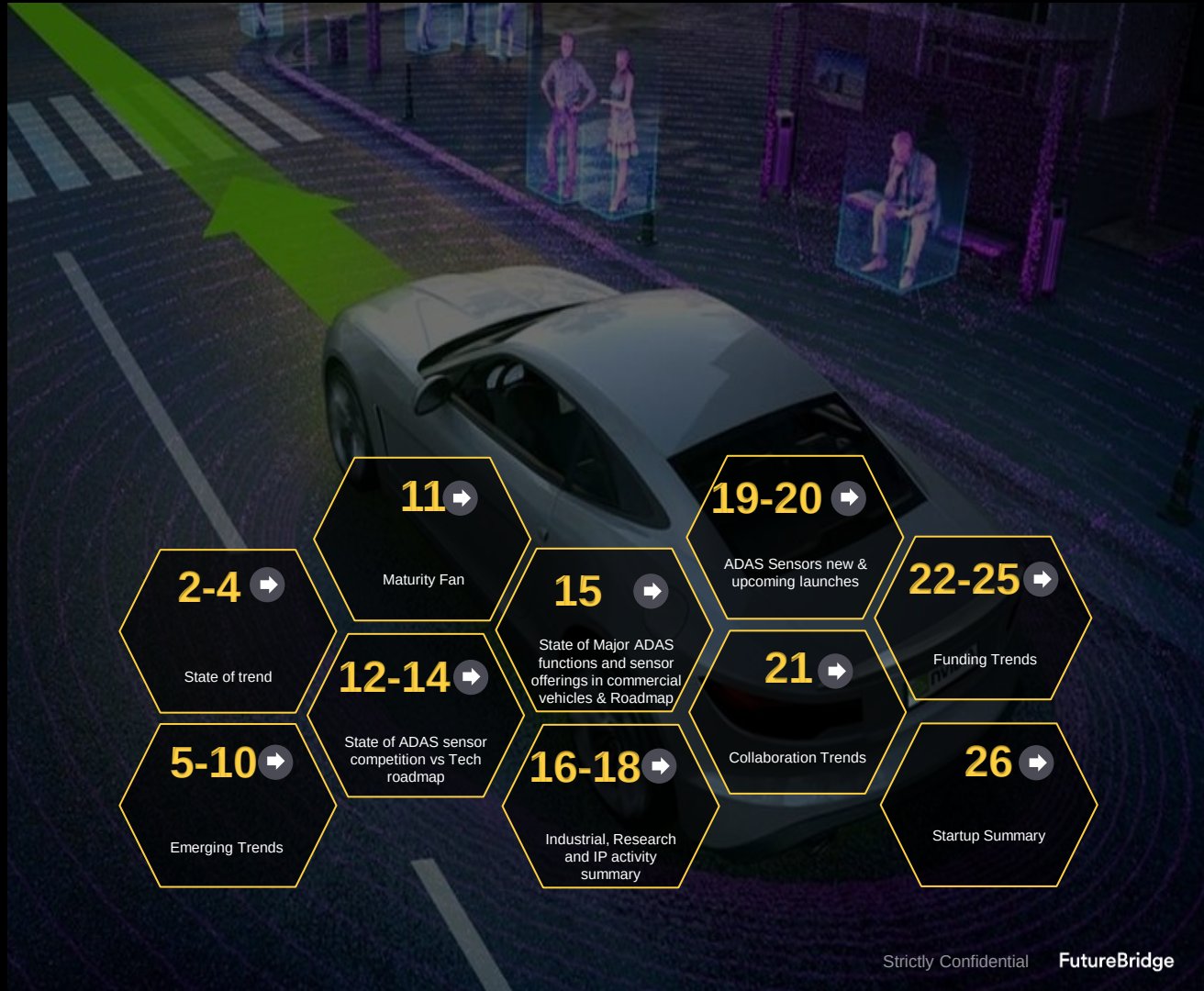
WHAT'S NEW?

H1 2020

EXECUTIVE LENS

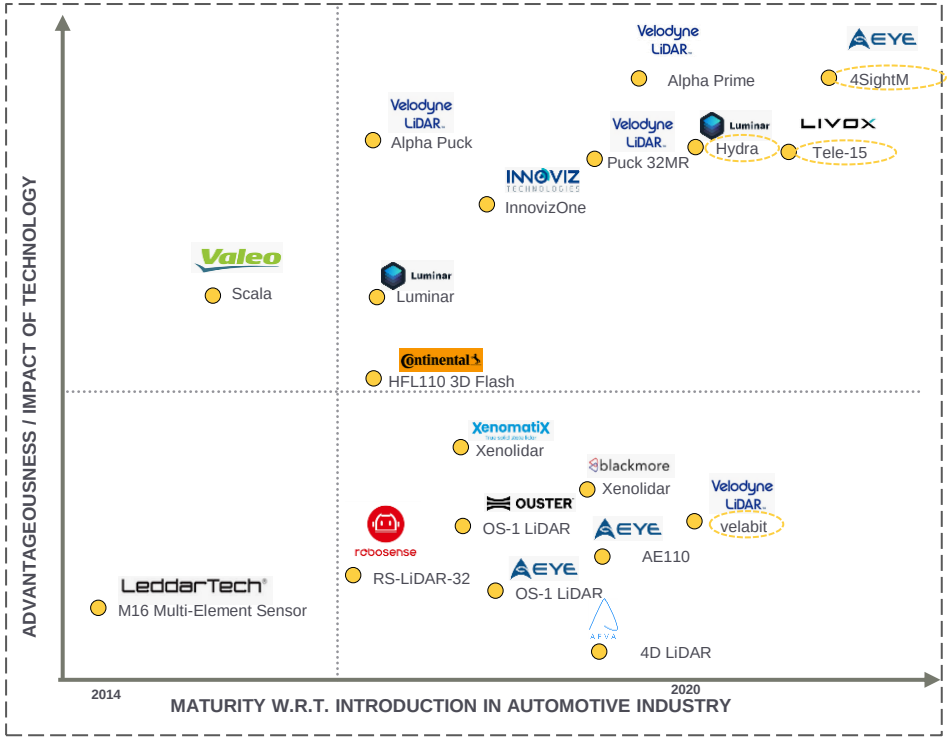
Summarized insights for ADAS Sensors w.r.t. trends in technology, market and players



FutureBridge

LiDAR State of the Art Trend-: Product benchmarking & Competitive Landscape in H1'20 (1/3)

In terms of commercialization, focus is on lidar miniaturization and low cost lidar along with developing lidar capable of measurement at long distance up to 500m



Competitive Landscape

LiDAR sensor | Newly add. Specs available | Newly launch. Specs not available | Vision system

Read Benchmarking Summary for detailed analysis

Activities in H1'2020

- In terms of product development, Mitsubishi Electric offered MEMS LiDAR for increased safety in autonomous car, Scale AI releases free lidar data set to power self-driving car development
- In commercial vehicles, Innoviz Technologies selected by Shaanxi heavy duty automobile co. for autonomous truck project at Chinese port with the help of its solid state lidar
- In terms of collaboration, Velodyne Lidar announces sales agreement with NAVYA; Quanergy Partners with Milexia for LiDAR development in Europe
- In terms of funding, Chinese LiDAR maker Hesai raises $173M for mechanical lidar, Cepton Technologies raises Series C funding of $50M for mirrorless lidar, Silc technologies raises $12M in seed funding to deliver long-range, single-chip lidar for autonomous vehicles
- RoboSense Smart LiDAR Sensor won the 2020 Edison Awards

Key Developments in the past 6 months

Technology — Velodyne LiDAR: Velodyne debuts low cost LiDAR "Velabit" which cost $100 and aims for mass production

Funding — HESAI: Chinese LiDAR maker Hesai raises $173M

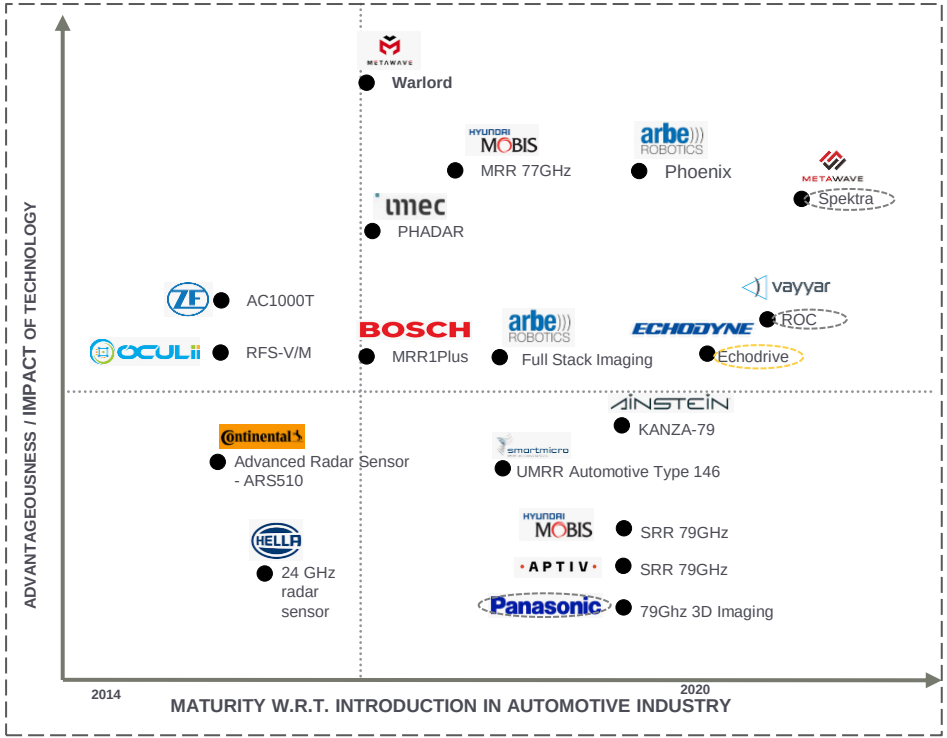
Technology — Pioneer: Pioneer unveils "3D-LiDAR sensor" capable of measurement at long distance of 500m

Technology — LIVOX: DJI's Livox introduces 500 meter lidar with unique scanning pattern

*List not very exhaustive

Radar State of the Art Trend-: Product benchmarking & Competitive Landscape in H1'20 (2/3)

Radar developments are progressing towards 77GHz frequency radar for determining speed and range of objects in the vicinity of car



Competitive Landscape

● Radar sensor ⬭ Newly add. Specs available ⬭ Newly launch. Specs not available

Vision system

Read Benchmarking Summary for detailed analysis

Activities in H1'2020

- In terms of new product development, Vayyar Imaging unveils 60 GHz radar-on-chip, Metawave demonstrates first 77GHz analog beamsteering radar for autonomous vehicles, Hella launches 77 GHz radar technology, series production to begin soon
- As far as new launch is considered, Echodyne debuts EchoDrive ,its MESA® beam-steering technology based radar for autonomous vehicles
- In funding , Bitsensing, Radar technology startup raises $5.8mn Pre-Series A
- Vayyar and Uhnder were most active players in collaboration, AISIN and Vayyar Imaging partner to develop exterior sensing solutions for vehicles, Vayyar Imaging joins CLEPA to drive global automotive safety, Gapwaves and Uhnder collaborate for high resolution radar to be deployed in last-mile applications, Uhnder and dSPACE cooperate in radar technology to increase safety of cars

Key Developments in the past 6 months

Technology — Tesla Model Y boasts heated radar to help Autopilot in the cold

Technology — New doppler radar system can detect moving vehicles around corners

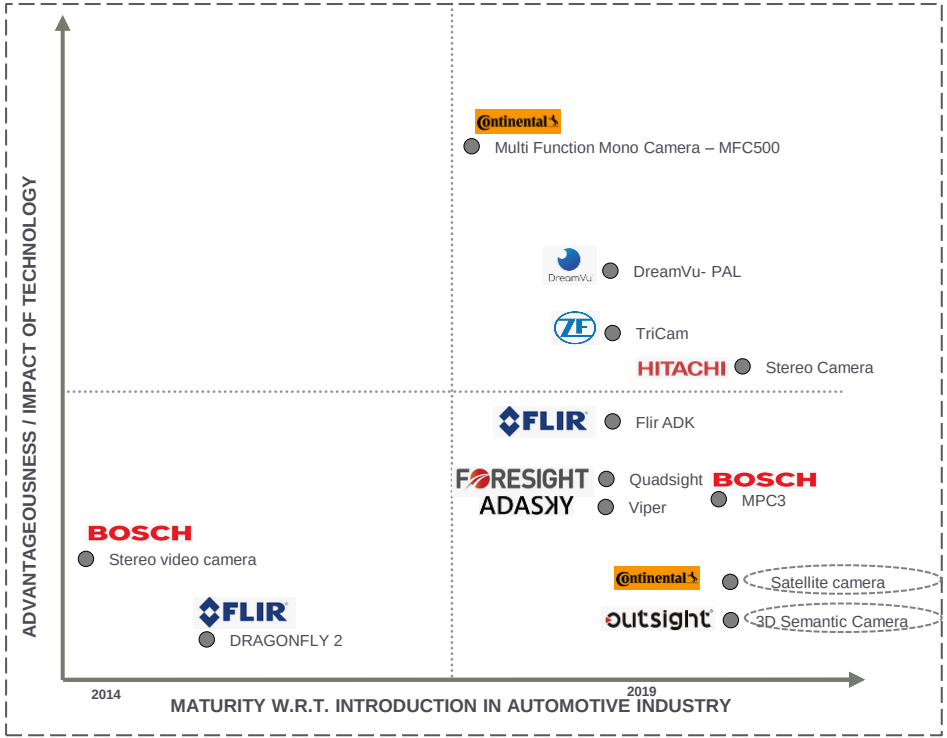
Partnership — BlackBerry Radar & Trimble partner on asset monitoring capabilities

Technology — WaveSense develops ground-penetrating radar for vehicles, robots

*List not very exhaustive

Camera State of the Art Trend-: Product benchmarking & Competitive Landscape in H1'20 (3/3)

Camera developments are progressing from mono to stereo to 3D semantic cameras for improved visibility and safety for self driving vehicles



Competitive Landscape

Camera sensor | Newly add. Specs available | Newly launch. Specs not available

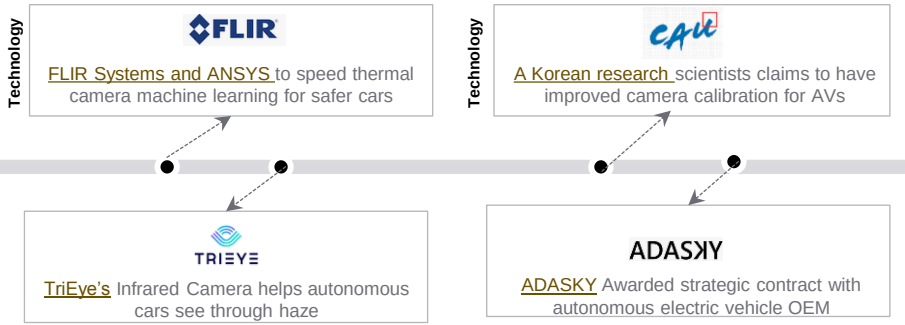
Vision system

Read Benchmarking Summary for detailed analysis

Activities in H1'2020

- In terms of new product launch, TI Reveals Automotive SoC with an AI Accelerator for camera
- In technology development Renesas Electronics simplifies power supply design for automotive surround view camera systems, Huge advances in 3d camera as photon-sensing 3D camera crosses the megapixel mark, TriEye's built Infrared Camera which helps autonomous cars see through haze, Helm.ai has built a full stack autonomous vehicle using only one camera
- In terms of collaboration, OmniVision and Artilux collaborate on 3D infrared sensors, ADASKY Awarded strategic contract with autonomous electric vehicle OEM

Key Developments in the past 6 months



*List not very exhaustive

Advancement in camera sensors, HD maps and AV datasets is accelerating

Emerging trends in Vision system sensors in H1-20' : Things to watch out for

Players collaborating with each other for HD maps development

- Toyota collaborate with Momenta to incorporate HD maps in its autonomous cars in China >>
- TomTom, Toyota Research Institute and DENSO partnered on advanced mapmaking for automated driving >>
- CARMERA and TRI-AD demonstrate urban and highway mapping in Japan and the US >>

As maps start to become universally used, redundancy on sensors can be reduced. Toyota is among the forefront in developing HD maps with suppliers.

Advancements in camera systems to improve visibility and safety

- Photon-sensing 3D camera crosses the megapixel mark >>
- Samsung working on 600MP camera sensors which can be used in autonomous car >>
- TriEye's Infrared Camera helps autonomous cars see through haze >>

With the advancement in cameras, it can be an inexpensive compliment to LiDAR sensors. There is a trend from moving mono to 3D cameras in the future.

Machine learning datasets released to accelerate development of algorithms

- FLIR releases first European thermal imaging dataset for ADAS development >>
- Scale AI launches Pandaset to promote urban driving situations in future >>
- MIT and Toyota release innovative dataset to accelerate autonomous driving research >>

Many more players are releasing their open-source datasets collected before COVID-19 pandemic to accelerate research into autonomous driving system.

Innovative technologies identified in vision system sensors in H1-20'

Advancements in Radar, Lidar and camera to further increase the safety of autonomous vehicles

NEW

Breakthrough technologies

Technology and Solutions to further increase the safety of autonomous vehicles and decrease the number of sensors and reduce the processing time

imec

University of Colorado Boulder

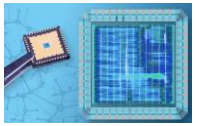
WaveSense

PRINCETON UNIVERSITY

Helm.ai

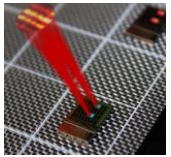
First spiking Neural Network-based chip for radar signal processing >>

- By mimicking the way groups of biological neurons operate to recognize temporal patterns, imec's chip consumes 100 times less power than traditional implementations as claimed by the company.



New Silicon Chip Development Could Revolutionize LiDAR >>

- A research team at the University of Colorado (UC) Boulder recently published a study that discusses a new form of LiDAR that allows the technology to avoid the large rotating mirrors that currently steer laser beams to create a 3D image.

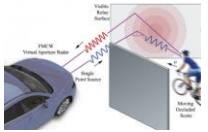


WaveSense develops ground-penetrating radar for vehicles, robots >>

- Unlike other sensing methods, ground-penetrating radar (GPR) is unaffected by snow, heavy rain, fog, or poor lane markings. In combination with GPS, cameras, and Lidar, GPR can significantly reduce navigation failure rates for autonomous and driver-assist systems as claimed by Wavesense

New Doppler Radar System can detect moving vehicles around corners >>

- The system, which is easily integrated into today's vehicles, uses Doppler radar to bounce radio waves off surfaces such as buildings and parked automobiles. It allows a level of collision detection that simply wouldn't be possible for humans.



Helm.ai has built a full stack autonomous vehicle using only one camera >>

- Helm.ai has built a full stack autonomous vehicle which is able to steer autonomously on steep and curvy mountain roads using only one camera and one GPU (no maps, no Lidar and no GPS), as claimed by the company

 Source: FutureBridge Analysis

Emerging Trends in H1-20': Many players are releasing their open-source datasets collected before COVID-19 pandemic to accelerate research into autonomous driving system

NEW

Visualizations of A2D2 data.
Left: semantic segmentation, **Center:** 3D bounding boxes **Right:** dense point cloud

FutureBridge Comments:

- Datasets are the collection of images, video clips captured during vehicle run on the roads.
- Various classes are identified during data collection like trees, cyclists, pedestrians, cars, etc.
- Annotations such as 2D & 3D bounding labels, Semantic labels, etc. are used to identify the objects.
- So to summarize, data contained in the data set is made available under an open-source license to researchers.

Ford

- Ford releases a data set to accelerate autonomous car development and has covered a range of driving environments & climates

Source

Audi

- Audi releases new autonomous driving dataset called as A2D2 which can be used for commercial purpose

Source

Flir

- FLIR releases first European thermal imaging datasets and has covered multiple countries to gather data

Source

Scale.AI

- Scale AI launches Pandaset datasets & is freely available for both academic and commercial used

Source

MIT&Toyota

- MIT and Toyota released unique dataset & has identified amorphous objects such as road construction and vegetation

Source

Emerging Trends: Sensor Integration in Level 3-5 Automated Driving

Different sensor mounting positions are being explored by leading players for enhancing perception, cost reduction, easy packaging, protection, etc.

Windshield

- Panoramic view
- Environmental protection

Velodyne offer LiDAR for placing behind windshield

XenomatiX and AGC developed a windshield-mounted(Zero IR absorbing glass) LiDAR system

Mirrors

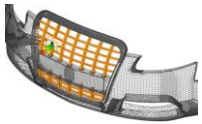
- Easy packaging
- Environmental protection

Ford patent LiDAR inside side mirrors

Aptiv is placing LiDAR on side view mirrors

Bumper

- Easy packaging
- Longer frontal coverage



Lyft places 40 beam LiDAR in bumper

VolksWagen is developing Autonomous Vehicle with LiDAR inside bumper

Over the vehicle, on the roof

- Panoramic view
- Non-solid state LiDAR/radar fitting
- 360 degree view

Waymo's AV is still using LiDAR on top of the vehicle

Lyft places LiDAR over the vehicle for 360 degree perception

Headlight

- Easy packaging
- Environmental protection

Koito to develop headlight build-in LiDAR by Blickfeld

Hella and Plastic Omnium partners for sensor integration to headlight

Emerging Trends: Sensor Fusion

Players are collaborating, funding, testing, revealing new products in the sensor fusion segment to ease higher levels of autonomy

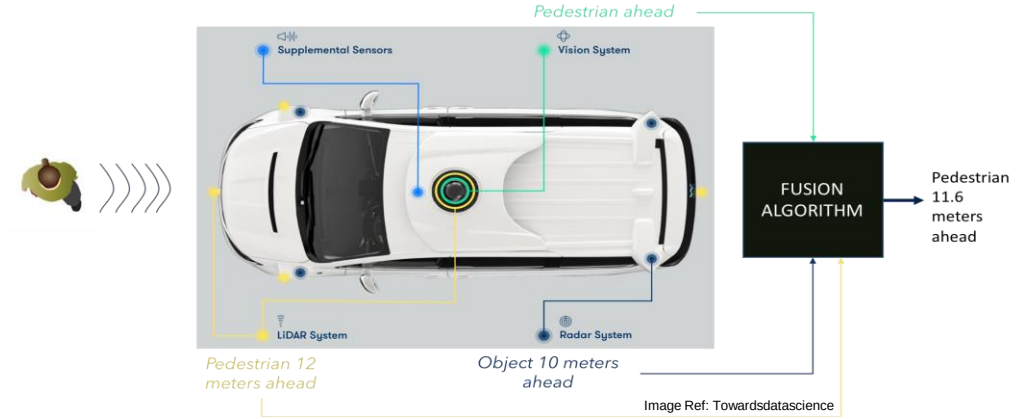


Image Ref: Towardsdatascience

FutureBridge Comments:

- For level 3 -5 Features, fusing information from different sensors is crucial for redundancy. It should permit scalability and adaptability to deal with different sensor technologies, as price will usually decide the sensors and potential options
- This fusion of data will assist the roll-out of the know-how and it could contribute to ADAS sensor set affordability in the long run

Collaboration

- ON Semiconductor and Almotive will work together to develop prototype sensor fusion platforms

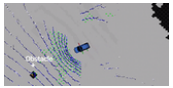
Source

Product Development

- Omnivision launches two image sensor fusion platforms OX08A and OX08B

Source

Funding



- Autonomous Solutions Inc receives funding for deep learning to support multiple sensors in GPS denied environment

Source

Testing

- DeepRoute plans to begin testing its Level 4 ADS by perfecting its Early Fusion sensor-fusion technology

Source

Announcement

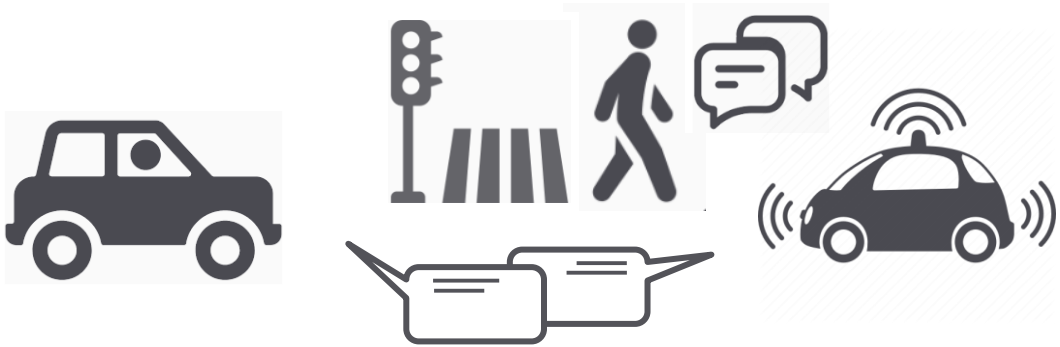
- Mitsubishi Electric's autonomous driving system unveils its sensor fusion technologies

Source

*Non comprehensive list: Only selected players are shown above, players like Harman, AEye, UVeye etc. are also developing the same

Lighting as a communication tool for Autonomous Vehicle's intentions

OEMs and suppliers are actively developing light-based communication technology and protocol for light as external HMI of AVs



FutureBridge Comments:

- Effective communications between AVs, road users and drivers of non-autonomous cars can act as key to safe AV mass roll out and quicker adoption
- Lighting (over the vehicle, headlight, body lights, etc.) are most possible solutions to fill communication gap
- Learn more in our webinar: **"Future of automotive lighting – game changed for safety, passenger wellness and autonomous driving"**

Mercedes-Benz Co-operative car

- Mercedes Benz showcases autonomous car that communicates its intention through lights

Source

Ford's Visual Language

- Ford is testing 'Visual Language' using lights to enabling Autonomous Vehicle to communicate with Pedestrians

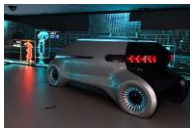
Source

Volkswagen Projection Light

- Volkswagen is testing vehicles that can communicate with pedestrian by light projection on road

Source

Hyundai Mobis Communication Light



- Hyundai Mobis showcases Communication Light for AV (LED, digital boards, projection and sound)

Source

Hella 360 Autonomous

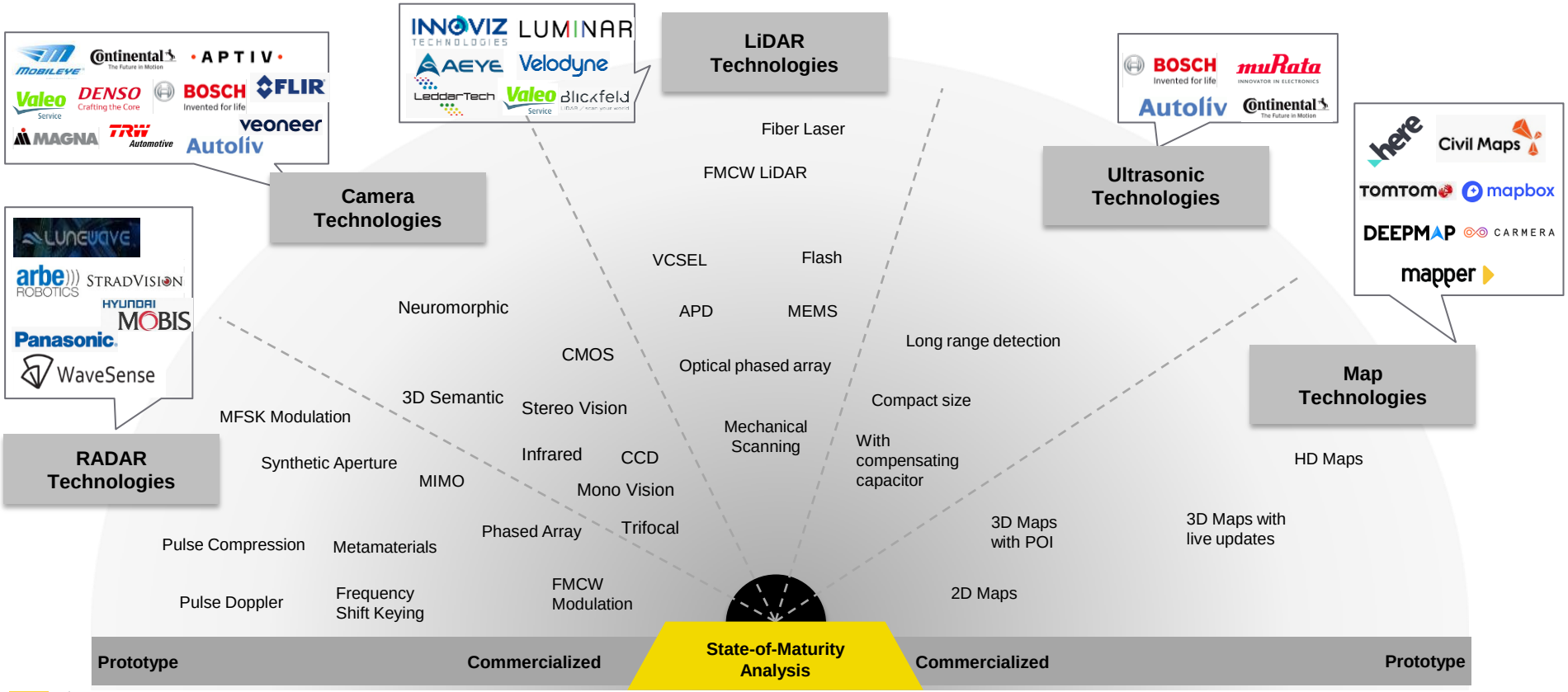
- Hella is developing AV lights to communicate with pedestrians and other human driver

Source

*Non comprehensive list: Only selected players are shown above, players like Toyota, JLR, etc. are also developing the same

Maturity Fan

Technologies enabling 3D vision (in Camera), Antenna miniaturization (in Radar) and solid state LiDARs moving faster towards commercialization



*Not exhaustive list of players, based on developments tracked in 2019-(H1-2020)

State of ADAS sensor competition in H1'20 vs Tech Roadmap

Sensor set requirements will vary depending on the operational design domain for achieving full self-driving capability

Levels of automation	Level 2+	Level 3+	Level 4	Level 4	Level 4
ADAS feature	Traffic Jam Assist	AI Traffic Jam Pilot	Full Self-driving capability	Full Self-driving capability	Full Self-driving capability
Model / OEM	2020 BMW 7 series	2020 Audi A8	2020 Tesla Model S	Waymo self driving minivan	TuSimple LiDAR less approach for L4 trucks
Expected sensor set in vehicles to draw a comparison at different levels of automation for passenger and commercial vehicles					
Forward-looking camera	Stereo camera	Mono camera	Main forward camera - max dist. 150 m Wide forward camera - max dist. 60 m Narrow forward camera - max dist. 250m	Stereo camera	Long range forward looking camera
Forward looking long range radar	LRR	1 – LRR on front	1 – LRR on front	1 - LRR on front	1 - LRR on front
Front corner radar	SRR	4 - mid-range radars at the vehicle's			
Rear corner radar	SRR	corner	Radar Max distance 160 m	Five radar sensors	short range radar
Surround camera	surround view camera	4 cameras of 360 degree on the rear	8 cameras of 360 degree upto 250 m range	8 cameras	8 cameras
LiDAR	X	LiDAR from Valeo	X	3 types of LIDAR sensors	X
Ultrasonics	12X	12X - front,side and rear	12X - max distance 8m	12X	12X
Night vision	Yes	Infrared camera	Infrared camera	Infrared camera	Yes
Maps	eHorizon	HERE maps	Tesla Maps using open source modules from Mapbox and Valhalla	Self 3D Maps	HD maps
V2X	X	Yes	Yes	Yes	Yes
Driver facing camera	Mobileye interior camera	front camera	X	Yes	Yes
Computing platform	Yes	Yes	Yes	Yes	Yes
SOTA updates	X	X	Yes	Yes	Yes

- Cameras play a pivotal role as we advanced in higher autonomy and we can see more adoption of stereo and thermal infrared cameras for image visibility and safety
- Radars will have its significant importance in terms of improving the distance coverage area and 4D imaging radar could impact autonomous vehicles
- 3D Solid state LiDARs, 4D LiDARs, miniaturization of LiDARs, cost –effective, mass production of LiDARs will decide the future fate as it is getting mixed opinion from industries, to go with or without LiDAR
- Future level of autonomy will further be enhanced with advanced computing platforms and software-over-the-air-updates for V2X communication and vehicle safety

LRR – Long Range Radar ; SRR – Short Range Radar ; X – Not available

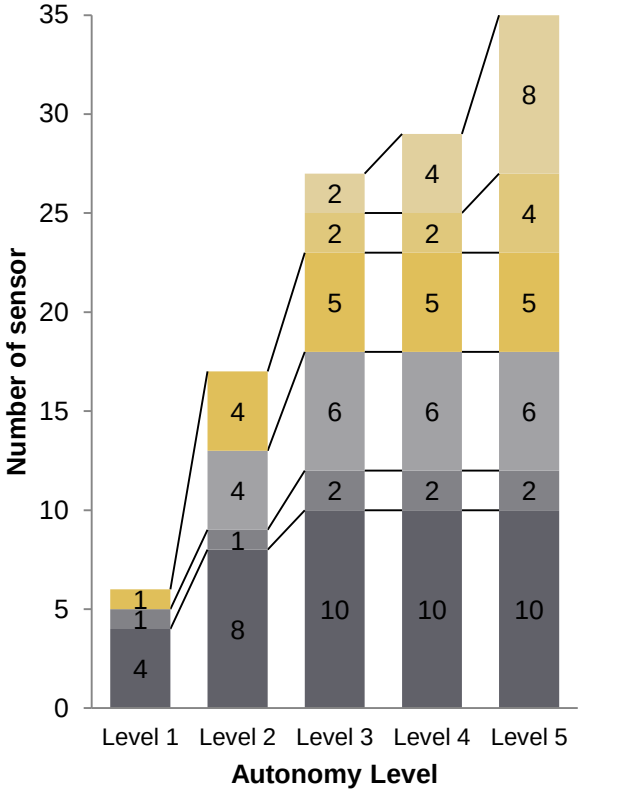
Passenger vehicle Commercial vehicles

Source: FutureBridge Analysis

Illustrative examples. Not very exhaustive

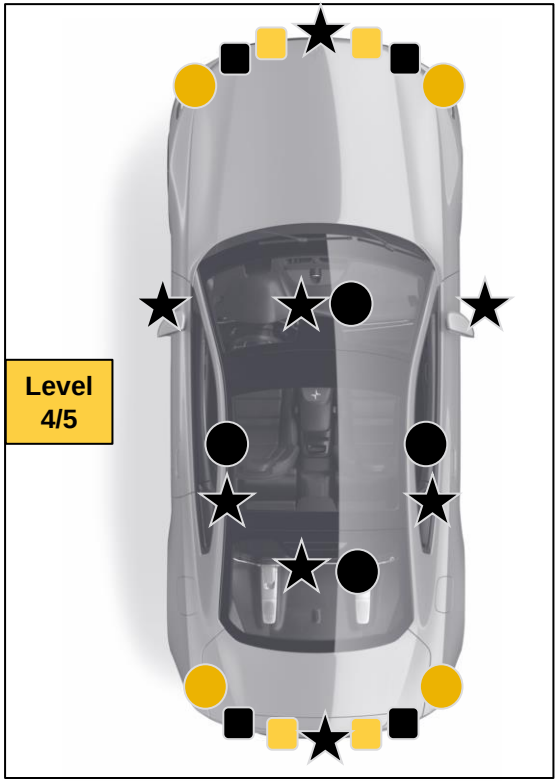
Sensor set requirements in different levels of automated driving

Multiple LiDARs, radars and cameras needed for L4/5 which stresses the importance of cost evolution and requirements for cost efficient sensor integration



FutureBridge Comments:

- Most companies are following standard best practice for sensor fitment as showcased by pioneers like, Waymo, Uber, Audi, etc.
- Disruptions like LiDAR-less autonomy strategy can altogether change perceived sensor requirements



Actual sensor position will depend on the carline's specifications

Source: Fierceelectronics

State of Major ADAS functions and sensor offerings in commercial vehicles

At present, most of the players offer sensor suite to support level 2 autonomous driving assistance functions for ease of driving and safety; wherein they are also focusing to offer level 3 ADAS functions in near future

Company	ADAS Functions in commercial vehicles (Trucks, Buses)											ADAS Sensor Offerings
Leading players in commercial trucks and buses	*Emergency brake assist*	*Blind spot detection*	*Lane departure*	*Right turn assist*	*Platooning*	*Traffic sign recognition*	*Headlight assist*	*Lane keeping*	*Adaptive cruise control*	*Highway Pilot*	*Predictive driving*	*Lane change*	*Different sensors consisting of LiDAR, Radar, Camera, HD Maps*
DAIMLER	✓		✓	✓				✓	✓	F	F		Offers sensor fusion set which consists of LRR, SRR, Stereo camera, side radar sensors, HD maps
VOLVO	✓	✓	✓		✓	✓	✓					F	Volvo Active Driver Assist (VADA) 2.0 platform integrates radar and camera capabilities
Continental	✓	✓	✓	✓	✓	✓	✓						Camera monitoring system “Proviu mirror” and Radar based system “RightViu” assists in turning
BOSCH	✓	✓	✓	✓	✓	✓	✓	✓					Multipurpose camera – Monocular camera platform and radar to prevent collision, apply brakes and evasive steering support
ZF	✓	✓		✓	✓								Short range corner radars monitors the traffic to the sides and the radius of the curve made by the trailer
IVECO	✓		✓		✓				✓				Iveco trucks will be equipped with Wabco’s OnGuardActive & OnGuardMax solutions featuring a new radar sensor

** Not exhaustive list . Expected to vary as per models*

TOP 3 offerings

- *Emergency brake assist*
- *Lane departure*
- *Platooning*

Future Offerings

- *Highway Pilot*
- *Predictive driving*
- *Lane change*

✓ Available

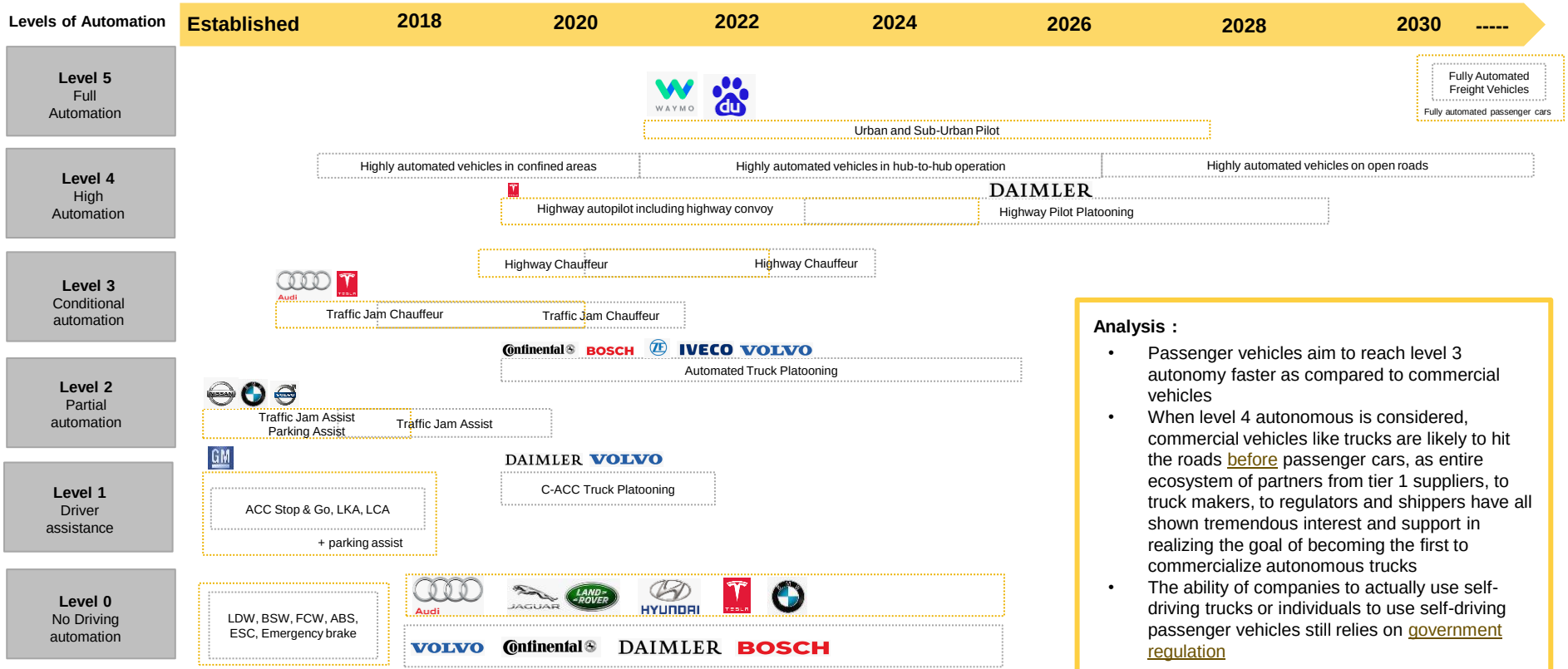
F Future offering

Source: FutureBridge Analysis

** Also refer to earlier H1’2019 version for on the road to autonomous trucks*

Technological Roadmap : Passenger vs Commercial Vehicle

In the near future, commercial vehicles are expected to hit level 4 autonomous as compared to passenger vehicle



Analysis :

- Passenger vehicles aim to reach level 3 autonomy faster as compared to commercial vehicles
- When level 4 autonomous is considered, commercial vehicles like trucks are likely to hit the roads before passenger cars, as entire ecosystem of partners from tier 1 suppliers, to truck makers, to regulators and shippers have all shown tremendous interest and support in realizing the goal of becoming the first to commercialize autonomous trucks
- The ability of companies to actually use self-driving trucks or individuals to use self-driving passenger vehicles still relies on government regulation

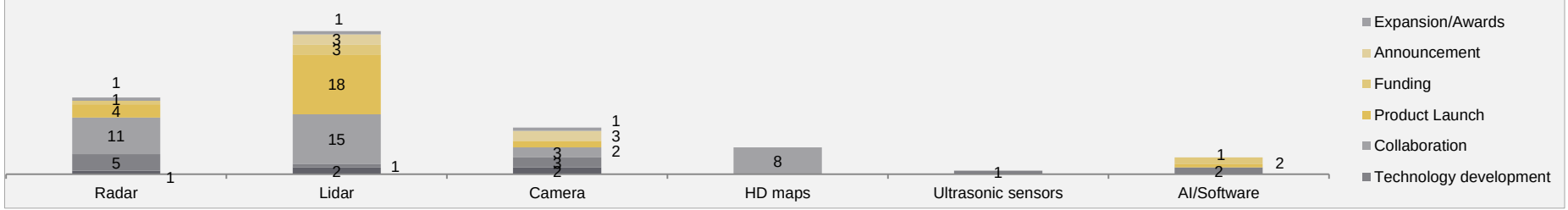
Source: ERTRAC Automated Driving Roadmap Report, 2019

** Not exhaustive list of player*

Industrial Activity Summary in H1'2020

Advancements are seen in vision sensor technology related to the development of sensor fusion platforms, improvement in visibility and security

Industry developments trends seen in H1'2020 from our Industrial Activity Tracker



Major Players

- In terms of product development, more advancements are seen for **LiDAR** sensors in categories related to future autonomous driving, commercial vehicles, safety and security
- Advancements in **camera systems** by players to improve visibility and security were observed.
- Suppliers are collaborating to develop sensor fusion platforms, sensor integration into mirrors and **4D radar technology** for image processing and security
- OEMs partnership with academic universities is seen to develop advanced Radars and HD Maps

Key Developments in the past 6 months

Funding — Chinese LiDAR maker Hesai raises $173M for its mechanical lidar tech

Technology — New doppler radar system can detect moving vehicles around corners

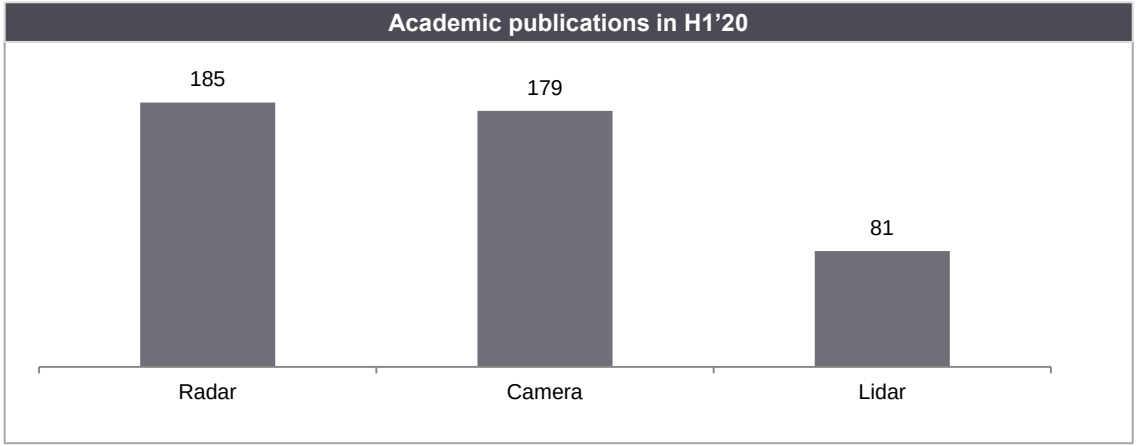
Technology — Huge advances in 3d camera as It crosses the megapixel mark

Collaboration — TomTom, Toyota and DENSO partnered on advanced mapmaking for automated driving

Read Development Summary for detailed analysis

Academic Research Activity Summary in H1'2020

Academic research is very active in vision system areas especially in addressing range, cost and detection challenges



* Count as per search string for only 2020 year

- Many researchers are exploring **camera** sensors for image analysis of traffic data for intelligent vehicles, lane detection and localization in 3D environment, vehicle motion estimation using infrared camera, Lidar and camera fusion to ease autonomous driving
- In the **LiDAR** category, research focus is seen on using 3D Lidar for pedestrian recognition and tracking, lane change identification , LiDAR-camera fusion for road detection
- In the **radar** segment, focus is seen on Road environment recognition for automotive FMCW RADAR systems through convolutional neural network, 77 GHz Radar Application, MIMO Radar and sensor fusion

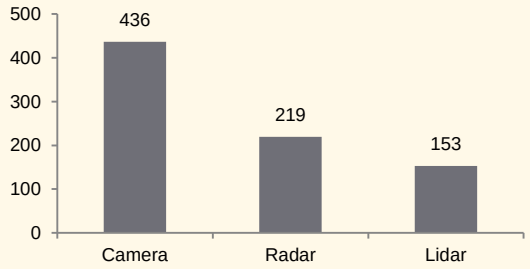
*For details of Research Activity Summary for H2-19, please refer to our earlier version >>

*For details of Research Papers analyzed, please go to Appendix >>

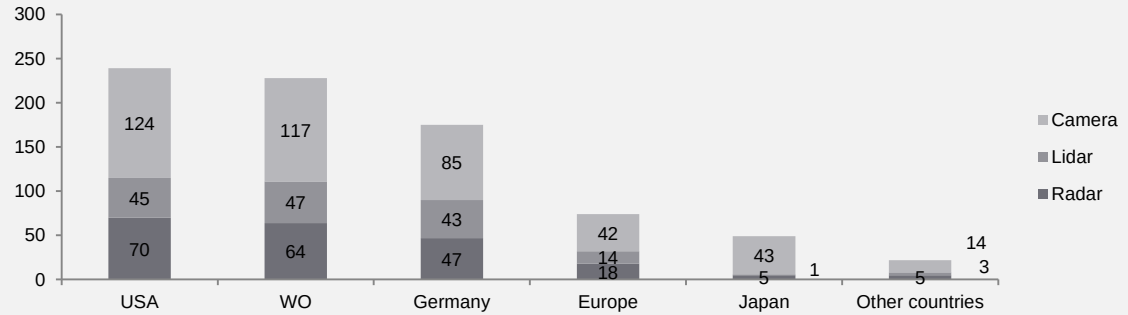
IP Activity Summary in ADAS Sensors in H1' 2020

Patent activity for camera sensor is very high as automakers are looking for advancements like 3D camera for better visibility and safety

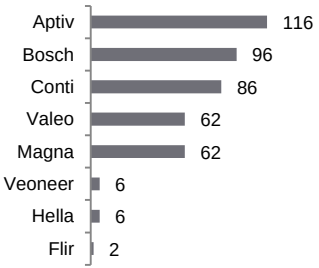
Patents published (H1 2020)



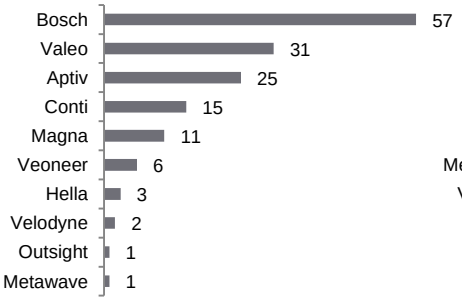
Geographical coverage of patents (H1 2020)



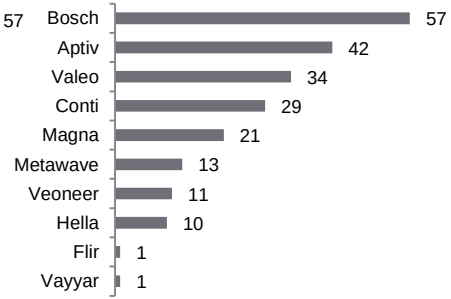
Camera



LiDAR



Radar



- Camera sensor leads the race for the largest patent publishes. This is also evident from our emerging trend wherein we have highlighted advancements in camera system for visibility and safety in H1'2020.
- Bosch has filed the maximum number of patents in vision system sensors among the players which we have studied in our patent analysis
- USA market leads the number of patents filed by the suppliers collectively for the major vision sensor elements
- In Radar, most of the patents filed were related to collision warning, sensor calibration, and FMCW based radar
- In Lidar, MEMS (Microelectromechanical mirrors) based technology was dominant during patent analysis
- In Camera, infrared camera technology was dominant during patent analysis

ADAS Sensor : New launches in H1’2020

The trend is related to launching sensors which are small in size, low in cost, and lidar particularly sensors which sees up to 500 meters

Key ADAS Sensor new launch in H1’2020

Key launches in Radar

- Vayyar → Vayyar Imaging unveils 60 GHz radar-on-chip
- Echodyne → Echodyne launches EchoDrive radar based on beam-steering technology
- Metawave → Metawave launches 77GHz analog beamsteering radar

Key launches in LiDAR

- Luminar → Luminar unveils Hydra, a lidar sensor sold on subscription
- Sense Photonics → Sense Photonics Introduces Osprey, Modular FLASH LiDAR
- Osram → Osram presents Infrared Laser for Short-Range Lidar Applications
- AEye → AEye unveils 4Sight™, LiDAR Sensor with software definable range optimization of up to 1,000 meters

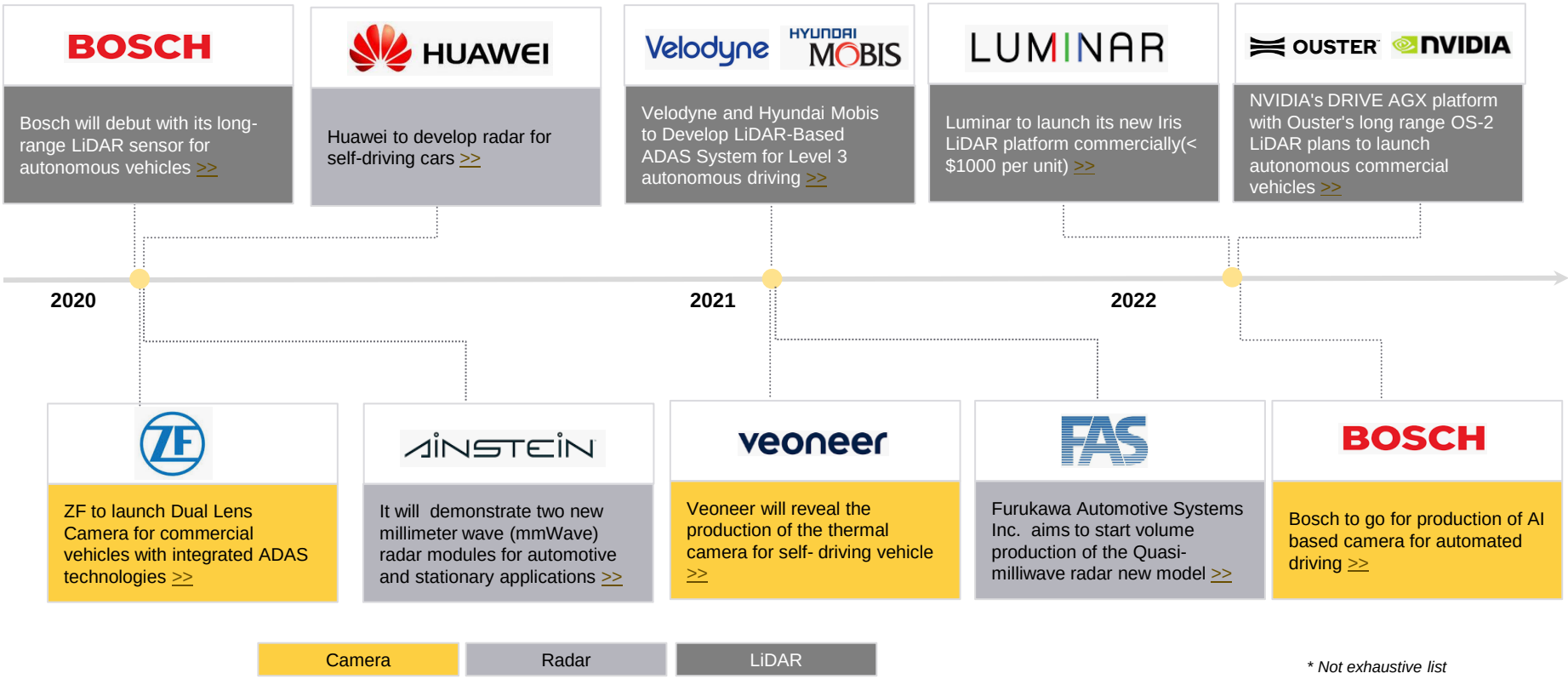
*Non comprehensive list:

Key launches in Camera

- Texas Instruments → TI’s first automotive SoC with an AI Accelerator launches for camera
- Ambarella → Ambarella unveils new AI chips for automotive cameras and driver assistance

ADAS Sensors: Upcoming launches in 2020-22

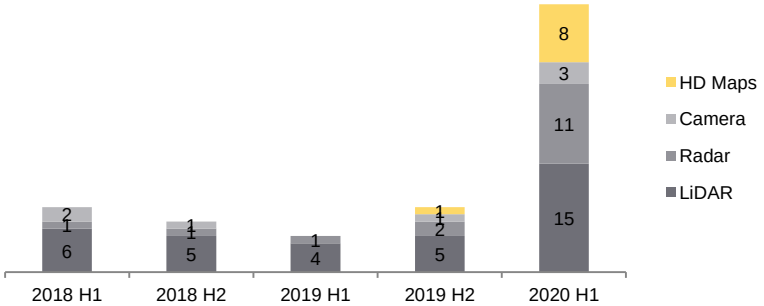
In near future, players will develop low cost , SoC, miniaturization of sensors to support automated driving and advanced driver assistance systems



** Not exhaustive list*

Collaboration Trends

OEMs are partnering with various HD map providing players on advanced mapmaking for automated driving



- OEMs are collaborating with research institutes for technology advancement in LiDARs and HD maps
- Also, sensor manufacturers are collaborating with each other to develop sensor fusion platforms for cost-efficiency and better packaging in level 3+ automation
- Velodyne has signed multiple agreements with players like Navya, easy mile, etc. to provide its lidar solution for automated driving

*Non comprehensive list

H1 2020

OmniVision and Artilux collaborate for 3D infrared sensors >>

Gapwaves and Uhnder collaborate for high resolution radar in last-mile applications >>

TomTom, Toyota and DENSO partnered on advanced mapmaking for automated driving >>

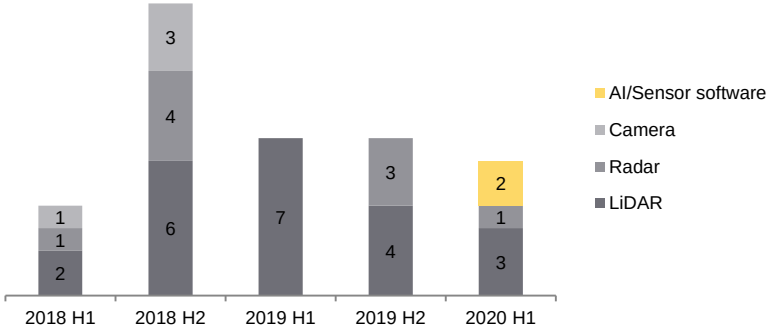
Toyota collaborate with Momenta to incorporate HD maps in its autonomous cars >>

Velodyne partners with easy mile for its TractEasy AV baggage tractors.>>

Quanergy Partners With Milexia for LiDAR development in Europe >>

Funding Trends

$264 million was raised by Lidar, camera and radar sensor startups in H1'20 comparing to around $382 million in H1'19



- Majority of funding activity concentrated on LiDAR focusing on technology like mirrorless lidar and single-chip lidar
- Bosch was leading investor in Chinese lidar maker Hesai tech which has received the highest funding among vision system sensors to the tune of $173M.
- There was no funding activity in camera technology-based startups and only single funding in radar startup i.e. in bitsensing equal to $5.8M

H1 2020

HESAI

Chinese LiDAR maker Hesai raises $173M for its mechanical lidar >>

CEPTON

Cepton Technologies raises $50M Series C funding for mirrorless lidar >>

SiLC

SiLC Technologies Raises $12M in Seed Funding to Deliver Long-Range, Single-Chip LiDAR for AV >>

HAILO
Empowering Intelligence

Hailo Raises $60M in Series B Funding >>

QCRAFT

Qcraft raises over $24 M to train autonomous vehicle systems in simulation >>

bitsensing

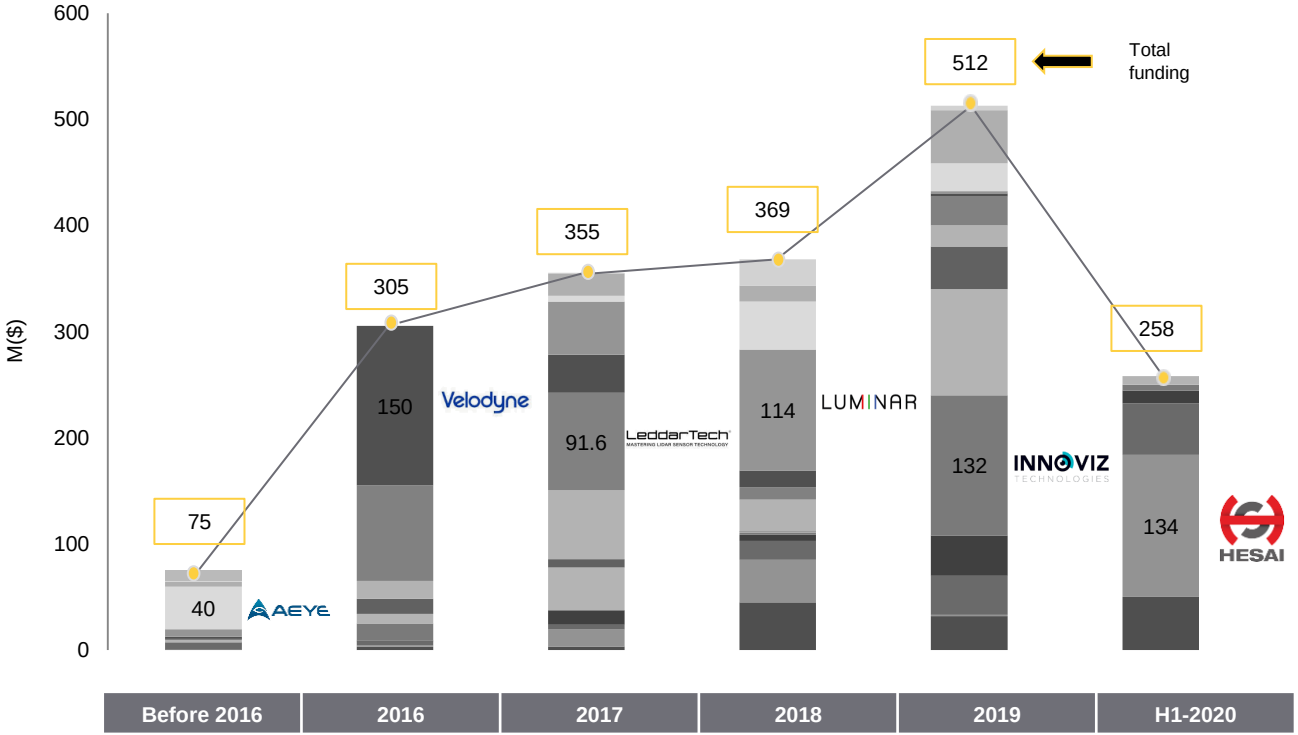
Bitsensing, Radar technology startup raises $5.8M Pre-Series A >>

Total funding in Lidar startups 2016-H1'20: $1.8B

NEW

Startup name	Total funding M($) till today	Technology
INNOVIZ TECHNOLOGIES	252	MEMS LiDAR
LUMINAR	250	Mechanical LiDAR
HESAI	230	Mechanical LiDAR
Velodyne	225	Mechanical LiDAR
LeddarTech MASTERING LIDAR SENSOR TECHNOLOGY	168	Flash LiDAR
QUANERGY	135	Optical phase array LiDAR
OUSTER	90	Flash LiDAR
oryx	67	FMCW LiDAR
AEYE	59	MEMS LiDAR
CEPTON	50	Micro motion tech based

- Investment has been down by 21% in H1-2020 y-y to $258M in Lidar startups (H1-2019: $325M).
- Innoviz has received the highest funding out of startups disclosing funding in Lidar. ($252M); Innoviz's tech is based on MEMS Lidar.
- Between 2016 and H1'20, $718M went to Mechanical scanning Lidar, or 40% of the $1.8B, $357M went to MEMS Lidar, or 20% of the $1.8B, $280M went to flash Lidar, or 15% of the $1.8B, $161M went to FMCW Lidar, or 9% of the $1.8B and $278M went to other type's of Lidar, or 16% of the $1.8B.
- The data comes from the investigation of 270 startups in ADAS and Vision Systems, 36 of which are working on Lidar and 24 have disclosed funding.

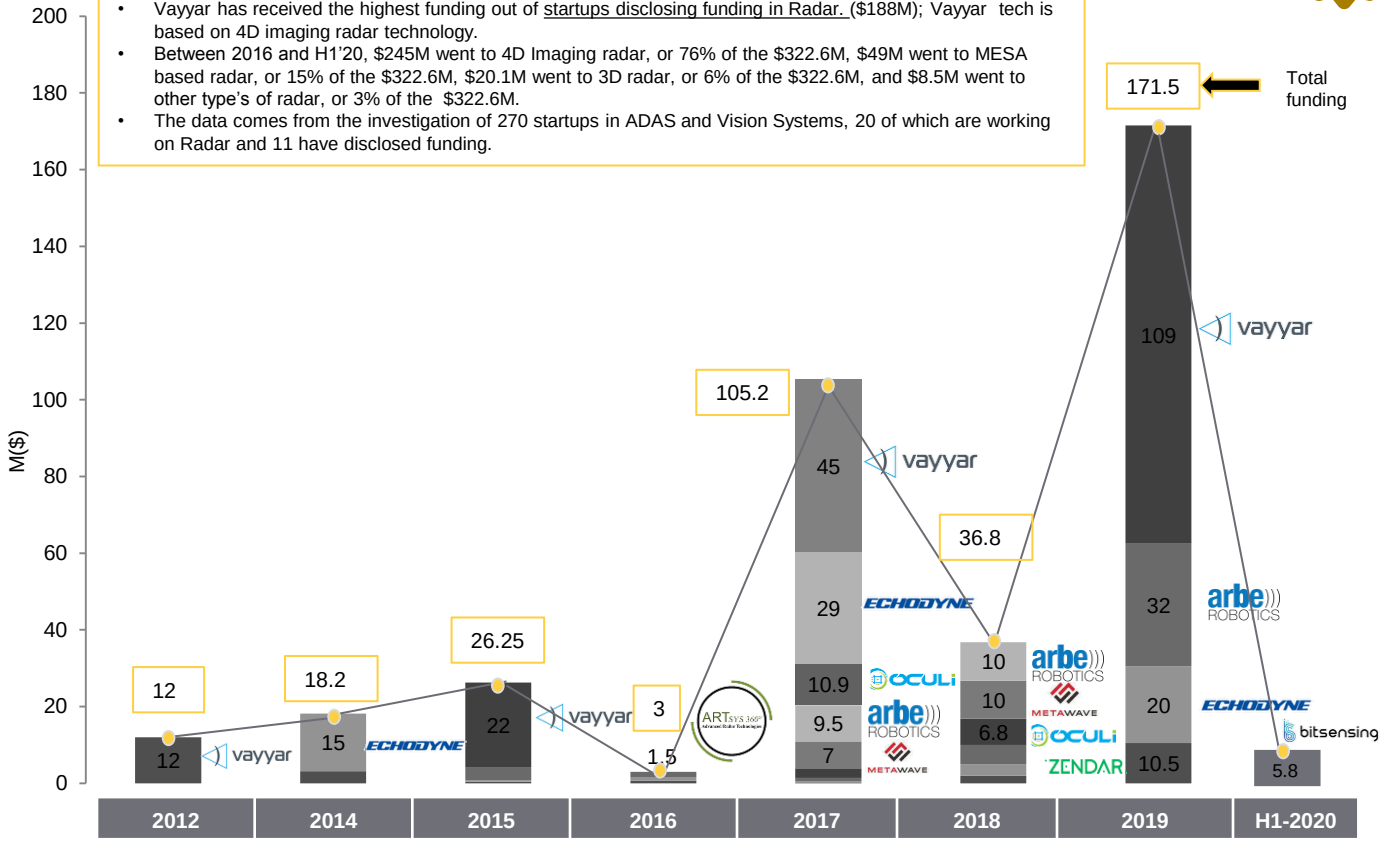


Total funding in Radar startups 2016-H1'20: $322.6M

NEW

Startup name	Total funding M($) till today	Technology
vayyar	188	4D imaging radar
ECHODYNE	64	MESA based radar
arbe ROBOTICS	54.6	4D imaging radar
OCULi	21.1	4D imaging radar
METAWAVE	17	3D Radar
ZENDAR.	10.5	4D imaging radar
LUNEWAVE	5.5	3D antenna based radar
ARTSYS 360	3.95	3D Radar
OMNIRADAR	3.19	FMCW based radar
WaveSense	3	Ground-penetrating radar
STERADIANSEMI	2.07	4D imaging radar

- Investment has been down by 45% in H1-2020 y-y to $5.8M in Radar startups (H1-2019: $10.5M).
- Vayyar has received the highest funding out of startups disclosing funding in Radar. ($188M); Vayyar tech is based on 4D imaging radar technology.
- Between 2016 and H1'20, $245M went to 4D Imaging radar, or 76% of the $322.6M, $49M went to MESA based radar, or 15% of the $322.6M, $20.1M went to 3D radar, or 6% of the $322.6M, and $8.5M went to other type's of radar, or 3% of the $322.6M.
- The data comes from the investigation of 270 startups in ADAS and Vision Systems, 20 of which are working on Radar and 11 have disclosed funding.

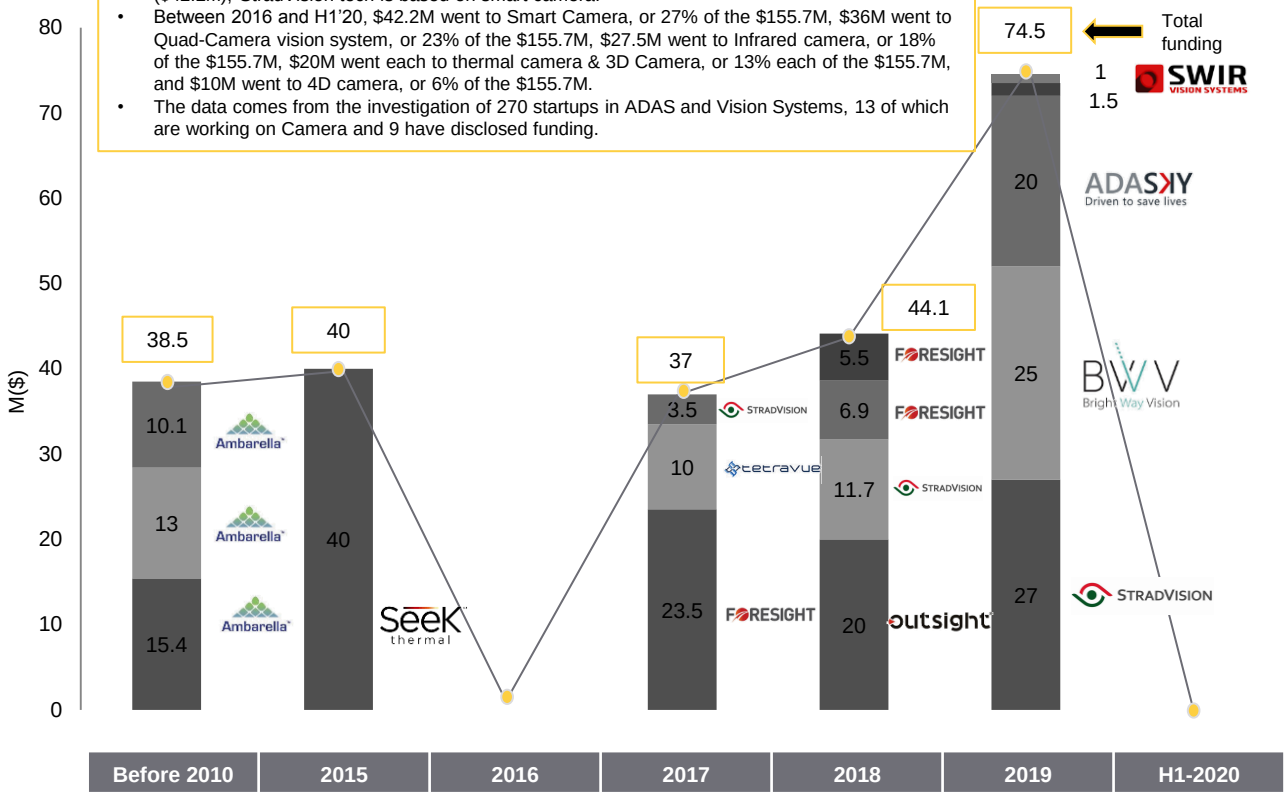


Total funding in Camera startups 2006-H1'20: $155.7M

NEW

- Investment has been down by 100% in H1-2020 y-y to $0M in Camera startups (H1-2019: $46.5M).
- StradVision has received the highest funding out of startups disclosing funding in Camera. ($42.2M); StradVision tech is based on smart camera.
- Between 2016 and H1'20, $42.2M went to Smart Camera, or 27% of the $155.7M, $36M went to Quad-Camera vision system, or 23% of the $155.7M, $27.5M went to Infrared camera, or 18% of the $155.7M, $20M went each to thermal camera & 3D Camera, or 13% each of the $155.7M, and $10M went to 4D camera, or 6% of the $155.7M.
- The data comes from the investigation of 270 startups in ADAS and Vision Systems, 13 of which are working on Camera and 9 have disclosed funding.

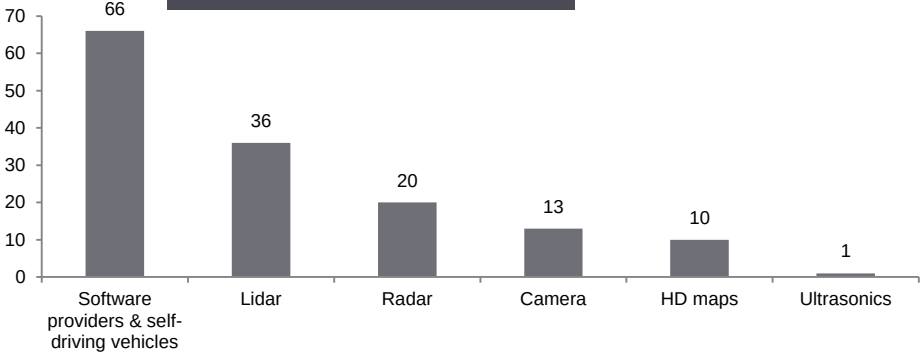
Startup name	Total funding M($) till today	Technology
StradVision	42.2	Smart Camera
Seek thermal	40	Thermal Camera
Ambarella	38.5	Infrared camera
Foresight	35.9	Quad-Camera
BWV Bright Way Vision	25	Infrared camera
ADASKY Driven to save lives	20	Thermal Camera
outsight	20	3-D Camera
SWIR Vision Systems	10	4-D Camera
tetravue	2.5	Infrared camera



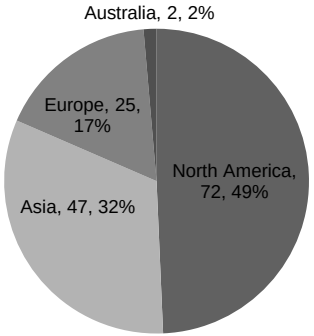
Startup Tracker Summary H1'20

North America has the highest number(72) of startup among 146 startups available in our startup tracker. Funding was dominated in Lidar sensors among Lidar($258M), radar($5.8M), and Camera($0M) startups in H1-2020

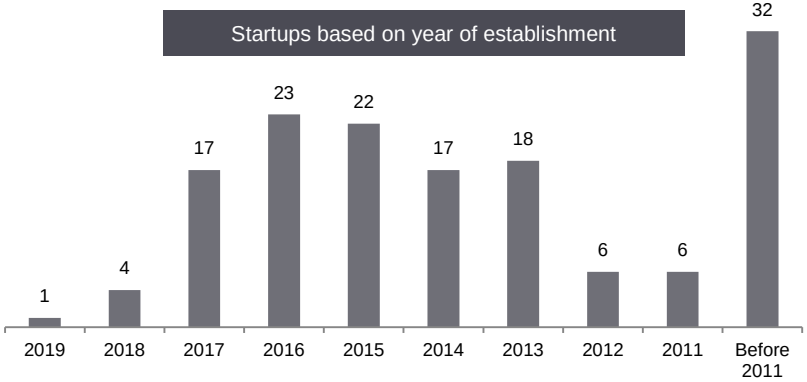
Startups based on technology



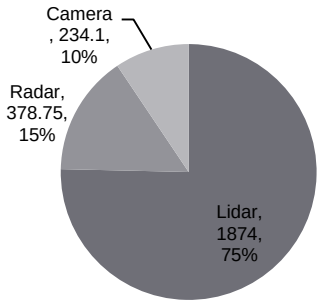
Startups region wise distribution



Startups based on year of establishment



Funding distribution between Lidar, Radar and Camera in M($), 2006-H1'20



For details see our Startup Tracker

North America
55 Madison Ave, Suite 400
Morristown, NJ 07960
USA
T: +1 212 835 1590

Europe
328-334 Graadt van Roggenweg
4th Floor, Utrecht, 3531 AH
Netherlands
T: +31 30 298 2108

United Kingdom
5 Chancery Lane
London EC4A 1BL
United Kingdom
T: +44 207 406 7548

Asia Pacific
Millennium Business Park
Sector 3, Building # 4, Mahape
Navi Mumbai 400 710
India
T: +91 22 6772 5700