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- Ten year forecasts.
- Assessment and roadmaps of enabling components and allied technologies driving progress.
- Detailed company profiles and direct interviews.
- Opportunities and demand assessment: the global picture.

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# Autonomous Cars and Robotaxis 2020-2040: Players, Technologies and Market Forecast

Peak car, robotaxi, mobility-as-a-service (MaaS), lidar, radar, camera, HD map, AI software, cybersecurity, 5G and V2X



Slides  
378

Forecasts to  
2040

Autonomous driving provides huge value opportunities for a wide range of stakeholders across the mobility sector. This report offers an in-depth analysis of key enabling technologies including lidars, radars, cameras, AI software, HD maps, and 5G & V2X. Key players with their latest technologies and product commercialisation plans are presented as the case studies of this report.

We provide a twenty-year market forecast, in both sales numbers and revenues, for both private-owned autonomous cars and shared cars for mobility services. For the market value forecast, we break it down into the revenues from AV sales as well as revenues from AV mobility services. We built a twenty-year model because our forecast suggests that the transformation towards fully autonomous driving will take place over a long timescale. We also build a twenty-year market value forecast for the key components of AV systems - lidars, radars, cameras, AI software, computers etc. According to our forecasts, by 2040 global autonomous car (SAE Level 3+) and robotaxi services will become a \$2.5 trillion market. By 2030, the autonomous driving system (including lidars, radars, cameras, computers, software and maps) market will reach \$57 billion; the market value will more than triple by 2040, reaching \$173 billion.

Key issues addressed in this report:

- *Introduction to autonomous driving and the passenger car market landscape*
- *Who are the key players in the autonomous car ecosystem? What are the progresses in terms of AD development so far and what are their commercialisation plans?*
- *Key enabling technologies for autonomous cars: in-depth and comprehensive analysis of technology trends of lidar, radar, camera, AI software and computing platform, HD maps, cybersecurity, teleoperation, 5G and V2X*
- *How MaaS and AD technologies will shape the future travel landscape? And how AD-enabled MaaS will impact the passenger car market?*
- *Twenty-year market forecast for autonomous cars in both unit numbers and market value*

This report provides a comprehensive view of all the enabling constituent technologies. In terms of radars, the report develops a comprehensive technology roadmap, examining the technology at the levels of materials, semiconductor technologies, packaging techniques, antenna array, and signal processing. It demonstrates how radar technology can evolve towards becoming a 4D imaging radar capable of providing a dense 4D point cloud that can enable object detection, classification, and tracking AI.

In terms of lidars, IDTechEx identified and analysed more than 100 players developing 3D lidars. This report examines all the technology options for the measurement process, light source, photodetector, and beam steering mechanisms. In case of the latter, it examines mechanical, MEMS/MOEMS, optical phase arrays, liquid crystal, 3D flash, and other technologies. The report examines the key players, categorising them by technology, investment, and geography. The report provides market share projections by lidar technology as well as price evolutions within the next decade.

In terms of cameras, the report first focuses on trends in global shutter (GS) CMOS image sensors. Here, we consider the key technology performance levels, pixel architectures, and latest innovations including back-side illuminated GS-CIS and organic and quantum dot hybrid GS-CIS. The report also examines means of boosting the NIR sensitivity of CMOS sensors. Finally, the report outlines and analyses existing and emerging technology options for SWIR sensing such as InGaAs, silicon (IPE process), quantum dots, and organics.

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# Robot Shuttles for Smart Cities 2021-2041

Symmetrical, multipurpose, empowering, zero-emission, future transport, robotics, artificial intelligence, lidar, radar, camera, MaaS, 5G, 6G, battery, taxi, bus, compare robotaxis, Toyota, Honda, Amazon, GM, Baidu, Dubai



Slides  
595

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2041

Robot shuttles just got serious. The first large orders have been placed. More of the world's giant companies have entered the fray, some even likely to be both customers and manufacturers. On cue, analyst IDTechEx has launched this new report to explain the new realities and to present technology roadmaps and forecasts for 20 years ahead.

Robotaxis are a partially competing option. They are autonomous, battery-electric cars operated by the likes of Uber and taxi companies. Private cars are only used a few percent of the time and then only rarely full. When autonomous, they may be bought by people with less money because they can be lent to Uber as robotaxis when not in use. If you believe Elon Musk.

The new report maps and predicts how robot shuttles are very different, nothing short of a new form of transport being created from the ground up by about 40 organisations. These boxes on wheels are designed for smart cities and for more than road travel. Usually maximum speed is gated at 30-60 km/hr. Front-back-symmetrical means no U turns so they can quietly, cleanly go where cars are banned - down paths, into shopping malls, over plazas. Some even have crab-action sideways. Unlike a regular taxi or car, large sliding doors create fast entry/exit even of the disabled in wheelchairs. These doors do not swing open to kill cyclists nor do they prevent exit in confined spaces.

Uniquely, robot shuttles are made to be rapidly reconfigurable for multiple tasks even in one day with many formats, signage changes etc. Most have standing room and all-round large windows prevent claustrophobia compared to a robotaxi. The windows can contain the new microLEDs selling advertising. Standing room minimizes cost and road footprint per passenger.

See new infograms, tables and graphs comparing all options and new technology commitments from 2021 such as solar bodywork. Absorb other ideas and benchmarking from multi-lingual PhD level IDTechEx analysts across the world.

Latest news is that the projects are splitting into small and large sizes. 4-6 seaters are not very versatile and compete with robotaxis in locations penetrated. They have lowest cost but limited ability to get people with monster bags to the airport at speed. More mainstream is the larger ones typically 10-25 passengers including standing. These can additionally compete with school, micro and midi buses, even last mile package delivery and repurpose to mobile libraries, fast food, temporary event ticketing stands and more. However, it now emerges that some of this is achievable electrically but some is best done with new modular body replacement allowing repurposing through the day or the week. The report therefore covers all this new progress and platforms.

Questions answered by the report include:

- *Forecasts numbers and value 2021-2041?*
- *Addressable market segments in detail and strategy options?*
- *Potential smart city partners and services?*
- *Results of trials from Japan to Europe and USA. Options of empowerment, inner city circulator etc.?*
- *Technology roadmaps 2021-2041?*
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# Automotive Radar 2020-2040: Devices, Materials, Processing, AI, Markets, and Players

ADAS and autonomous driving, 4D imaging radars, semiconductor technology, low insertion loss materials, advanced packaging, deep learning, object detection/classification/tracking



Slides      Forecasts to  
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This report investigates the market for radar technology, specifically focusing on automotive applications. It develops a comprehensive technology roadmap, examining the technology at the levels of materials, semiconductor technologies, packaging techniques, antenna array, and signal processing. It demonstrates how radar technology can evolve towards becoming a 4D imaging radar capable of providing a dense 4D point cloud that can enable object detection, classification, and tracking.

The report examines the latest product innovations. It identifies and reviews promising start-ups worldwide. The report builds a short- and long-term forecast model covering the period between 2019 to 2040. The market- in unit numbers and value- is segmented by the level of autonomy and by passenger vehicles, shared vehicles, and trucks. In the first decade, ADAS (level 1 and 2) will be the primary market drivers whilst in the second decade autonomous vehicles will be.

Radars are a key element of the sensor suite in ADAS and autonomous mobility. This report first examines the role that radars play in various ADAS functions such as ACC, AEB, FCA, BSD, LCW, HWA, and so on. It then examines how the radar content per vehicle- both for short/medium and long-range radars- will increase with increasing ADAS and autonomy level.

The report then examines the drivers and trends in operational frequency worldwide. It examines how device parameters- including centre frequency, bandwidth, measurement time, and virtual aperture- affect key performance indicators (KPIs) such as velocity, range, azimuth, and elevation resolution. The common products on the market today are then reviewed and benchmarked. The value chain- from chip (fabless/IDM/foundry) to module makers is outlined.

Detailed market forecast models are built. We consider the diffusion of different levels of ADAS and autonomy into the vehicle market over a twenty-year period. We have selected this long timeframe because higher levels of autonomy will take time to become technologically ready and commercially viable.

Our model, therefore, offer a twenty-year unit number forecast (2020 to 2040), segmenting the vehicle market by level 0 to 5 of autonomy. This model clearly shows that how level 0 will tend towards obsolescence before the 2032-2034 period. It shows how level 1 will slowly give way to ADAS level 2, enabling this level to become the dominant level of automation in the short and medium terms.

Our model then considers the rise of higher levels of autonomy (level 3, 4, and 5). In particular, it considers the impact of shared autonomous vehicles and robotaxis on total demand for vehicles, showing that a peak car sales scenario can be anticipated in 2031/2. The comes about because a shared vehicle can service a higher mileage of travel demand than a private vehicle. The total vehicles sales are then forecast to fall beyond this point, creating complex and far-reaching questions for the global automotive industry.

We translate our vehicle and truck unit number forecasts into radar units. Here, we consider the radar content- for short/medium and long-range radars- per vehicle for each level of autonomy. The increase in radar content per vehicle will compensate for the emergence of peak-car. We also develop market value forecasts, considering a moderate and an aggressive price erosion scenario for short/medium and long-range radars.

Finally, we also segmented the unit number forecasts by semiconductor technology, showing how a technology transition has already taken place and how we are at the starting phase of another technology replacement round.

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- Packaging trends: from discreet bare die (COB) to wafer-level packaging and beyond?
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# Mobile Robots, Autonomous Vehicles, and Drones in Logistics, Warehousing, and Delivery 2020-2040

Automated guided vehicles/carts; autonomous industrial material handling vehicles, goods-to-person robots, collaborative autonomous mobile robots, mobile picking robots, and sidewalk last mile delivery robots: technologies, markets, forecasts



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Automation in the delivery/logistic and warehousing/fulfilment chain is a growing market. A particularly exciting subset of this is the use of mobile robots, drones, and autonomous vehicles for automation of movement-based tasks. This field encompasses all manner of robots, drones, and autonomous vehicles, which help goods in their journey from origin to destination. This report finds that the market for mobile robots, drones, and autonomous vehicles in delivery and warehousing is likely to reach a staggering \$81 and \$290 Billion in 2030 and 2040, respectively.

The report provides a comprehensive analysis of all the key players, technologies, and markets. It covers automated as well as autonomous carts and robots, automated goods-to-person robots, autonomous and collaborative robots, delivery robots, mobile picking robots, autonomous material handling vehicles such as tuggers and forklifts, autonomous trucks, vans, and last mile delivery robots and drones.

We provide technology roadmaps and twenty-year market forecasts, in unit numbers and revenue, for all the technologies outlined above (13 forecast lines). We built a twenty-year model because our technology roadmap suggests that these changes will take place over long timescales. In our detailed forecasts we clearly explain the different stages of market growth and outline the key assumptions/conditions as well as data points that underpin our model.

Furthermore, our granular forecast model includes price projections, often at component level, for all the technologies outlined above. Our technology assessments and price projections feed directly into our market forecast model, governing the adoption timescales and the estimated technology market share evolutions.

We further provide investment/trend analysis, always seeking to put each technology within its greater quantitative as well as qualitative context. We also include company interviews/profiles/reviews. Our company profiles and interviews provide valuable insight on company positioning, strategy, opportunities, and challenges.

For a long time, automated guide carts and vehicles (AGC and AGV) have been in use. They are infrastructure dependent, meaning that they follow a fixed infrastructure, such as conductive wire or magnetic tape, in going from A to B. They are reliable and trusted to handle all manner of payloads. Their installation is however time-consuming, and their workflow is difficult to adapt.

Consequently, as a technology, they are on shaky ground, unless they adapt. This is because the technology is evolving towards more autonomous and infrastructure-independent navigation. We forecast that they will tend towards obsolescence and increasingly become confined to ever narrower market niches. Overall, we predict that their market will shrink by 50% in 2030 compared to the 2019 level.

One very bright spot for automated robots is in goods-to-person automation within fulfilment centres. Special robot-only zones are created within warehouses in which these robot fleets move racks at high speeds to a manned picking station. The productivity gains are clear and proven.

This is a fast-growing market space. The landscape was set on fire when Amazon acquired Kiva Systems for \$775M in 2012, thereby leaving a gap on the market. Today, significant well-funded alternatives such as GeekPlus (\$389M), GreyOrange (\$170M), and HIK Vision (\$6Bn revenue) have emerged, achieving promising and growing deployment figures. The number of start-ups has also increased, especially between 2015-2017.

We forecast the annual unit sales to double within 6 years. Despite the large deployments already, we assess the real global inflection point to arrive around 2024. Indeed, our report forecasts that between 2020 and 2030, more than 1 million such robots will be sold accumulatively.

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# Lidar 2020-2030: Technologies, Players, Markets & Forecasts

Analysis of 100+ 3D lidar companies; automotive focus. Mechanical, MEMS, OPA, flash, liquid crystal and other solid-state lidar for ADAS, autonomous vehicles, industrial, smart city, security and mapping.



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Forecasts to 2030

# Air Taxis: Electric Vertical Take-Off and Landing Aircraft 2021-2041

eVTOL Players, 20-year Market Forecasts, TCO Analysis, Advanced Batteries, Electric Motors, Distributed Electric Propulsion, Composite Materials for Aviation, and Air Taxi Skyport Infrastructure.



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Forecasts to 2029

Following a period of dedicated research by expert analysts, IDTechEx published a report that offers unique insights into the global 3D lidar market. The report contains a comprehensive analysis of 106 players developing 3D lidar for the ADAS and autonomous vehicles market, which includes a detailed assessment of technology innovations and market dynamics. While the market analysis and forecasts focus on the automotive industry, the technology analysis and company profiles also cover lidar for industrial automation, robotics, smart city, security, and mapping. Importantly, the report presents an unbiased analysis of primary data gathered via our interviews with key players, and it builds on our expertise in the transport, electronics and photonics sectors.

This research delivers valuable insights for:

- Companies that require lidar\*
- Companies that develop lidar
- Companies that supply components and materials for lidar
- Companies that invest in lidar
- Companies that develop other technologies for machine automation

\*or similar and competing sensors

Our report answers important questions such as:

- What are the lidar technology choices available today, and how do these choices impact on product development and product positioning?
- What is the present status of each lidar technology and what are the future opportunities?
- How is the lidar business landscape evolving in terms of the supply chain, investments and partnerships?
- How will each lidar market segment evolve in the short-term and long-term?

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IDTechEx's new report "Air Taxis: Electric Vertical Take-Off and Landing Aircraft 2021-2041" is intended to help companies understand the exciting emerging urban air mobility (UAM) market. Our research provides comprehensive detail, from the basic pros and cons of the different electric vertical take-off and landing (eVTOL) aircraft design architectures, through to more nuanced detail on opportunities in key enabling technologies, such as aviation grade batteries, advanced electric motors and propulsion systems, composite materials and eVTOL ground infrastructure. Along with information and insight into the eVTOL air taxi market our report contains IDTechEx's 20-year outlook for eVTOL air taxi sales, market revenue, battery demand and battery market revenue, with a detailed breakdown of our forecasting methodology.

The concept of flying taxis is easy to hype. We have all grown up with images of the future that include mass mobility in the air. It is one of the staples of any depiction of advanced societies and a trope of almost every science fiction movie or book (however dystopian). IDTechEx's new report "Air Taxis: Electric Vertical Take-Off and Landing Aircraft 2021-2041" is not that hype. Our independent research into eVTOL aircraft for passenger transport reflects the reality of the eVTOL market at this early stage of its development.

Our analysis of air taxi / passenger drone operations within Urban Air Mobility (UAM) suggests that there are frequently talked about areas for air taxi deployment which simply do not look viable, offering commuters no perceivable benefit at a greater expense. However, IDTechEx's research also indicates applications where eVTOL aircraft could provide a faster, more direct, and flexible journey, at a lower cost than competing transport modes. It is this potential which has attracted the attention of huge companies both inside and outside the aviation industry and stirred major investment into this nascent market.

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16. FORECASTS

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