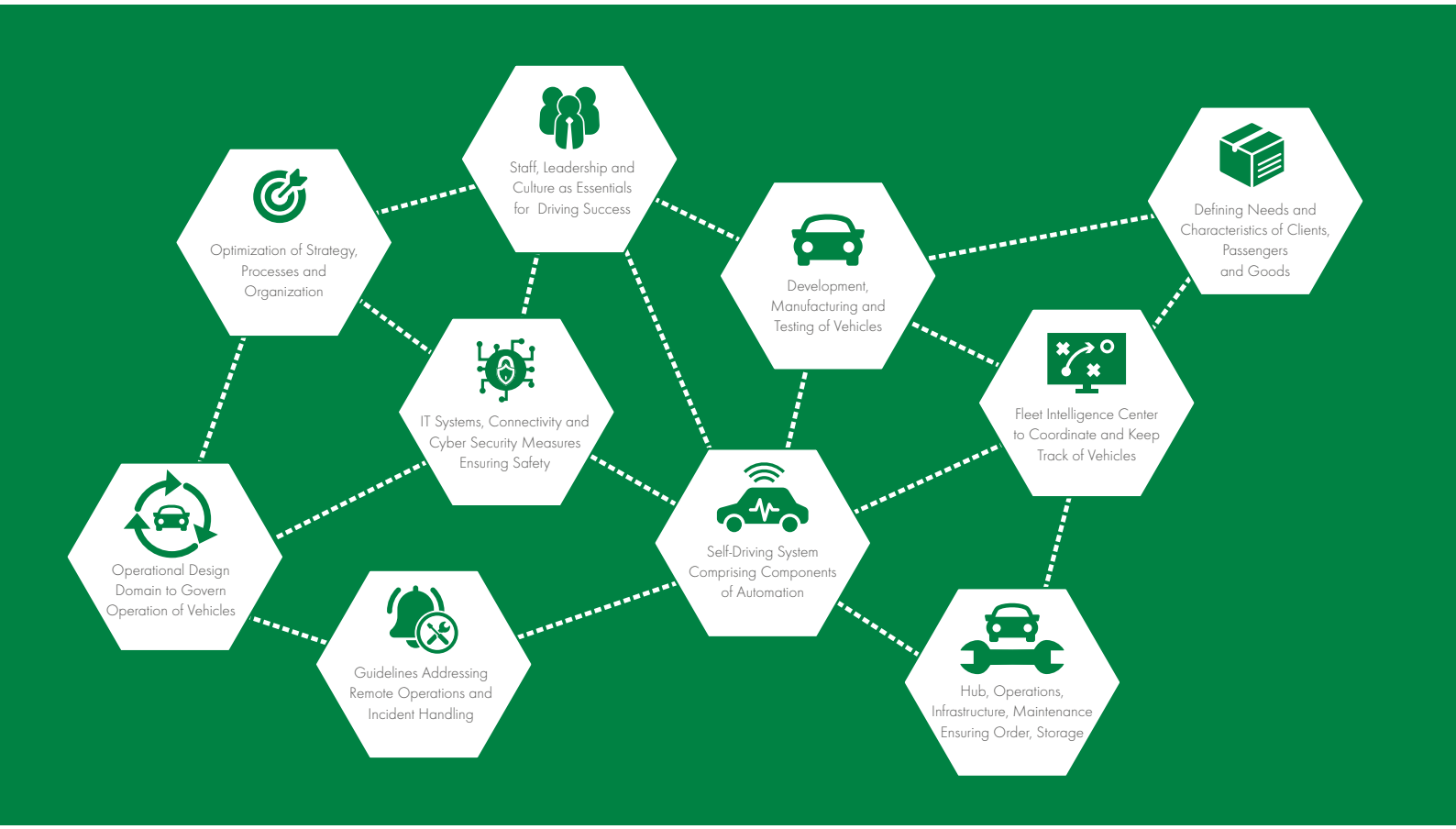
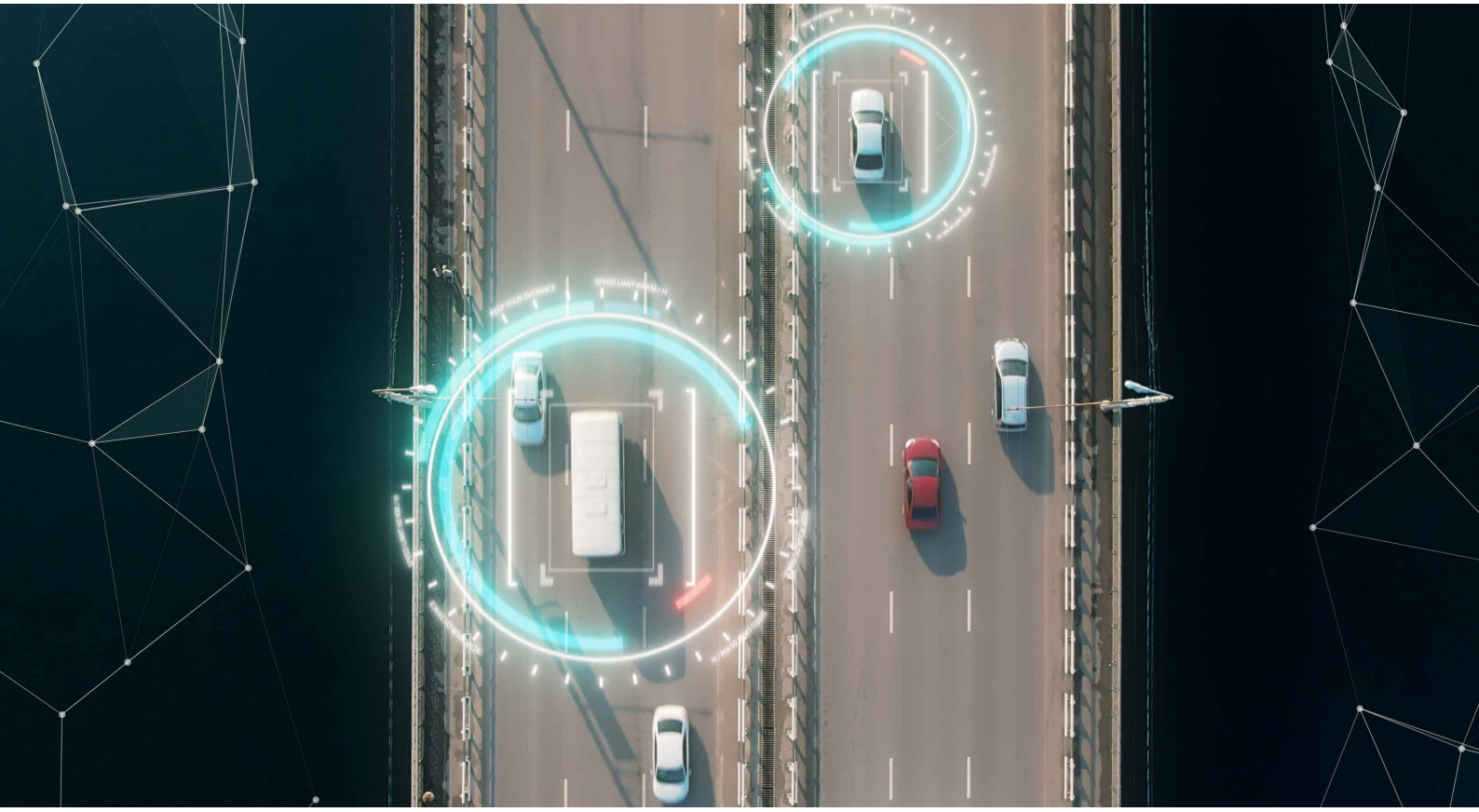


Figure 3: Elements making up an autonomous mobility service concept



design dictate whether and for how long an AV may stop in sensitive areas—in front of a fire station, for instance, or if vehicles can be sent to heavily trafficked areas at crucial times.

Hub, operations, infrastructure and maintenance keep the fleet in good working order and safely stored when not in service. Operating companies will need to decide where their fleet "rests," when, where and by whom vehicles are maintained and ensure that the necessary infrastructure is available.

AVs are reliant on IT systems, apps, connectivity and **cybersecurity**. Any autonomous mobility and logistics concept that does not take security seriously is running grave risks, both to the survival of its business and to the safety of customers and the public, since AVs will be prime targets for hackers, both those with criminal intent and those with other motivations. Moreover, if connectivity is weak or spotty or the related apps don't work as expected, the whole service can be undermined.

Depending on the sector, the new mobility concepts are based on transporting passengers, delivering goods or providing a service to clients. As such, the needs and characteristics of clients, passengers and goods are fundamental. Will **hazardous materials** be transported? If so, how can they be handled safely? How can the service meet the needs of passengers? Will child safety seats be available?

In some ways, these service providers of the near future are like traditional companies, in that their strategy, processes and organization need optimizing if they are to perform to their fullest potential. This aspect should be highlighted, however, since it can be neglected in favor of the "shiny objects" made available by advanced technology.

Finally, no matter how technologically advanced, autonomous mobility and logistics companies are still comprised of people. This means staff, **leadership** and culture can make or break their success. Hiring for brand new jobs can be tricky and, in any case, new hires might require specialized training. Even experienced leaders will be embarking on new territory here, and chances are at least some of these companies or franchises will be headed by first-time business owners or managers.

In summary, each of these elements require special attention and bring with them a host of issues to be resolved, policy questions to be answered and decisions to be made. As they make their choices, mobility and logistics companies will be positioning themselves in a burgeoning market, and safety will be a major differentiator and an added value for clients and

consumers. If, as expected, few of those leading the way have safety or manufacturing backgrounds, there will be a global opportunity for operational safety experts to offer guidance, advice and solutions.

Integrating Safety Into Autonomous Mobility and Logistics Concepts

In a perfect world, fully automated or autonomous solutions would be all-knowing. Algorithms, sensors, and communication systems could predict threats, avoid risks and ensure reliable and safe operations. But until a wholly omniscient autonomous system (including its supporting infrastructure) is a reality, there will be the challenge for operators and developers to create and implement concepts that provide reliable and trustworthy operations even in this transition period. The transition period from current partial and conditional automation (levels 2&3) into high and full automation (levels 4&5) will take time, and level 4 and 5 generations will have to deal first with teething problems, as do all new technologies. This makes it even more important to eliminate or mitigate such issues through robust, top-notch safety and business continuity approaches.

Ultimately, to be effective, safety must be embedded across all four interconnected aspects of autonomous mobility, from technology to strategy & policies, processes and people. Companies that are able to do this successfully will be at the vanguard of a social, economic and environmental transformation. However, without comprehensive safety expertise this transformation cannot live up to its potential. To ease the transition to new forms of mobility, the autonomous mobility and logistics sector needs the support of established safety experts with years of experience, objectivity, resources and perspectives. Therefore, system integrators and future operators are well advised to get the necessary expertise at an early stage.

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