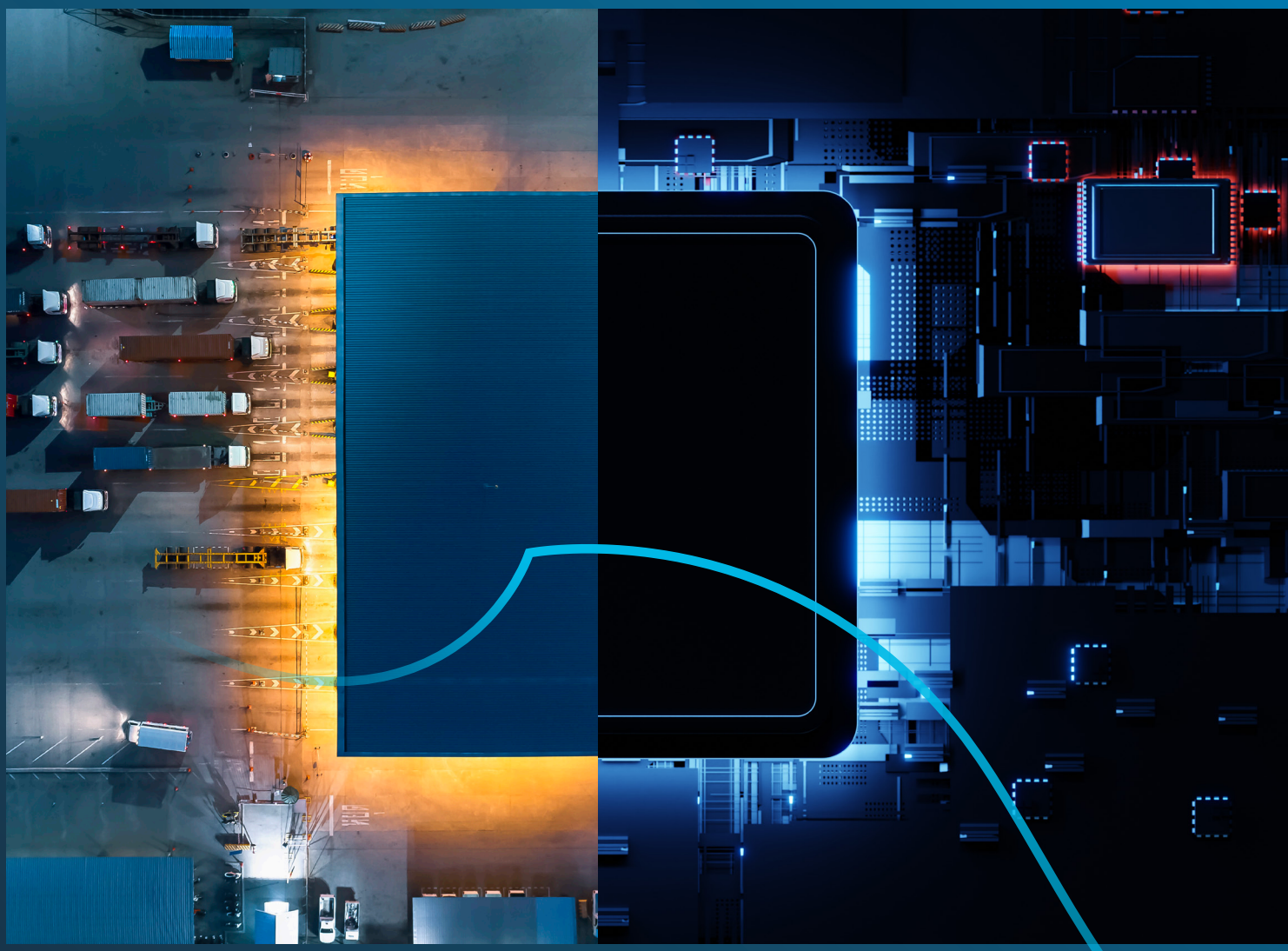

Software-Defined Vehicles for the Commercial Vehicle market

Capgemini

Executive summary

Software-Defined Vehicles for the Commercial Vehicle market

The software-defined vehicle (SDV) concept is perhaps even more critical to commercial vehicles (CVs) than to passenger cars because of its potential to address the CV sector's growing operating cost pressures (arising from, for example, escalating fuel prices and driver wages).

However, although the passenger car sector embarked on its SDV transformation at least five years ago, it has not yet realized the expected financial and technical returns on its investments. This is due largely to the complexity of the transformation, which involves integrating strategic, cultural, organizational, and technological changes. High development costs are another obstacle, along with the intrinsic difficulty of creating bug-free, safe, and compliant digital end-to-end solutions.

CV companies must leverage these experiences as they rethink their future around customers using digital technologies. By doing so, they can overcome not just technical challenges (such as enabling over-the-air (OTA) updates and harnessing AI) but also critical top management challenges like transforming a prescriptive organization into an adaptive one, equipped to succeed in the volatile and highly competitive world of SDVs.

By leveraging passenger car experience together with proven approaches like software-driven transformation frameworks, truck OEMs and suppliers can optimize company strategy, sovereignty, and – most fundamentally – company architecture. In this way, CV companies can excel in delivering SDVs and services at scale and at the same time achieve growth.

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The increasingly complex context of the ground transportation sector

A combination of environmental, technological, and regulatory trends have come together to create an impetus for transformation in the commercial vehicle sector

Transportation companies are incentivized to adopt low-carbon mobility solutions. Many manufacturers have developed new vehicles to reduce emissions and comply with environmental regulations. All truck and bus manufacturers now offer battery electric vehicles (BEVs) and some are experimenting with hydrogen power units. The coming 5 to 10 years will see widescale adoption of biofuel, natural gas, hydrogen, or electric CVs.

This trend affects OEMs, suppliers, infrastructure operators, fleet operators, and investors like cities and transportation companies. Smart energy management is therefore becoming essential for all customers, because of increasing energy prices. This will make a big difference to total cost of ownership (TCO) payback.

The development of connectivity and telematic technologies in commercial vehicles has enabled real-time data collection and analysis to improve fleet management, predictive maintenance, and route optimization. However, fleet and transportation companies urgently need to optimize their operations through better management of rolling stock and assets, and to improve fuel efficiency by 10-15%.

There are additional opportunities to transfer technologies that have already been widely adopted for passenger cars – for example, driving assistance – across to trucks. Assisted CVs could help reduce operating costs by improving the safety of the asset.

The rise of E-commerce has transformed logistics and delivery services. Commercial vehicles are increasingly being used for last-mile delivery, leading to innovations in vehicle design, routing services, and smart delivery systems.

There is a critical lack of CV drivers, with around half a million vacancies in Europe, and 48% of European companies are expecting to face more difficulties filling truck driver positions next year. They could be right: More than a third of truck drivers are at least 55 years old, while only 5% are younger than 25. Around 50% of trips are over 100 miles, which means drivers are often away from home, making the job less desirable and contributing to driver shortages. This situation means transportation companies must help to make the job more attractive by meeting new expectations about improved conditions on board, including better wellbeing, comfort, and security.

With the cost per mile going up every year, operators are feeling the pressure, especially since fuel (~40%) and driver wages (~40%) are two of the biggest expenses.

Improving security and safety is also mandatory. In the US, Australia, and the European Union, road crashes are estimated to account for between a quarter and a third of all work-related deaths – perhaps more. The automotive industry has developed many solutions to prevent and anticipate vehicle incidents based on cameras, radars, and similar technologies.

In the EU, advanced driver assistance systems are now mandatory for all road vehicles, with intelligent speed assistance, cameras or sensors to aid reversing, alerts in case of driver drowsiness or distraction, event data recorders, and emergency stop signals. For buses and trucks, there are technologies for tire pressure monitoring systems and for better recognition of possible blind spots, as well as warnings to prevent collisions with pedestrians or cyclists. In this context, trucks and buses can no longer be considered as standalone solutions for service provision.

In a world of continuous improvements around data and AI, the vehicle is one element of the business equation and must be augmented by digital solutions to maximize customer satisfaction.

Digital technologies and software are therefore key enablers of a successful future for CV companies, and we believe that a software-defined vehicle (SDV) approach is the only feasible way to manage the complexity that follows from increasing use of software.

Are CVs an easier and quicker use case for SDV adoption? How much can be reused from the passenger car, and where do CVs differ significantly? There are huge opportunities, but also major responsibilities for managers.

The CV sector urgently needs to transition to an SDV approach

Multiple factors are intensifying – and complicating – the pressures in the mobility sector

On the one hand market actors operating commercial vehicles must optimize the usage of their vehicles to minimize lifecycle costs. The entire value chain is affected. The providers of transport, logistics, and mobility services should optimize vehicle usage, by reducing maintenance time and costs and ensuring compliance with sustainability regulations.

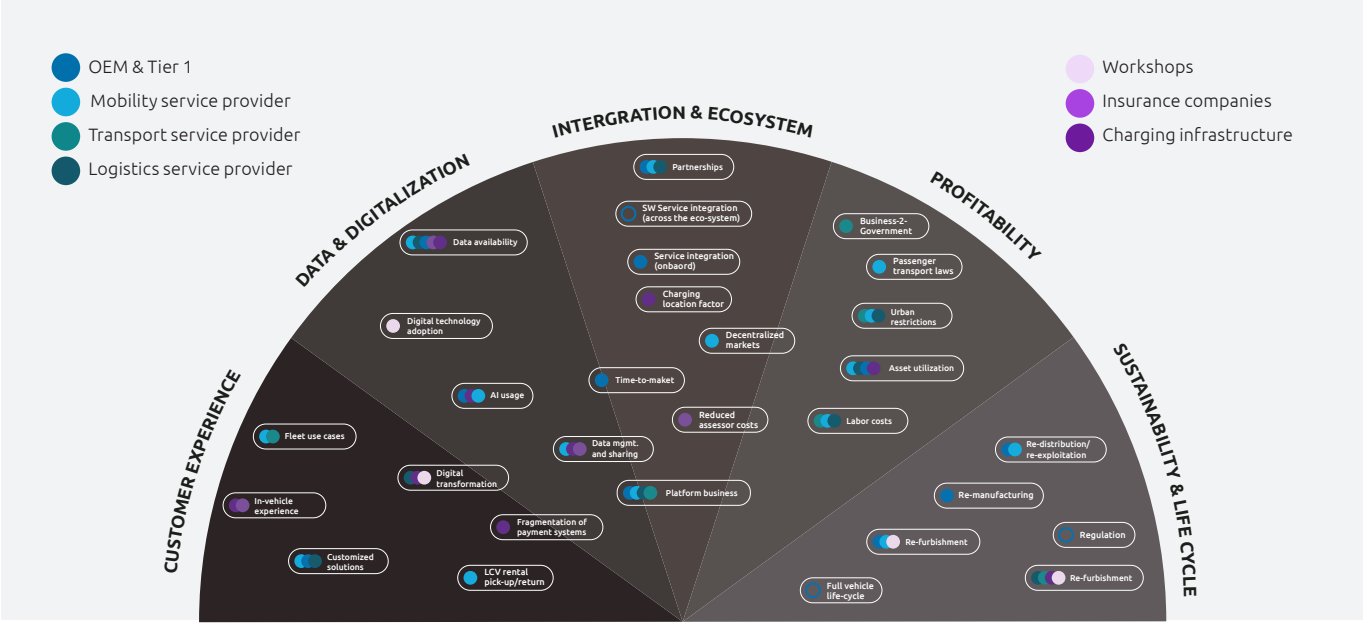
In addition, they need to make driving easier and create more attractive workplaces with helpful systems and improved in-vehicle experiences.

On the other hand, the manufacturers must architect the software-defined operating model, cut costs, and speed up software deployment. To achieve this, they must start at the core, adopt centralized architectures, decouple the software from the hardware, and reinvent their management of software development, despite limited resources due to lower production volumes than those for passenger cars.

In addition, OEMs and suppliers will face technical challenges like shifting to software-based organizations and building new platforms in a changing partner network. They must break down internal barriers and update old ways of working to succeed. This change will also bring cultural challenges.

Players in the automotive aftermarket face similar challenges. Integrating data and services throughout the vehicle life and trying to make the “as a service” business model profitable will remain a challenge.

Clustered pain points highlight the need for digital centric business approach



Operational efficiency is a way to offset operating costs and ensure that the asset is fully utilized

Transportation companies are gradually being pressured to optimize their return on investment (ROI) on assets, for example by adjusting the way they operate their commercial vehicles, or enabling fleet owners to provide additional services. But how can they go about comparing and identifying the mobility solution best suited to their specific operations?

Capgemini has developed a total cost of usage (TCU) model to supplement conventional TCO calculation methods, which demonstrates how to generate more insightful conclusions from a business case, comparing multiple mobility solutions in the context of fleet operations.

Vehicle profile

Vehicle regulatory classification, e.g. impact of the vehicle design on insurance costs over time. Vehicle load profile, e.g. costs of acquiring additional operational assets if the vehicle is not designed for specific usages. Vehicle powertrain category, e.g. costs of acquiring additional vehicles due to the range limitations of vehicles in the fleet.

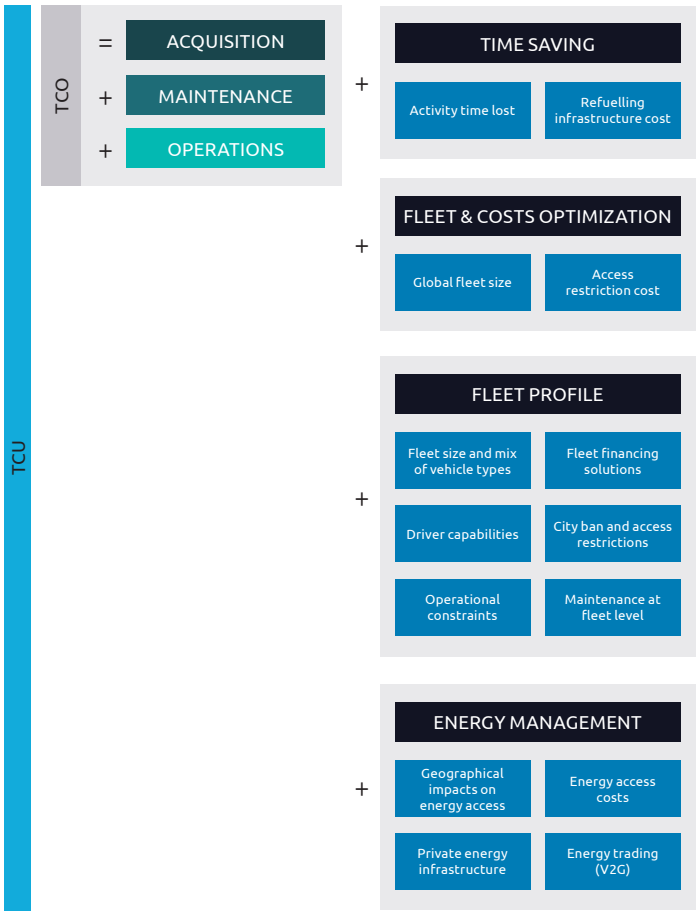
Fleet profile

Fleet size and mix of vehicle types, e.g. costs arising from having an inappropriate mix of vehicle types such as a surplus of diesel pick-up trucks and a lack of electric people carriers. Fleet financing solutions, e.g. if the fleet is under variable financing deals based on usage, costs arising from overuse of the fleet.

Energy management

Energy access costs, e.g. does the fleet incur costs related to accessing refueling and charge points? Vehicle-to-grid, e.g. revenue generated by vehicles transferring power to the grid. Design criteria refinement for an automotive OEM building a vehicle specifically designed for last-mile delivery markets. Augmenting traditional TCO information, the TCU model integrates the costs generated by three factors: vehicle design, fleet profile, and energy management. These factors make it possible to calculate the total costs incurred by a fleet when operating multiple mobility solutions.

TCU main building blocks



"Our customers are now convinced by a service-based approach with optimization of uptime, predictive maintenance and anticipation of failures. Our dealer network understands these new customer expectations and is motivated to meet them. SDVs will enable dealers to improve their offer, but they will need additional training on software and data to be able to sell services."

Laurent Bianchini
Vice President Customer Uptime & Productivity, Renault Trucks, Volvo Group

An SDV approach is the only realistic way to manage this level of complexity

The complexity of the software and digital landscape is escalating, both inside and outside the vehicle. The need to manage this complexity is a major reason for the move to SDVs. By creating comprehensive SDV platforms and a coherent approach to building them, manufacturers and operators can bring different software initiatives together and manage them more effectively.

In our opinion, SDV platforms for CVs will need to go well beyond what is available for passenger cars. They need to provide a comprehensive solution for maximizing efficiency and optimizing transportation and logistics companies' value chains.

"We started a long time ago to transition to a service-based model, before the SDV trend, by measuring and managing lots of data and providing services to our customers. With too many ECUs in the vehicle, we have too many management issues which can lead to quality risks. That is why we need a new approach based on a simpler architecture. SDV adoption will facilitate configuration management and lead to real quality improvements."

Laurent Bianchini
Vice President Customer Uptime & Productivity, Renault Trucks, Volvo Group

SDVs: Our definition

The Eclipse Software Defined Vehicle working group defines a software-defined vehicle as one "where the physical and digital components … are decoupled, and features, functionality, and operations are defined through software. In a fully programmable car, digital components – such as modules for safety, comfort/infotainment, and vehicle performance – would be regularly developed and deployed through over-the-air updates."

In addition, Capgemini believes all SDVs will feature:

1. Hardware consolidation – Tens or hundreds of electronic control units are replaced by just a few single-board computers, also known as high-performance computers and zonal controllers. Many functions previously handled by specialized microcontrollers are coded as software modules.

2. Software abstraction – Software infrastructure handles deployment, roll-out, and roll-back of code via OTA updates, with transparent communication. Software abstraction in SDVs limits complexity, increases flexibility and maintainability, and smoothly bridges onboard and offboard environments.

3. Convergence of on-board and off-board software to augment the vehicle with ecosystem services.

"A major driver for SDVs is the concept of keeping a truck 'fresh' throughout its lifecycle. The goal is to transform the truck into a rolling asset within a digital ecosystem. This involves continuous monitoring, control, and optimization of the truck, integrating backend, on-board, and off-board systems in a dynamic cloud environment. Traditional development methods would result in overly complex interfaces, making transformation impractical. Therefore, the value proposition of SDVs lies in their ability to interlink onboard and offboard technology domains."

Micha Muenzenmay
Department Head System Development Commercial Vehicle and Off-Road Robert Bosch GmbH

"Today's trucks can have more than 60 ECUs from many different suppliers. By moving to a centralized architecture, with one or two ECUs that are managed and updated through the software, OEMs can reduce cost and complexity. But before they can do that, they need to justify the cost of changing the architecture in an established range."

Thierry Simonin
Group Customer Vice President Commercial Vehicles, Valeo

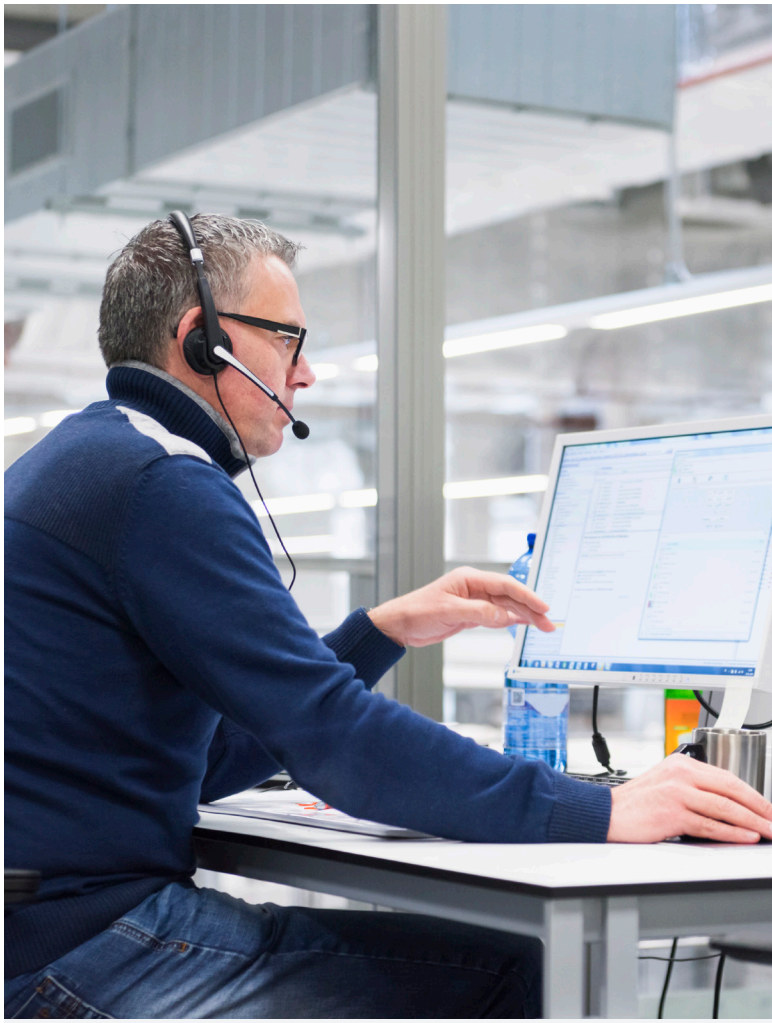
A software-centric transformation provides major opportunities

Advanced driver assistance systems (ADAS), autonomous driving (AD), personalization, and electrification are all dependent on software. New architectures and platforms will allow us to manage increasing complexity over the next decade. They provide the flexibility, adaptability, and modularity required to meet market demands, environmental challenges, and customer expectations in dense urban areas resulting from the growth of last-mile delivery.

Remote monitoring enables both predictive and scheduled maintenance, and means the vehicle is returned to the customer faster.

OEMs will offer a wide range of services with SDVs, transforming from truck sellers to transportation platform providers. This shift will unlock efficiency, requiring fewer trucks to do the same work but creating greater value.

Vehicles will be updated throughout their lifecycle as efficient, cost-effective products that can run for 20 years and take advantage of new functionalities for safety, data transparency, battery management, regulatory compliance and so on. Continuously logging, tracking, and optimizing supports productivity, uptime, and driver welfare.



"We aim to improve the vehicle's uptime, with 'update, upgrade, integrate' as our key drivers. We will continuously update the vehicle, upgrade it with more services, and integrate it into an extended ecosystem."

Pierre Sirolli
Head of Services and Solutions, Flexis

Market variation

OEMs with international markets need to cater to different needs. In the US, owner-operators value personalization and user experience, while in Europe, fleet operators focus strongly on total cost of usage (TCU). SDV customers can configure the in-truck experience through parameter-setting. In large logistics companies, it will be the fleet manager that defines those parameters, while for an owner-operator it will be up to the individual driver.

Despite these differences, both large transportation companies and owner-operators aim to reduce operating costs, such as minimizing downtime due to battery charging.

Customers will pay for SDV services if OEMs update CVs with new functions over the air, providing ROI with improved uptime and vehicle longevity.

Vehicles will become more componentized, enabling new ownership models like leasing batteries, which can be recycled and reused. This trend will likely become clearer in the next few years.

SDVs also offer a unique way to tap into talent from diverse locations. Being software-centric, they align with a software culture that can thrive anywhere in the world.

There will be opportunities to reach new customers. Some customers of logistics companies – retailers and manufacturers for example – may decide to take control of end-to-end delivery themselves. We are already seeing this in the case of Chinese manufacturers who are building giant ships, and Amazon which has bought several airlines. OEMs have an opportunity to appeal directly to these companies.

As the SDV ecosystem matures, additional opportunities will appear. For example, a full product lifecycle management approach will become possible, with benefits for the way OEMs and Tier 1s do R&D. Vehicles may never really become outdated because they will be constantly updated. The only reason to replace a vehicle will be mechanical failure or outdated performance properties – not the IT or platform becoming obsolete. And with continuous monitoring of the physical parts, mechanical failure may be deferred too.

"For SDVs to make sense, OTA updates are essential. Time spent in the workshop to fix errors means that you have an expensive piece of equipment standing idle – and recalls are even worse. If you can update the truck remotely, you can maximize its uptime."

Thierry Simonin
Group Customer Vice President Commercial Vehicles, Valeo

"SDVs will bring us the foundations on which to evolve our product. These foundations will limit time-to-market risks for us and for our customers by enabling us to keep adding new features. We always have to find a compromise between time-to-market and complex features, but OTA updates will considerably extend the opportunities."

Pierre Sirolli
Head of Services and Solutions, Flexis

SDV transformation is already underway in the CV sector

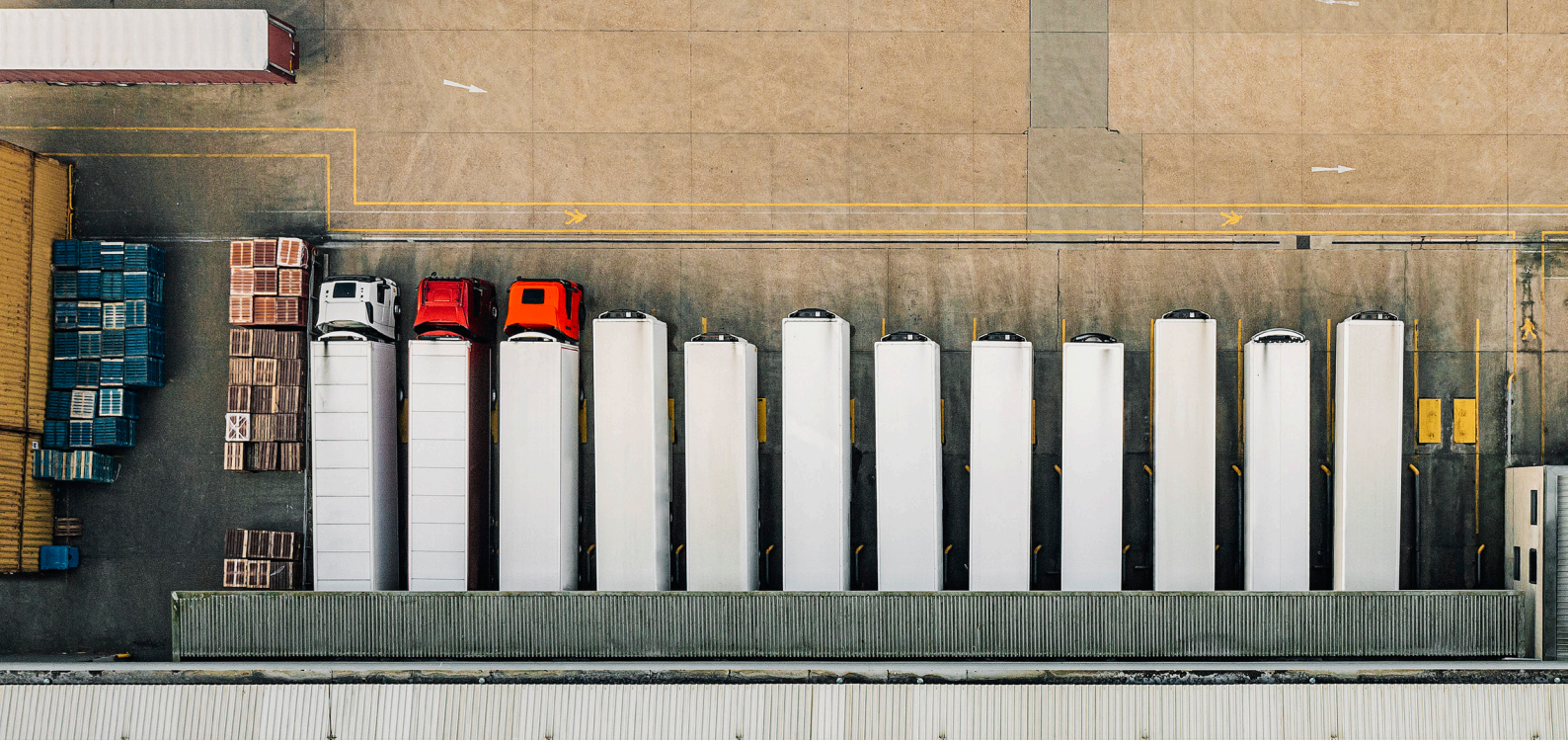
SDV transformation is already underway in the CV sector Software and connectivity in trucks are nothing new

Software has been present in both CVs and passenger cars since the inception of ECUs and the functions they support. Moreover, CV-specific software and functions such as telematics have been prominent in the CV market for 8 to 10 years, driven, for example, by MAN Truck & Bus and the RIO platform, a cloud-based digital fleet management service available since 2015. While some manufacturers fitted telematics equipment to their own trucks, this equipment was also offered to other brands "as a service." However, these telematics solutions were often added to the vehicles after start of production (SOP).

Around five years ago, we started to see increased use of connectivity to enable remote monitoring and tracking of both trucks and drivers. This was the first wave of smart trucks. Large companies are now using this technology to monitor heterogeneous fleets of vehicles across whole continents.

The switch to SDVs gathered momentum in 2024 and 2025

It is not easy to pinpoint when the industry started to focus on SDVs, but it arguably happened when companies realized that they needed a dedicated approach to managing technical – and other – complexity. That switch has been taking place over the past two years, with the first investments appearing from the start of 2024. Several software-centric initiatives from CV players are expected to grow during 2025, for light commercial vehicles and heavy-duty trucks.



Major announced initiatives to date

Flexis: This joint venture between Renault, Volvo Group, and CMA CGM is aimed at the light commercial segment of the market, and is one of the most concrete examples to date of an SDV initiative integrated into amodular vehicle platform to address several urban commercial mobility use cases.

Kia: The Hyundai brand is intending to release an SDV truck using a platform called “platform beyond vehicle” – meaning that the vehicle itself is secondary to the platform.

Tesla: Tesla is known to be bringing to the market adisruptive heavy-duty mobility solution. The Tesla SEMIheavy-duty truck is intended to replace diesel atlower operating costs, with high-efficiency energy management, combined with megawatt charging that will remove the need for dedicated charging stops.

Iveco Group: Iveco Group in Italy is embarking on a global softwareinitiative to prepare the company to develop futuresoftware-centric platforms.

Volvo and Daimler Truck: These two companies have announced the launch of a joint venture to create their SDV platform.

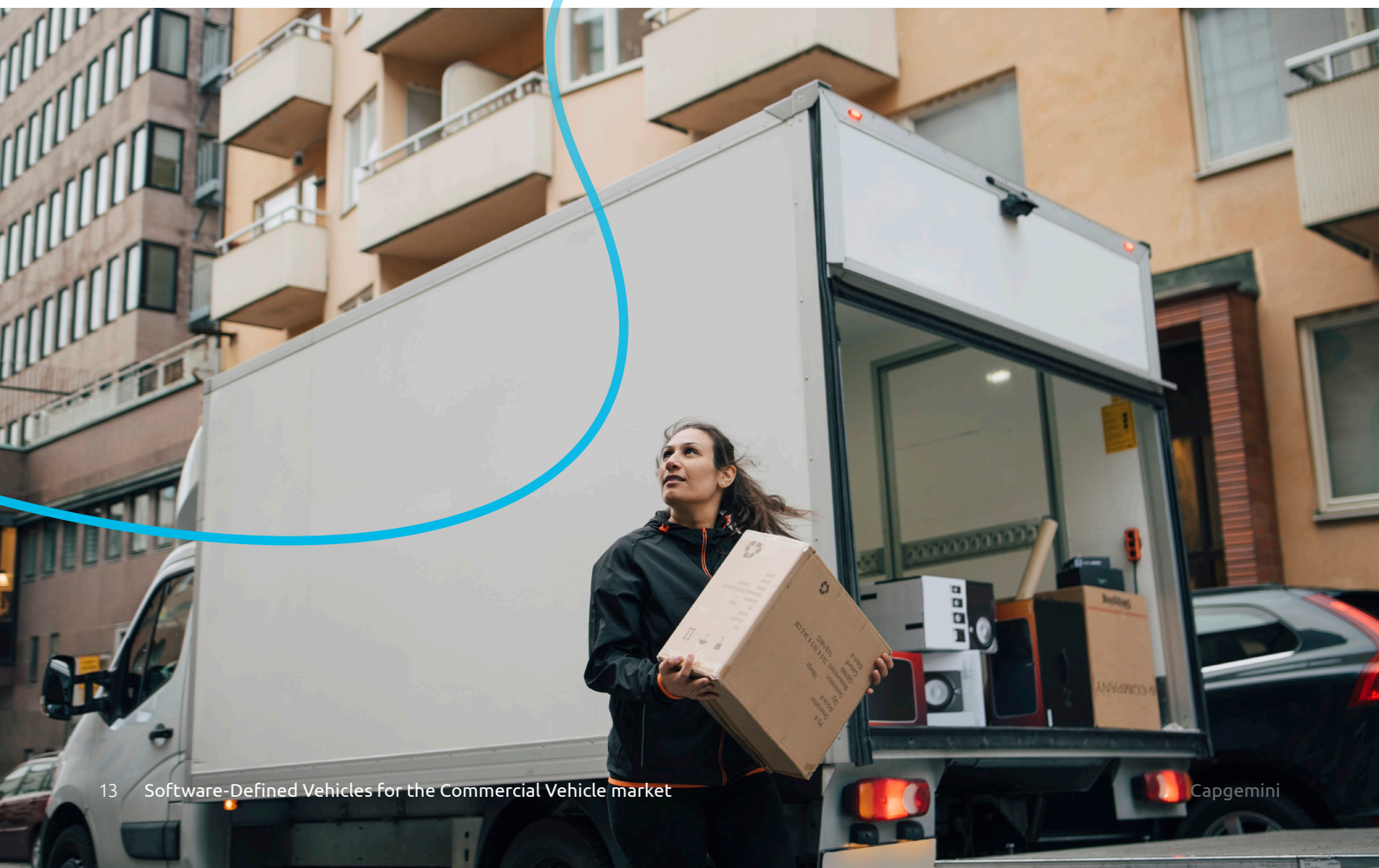
> “The passenger car segment is ahead with SDV technology. Thanks to the positioning of light commercial vehicles between passenger cars and heavy-duty trucks, we will get the benefit of these new technologies and will bring Europe’s first SDV LCV to market.”
>
> **Pierre Sirolli**
> Head of Services and Solutions, Flexis

Commercial vehicle companies must learn from passenger car SDV experience

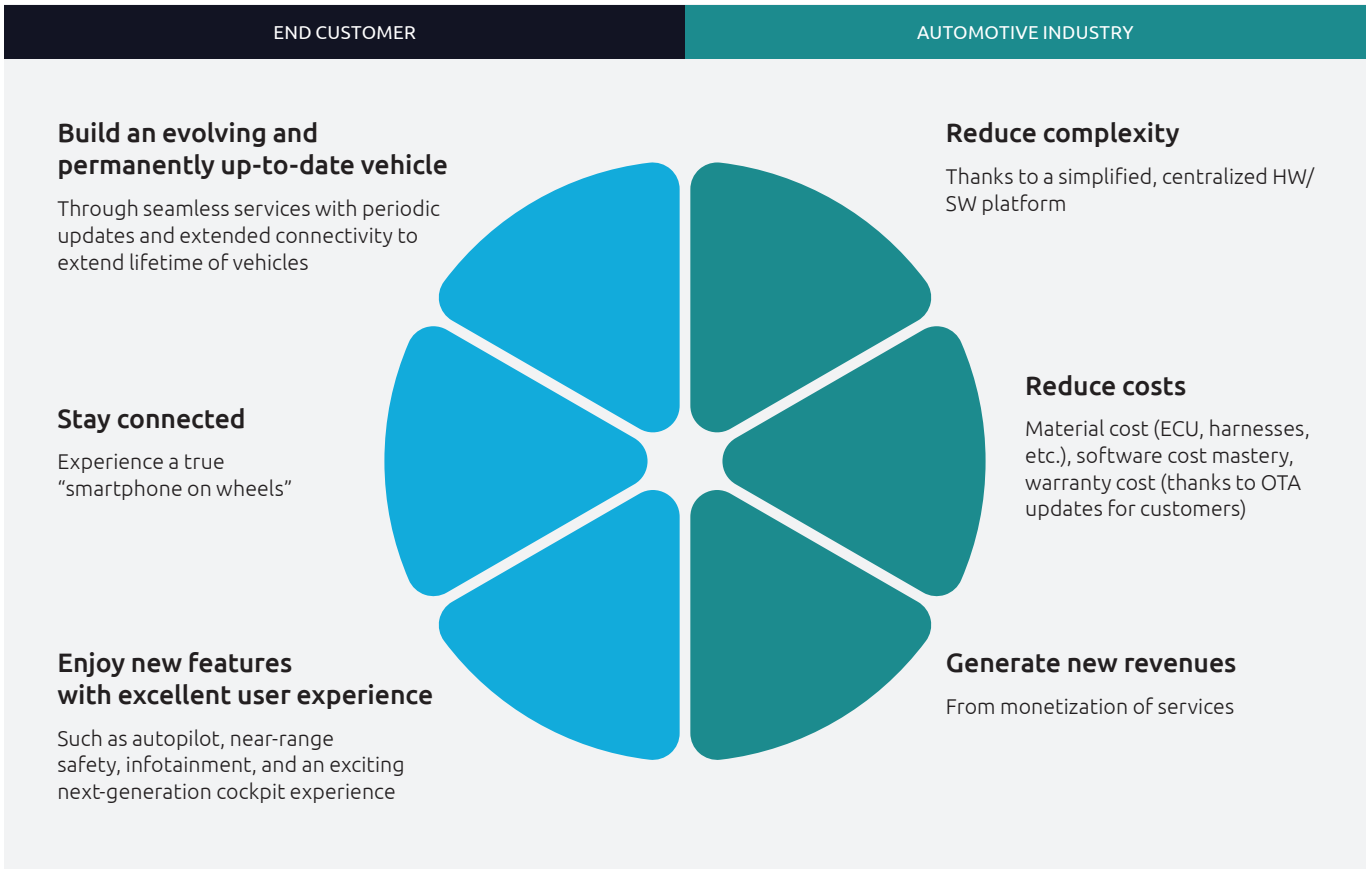
For five years, traditional automotive OEMs have been investing heavily in SDV initiatives that aimed to revolutionize the industry by integrating advanced software functions into vehicles and providing new connectivity-enabled services. Goals for enhanced revenues were ambitious (up to 50% of revenue from digital services in 2030 for some CV OEMs, and 25% for passenger car OEMs).

The initial promise covered:

- Creating a seamless digital experience
- Enabling complex cross-domain functions such as highway assist
- Achieving software-based revenues from new business models and subscriptions
- Leveraging OTA updates to continuously improve vehicles and customer satisfaction



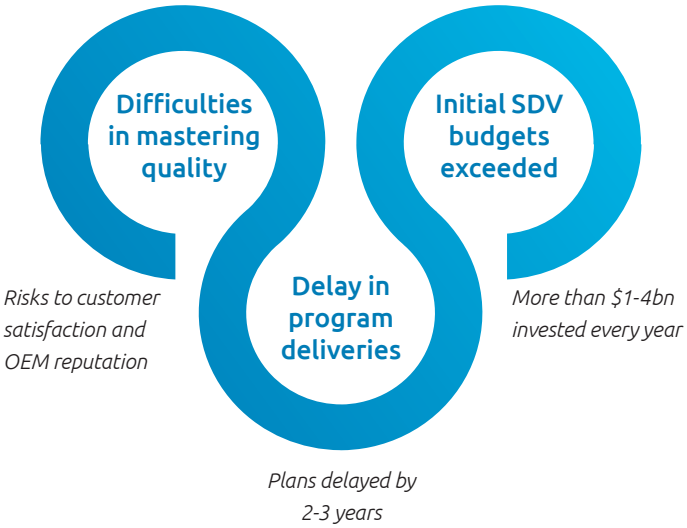
Back in 2020, SDVs seemed to herald a promising business era driven by new customer expectations



Back in 2020, SDVs seemed to herald a promising business era driven by new customer expectations However, capabilities in technologies such as service-oriented architecture (SOA), hypervisor, and high-performance computing (HPC) were needed. Companies typically invested $1-4 billion per year to create internal or standalone software entities. Thousands of software engineers were hired, and supported by software academies.

Unfortunately, the expected financial returns from these investments have not materialized. Budgets have been exceeded, and programs delayed – sometimes by several years. The expected value for end customers was not seen. As a result, strategic restructurings have been launched.

The economic and technical contexts are an additional burden on an already-complex SDV transition forcing companies to restructure.



Lessons from passenger car experience

Transforming automotive companies into software companies will likely take closer to eight years rather than the four years initially targeted, given the major tasks involved.

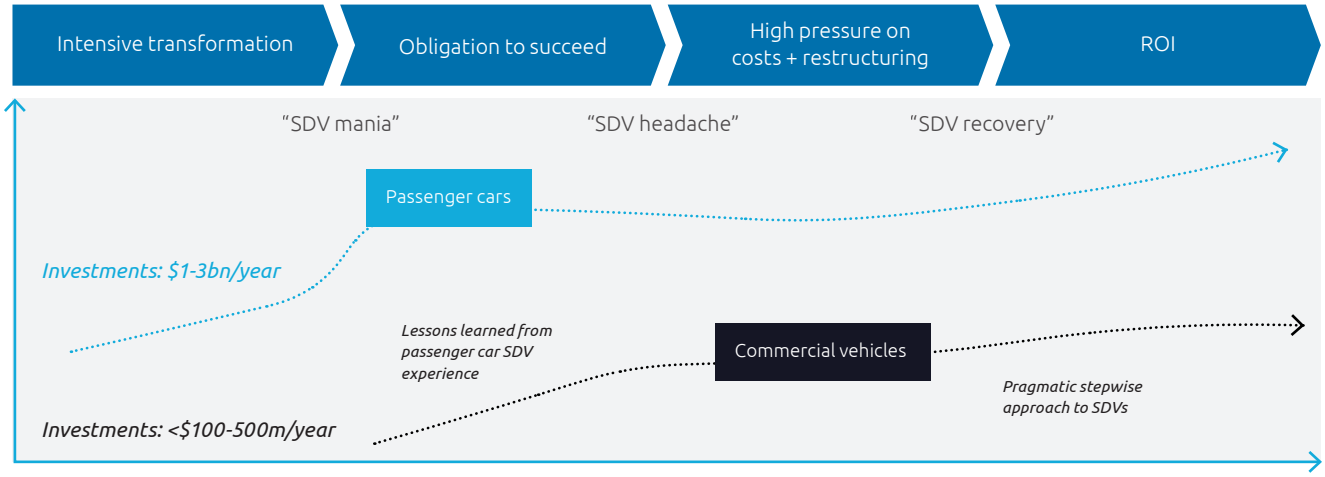
Large software delivery organizations take up to five years to scale up and reach full efficiency, while talent management remains a huge challenge. Mindsets have to be combined: systems engineering with those from the digital and tech ecosystem, for instance. New organizational structures and management approaches are needed, as well as new incremental software delivery methods and tools based on Dev/Sec/Ops and SAFe. Top leadership must promote new organizational practices to overcome resistance to change.

Developing cross-domain vehicle features requires intensive R&D effort plus an appropriate organizational approach. Complex functions such as ADAS Level 2+ and 3, or infotainment with digital experiences, require unprecedented collaboration across engineering domains, and between OEMs and Tier 1s: The R&D supply chain must be addressed as a whole.

Implementing the quality processes, methods, and tools needed to deliver high-quality, safe, and compliant software takes a minimum of three years. The software organization should be prepared to successfully undergo external audits, with evidence of compliance with industry norms (ISO 26262, ISO 21434, A-Spice, etc.). Quality management, along with process, methods, and tools (PMT) management, is vital.

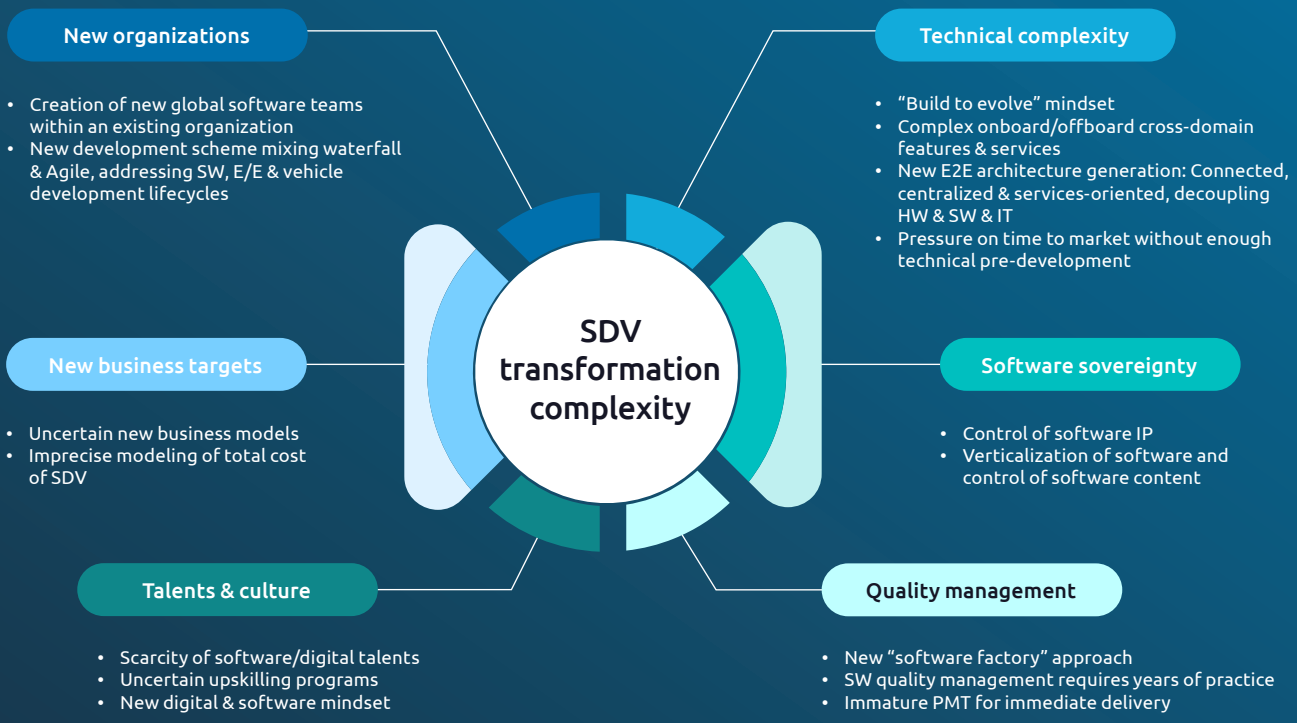
Engineering software at scale requires implementation of a broad set of dedicated technological infrastructures, guided by corporate strategy. This prevents internal competition between embedded software engineering driven by R&D and offboard application developments implemented by IS/IT organizations. Onboard and offboard development must be treated as one. Cloud-based developments, virtualization, and massive data storage must be in place to foster AI-based software development.

A pivotal moment for the automotive industry on the SDV journey
Commercial vehicle actors should learn from passenger cars



Passenger cars switching to SDV is an 8-year+ transformation - ROI is not expected before 2030

The complexity of SDV transformation was underestimated



Now is the time to start applying passenger car lessons

2025 is a decisive year for CV companies looking to move to SDVs. CV companies are allowing four to five years to produce an SDV, just like their passenger car counterparts five years ago. However, this time the plans are feasible, even though CV companies have lower initial budgets and investment capabilities than passenger cars.

The key is to adopt a strategic framework informed by passenger car SDV experience. With most CV companies just starting to define their SDV strategy, there is a great opportunity to do so.

"We urgently need to identify the business case for software-defined trucks, together with the business model, and the payback for customers. I can't wait to do that during 2025. There's a lot of interest, and now we need to translate that interest into something more concrete."

Derek de Bono
Software Defined Vehicle Vice President, Valeo

"In passenger cars, we have seen a strong imbalance between strategic discussions about software-defined vehicles and what actually ended up in series vehicles. We must understand that the only meaningful measure of progress in software is what you deploy to production, not demos, not proofs of concept."

Christian Uebber
CTO ETAS GmbH

Truck companies transitioning to SDVs face common challenges

Challenge 1: Moving to SDVs influences every aspect of the business

The industry must adopt a holistic approach, considering all aspects of intrinsic vehicle functions like powertrain and braking, while addressing both commercial and organizational development challenges. Siloed thinking must end. But this type of change is not easy.

"This transformation is ongoing and requires companies, regardless of size, to rethink their setup. It is not just about changing organizational charts but about fostering the right mindset and collaboration model, where horizontal layers ideally serve the next level. All ecosystem players need to address three levels of change – organizational change, mindset change, and technology change – to successfully transition to SDVs."

Timo Wenninger
Head of Business Unit Commercial Vehicles and Off-Road, Robert Bosch GmbH

Challenge 2: Innovation must be balanced against support for older vehicles

Legacy practices usually bring even greater challenges than legacy technology. Shifting from traditional engineering to software development disciplines is tough. However, some companies can see ways to make their legacy into a strength.

"Of course we need to transform, but we also have value in our pockets. In the past, this know-how and abilities of suppliers such as Bosch were inside a black box. With SDV we're cutting this black box open, decoupling hardware and software. Our value is more tailored allowing us to offer modular components, software and services to our customers. This is especially advantageous given Bosch's strong foundation in passenger car platforms. We can leverage this experience in the Commercial Vehicle sector, benefiting from existing expertise in sensors, high-performance ECUs, software offerings, and related engineering services."

Dr. Micha Muenzenmay
Director System Development Commercial Vehicles and Off-Road, Robert Bosch GmbH

Challenge 3: Essential resources are scarce – especially talent

With high demand across industries, attracting top software professionals to the truck industry requires customized talent management models. Change management is also essential to merging hardware and software disciplines, while fostering collaboration and mutual understanding.

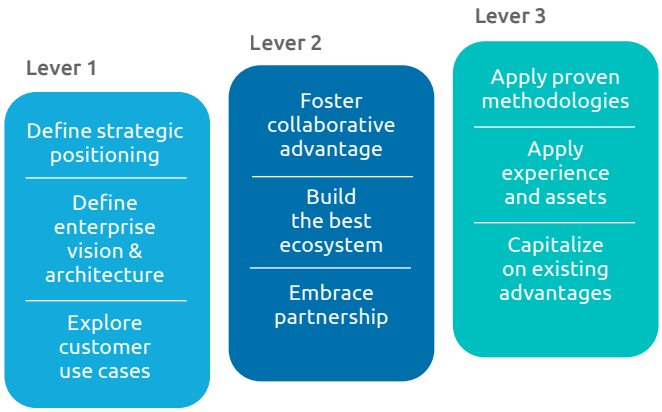
CV companies may struggle to use technologies like GenAI due to a limited supply of developers and the need to adapt processes and mindsets.

Challenge 4: Goalposts are continually shifting

During the time it takes to develop SDVs, market conditions will change, making it necessary to adjust the vision in response. It is even better, though, to anticipate change.

For instance, if truck OEMs foresee Asian competitors leading SDV design, they might consider partnering with Asian R&D now to benefit from emerging approaches – subject, of course, to business objectives, customer preferences, and the politico-economic context.

Three levers enable SDV success for CV companies



Lever 1: Get your company's strategic positioning right

Ensure top management defines the right vision for company transformation.

To succeed with SDV transformation, the right decisions need to be made about company strategy, business sovereignty, and company architecture. Business & enterprise architecture, as well as technical architecture, is vital to long-term management of complexity.

Business & enterprise architects can examine how a new business model affects the organizations and the operating models, and the demands it makes on information systems. They can explain necessary change in a way that makes sense to CXOs. Their perspective avoids the danger of focusing on a specific silo, such as engineering, at the expense of other essential aspects. It ensures coverage of all business and technical layers (addressing data, IT, program management,and infrastructure).

With this support, senior management can define the global company transformation. Capgemini has demonstrable experience of doing this with many frameworks and consulting approaches.

"Enterprise & business architects draw on techniques that have been used successfully in industries such as energy, which have already undergone complex transformations. Their experience and skills make them trusted advisors for senior management, and enable them to provide the missing link between – for example – business and IT."

Thierry Jourdan
Vice President – Chief Technology Officer - Intelligent Industry - Capgemini Invent Global

"The transformation to SDVs is not just a technical change; it is a more holistic shift.

As an engineer and architect, I am now much more involved in discussions where the question is raised: 'Is my solution architecture future ready and does the company's organization support this?'"

Dr. Micha Muenzenmay
Director System Development Commercial Vehicles and Off-Road, Robert Bosch GmbH

Create the technical vision, while moving to a new adaptative way of working

The company then needs to translate the business vision into a technical vision, but to do this successfully, the organization itself must change. Instead of being a prescriptive organization executing strategy set by senior management, it must become an adaptive one, where middle managers and their teams translate that executive vision into a day-to-day roadmap – in this instance the technical vision for SDVs.

This adaptive way of working, enabled by adoption of Agile at scale, is far better suited to a volatile, uncertain, complex, and ambiguous (VUCA) environment like today's truck market.

"Concepts like Agile, along with Lean and DevOps, are key to success in the transition to adaptive working, because they impose order on what can feel like chaos. But to succeed at enterprise level, Agile must be implemented using a proven approach and methodology that enables it to scale effectively."

Thomas Quartier
Doctor in Business Administration, Government SPCT, Principal, Capgemini

Consider collaborations by industry consortia… provided they are compatible with your start of development and start of production

Successful SDV implementation relies on robust technical foundations like OS and middleware, which were not available for the first wave of SDV five years ago. With the target of bringing in a new generation of trucks in four to five years, there are possible options like the reuse of existing implementations from the passenger car world or considering recent initiatives to bring together all relevant stakeholders to accelerate the development of an SDV ecosystem and standards.

For example, the FEDERATE consortium is formed by major European OEMs, automotive tiers, semiconductor companies, relevant industry associations, and industrial SDV initiatives, including the Eclipse SDV WG, and supported by a scientific board.

FEDERATE will work over the next few years toward a common vision for the SDV program and create orchestrated advice for current and future projects in the program. It is up to program and engineering managers to decide the right direction, but we would recommend engaging on a safe path with the most advanced available solutions to derisk the start of development for SDV CVs for model year 2028-2030.

"If you've identified SDV elements that you would be willing to undertake collaboratively, it's worth getting active in the open-source community, rather than just waiting for others to produce something you can adopt later. If you're part of the community, you can influence the result by contributing to it, and make sure your problems are solved in a way that's beneficial to you."

Ansgar Lindwedel
Director SDV Ecosystem Development, Eclipse Foundation

Unlock the potential of your SDV by first exploring every possible customer use case and B2B business opportunity

Use cases for SDVs should be evaluated by viewing the truck as an asset in the context of the customer's business, and of the customer's efficiency criteria. 100% uptime over a long period with optimized use of labor is likely to be the goal. The emphasis here is on use cases that have business value – primarily those that reduce TCO and TCU or extend longevity.

Value for customers and value for OEMs are closely related. For example, SDV-enabled maintenance services are often seen as beneficial for OEMs, but clearly, better predictive maintenance reduces TCO/TCU for operators. SDV-enabled collection of fleetwide data about driving styles, breakdowns, HMI use and so on, in combination with a closed-loop engineering approach, gives OEMs a big advantage in optimizing their product and their predictive maintenance, while improving productivity and reducing maintenance costs for operators.

Customers' willingness to pay for services is a major input to prioritization of use cases. Because of cost pressures, transportation companies are likely to pay for any services that will save money. Reducing paperwork and optimizing logistics operations through digitalization is one major way of driving down cost. Aftersales services that help to optimize operations, and to keep vehicles on the road, are likely to be attractive.

In-vehicle driver training, enriched data, can help fleet operators improve driver performance and safety.

Connectivity is also key for CVs, with a variety of use cases which are different from passenger car ones. Sharing real-time information across the fleet about road blockages and driving conditions is, of course, valuable for route optimization and productivity. But CV users also need to harvest intelligence about the fleet itself to optimize operations. For example, if a transportation company has two trucks in the same area and half of each load has already been delivered, it is often possible to reload and continue with just one truck. The other one can then be reallocated to a different task.

ADAS/AD, including cockpit monitoring systems, presents opportunities for interesting business cases in relation to safety, security, and generally assisting drivers with their demanding jobs.

Driver experience should not be overlooked, even when fleet operators, rather than owner operators, are the customers. Addressing driver experience can help to overcome labor shortages and optimize the working experience, as well as ensuring that productivity tools work as intended.

"We will only apply a SDV concept where we see value. That value falls into three categories: first, efficiency in terms of variable cost, number of components, and cost of quality; second, enabling new business models such as customization of software to add new revenue pools; and third, using ecosystems to enable collaboration with third parties and V2X interaction."

Fabrizio Conicella
Head of Software & Analytics Lab at Iveco Group

Additional questions to consider when evaluating and prioritizing use cases include:

- **Does the use case have value for the OEM as well as the customer?** Data on driving styles helps with product optimization, for instance.
- **How mature is the use case?** For example, platooning is mature in the CV market, while ADAS is well advanced for cars.
- **How easily can the use case be integrated?** Can the E/E architecture and platform enable the use case, i.e. screen availability or processing power?
- **Are there external constraints?** Regulatory limitations on testing have slowed progress on autonomous driving, for example but there are lot of progress in digital homologation.
- **Are truck customers willing to pay?** The answer is usually "yes" if the service will save money – and if it improves significantly on related services that were previously free.

Capitalize on existing advantages

Established truck players know that they have some disadvantages compared with newcomers, especially in terms of legacy technology, processes, and culture. But these traditional players can leverage advantages, such as their pragmatic, business-focused approach, industry knowledge, and telematics experience.

"For truck customers, payback is what counts, no matter what the price is. To demonstrate payback, we need to produce calculations comparing the TCO of SDVs with that of conventional trucks in a similar way to what's already been done for BEVs versus ICE. An electric truck is expensive, but if you get payback in a year through reduced fuel consumption, a fleet owner will still be interested."

Thierry Simonin
Group Customer Vice President
Commercial Vehicles, Valeo

"New entrants are starting from scratch in an SDV world and don't need to change their culture or architecture. That, together with their lower costs, gives them an advantage. But the biggest challenge is to identify customers' real needs, and what will generate positive disruption for them and that's where all players will work on to take competitive advantage"

Fabrizio Conicella
Head of Software & Analytics Lab at Iveco Group

Lever 2: Collaborate for competitive advantage

No one company can deliver a complete SDV offer, typically with thousands of features, given real-world constraints. To succeed with SDVs, the industry must move away from closed systems and toward open, collaborative models, sharing both functionality and data and embracing partnerships working across the ecosystem.

All participants in the ecosystem, not just OEMs and suppliers, will have to intensify collaboration. For example, infrastructure providers such as power generators must contribute intelligence, planning and logistics service providers must use vehicle data to optimize truck usage, and regulatory agencies must streamline processes.

"The subsystems for commercial vehicles, such as high-voltage batteries or Hydrogen tank systems & fuel cells, require intensive R&D development and certification efforts. Their prices are significantly higher than for passenger car solutions, to reach long-range mission profiles with high reliability. We consider it strategic to share with our customers the data generated by our components throughout the vehicle lifecycle, from R&D until end of life. This mutualization of data from the vehicle and the infrastructure within a digital twin concept will benefit our customers and enable OPmobility to put more affordable mobility solutions on the market with lower TCU and higher peace of mind in the adoption of these new technologies."

Yannick Raynaud
Group Scientific Director, OPmobility

Collaboration on standardization is essential. To leverage new technology effectively for SDV use case realization, companies must decouple software and hardware, using virtual ECUs and software in the loop. In this way, the development process of new features can be shifted left and integrated across various vehicle components before the final hardware is available. This can improve time to market for new services from three to four years to a year or even less. To make this strategy work, standardization is required in hardware and software.

"In the ecosystem, there are system-on-a-chip (SOC) suppliers as well, which are important players. We need to find the right SOC strategy for the industry – a CV-specific SOC could be commercially critical.

We need standardization in hardware and of course in the software as well, when it's not differentiating. Bosch already has strong partnerships with SOC suppliers today. This is one of our assets, because we are very experienced in the semiconductor area."

Timo Wenninger
Head of Business Unit Commercial Vehicles and Off-Road, Robert Bosch GmbH

Enabling management of heterogenous fleets

Fleet managers need to be able to run heterogeneous fleets seamlessly. This requires both standardization and collaboration.

In terms of standardization, efforts at the signal level, such as fleet management system (FMS) specifications, have laid the groundwork, but further abstraction layers are needed to ensure seamless data exchange across different vehicle platforms. Current initiatives include the Eclipse SDV working group, focused on software components that facilitate connectivity, OTA updates, and fleet management capabilities.

However, the CV industry still lacks a fully established SDV standard. Continued collaboration between OEMs, Tier 1s, software providers, and open-source initiatives is essential to building a scalable and sustainable SDV ecosystem.

"Our community focuses on the non-differentiating aspects of SDVs. Companies managing fleets of vehicles want to connect them all up, and there's a lot of non-differentiating enabling technology you need for that."

Sara Gallian
Senior Manager, SDV & Automotive Programs, Eclipse Foundation

"A use case that's particularly interesting for CVs is OTA updates. The heterogeneity of the fleet could be a barrier there, but with a standardized interface you can overcome this barrier. So by standardizing, each OEM can provide more value to the end customer."

Ansgar Lindwedel
Director SDV Ecosystem Development, Eclipse Foundation

Build and use the best possible ecosystem

Ecosystem working is vital to SDV transformation, enabling essential sharing of services and information via a pre-agreed contractual and technological framework. Ecosystem partners must be carefully selected, preferably with guidance from advisers experienced in both passenger car SDVs and CVs.

The ecosystem should extend well beyond traditional software supply chain partnerships. For example, it may include:

Software development tools and software stacks editors, who already have demonstrable experience of SDV for passenger cars.

Technology companies such as hyperscalers, who will enable further collaboration (e.g. by providing Android Automotive as a common SDV operating system).

Infrastructure providers, who will share information to streamline operations (e.g. trucks can be directed to the charging station with the shortest queues).

Embrace partnerships to address an increasingly dynamic environment

OEMs and Tier 1s are starting to work with partners at various levels of the supply chain to develop solutions: For instance, some OEMs are already buying directly from chip suppliers. In addition, technology is facilitating opportunistic responses to market needs, in place of fixed supplier contracts with clear timelines. This new environment requires a partnership mindset, plus agility and a focus on opportunity management.

"Even more than for cars, success with trucks depends on being part of an ecosystem, and on genuine partnership between truck makers and companies like ours. We can also expect to see more collaborations between different truck makers, as is already happening in the case of Daimler Truck and Volvo Group. It's just not realistic for one company to do everything itself. What's important is to give clear messages about where you want to go and what you want to do, then build it with ecosystem partners."

Thierry Simonin
Group Customer Vice President Commercial Vehicles, Valeo

"In the SDV world, we think that the typical "OEM – Tier 1 – Tier 2" or "fleet operator – OEM" approach is changing. As a Tier 1, we are more and more partnering with ecosystem players in new, different and more dynamic relationships."

Timo Wenninger
Head of Business Unit Commercial Vehicles and Off-Road, Robert Bosch GmbH

Give careful attention to make-or-buy decisions

Attempting to develop all the software in-house has proved unsuccessful and disruptive on some early SDV projects. Working with the ecosystem is key to success with SDV trucks and so is getting make-or-buy decisions right.

These decisions must consider:

- What functionality is core to the business, will create significant revenue, or will confer a competitive advantage.
- What IP and capabilities (including management capabilities) are available in-house or can be obtained in the appropriate timescale.
- Which ecosystem partners already have the necessary assets or capabilities available.

Building core functionality in-house is often thought to confer advantages. With a better integrated technology stack and a more streamlined workflow, it is easier to improve, say, antitheft monitoring by combining improved detection algorithms with data from cameras around the truck. However, control and integration of core functionality can be achieved through contracts, as well as by in-house development. Intellectual property (IP) can be bought as well as created.

Each CV player will need to make its own analysis of what it needs to do, own, control, etc., but existing standardized approaches can help.

Lever 3: Use proven methodologies and accelerators backed by experience

Adopt a structured approach to software delivery

Developing SDV software requires an approach that is more rigorous than truck OEMs may have experienced in the past. For example:

- The development process must be as efficient as possible, while respecting the industry's rigorous safety and security constraints.
- The delivery model must orchestrate and optimize the entire process of software development, for example for a new vehicle feature, and not just individual items.
- Automation of software creation, for example using generative AI, may make some of these other objectives harder to achieve.

To overcome software challenges like these, it is critical to have the right organizational structures and approach in place. Please refer to our recent report on Software-driven Mobility for a detailed discussion of these topics with practical recommendations for a structured approach to software development as factory model.

"Software organizations need to strive for fast iteration. A high degree of infrastructure automation, especially for testing, makes it possible to reduce the risk associated with changes. Integrating with partners and exchanging components becomes much easier than with traditional project management approaches."

Christian Uebber
CTO ETAS GmbH

Apply passenger car experience and assets

As noted above, CV companies can learn from the SDV transformation already conducted by car companies. By studying outcomes there, truck makers can avoid pitfalls such as overlooking the special requirements of software (particularly around testing); underestimating the importance of OTA updates; rewriting software elements when they could be re-used; and tackling the whole portfolio at once instead of a specific segment.

It should also be possible to transfer assets from the car world to trucks, using parameters to reconfigure them as necessary. For example, ADAS takes account of weight and steering ratios, so going from a car to a truck has a lot in common with going from a small car to a large one. This could provide a huge advantage over starting from scratch.

"Our range of products for the passenger world – for example, the high-performance computers – are a strength for us in developing dedicated truck products. Naturally, it's not just a matter of cut-and-paste because truck-specific additions will be needed in areas like Lidar and cameras, but it gives us a good base to work from. Using our existing building blocks, rather than reinventing, will ensure we're competitive in the truck SDV market."

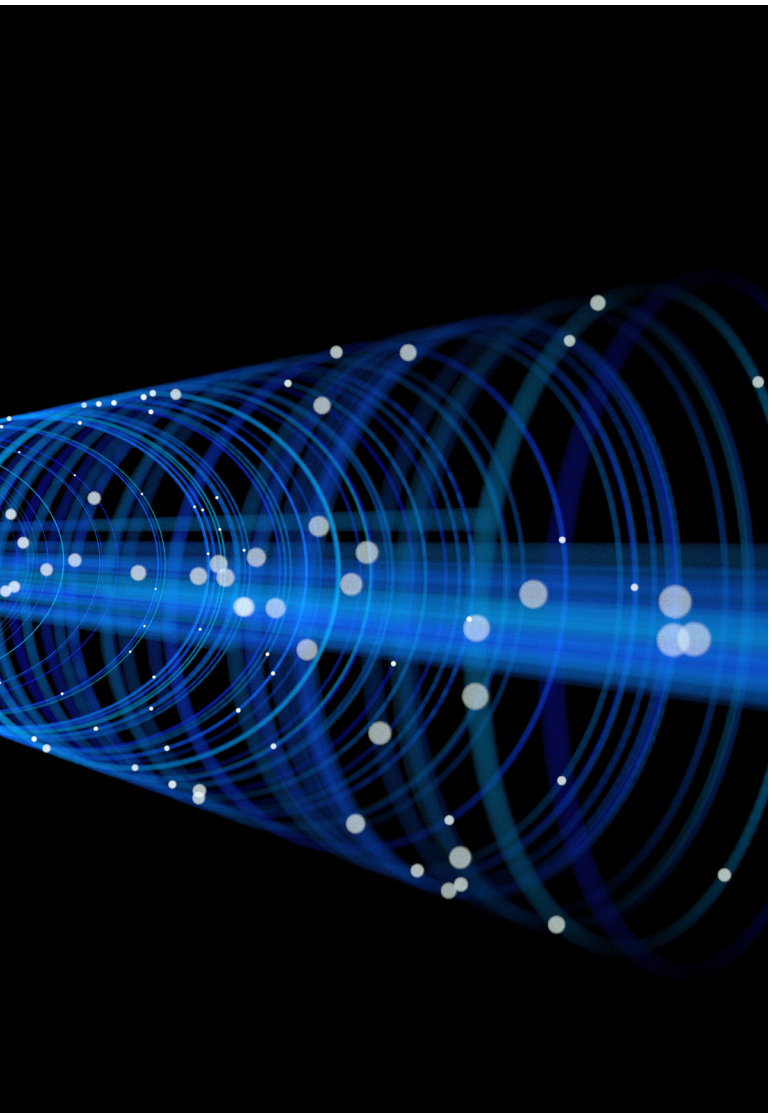
Derek de Bono
Software Defined Vehicle Vice President, Valeo

"The biggest lesson learned from the passenger car sector is to start small and think big. Have a clear vision in your mind, but don't try to tackle all domains in one shot. It's much better to start with a small, capable team collaborating with the right Agile partners, and then expand later."

Fabrizio Conicella
Head of Software & Analytics Lab at Iveco Group

Consider building an end-to-end system combining software with services

To optimize time to market and stay within budget, a platform-based architecture is likely to work best. Custom add-ons to a standard foundational platform can then be used to meet specific client requirements. This approach means that a minimum of 80% of the product must be common to all vehicles, and just 20% needs to be customized.



Understand the starting point

It is vital that the SDV development strategy reflects the individual company's current maturity in terms of software engineering. Companies must assess up front what they have in terms of relevant people, skills, assets, tools, software and so on, and plan accordingly.

Capitalize on existing advantages

Established truck players know that they have certain disadvantages compared with newcomers – mainly in terms of legacy technology, processes, and culture, but also because in many cases OEMs have vertically integrated items like batteries, power electronics, and drive systems.

However, the traditional players can leverage their brand image, customer network, and aftersales loyalty by enhancing an already established customer experience through SDV features.

Advantages of "software to cloud" approach combining vehicle engineering and off-board services

By providing more control over the supply chains, vertical integration can make it faster and easier to integrate different features such as wellbeing, driver communications, and ADAS. With a better integrated technology stack and a more streamlined workflow, it becomes straightforward to improve, say, antitheft monitoring by combining improved detection algorithms with data from cameras around the truck and so on. There are opportunities to negotiate the use of suppliers' IP or obtain interface details. Siloed working must be avoided.

Launch – or accelerate – your SDV journey with Capgemini

The next few years will decide CV companies' success with SDVs. Capgemini has a dedicated team of experts ready to support clients' journeys. In fact, we are already engaged in trailblazing initiatives to implement SDVs for CV clients. Our capabilities include the following combination of strategic advisory, transformation programs, engineering product development and connected services.

Defining strategic positioning for a new market: CV companies must decide where to play to optimize their profitability and market position. A company could focus on core development, charging, or analytics, for example. Alternatively, it could invent something unique, making its product critical to customers' businesses. Capgemini helps clients find the best fit for their organization and ambitions.

Transforming enterprise behavior: SDV deployment changes the way a CV company operates and is structured, and the process and methods it uses to build products and services and to make decisions – which implies challenging cultural change. Capgemini has the transformation management know-how to make all this happen.

Leveraging and seamlessly integrating a partner ecosystem: Capgemini knows how to integrate different solutions into a homogeneous, effective, and maintainable landscape. That allows our CV clients to focus on developing differentiating features, while safely and securely handing other elements of the value chain to external partners.

Deploying SDVs in the context of software-defined transformation (SDT) and software driven mobility (SDM): SDVs require complex concepts such as compute on the edge and OTA delivery. We help clients select or build, deploy, and integrate all these technologies in a way that makes sense within their wider SDT and SDM strategies.

Offering a proven, structured approach: The right approach makes it possible to combine the skills and practices of established IT with new digital ones, and with those of manufacturing and vehicle engineering. We have the frameworks and toolsets to achieve all this fast and effectively. For example, our software approach is summarized below.

Our software approach

Accelerating to transform into a **Software Company**	Setting the foundation of a **Software Platform**	Streamlining industry-grade **Software Delivery**
Defining a Software Strategy leveraging core capabilities and prioritizing investments	Establishing end-to-end Architecture Standards for product and services	Creating a streamlined Software Factory [Processes | Methods | Tools]
Addressing Talent & Culture through a reskill & upskill and change management program	Ensuring Software Compliance to regulations, standards, and contractual terms	Shaping an innovative Testing Strategy focused on end-user experience
Driving the Software Transformation and execution of the value model	Setting up and running a Cyber-Security Program [Define | Protect | Defend]	Setting up and running Efficient Testing across all environments

Customizing Software across business:

Software for Products | Software for Services | Software for Enterprise

Credentials

https://www.capgemini.com/insights/expert-perspectives/software-defined-vehicles-answer-to-truck-driver-shortages/

https://www.capgemini.com/insights/research-library/delivering-software-driven-mobility-experiences/

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With thanks

We would like to thank the following people for sharing their insight to help us shape this paper

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About Capgemini

Capgemini is a global business and technology transformation partner, helping organizations to accelerate their dual transition to a digital and sustainable world, while creating tangible impact for enterprises and society. It is a responsible and diverse group of 340,000 team members in more than 50 countries. With its strong over 55-year heritage, Capgemini is trusted by its clients to unlock the value of technology to address the entire breadth of their business needs. It delivers end-to-end services and solutions leveraging strengths from strategy and design to engineering, all fueled by its market leading capabilities in AI, generative AI, cloud and data, combined with its deep industry expertise and partner ecosystem.
The Group reported 2024 global revenues of €22.1 billion.

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