Impact of smart electric mobility as a service on the automotive industry and supply chain

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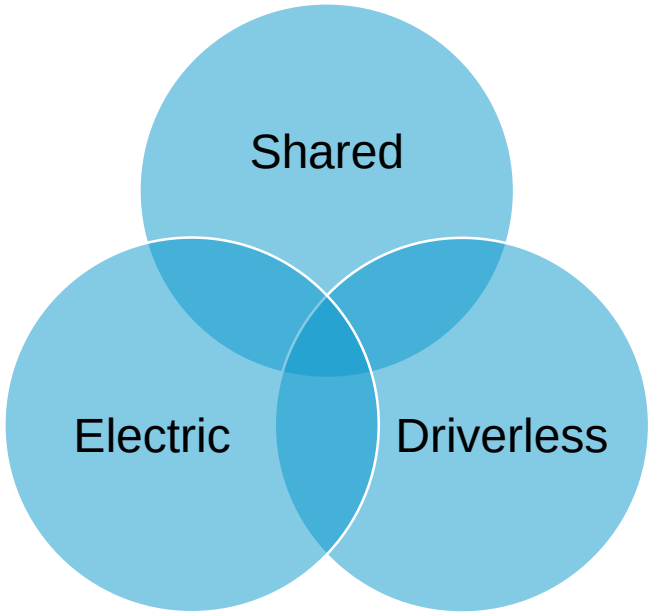
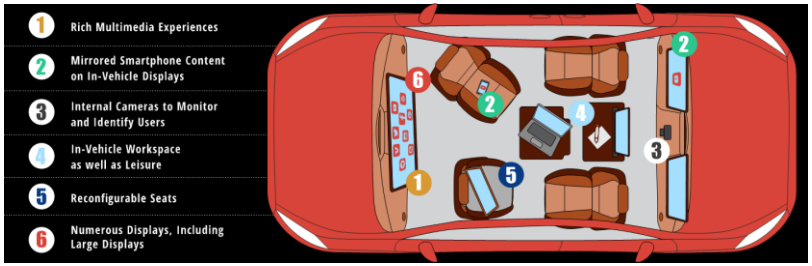
New Smart Mobility Paradigms

Mutually interdependent paradigms

- **Ridesharing and driverless vehicle sharing**
  - Decreasing vehicle ownership
- **Mobility as a Service (MaaS)**
  - Multi-modal – vehicles, transit, 2-wheel
- **Electrification**
  - Seamless wireless charging and V2G
- **Networked Vehicle – V2X, V2H, ….**
  - Cooperative and collective environment

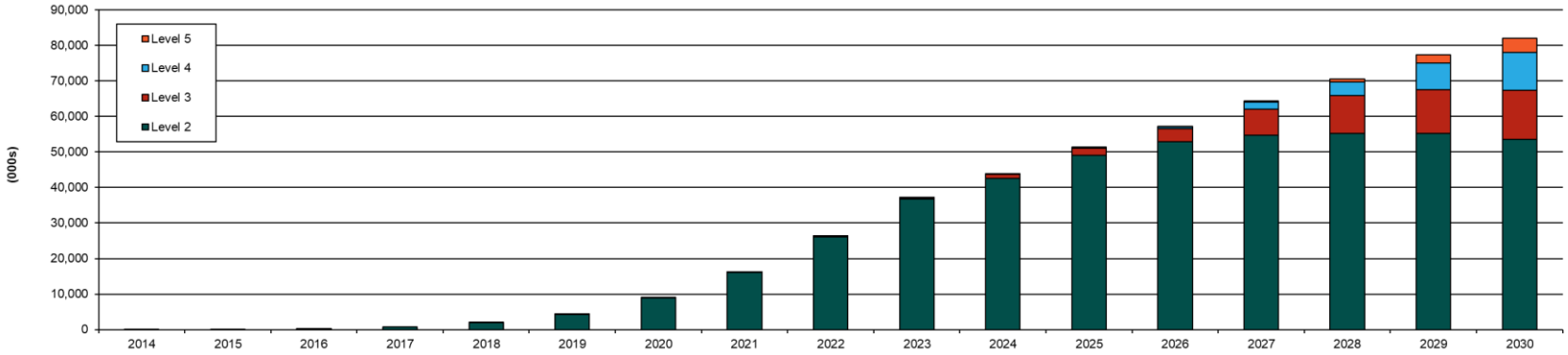


- Commoditization and consolidation
- Fleet paradigm – shift from B2C to B2B
- Much higher mileage
- Shift from mass market to batch designs
- Multi-use / modular vehicle designs
  - Mixed mobility / freight use
- Cross-vertical applications

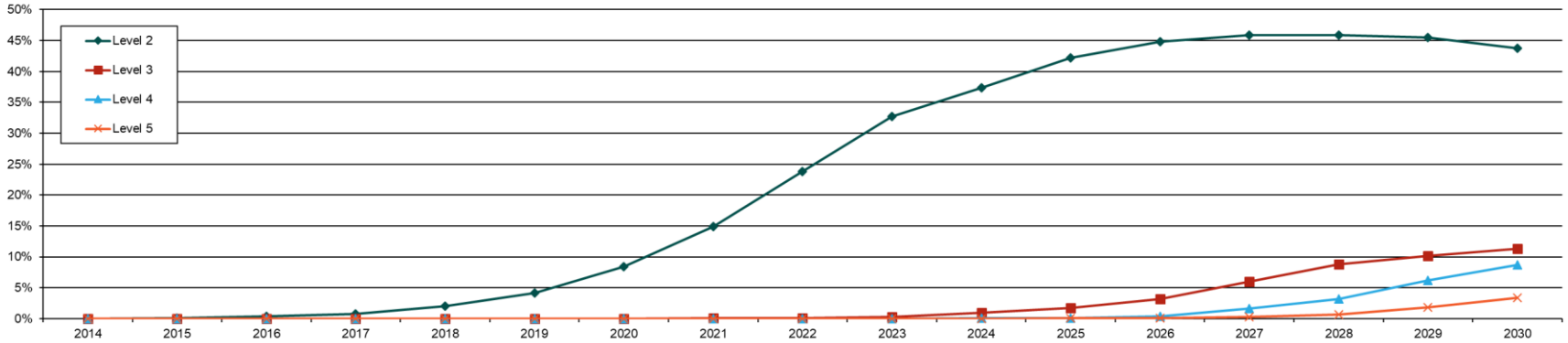


Driverless Vehicles: data points and forecasts - shipments

Autonomous Passenger Vehicle Shipments by SAE Level, Global, Forecast: 2014 to 2030

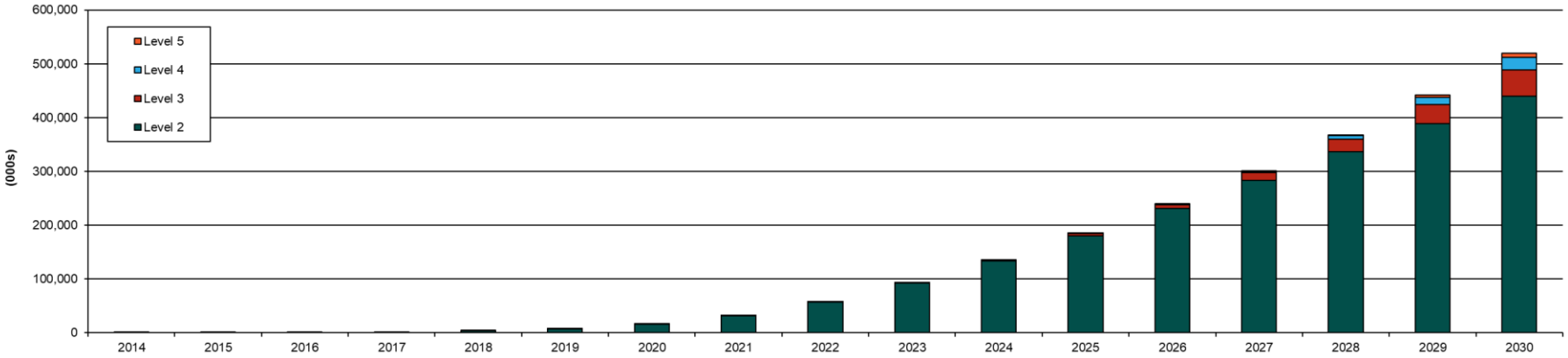


Autonomous Penetration of New Passenger Vehicle Sales , Global, Forecast: 2014 to 2030

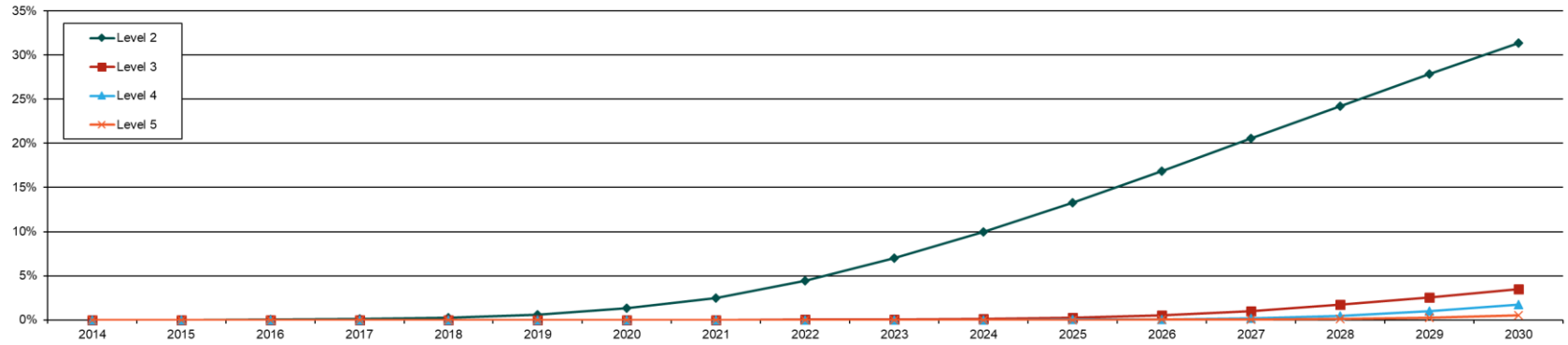


Driverless Vehicles: data points and forecasts – installed base

Registered Autonomous Passenger Vehicles by SAE Level, Global, Forecast: 2014 to 2030



Autonomous Penetration of Registered Passenger Vehicles , Global, Forecast: 2014 to 2030



Driverless Vehicle Sharing Dynamics in Cities

By 2030	Consumer Owned	Ridesharing	Driverless Car Sharing	Driverless Carpooling
Utilization Rate	< 5%	20-30%	> 50%	> 50%
Yearly Vehicle Mileage	10k	30k-50k	100k	100k
Yearly Person Mileage	15k	40k-60k	100k	300k
Number of cars	1 billion	33 million	10 million	1 million
Number of Users	1.2 billion	1.7 billion	730 million	150 million
Share of Cars	> 95%	3.3%	1%	0.1%
Total Vehicle Miles	10 trillion	1.32 trillion	1 trillion	100 million
Share of Vehicle Miles	80%	10.5%	8.5%	0.9%
Total Person Miles	12 trillion	1.65 trillion	1 trillion	300 million
Share of Person Miles	80%	11%	6.7 %	2%
Cost per Mile Person	US$1	US$1.5	Less than US$0.50	Less than US$0.15

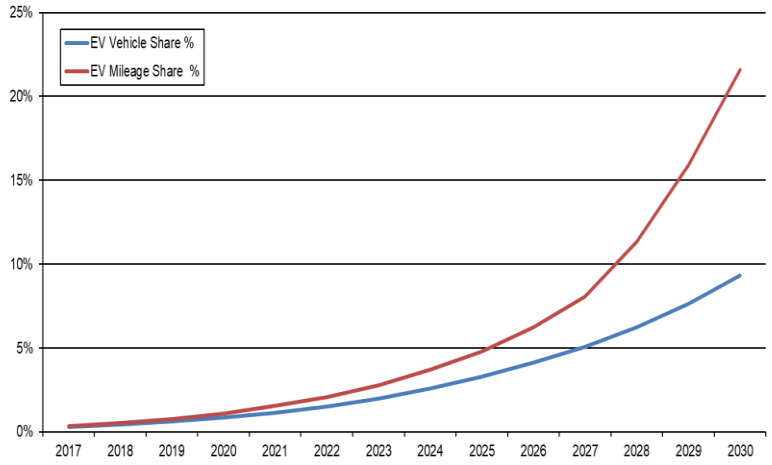
- **11 million driverless cars by 2030**
- **Less than 1% of registered vehicles**
- **10% of total number of miles/journeys**

By 2050

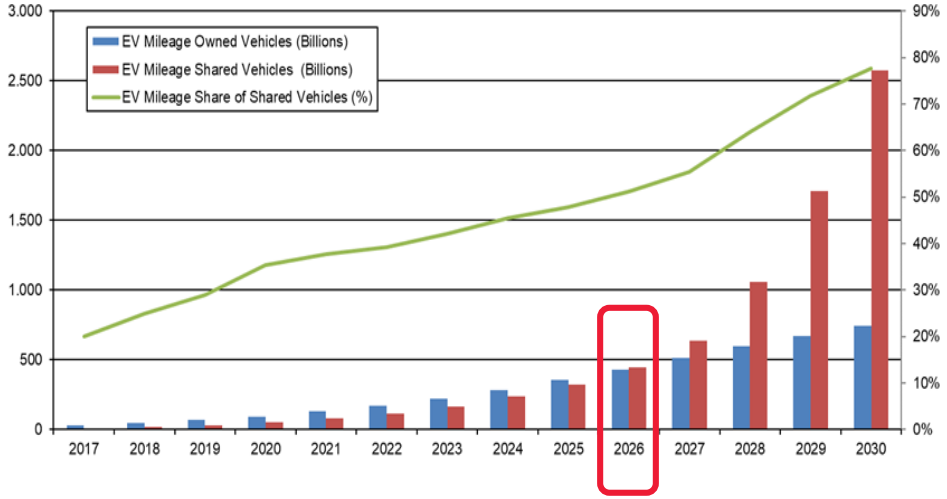
- **50 million driverless (5% of vehicles)**
- **50% mileage share**

Electrification and Vehicle Sharing

Electric Vehicle Share versus Electric Mileage Share, World Market, Forecast: 2017 to 2030



EV Mileage and Share of Owned versus Shared Vehicles, World Market, Forecast: 2017 to 2030



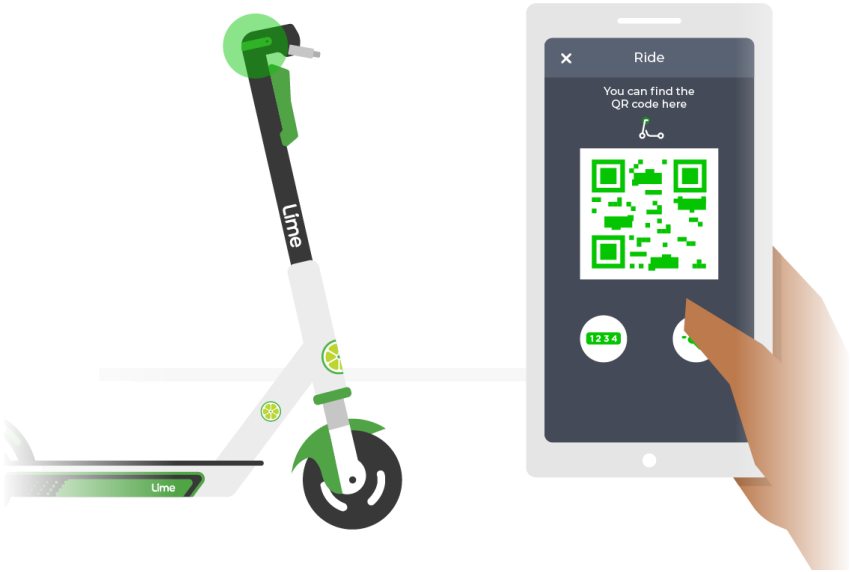
Uber EV Champions Initiative

California State Senate Bill:
Electrify California Ride-Hailing (E-CAr)

- Quotas for miles traveled by ride-hailing services in EVs:
  - 20% by 2023; 50% by 2026
  - 100% of vehicles purchased/leased/contracted to be EVs by 2030

Dockless electric 2-wheel vehicle sharing

Bikes, Scooters, and Motorbikes



Impact on Automotive Supply Chain

- **Lower volumes shipping**
  - Sharing paradigm, driverless taxi, car as a service
- **Number of components**
  - Increase of complex hi-tech components
  - Electronic components represent 35% of total material costs; 50% by 2030
  - Up to 50% engineering budgets spent on electronics R&D development
  - Reliability/testing requirements
- **New design, testing, and verification methods for driverless technologies**
  - Hardware-in-the-loop, model-in-the-loop, and software-in-the-loop products
  - Simulation
- **New manufacturing technologies**
  - Generative design – lighter and stronger components
  - Additive / 3D printing for complex mechanical parts
  - More distributed and adaptable manufacturing supply chain
    - Additive manufacturing equipment can be repurposed instantly by updating digital designs
    - Can be replicated instantly anywhere in the world, less of a delay in rolling out new designs.
    - More uniform adoption of new innovative vehicle designs
    - Enables repair/maintenance/lifecycle management
    - Individual parts can be more easily replaced on demand and manufactured closer to the point of consumption
    - Reduction in supply chain and shipping costs

Impact on Automotive Supply Chain

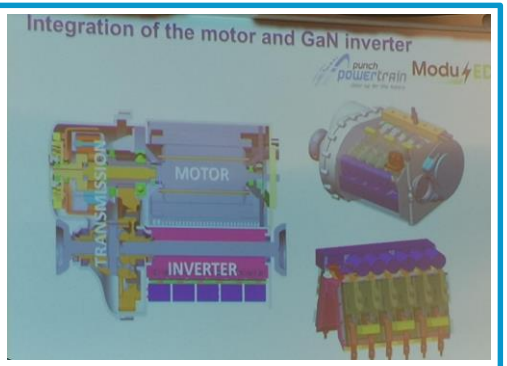
- **Personalization and customization**
  - Shift from mass production of standard vehicle models towards …..
  - …. manufacturing of customized designs optimized for shared mobility in geofenced contexts
  - Changing market trends and consumer demands
  - Shift from B2C to B2B

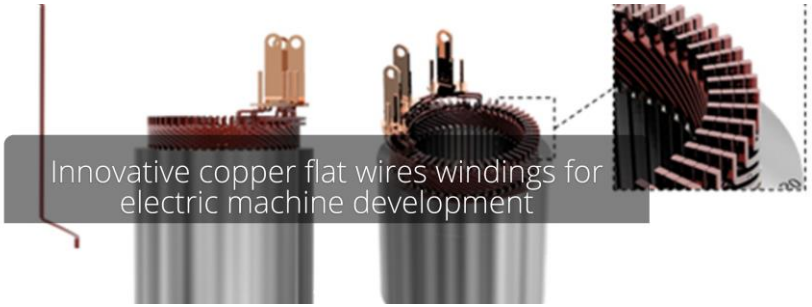
- **On-demand Manufacturing and Supply**
  - Small batch sizes – design to spec of shared mobility operator
  - Strategic deployment and flexible redeployment of vehicle
    - According to short and long term demand patterns in order to optimize utilization

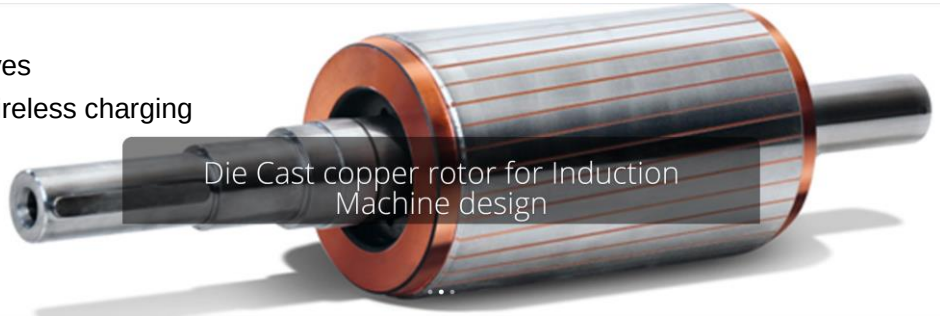
- **Lifecycle management of vehicles on the road: from products to software and services**
  - Software updates (cyber security monitoring outsourced to suppliers)
  - Hardware upgrades (modular designs)
  - Overall refurbishing of vehicles (blockchain)
  - End-of-life recycling (reverse logistics)
    - Expensive materials
    - Environmental concerns

Impact on Automotive Supply Chain – Electric Vehicles

- **Huge increase of number of EV models**
  - VW plans 70 electric models by 2030
- **New (lightweight) materials and new suppliers**
- **Huge reduction in number of components and parts**
  - Integrated motor, inverter, transmission, regenerative braking, and cooling designs
  - EU-funded ModulED consortium
- **Transportation of hazardous materials (batteries)**
- **New manufacturing methods**
  - Injection molding of magnets in rotors of electric motors
  - Hairpin rotors
- **Rare Earth magnets (Neodyium) free electric motors**
  - EU-funded ReFreeDrive project
    - Induction and Synchronous Reluctance Machines for electric vehicle drives
    - Replace permanent magnets with copper coils
- **Recycling of expensive / limited resources EV materials**
  - Copper
    - European Copper Alliance – limited copper reserves
    - Increased use of copper for electric motors and wireless charging
  - Magnetic materials



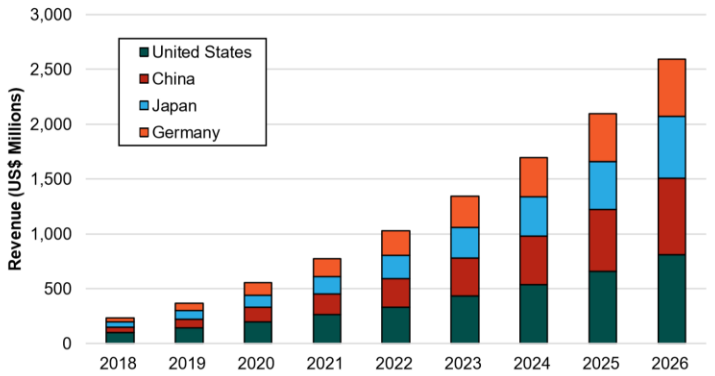




How should the Automotive Supply Chain React?

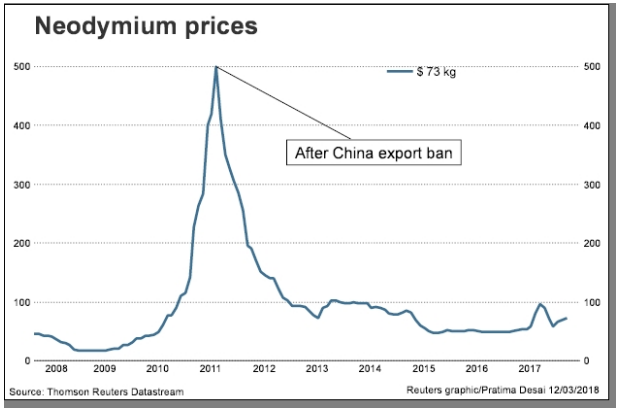
- The automotive supply chain will have to become more **agile**
  - Pressures linked to consolidation, automation, and globalization
  - Develop new skillsets
  - Accelerate responsiveness to market changes
  - Support and manage rapidly changing R&D processes
  - Improved demand planning and forecasting
    - Virtuous cycle: feed in demand data / anticipate changes in demand
    - Use of AI to detect longer term patterns and trends
    - "Connects the supply chain with the demand chain"
- Prepare for supply chain **disruption**
  - Support new components, new suppliers, new ownership models and new vehicle types
- Achieve extreme level of **operational efficiencies and cost savings**
- Increased **competitiveness** via supply chain digitization and automation
  - Industries 4.0 / IoT platforms
  - Robotics

Digital Factory Revenue (Excluding Hardware) in Automotive Manufacturing by Country
China, Germany, Japan, and the United States, Forecast: 2018 to 2026 *(Source: ABI Research)*



How should the Automotive Supply Chain React?

- **Just-in-time delivery and logistics**
  - Supply of materials in the global production networks
  - Reduction of inventories
  - On-time deliveries of new vehicles to clients
- **Higher degrees of cooperation and integration across the supply chain**
  - New manufacturing paradigms such as additive & automation
  - Cross-dependency among OEMs and suppliers
- **Automotive supply chains will have to be reorganized**
  - Adoption of new technologies in order to support on-demand deliveries
- **Visibility, responsibility and sustainability in the EV materials supply chain**
  - Supply risk – commodity monopolies
  - Cost
  - Market uncertainties
  - Environment
  - Human rights and worker protection



How should the Automotive Supply Chain React?

- **New R&D, engineering, design, and testing tools and approaches**
  - **CAD / CAM**
  - **Augmented and Virtual Reality**
    - Augment worker capabilities
    - Training
    - Prototyping for accelerating development and cost savings
  - **Digital twins** - manufacturing process efficiencies and up-time
  - **Blockchain** – reliable end-to-end component tracking across the supply chain
  - **Data analytics and AI**
    - Crowdsourcing usage data from connected vehicles in the field
    - Predictive maintenance – critical for always operational fleets of shared vehicles
    - Product development
  - **Cloud storage and processing**

- **Collaborative robots**
  - Mobile robots / Autonomous Mobile Robots (AMR)
    - Automated warehouses / distribution centers
    - Robots added/removed to the intralogistics workflow
  - Flexible robotic intralogistics

Case Study - Mercedes-Benz - Blockchain

Transparency/visibility in supply chain and procurement

- Partnership with contract management software provider Icertis
  - Icertis Blockchain Framework / Smart contracts
- View, share and update critical documents such as bills of lading, invoices, terms and agreements relating to a particular shipment or transaction.
- From supply of raw materials, their refinement, use in components across the supply chain to factory delivery
- Sub-suppliers contractual obligations on working conditions, human rights, environmental protection, safety, business ethics and compliance within the supply chain.
- Improved traceability of components and raw materials
- Each supplier is required to record contract details, including sustainability requirements
- Increase transparency in increasingly complex global supply chains
- Enforce compliance requirements
  - GDPR, security, International Trade in Arms Regulation (ITAR), Foreign Corrupt Practices Act (FCPA)

Similar initiatives from SEAT and Ford

Summary and Conclusions

- **Automotive Smart Mobility revolution**
  - The shared, electric, and driverless vehicle
- **Manufacturing and supply chain are an integral part of the automotive revolution**
  - Technology adoption to match that of in-vehicle technology
- **Electrification creates new challenges for manufacturing and supply chain**
  - Design, materials sourcing, recycling
- **Organizational and business challenges**

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