Press Release
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LYON, France

Sensors are at the heart of the robotic mobility disruption[1]

OUTLINES:

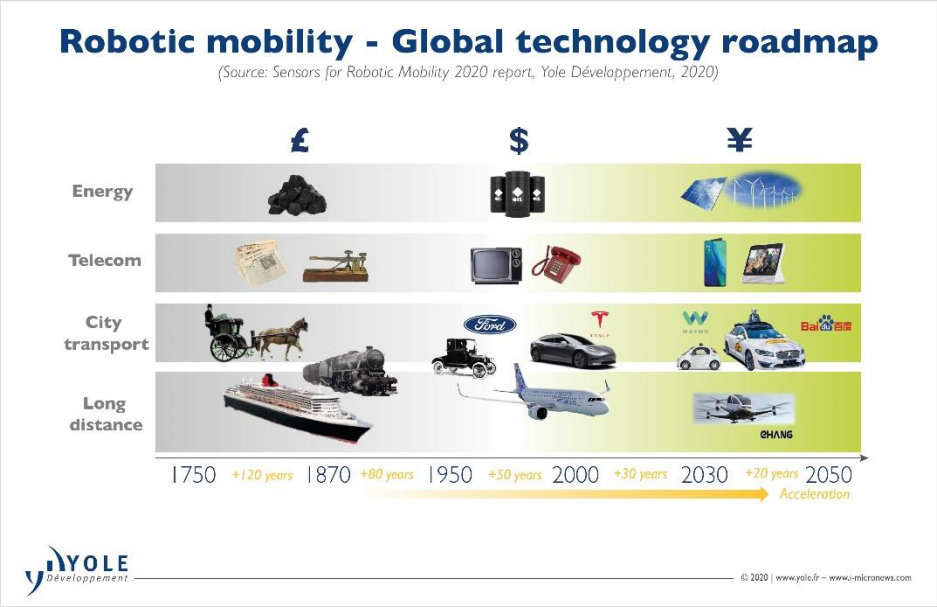
- A new generation of robotic vehicle is bringing MaaS[2] to the masses.
- High end sensor technology and raw computing power is at the center of this ongoing market disruption.
- Sensors for robotic vehicles will become industries of their own: 51% CAGR[3] expected for the next 15 years.

"Disruption is coming to our streets and cities" says **Pierre Cambou, Principal analyst, Imaging, at Yole Développement (Yole)**. *"Mobility has defined the way humans have organized their society for ages and our world is currently being reimagined around a new generation of robotic vehicles. They appeared insignificant two years ago when we published our first report on the matter, today they are on the brink of changing the world as we know it".*
In this context, the market research & strategy consulting company Yole, intensively analyses the robotic mobility market and technologies and offers a comprehensive understanding of the industry in the Sensors for Robotic Mobility 2020 report. Aiming to provide a scenario for sensors within the dynamics of the robotic vehicle market, this report includes market and revenue forecasts, key technical insights and gives an in-depth understanding of the ecosystem and players.

Current means of mobility are hitting five major limitations. The first concerns the most vulnerable modality, namely that pedestrian safety is deteriorating. Second, in the major cities where people tend to live nowadays, public transportation is facing challenges in terms of efficiency and cost. Third, cars are no longer the grand solution to mobility they used to be. Congestion and cost of ownership is undermining this option. Four, air mobility is currently enjoying rapid expansion, but travel remains difficult as city to airport connections remain poor. Fifth, CO_2 emissions due to all current means of mobility make urgent change vital. Regulators and customers are willing to change in both top-down and bottom-up manners.

[1] Extracted from : Sensors for Robotic Mobility 2020, Yole Développement
[2] MaaS : Mobility as a Service
[3] CAGR : Compound Annual Growth Rate

According to **Pierre Cambou**: *"The mobility industry will have to adapt, and for some this will be a massive opportunity. In this respect robotic mobility clearly checks all the right boxes. Whether it is robotic cars, shuttles or electric VTOL[4] aircraft, the combination of all these new modalities will provide "MaaS" from inner cities, from cities to suburbs and cities to cities. Previous means of mobility will not disappear, just as cinema still existed while TV was massively deployed. Regardless of the naysayers, robotic vehicle technology will provide the Netflix of mobility before 2032".*



Carmakers developing ADAS[5] technology have now mainly chosen a camera-and-radar approach. As **Mr E. Musk, the CEO of Tesla**, said, *"LiDAR is a fool's errand […] in the automotive context"*.

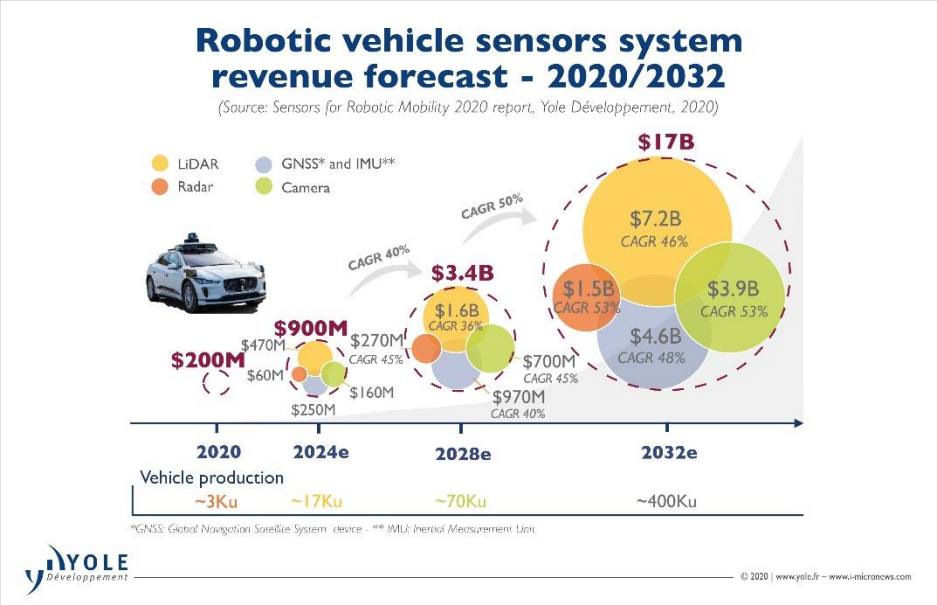
Robotic vehicles do not focus on the cost and long-term reliability issues that are the main concern for other automobiles. All that matters is the immediate availability, performance, and supportability of their sensor suite. The robotic sensor data flow is utterly limited by downstream computing power. While previous generations were in the range of several hundred Tops[6], the latest robotic vehicles are in the range of a thousand Tops.

This gives limited increases in terms of sensor data flow, which relates to what Yole calls "More than Moore's law". The computing power needed increases with the square of data flow input. The number of sensing cameras, radars and LiDARs will grow far slower than the performance of robotic vehicle computers.

The way around data sparsity is for roboticists to use "better" data, meaning sensors which bring other types of information. The quality of information is increased, not the quantity. On

[4] VTOL : Vertical Takeoff and Landing
[5] ADAS : Advanced Driver Assistance System
[6] Tops : Tera Operations Per Second

top of industrial grade cameras and radars, they are massively using 3D sensing Lidars, navigation grade GNSS[7] devices and IMUs[8] and more recently Thermal IR[9] cameras.
These sensors come with significant price tags, and will therefore generate US$900 million in revenues by 2024, US$3.4 billion by 2028 and reach US$17 billion by 2032, a time when a million robotic vehicles may be roaming our streets.



For **Pierre Cambou**: *"Growth rates are expected to be impressive. In 2019 production of robotic vehicles was in the range of a few thousand worldwide. We expect production volumes to reach 400k units annually, with cumulative production of 1 million units, by 2032".*
This ramp up forecast is based on a 51% CAGR for the next 15 years. By then, the total revenue associated with the production of robotic vehicles will reach US$60 billion. 40% of that figure will originate from the vehicles themselves, 28% will come from sensing hardware, 28% from computing hardware and the remaining 4% will be from integration. This means that within 15 years complete industries will be structured around robotic vehicle technologies.
When looking closer to the present, in 2024 Yole's analysts expect sensor revenues to reach US$0.4 billion for LiDAR, US$60 million for radar, US$160 million for cameras, US$230 million for IMUs and US$20 million for GNSS devices. The split between the different sensor modalities may not stay the same for the 15 years to come. Nevertheless the total envelope for sensing hardware should reach US$17 billion in 2032, while, for comparative purposes, computing should be in the same range.
Today's car sales account for US$2.4 trillion and are the natural target of internet giants like Google, Baidu, Amazon and Uber. They are mostly attracted by the MaaS market, which Yole believe should reach the same value of US$2.4 trillion within the next decade. With an

[7] GNSS : Global Navigation Satellite System
[8] IMU : Inertial Measurement Units
[9] IR : Infra-Red

additional US$1.1 trillion to be generated by sales of personally-owned autonomous driving vehicles, the added value of autonomous driving will reach a total of US$3.5 trillion by 2032.

Throughout the year, Yole Group of Companies, including System Plus Consulting and Yole Développement, publish numerous robotic mobility reports. Make sure to be aware of the latest news coming from the industry and get an overview of our activities, including interviews with leading companies, analyses from our experts and dedicated online and onsite events on i-Micronews.

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About the analyst

Pierre Cambou MSc, MBA, is a Principal analyst in the Photonic and Display Division at Yole Développement (Yole). Pierre's mission is dedicated to imaging related activities by providing market & technology analyses along with strategy consulting services to semiconductor companies. He has been deeply involved in the design of early mobile camera modules and the introduction of 3D semiconductor approaches to CMOS Image Sensors (CIS). Pierre has a broad understanding of the various markets and technologies associated with CIS, having obtained 6 patents in this field and founded one startup company in 2012. At Yole, Pierre is responsible for the CIS Quarterly Market Monitor while he has authored more than 15 Yole Market & Technology reports. Known as an expert in the imaging industry, he is regularly interviewed and quoted by leading international media. Previously, Pierre held several positions at Thomson TCS, which became Atmel Grenoble (France) in 2001 and e2v Semiconductors (France) in 2006. In 2012, he founded Vence Innovation, later renamed Irlynx (France), to bring to market an infrared sensor technology for smart environments. Pierre has an Engineering degree from Université de Technologie de Compiègne (France) and a Master of Science from Virginia Tech. (VA, USA). Pierre also graduated with an MBA from Grenoble Ecole de Management (France).

About the report

Sensors for Robotic Mobility 2020

The one million robotic vehicle milestone will be reached by end of the decade: the industrial phase has been launched.- Performed by Yole Développement

Companies cited:

A3, Aeye, Ambarella, Ams, Aptiv, Allied Vision, Arbe Robotics, Asc, Blackmore, Basler, Bosch, Cepton, Continental, Cruise, Denso Ten, Didi, Easy Miles, Flir, Furuno, General Motors, Gentex, Grab, Geely, Hella, Hexagon, Honneywell, Ibeo, Infineon, Innoviz, Intel, Ixblue, Joby, Kalray, Konica Minolta, Kittyhawk, KVH, LeddarTech, Lilium, Luminar, Lyft, Magna, Metawave, Mitsubishi Electric, Mobileye, Murata, Navtech, Navya, Neptec, Novatel, Nuotomy, Nvidia, NXP, Oryx, Physical Logic, Pioneer, Prophesee, Quanergy, Robosense, Sensible 4, Sensonor, Sick, Sony, Socionext, STMicroelectronics, TDK, Texas Instruments, Telit, Terrafugia, Toshiba, Trieye, Trimble, Uber, Ublox, Velodyne Lidar, Valeo, Waymo, Wisk, Xenomatix, Zoox and more…

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- Radar and Wireless for Automotive: Market and Technology Trends 2019
- Artificial Intelligence Computing for Automotive 2019
- Imaging for Automotive 2019
- The Audi A8 zFAS ADAS Platform by Aptiv – System Plus Consulting
- LiDAR for Automotive and Industrial Applications 2019

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Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide… More

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