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2016

F RESIGHT

The Quantum Leap towards

Autonomous Vehicles

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Foresight – the making of a market leader

Founded in 2015 by Haim Siboni as a spin-off from Magna BSP, Foresight, is an Israeli innovative software start-up company developing a state-of-the-art platform for Advanced Driving Assistance Systems (ADAS). The ADAS industry is regarded as the fundamental building block in the development of the autonomous vehicle industry and Foresight with its potential to overcome industry giants has the vision to become one of the three market leaders in the coming years.

Autonomous vehicles – fighting the road mortality pandemic

Just a little over a century ago, it was a rare incident to see an automobile – a horseless carriage, driving down the street. Despite the fact that Ford's Model T was not the first automobile, its introduction to the market in October of 1908 signaled the beginning of an era of independent transportation for the masses. Since then, little has changed on the roads. The fuel combustion engine is still the most commonly used, traffic jams and accidents are an unfortunate fact of everyday life, but most importantly, a human driver is still behind the wheel. What has changed dramatically is the amount of vehicles on the roads. Owning a car has become a global standard; driving licenses are given at a very early age, and rarely revoked.

Humans making real time decisions is something we take for granted, but it's exactly this fact that is responsible for the better part of the 1.2 million unnatural deaths and injuries on the road every year. Humans are emotional, they get tired, and their perception is often hindered by age, illness, drug abuse, and in recent years by external distractions, mainly the use of cellphones during driving.

It is estimated that 5% of the world's GDP is spent on dealing with the hazards and repercussions of driving. If we had a choice, we would most probably ban humans from driving vehicles. But unless society is willing to forfeit its ability to reach distant places with ease and comfort, this is not an option. However, it seems that there may yet be an alternative to the problem of human frailty on the roads.

Computers have been around for decades – making complex decisions based on infinite amounts of data. But only in late 1998 was the first Carputer (car computer) introduced to the market by Clarion Co. Despite the fact that on-board analysis and diagnostics have been available since the 1980s, the equipment installed could not be labeled as a computer. Nowadays, there is no such thing as a car without a computational system that integrates all its essential components. But has this truly revolutionized driving, as it has healthcare, education, and agriculture? The horrendous casualty rates on the road attest otherwise; but in the past half-decade or so, it seems the industry is heading in the right direction.

In the not so distant future, cars will be able to autonomously drive themselves through the hectic hustle and bustle of city centers, as well as the open road, efficiently negotiating unexpected occurrences, and most importantly transporting us safely to our destination. In order for this vision to materialize, both technological and social challenges will need to be overcome.

The moment of singularity, when a machine will finally be in the driver's seat might not be upon us, but features of autonomous vehicles are already installed in most modern vehicles. ADAS are embedded or added to vehicles to increase safety and aid the driver in real time decision making. ADAS are integrated with detection hardware such as cameras, radar systems, laser detectors (LIDAR), infra-red (IR), and other systems, combined with advanced software algorithms that analyze the data received from the detection indicators. ADAS includes features as simple as reverse driving indicators and adaptive lighting, all the way to the very complex and even interventional features such as automatic braking and lane keeping systems. ADAS technology is rapidly evolving, and markets are growing as consumer awareness of its enormous potential increases, but naturally the competition is becoming fiercer.

ADAS – revolutionizing driving

ADAS are technology platforms integrating hardware and software applications that have an interface with the vehicle's infrastructure, or in most current cases with the driver's senses – hearing or sight. Five technologies are commonly recognized in ADAS platforms:

- **Sensors** – the peripheral equipment mounted on the vehicle looks far into the horizon, or very close to the car itself depending on their role and functionality. The most prevalent sensors in the market are:

    - LIDAR – light detection and ranging devices that rely on laser technology to measure distance and detect obstacles surrounding or approaching the moving vehicle. These devices are extremely efficient and accurate thanks to their 360° perimeter of operations. Google uses LIDAR as the cardinal sensor on its autonomous car, and most mapping devices use it to achieve 360° coverage. The major downside of LIDARs is their cost. It is estimated that a single system costs somewhere between 50 and 90 thousand USD – much more than the average car itself, rendering the technology currently irrelevant for mass production purposes. Apart from the heavy price tag, LIDAR is colorblind and thus oblivious to traffic lights changing to red, brake lights turning on, and other color sensitive factors. However, LIDARs work very well in all weather, lighting, and road conditions.

    - Cameras – account for 25% of sensors used in ADAS. Photoelectric systems are based on commonly used technologies that have been around for decades, but of course have evolved and advanced to deliver better accuracy and extended features. Since this technology is so common, it comes with a very attractive price tag; a McKinsey analysis predicts that if photoelectric technology advances just a bit more, it just might render LIDARs obsolete thanks to the immense cost difference. While cameras can see colors, have a wide detection angle, and can be easily mounted on the car, their major drawback is their lack of accuracy in measuring speed and distance. Moreover, adverse weather conditions such as rain or fog, unfavorable light conditions such as twilight or darkness, and extreme road conditions, severely hinder the performance of cameras, up to the point that they are essentially useless.

- Radar – using electromagnetic waves, radar detects short, medium, and long-range objects. It is sometimes used as a complementary system in ADAS, providing detection in all weather conditions. The most notable advantage of radar is the range in which it is able to provide detection; even if an object is somewhat obscured from view, radar will still be able to detect it. Since radar relies on object signature for detection, non-metal objects such as a child crossing the road will return a faint signal, diminishing the system's detection ability. Radar is of course color blind and its accuracy is not the best in the market.

- Ultrasonic and IR – commonly used for park assist systems, send out short-ranged infra-red beams to detect objects coming from behind, or sometimes from in front of the vehicle.

- **Processors** – signals gathered from the peripheral equipment are sent to a central processor for analysis. As mentioned, vehicles have been equipped with computers since the late 1990s, but their function was to monitor the internal aspects of the car, whereas the ADAS processors analyze the external environment. State-of-the-art ADAS processors also have interventional capabilities, influencing internal systems such as brakes, steering, and illumination.

  Advanced processors have the ability to deliver a "one box" solution, applying advanced algorithms to integrate different types of sensors into unified data.

- **Software algorithms** – the very heart of the ADAS system, and probably the most complicated part of it. It's all about software nowadays since many of the previous limitations of hardware and processing power have been overcome. The efficiency, accuracy, and robustness of ADAS systems all rely on the level of sophistication of the algorithm.

- **Network devices and mapping** – GPS systems, which are one of the most prevalently used ADAS, completely rely on mapping. An area which is not mapped will not be supported by any guidance system, regardless of GPS signals. However, many other ADAS systems of the leading developers also rely heavily on mapping, not only of roads and traffic, but also of images. Vehicles, pedestrians, road blocks and countless other obstacles are mapped, stored in databases, and retrieved when necessary. Maps and

images are stored on the cloud; therefore tapping into this sea of information requires a stable and rapid network connection. On the road an almost instant reaction on the part of the vehicle or indication systems is required, so if the information is not processed, compared and tagged in a matter of microseconds, it becomes irrelevant. Drivers cruising at 100 KMPH need the systems installed on their vehicles to react instantly and in real time, rather than indicating that an object was there a few seconds ago.

- **Smartphones** – the hardware and software installed on smartphones have the capability of providing detection for ADAS purposes, almost as well as mission-specific cameras. New generation devices using two rear cameras enable 3D capabilities as well.

As smartphones provide the detection hardware for the ADAS, they can also provide processing power and signaling features. Indeed, since hardware, software, and network connectivity are now provided by smartphones, a device that has become so natural to users, navigation systems using them have rendered the entire market of single feature GPS companies almost obsolete. Waze for example, another Israeli start-up company, revolutionized automated navigation support through the inception of social driving. Waze was originally planned to create income from location-based advertising, only to be purchased by Google for over a billion dollars in June of 2013. Apart from the financial logic, there are still regulatory hurdles, alongside technological challenges.

ADAS – past, present and the inevitable future

Those who live in Mountain View California are perhaps the only ones who have actually seen what the future holds; the Google autonomous vehicle is the only exclusively self-driving car on earth at the moment. True, others have very advanced products, but none as spectacular as the Google car. For one, it has no steering wheel – not even allowing the option of a human to make any critical decisions on board, except for the destination of course. For those of us who live and work anywhere else, the future is still distant when it comes to vehicles driving themselves.

It's generally agreed that there are four main categories of automated driving, excluding the virgin category in which no systems exist on board, leaving us biased decision makers to do everything by ourselves:

1. Certain basic features of automated driving exist, providing drivers with alerts and indicators of safety issues. These can range from the most basic reverse proximity indicators, to the more advanced lane departure alerts. They are added to the basic systems of the vehicle, and are seldom designed as an integral part of the car.

2. ADAS features are embedded and fully integrated into the vehicle. Here, the ADAS will also have interventional measures, such as autonomous emergency braking, automatic distancing from other vehicles, and adaptive cruise control.

3. The semi-automated vehicle still has a steering wheel and cannot do without a human operator, but in certain environments, the driver can doze off and the car will do perfectly fine on its own. These vehicles can autonomously drive in traffic jams, as well as on the open road, where it's not as chaotic as in the city.

4. The fully autonomous vehicle not only has all the systems, but also the ability to make decisions in all situations, extreme weather conditions, and most importantly adapt driving style and behavior in light of the situation. In other words, this is not only an autonomous car; it's an object with Artificial Intelligence (AI).

Essentially, all ADAS systems contribute to either the safety of the vehicle and passengers, the driving experience and the comfort of the process, or to conservation aspects such as fuel consumption. However, many flaws need to be dealt with by various players in the eco-system before an autonomous vehicle can be sold on the open market. In category 3, the transition from autonomous to human driver is highly sensitive. The car disengages automatic mode in situations when it's too complex or ambiguous for the computer to drive the car. Research shows it will take an inattentive person approximately 25 seconds to gain his bearings, make a decision and act on it. So even if you cut this time by half, there is still too much time for things to go devastatingly wrong.

Moving from semi-automatic to fully autonomous requires much more than cutting edge ADAS systems that are fully in sync with each other and other systems within the vehicle. As noted, fully autonomous requires AI, but that alone will not do. Fully autonomous vehicles will have to communicate with one another and with the environment to be able to negotiate mundane situations. Think of a four-way intersection without a traffic light. If four

fully autonomous vehicles reach the intersection at the same time, they might be there forever, unless they communicate or set agreed upon protocols of collective behavior.

Many regulatory and liability issues will have to be addressed before fully autonomous vehicles are allowed onto the streets and highways. Insurance companies and regulators will need to resolve issues of accountability, standards, privacy, and even make up an entirely new set of laws, for this unprecedented era of self-driving machines. Imagine the dilemmas confronting policemen or judges in a situation in which a driver failed to stop his vehicle when required, due to the fact that no alert was received from the automatic system, or better yet, convincing insurance companies to cover such situations in their policies.

The ADAS Market

As opposed to the stagnating and consolidating automobile market which is experiencing an annual growth rate of about 2%, the ADAS market is sizzling. A P&S market research report published in March 2016 gave an estimate of 27% for the compound annual growth rate of the ADAS market during 2016 to 2022. In monetary terms, this means that a global expenditure of $20 billion in 2015 on ADAS will grow to as high as $100 billion by 2022. Some would argue that these might be somewhat conservative estimates. An IndustryARC analysis predicts a more gradual growth rate with a CAGR of 14.9%, but claims that the ADAS market generated $39 billion in revenues during 2015 alone, thus predicting a healthy market size by 2020. Research has found large disparities between analysts covering the market, with estimates ranging from a CAGR of 10% to as high as 29%. Nevertheless, these estimates put the sector as one of the fastest growing within the automotive market, if not the fastest.

When analyzing the market from a geographical perspective, it seems that in 2015 Europe was leading with an estimated expenditure of about $7 billion. However, over the course of 5-7 years APAC will outpace the rest of the world with an estimated CAGR of 40.5% and revenues far exceeding any other geographical region. In the likely case that a disruptive technology will lower system prices significantly, alongside regulators adopting a fiercer approach towards fighting road casualties, the market is expected to surpass all estimates.

Despite these promising figures, the automotive market might not be able to support such radical growth. Every year 90 million new vehicles are sold globally, though this figure might shrink if estimates are correct and the percent of shared cars rises. As of today, it is estimated that about 20% of new cars sold are intended for the shared car segment, and the demand for shared services is rising every year. Moreover, with the development of mass transportation systems, corporations and employees gradually shifting to more flexible work configurations, and environmental concerns, the number of vehicles sold worldwide may fall significantly.

Eventually it is up to consumers to decide if and how much to spend on ADAS; bringing the benefits of ADAS to the of consumers' attention, convincing them to invest in these systems not only their money but also their trust, is a behavior changing matter.

Industry segmentation

ADAS systems are installed in vehicles through two industry players – the OEMs and aftermarket vendors; the eco-system also includes Tier 1 and Tier2 developers.

- **Original Equipment Manufacturers (OEMs)** are the automobile manufacturers, which play a dominant role in the market, and control the pace of adoption of such systems. Despite their pursuit for differentiation and innovation, auto companies tend to be conservative players, focusing on cost reduction to keep their margins as high as possible. OEMs uphold high standards of quality assurance, thus making it difficult for new players to infiltrate the market. On the other hand, aftermarket vendors are able to integrate the systems on existing platforms, but these are highly fragmented, making it difficult for small ADAS developers to reach a significant market share.

  Most automobile manufacturers offer certain types of ADAS in their products; some are organically developed, others purchased and integrated. Subaru and Toyota are examples of OEMs that have integrated proprietary ADAS systems.

  If small or medium companies with innovative ADAS solutions wish to enter the market and ensure a sizable market share, they can also do so through Tier 1.

- **Tier 1** companies are system integrators, which predominantly already have working contracts with the major automobile manufacturers. Once an ADAS system developer

gains access to a Tier 1 player, augmenting the integrated system to provide driving aid solutions together with the existing features provided, the chance of adoption by leading car manufacturers rises significantly. Notable Tier 1 companies are Valeo, Herman Int. and Bosch;

- In **Tier 2** are ADAS system developers; amongst the leaders are companies such as Autoliv and Mobileye. With a market value of around $8 billion, and strategic contracts with both OEMs and Tier 1 companies, Mobileye is a veteran and one of the most advanced ADAS developers, with proven technology and features that revolutionized the market. Mobileye spent years in mapping roads, driving behavior, obstacles, and additional traffic factors. According to its CEO, Mobileye holds strategic contracts with all OEMs, apart from Toyota and Mercedes. Its technology is mature and perhaps closest to the development of full vehicle automation.

  Mobileye is challenged by players of all market segments, but in addition to the usual suspects, giants such as Intel, Panasonic, Qualcomm, Samsung, and Sony are also entering this potentially lucrative market. Since the industry is highly competitive and fragmented, the greatest threat comes from innovative start-up companies with disruptive technologies.

- **After Market –** Approaching users through after-market vendors is entirely different for small solution providers. Since the software can work with any hardware with supporting parameters, accessing the market by means of the service providers, those who have the most intensive interaction with the drivers, presents an opportunity. However, reaching hundreds of thousands of service points across the globe is extremely challenging.

Foresight – becoming a market leader

An innovative software company that develops a state of the art technology platform for the ADAS industry, Foresight was founded as a spin-off from Magna BSP (magnabsp.com). It has the potential to overtake industry giants and realize its vision of becoming one of the three market leaders in the years to come.

Both Magna and Foresight are located in Dimona, a development town in the Negev Desert that was established in the 1950s as part of the vision set by Israel's first Prime Minister,

David Ben-Gurion, who stated that the ultimate test of Israel is not a struggle against outside hostile forces, but of settling the barren land spaces of the Negev Desert through science and pioneering.

At the beginning of 2016, the company raised $6.5 million from private strategic investors in Israel, amongst which are Israeli exclusive importers of Citroen & Peugeot, Porsche, Audi, Volkswagen, Seat & Skoda brands. Foresight is listed on Tel Aviv Stock Exchange (FRST) with a market cap of about $40 million and in order to raise additional funds which are necessary for its future development, the company is exploring the possibility to raise it on NASDAQ in the near future .

 Foresight has 20 employees, mostly software engineers working on the development of the ADAS features and hardware engineers researching the specifications of the optimal boards and equipment to provide input and processing power for the algorithm. Management and administrative staff account for the remaining personnel.

At the current burn rate, Foresight has enough funding to last till the summer of 2017. An additional funding round is already underway, and when it is completed the company will have enough funds to last till the end of 2018. Revenues from the ADAS industry are not expected to come in before 2019.

Foresight – looking at the world with two eyes

Foresight's competitive advantage is based on technology developed by Magna BSP, a leading Israeli innovator in the field of homeland security surveillance solutions. After operating for over 15 years, Magna BSP holds a respected place at the forefront of the global industry. Magna's technology provides perimeter security on land, as well as intruder detection in maritime and aviation routes. For the past decade and a half, Magna has gained knowledge and experience in data analytics simultaneously coming in from two cameras, while most of the world remains monocular.

Since 2011 Magna BSP has been investing in specific R&D for homeland security technology to cross over to civilian applications. The fundamental challenge was to adapt the software designed to analyze data coming in from cameras positioned on a fence a few meters from one another, to a situations in which the cameras are mounted on a vehicle's windshield,

allowing a maximum distance of one meter between cameras. Foresight was established in 2015 to address this challenge.

In a world of one-eyed sensors, Foresight's platform provides accurate distance measurement, reliability in all weather and lighting conditions, with a true hallmark of zero false positive indications. What would the market feedback be if a vehicle's emergency brakes engaged whenever a roadside garbage bin, mistakenly taken for a crossing pedestrian is detected at a certain angle? All systems are designed to ensure safety, but enhanced safety entails high sensitivity; the tradeoff is frequent false positives.

Just like the human brain creating three-dimensional representations from information received from both eyes, the cameras allow Foresight's systems to provide accurate decision making support.

The Foresight technology algorithm platform can be integrated with any hardware that abides by certain specifications. Its strategic advantages are twofold. First, instead of the single camera system commonly used by most other competitors, it has dual camera analysis capabilities that only a few companies such as Subaru and Valeo have, although these are limited to daytime use only. Foresight's software optimizes indications received from two cameras, creating a 3D representation both in favorable lighting and in the dark. The algorithm has a proven ability to process data coming in from regular cameras in all lighting situations, complemented with thermal cameras that kick-in when it gets dark or foggy. The second advantage is its robustness – being able to work with an unlimited range of hardware systems, it provides a patented software platform that can support many ADAS features with the same peripheral and central equipment.

Using a stereo-scoping system might be regarded as trivial. After all, we humans and almost all animals on land and sea use two eyes. Even if the industry hasn't yet thought of it, why not simply evolve and start using this for their ADAS products? The answer is that it's not that simple. It is extremely challenging for an algorithm to achieve what the human brain is intuitively capable of doing – comparing two feeds and constructing a coherent unified view, while compensating and adjusting action. But once this is done, the benefits are immense.

Foresight's vision is to revolutionize optical-based driving assistance systems. This will be accomplished through the creation of a 3D stereo-based system, providing over 99%

detection probability and minimum false positives, working in all weather conditions and providing optimal results during the day or night in extreme road situations.

Foresight's ADAS Features

A company the size of Google has the prerogative of adopting an all or nothing approach, one that a small company such as Foresight cannot afford to do. Foresight is a solution company with a strategy of releasing one feature at a time, slowly but surely reaching autonomous capabilities in the medium to long range. Teams at Foresight are working in parallel on several features, which will be released once matured, tested, and perfected.

Since Foresight has a technological superiority in certain road, weather, and situational occurrences (day-night for example), features supporting these occurrences will be pursued first. Initially, features will not have interventional capabilities – physically manipulating the vehicle, but rather only indicative signals warning the driver.

- Pile-up prevention – a unique feature that no other ADAS player currently has the ability to offer. Pile-up accidents are very common, once a vehicle's brakes are applied, in an attempt to make an emergency stop, the driver coming right after it sometimes has very little time to react and brake hard. This lag time affects not only the next vehicle, but also of those behind it. Using Foresight's technology, once the cameras of the second car detects the red brake lights of the car in front; an emergency rear led light will go on, warning the car (and also the driver) behind that it needs to brake too. The ADAS system is applied instantly, while the driver of the second car is still processing the environment.

- Traffic light recognition – most drivers run a red light not because they are outlaws with no respect for others' safety, but simply because they are not paying attention to the road and visual signals. Foresight's application will turn on an emergency indicator within the vehicle if the algorithm predicts the driver is about to run a red light. This is another feature unique to Foresight's technology, being able to handle more complex situations – distance from intersection, speed, differentiation between several traffic lights in the interchange and determining which is relevant for the vehicle.

- Lane departure warning / prevention – this feature is offered by most ADAS vendors, but in Foresight's case, the results are significantly enhanced. Once a vehicle starts to deviate

from the lane it is using without signaling or other intentional intent signals, the vehicle either sends out a warning signal, or physically intervenes, returning the vehicle back to its original lane. This is accomplished by relying on road lane markings. But what if these are unclear or inconsistent? Many false positive indications occur when applying this feature, but not in Foresight's case, even at night, thanks to the heightened sensitivity achieved by comparing images from both cameras without the collateral price of false indications.

Foresight's system deals efficiently with not only unintentional lane departures, but also other hazards. If a vehicle is driving on a street where there is a large pothole that has to be avoided, most systems will not be able to recognize the pothole and engage the Lane Departure Prevention system, while Foresight's solution will recognize the pothole and foresee the lane deviation.

- Adaptive Cruise Control (ACC) / Forward Collision Warning (FWC) – another common ADAS feature, both rear and front cameras can detect dangerously close vehicles, warning the driver of an imminent potential collision. If a 2D system sees a car from its side rather than its rear or front, it will not be identified as a car and the chances of a collision climb significantly. 3D systems on the other hand will have no problem to cope with such situations.

- Detecting pedestrians and cyclists– roads are designed to serve the needs of mainly motorists, neglecting to take into account the full spectrum of users. A WHO Global Status Report on Road Safety shows that 49% of all road traffic deaths occur among pedestrians, cyclists and motorcyclists. At the same time, the report claims that the solution lies in adapting infrastructure, something that developing countries are unlikely to do, though they are the countries that need a solution most. Affordable ADAS features providing motorists another two seconds to brake hard if a child suddenly dashes into the road, might be the catalyst in the fight against traffic casualties.

  When looking at an image in 3D, the Foresight algorithm is able to differentiate between a meter-high four-year-old child and roadside clutter. Synchronized multi-angle input nullifies false positives, promoting safety and confidence in the system.

These and many other driving aid features are currently being developed; just these past two years many breakthroughs have been made, not only in technology, but also in market adoption and expenditure. Nevertheless, we still have a long way to go until the staggering numbers of people losing their lives on the road is dramatically diminished. Road traffic injuries are currently estimated to be the ninth leading cause of death across all age groups globally, and it is predicted to become the seventh leading cause of death by 2030 if proactive measures are not taken.

In 2010 the United Nations General Assembly adopted a resolution that led to the establishment of the Decade of Action for Road Safety (2011–2020), calling on countries to take the necessary steps to make their roads safer. As numbers are still going up, perhaps a change in paradigms needs to be adopted, looking at the problem with two eyes instead of one.

The main dilemma

The ADAS market presents potentially lucrative opportunities with rapid growth rates, but many large corporations alongside quick moving start-ups are trying to operate in it. Penetrating the traditional automotive market might take years, but those who have succeeded, as in the case of MobilEye, enjoy lofty rewards.

As opposed to the traditional market approach, integrating Foresight's solutions on the smartphone platform has the potential of reaching millions of users in a screen-swipe and enjoying a much faster penetration rate, although the business models are more complex, and have yet to be proven.

Foresight's vision is to become one of the three leading companies in the ADAS market in the years to come and generate value for its shareholders in the next five years. Its management has confidence in the company's technological capabilities, which provide it with a strategic advantage over competitors. Technology is indeed a crucial element in attaining the company's goals, but it might not suffice in this volatile market.

Foresight faces core strategic dilemmas when it comes to the company's growth avenues, fulfillment of its vision, and maximizing value:

- Should the company focus on the traditional ADAS market, on smartphones, or both?

- In which markets should the company operate, with whom should it cooperate, and under what types of agreements?

- What are the financial resources that will be required throughout the company's lifecycle?

- What are the milestones that should be set in implementing the company's strategy in the next five years? And in light of these, what is the expected value the company is forecasted to generate?

Addressing these strategic dilemmas is essential for Foresight's development, and will undoubtedly determine how its future will look; therefore immediate decisions need to be made.

Appendixes

**Exhibit 1 – Top 20 countries by the number of road motor vehicles per 1000 inhabitants**

Rank	Country	Motor vehicles per 1000 people
1	San Marino	1,263
2	Monaco	842
3	Liechtenstein	826
4	United States	809
5	Iceland	747
6	Luxembourg	741
7	Australia	731
8	Malta	709
9	New Zealand	708
10	Guam	703
11	Italy	682
12	Canada	662
13	Spain	593
14	Norway	591
14	Germany	588
15	Japan	588
16	Austria	585
17	Poland	580
18	France	578
19	Switzerland	573
20	Lithuania	560

Source: en.wikipedia.org/wiki/List_of_countries_by_vehicles_per_capita

Exhibit 2 – Forecasted Life Saving Due to Global Road Safety Action
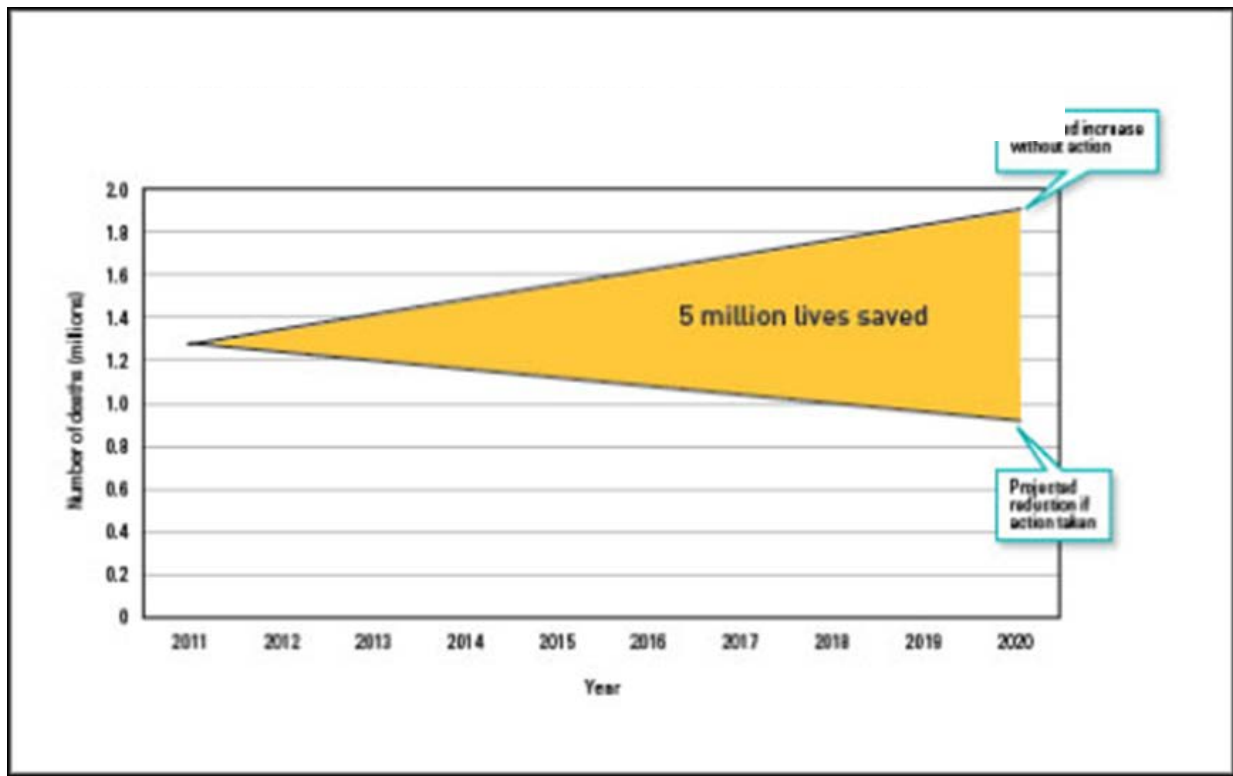
Source: Decade of action for road safety 2011–2020, WHO report

Exhibit 3 – Top 10 Leading Causes of Death, 2004 and 2030 Comparison

2004		2030	
Rank	**Disease or injury**	**Rank**	**Disease or injury**
1	Ischaemic heart disease	1	Ischaemic heart disease
2	Cerebrovascular disease	2	Cerebrovascular disease
3	Lower respiratory infections	3	Chronic obstructive pulmonary disease
4	Chronic obstructive pulmonary disease	4	Lower respiratory infections
5	Diarrhoeal diseases	5	Road traffic injuries
6	HIV/AIDS	6	Trachea, bronchus, lung cancers
7	Tuberculosis	7	Diabetes mellitus
8	Trachea, bronchus, lung cancers	8	Hypertensive heart disease
9	Road traffic injuries	9	Stomach cancer
10	Prematurity & low-birth weight	10	HIV/AIDS

Source: Decade of action for road safety 2011–2020, WHO report

Exhibit 4 – Average Value of Prevention Per Reported Casualty and Per Reported Road Accident

£2014

Accident/casualty type	Cost per casualty	Cost per accident
Fatal	1,836,054	2,066,732
Serious	206,321	235,791
Slight	15,905	24,887
Average for all severities	54,849	77,825
Damage only	-	2,204

1 The costs were based on 2014 prices and values

2 The numbers of reported road accidents were based on 2014 data

Source: Reported Road Casualties in Great Britain: 2014 Annual Report
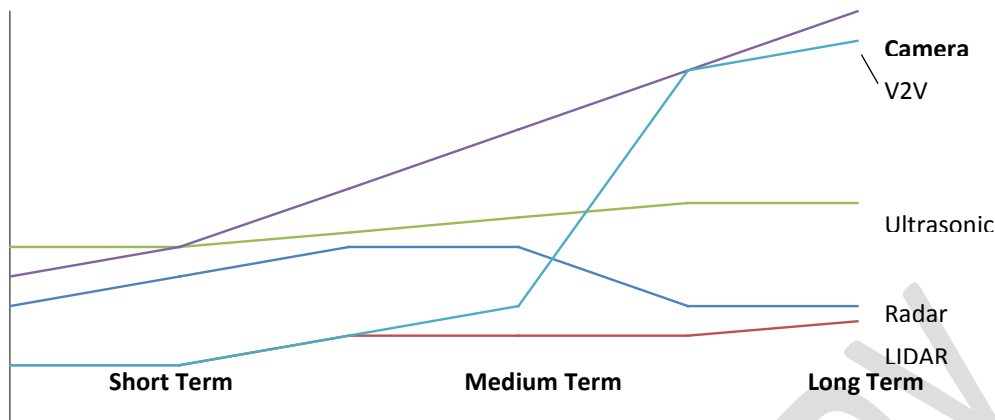
Exhibit 5 – Eras of Automotive Safety Technology
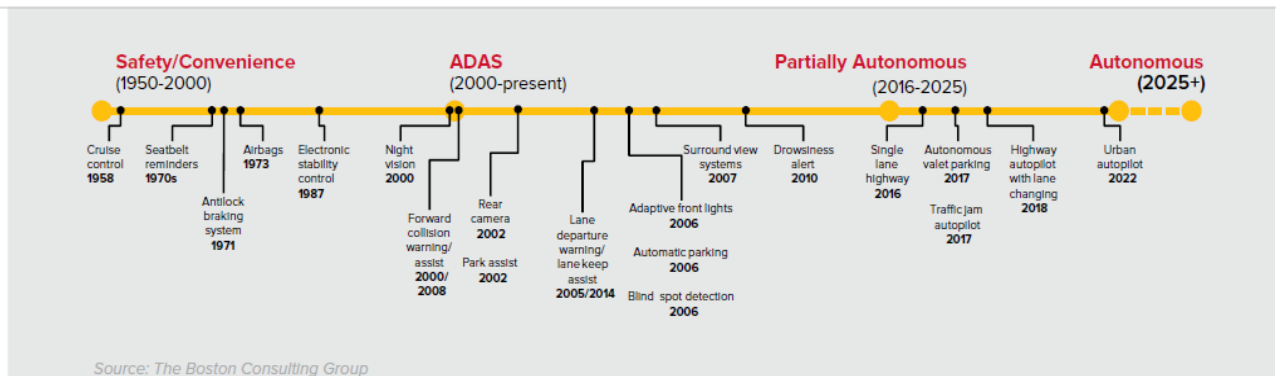
Source: The Boston Consulting Group

Exhibit 6 – ASAD Supportive Technology Development

Source: MSI research

Exhibit 7 – ADAS Main Products

Adaptive Cruise Control (ACC) systems automatically adjust a vehicle's speed to maintain a safe following distance from the vehicle in front of it using cameras, radar or LIDAR sensors in front of the vehicle to detect the time-to-contact and distance of the vehicle ahead of it.

Adaptive High Beam Control (AHC) automatically adjusts the height of the high-beam pattern depending on traffic conditions to give the driver the maximum amount of illumination.

Autonomous Emergency Braking (AEB) avoids and/or mitigates an imminent collision with another vehicle by automatically applying the brakes to slow down the vehicle. Depending on the host car speed, the collision can be avoided or mitigated.

Construction Zone Assist systems sense and measure the position of possible stationary obstacles located in the periphery of the driving path to enable automatic lateral control of the vehicle to find a "clear path" moving forward in a cluttered scene – such as construction areas.

Dynamic Brake Support (DBS) provides additional support when a driver has initiated insufficient brake pedal input to avoid a crash.

Forward Collision Warning (FCW) systems use cameras, radar or LIDAR sensors to monitor the area in front of a vehicle and alert the driver of a potential rear-end collision with another vehicle.

Headway Monitoring and Warning (HMW) recognizes the preceding vehicles in the host vehicle's lane and adjacent lanes and provides accurate time-range (range divided by host car speed) estimation for contact with the targets.

Lane Departure Warning (LDW) systems use visible lane markers to track vehicle position within a lane and issue a warning for an unintended road departure.

Lane Keeping and Support (LKS) is a steering system that provides torque overlay in cases where the host vehicle approaches the lane marker without the turn signal having been activated, both alerting the driver of a lane departure and directing the vehicle to stay in the lane.

Lane Keeping Assistant (LKA) is a Lane Departure Warning (LDW) system in which the controller sends torque input to the steering system in order to keep the vehicle inside lane boundaries.

Pedestrian Autonomous Emergency Braking (Ped-AEB) is similar to AEB, but here the imminent collision threatens a pedestrian who is stationary, walking, running or emerging behind an occlusion boundary.

Pedestrian Collision Warning (PCW) warns the driver about potential collision with pedestrians.
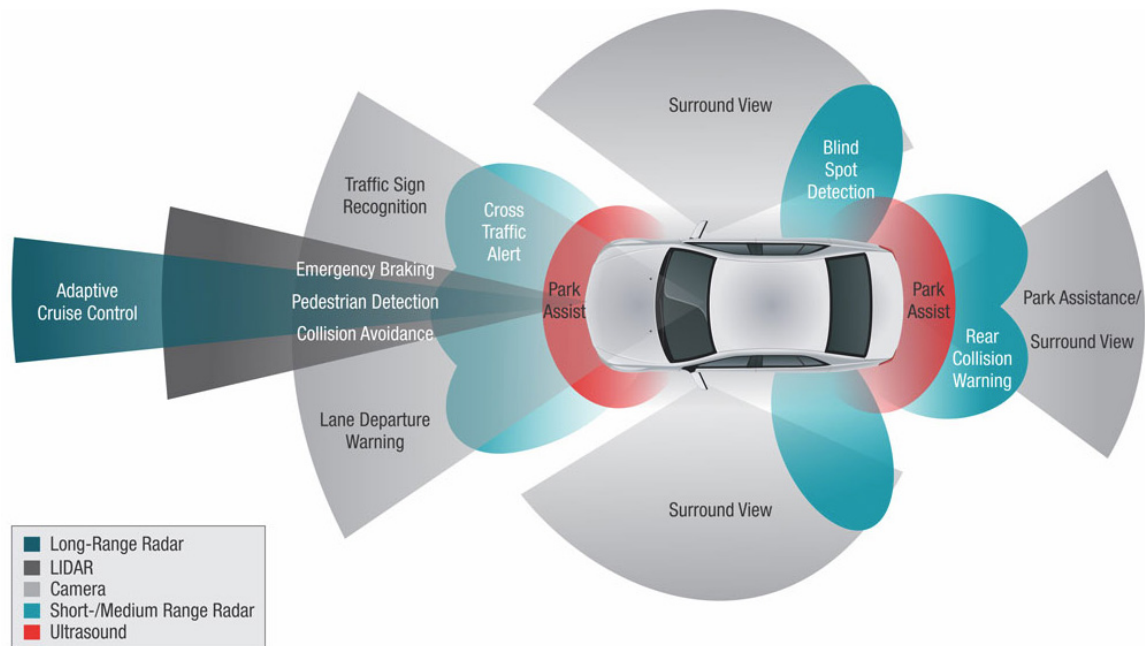
Traffic Jam Assist systems control the car autonomously up to a pre-set speed during traffic jams by controlling following distance as well as providing active steering input.

Traffic Sign Recognition (TSR) notifies and warns the driver which restrictions may be effective on the current stretch of road.
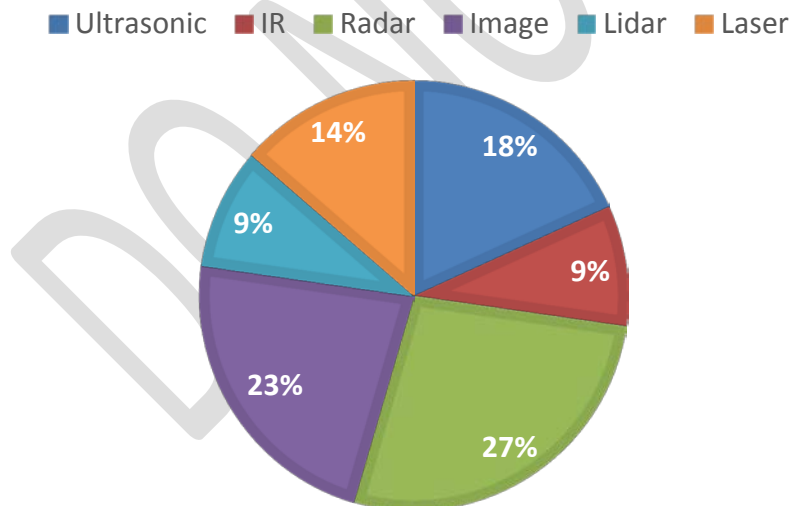
Source: Mobileye report, 2015

Exhibit 8 – ADAS Sensors, by Type

Source : ABI Research

Exhibit 9 – ADAS Sensor Market Segmentation, 2016

Legend: ■ Ultrasonic ■ IR ■ Radar ■ Image ■ Lidar ■ Laser

- Laser: 14%
- Ultrasonic: 18%
- IR: 9%
- Radar: 27%
- Image: 23%
- Lidar: 9%

Source: ABI Research, 2016

Exhibit 10 – Accumulated ADAS Sensor Demand Forecast (Million units)
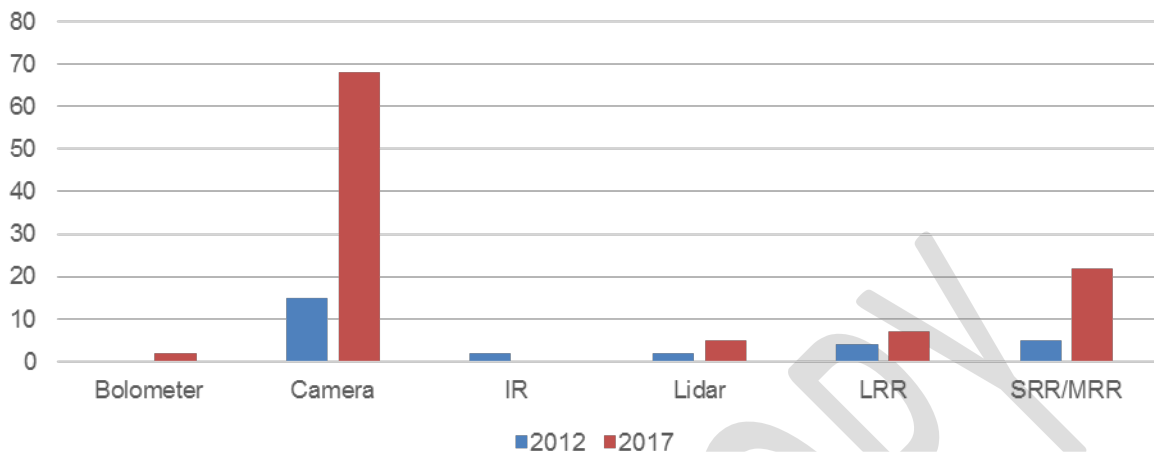
Source: ABI Research, 2016

Exhibit 11 – Key Factors for Consumer of ASAD Systems
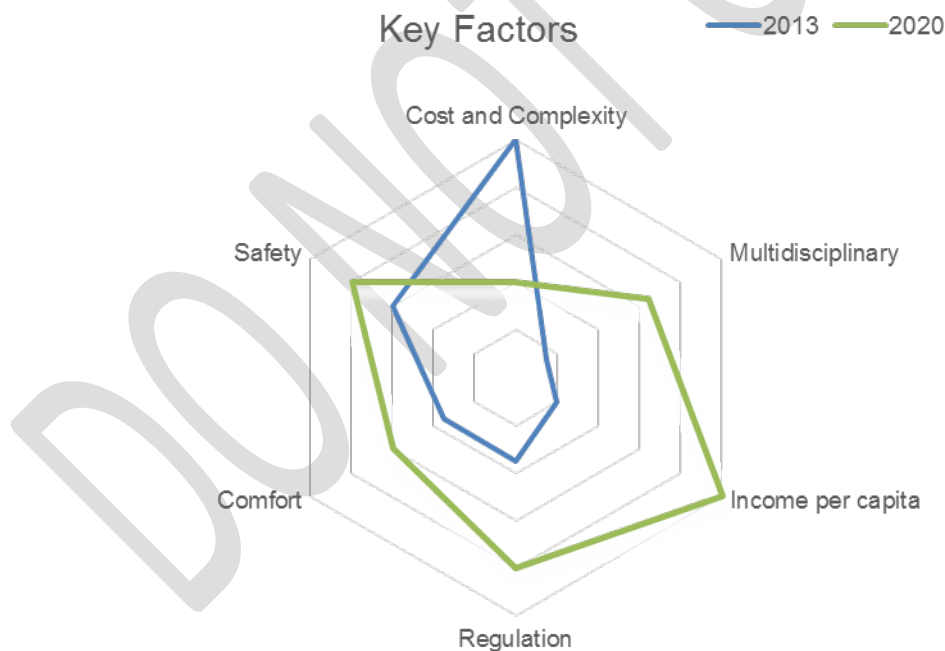
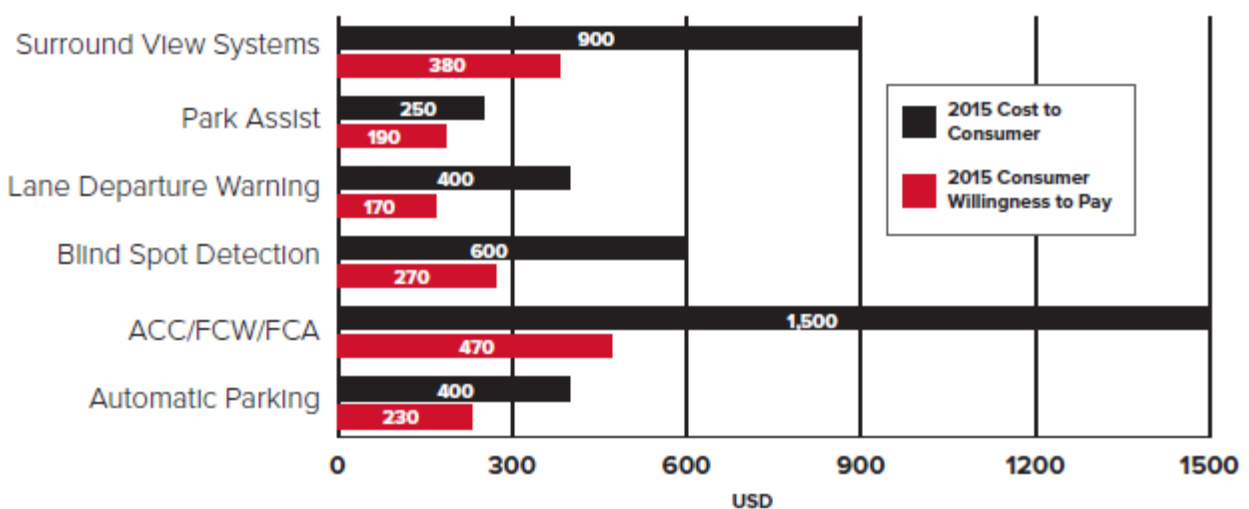
Source: Frost & Sullivan, April 2014

Exhibit 12 – Total Passenger Safety Market: Key Vehicle Selection Criteria, Europe 2013

Total Passenger Car Safety Market: Key Vehicle Selection Criteria, Europe, 2013

Criteria	%
Reliability	90%
Safety	86%
Ride and handling	83%
Fuel economy/efficiency	82%
Price of vehicle	73%
Comfort and convenience	62%
Environmentally friendly	52%
Power train	50%
Design and style of the exteriors	44%
Design and style of the interior	41%
Infotainment/ entertainment features	39%
Customization or personalization	37%
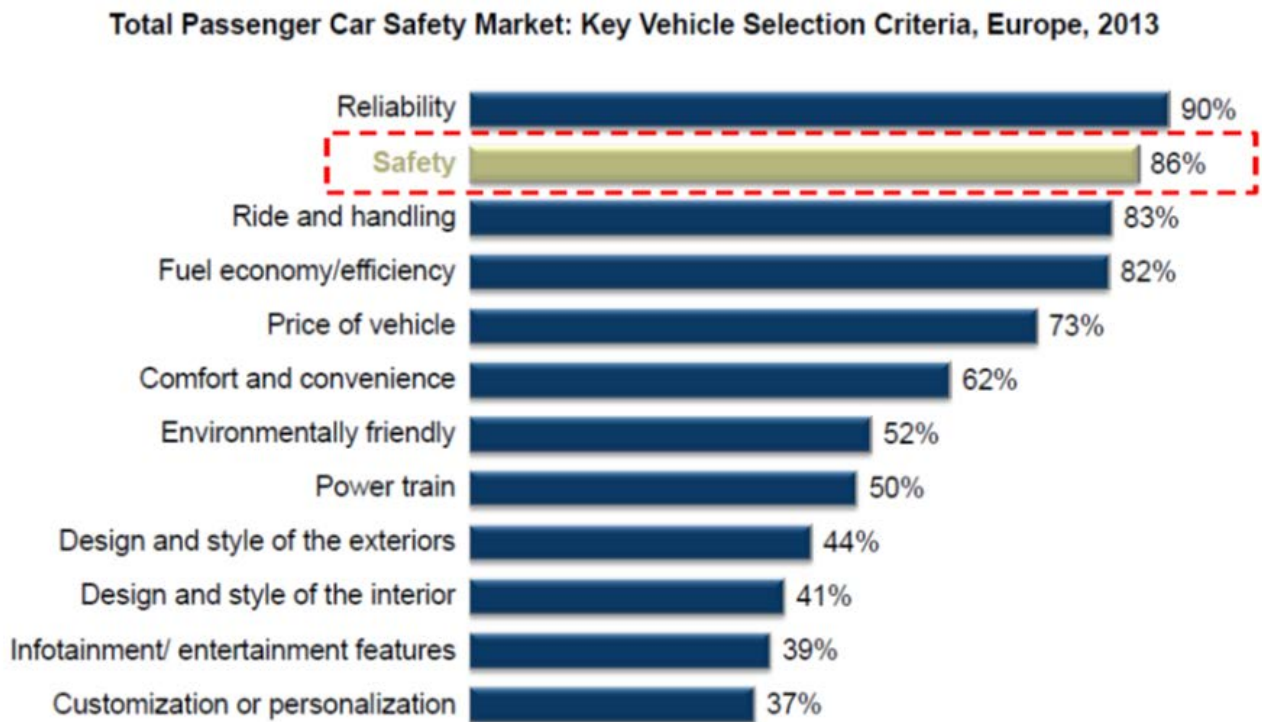
Source: Frost & Sullivan

Exhibit 13 – Gap Between Current Cost to Consumer and Consumer Willingness to Pay for ADAS Features

Feature	2015 Cost to Consumer	2015 Consumer Willingness to Pay
Surround View Systems	900	380
Park Assist	250	190
Lane Departure Warning	400	170
Blind Spot Detection	600	270
ACC/FCW/FCA	1,500	470
Automatic Parking	400	230

USD

Source: The Boston Consulting Group, 2015

Exhibit 14 – Global ADAS Expected Growth ($ billions)
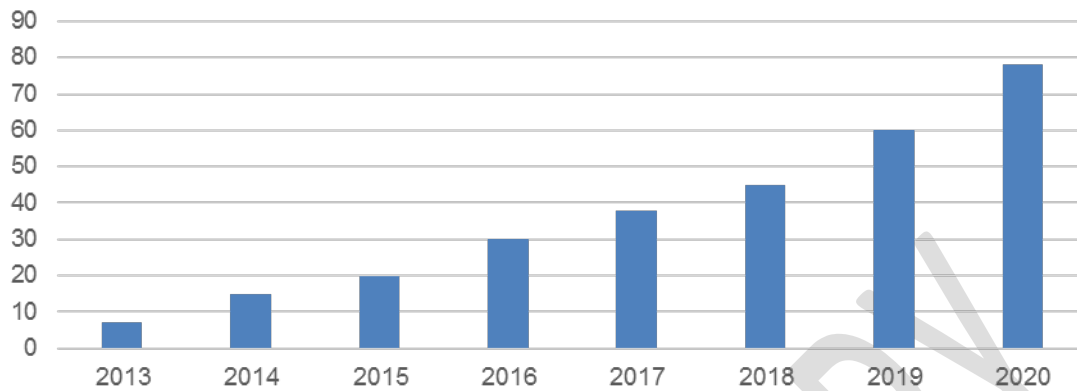
Source: ABI Research, 2016

Exhibit 15 – ASAD Market Penetration by Region – 2014-2020

NA   Europe   Asia
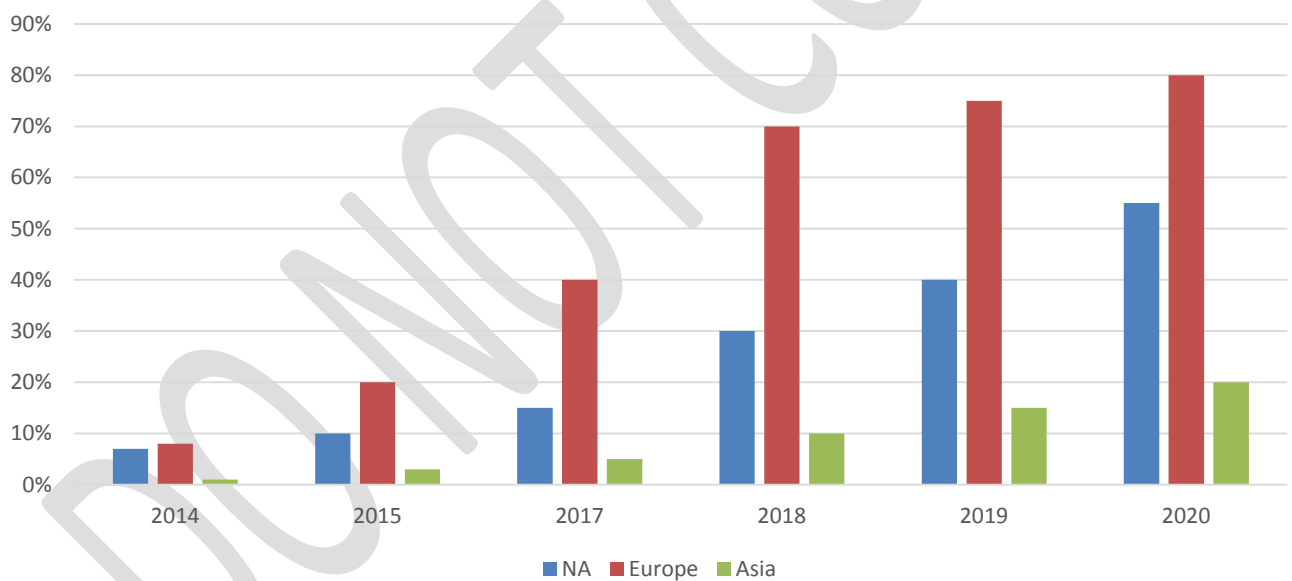
Source: MSI research

Exhibit 16 – ADAS Global Main Competitors

Mobileye

Mobileye N.V., together with its subsidiaries, develops computer vision and machine learning, data analysis, and localization and mapping for advanced driver assistance systems and autonomous driving technologies. The company operates through two segments, Original Equipment Manufacturing and After Market. Mobileeye offers Roadbook, a localized drivable paths and visual landmarks using its proprietary REM technology through crowd sourcing; and proprietary software algorithms and EyeQ chips that perform detailed interpretations of the visual field to anticipate possible collisions with other vehicles, pedestrians, cyclists, animals, debris, and other obstacles. Its products also detect roadway markings, such as lanes, road boundaries, barriers and related items; and identify and read traffic signs, directional signs, and traffic lights. In addition, the company provides enhanced cruise control, pre-lighting of brake lights, and Bluetooth connectivity, as well as related smartphone application. It serves original equipment manufacturers, tier one system integrators, fleets and fleet management systems providers, insurance companies, leasing companies, and others through distributors and resellers. Mobileye N.V. was founded in 1999 and is headquartered in Jerusalem, Israel.

Valeo

Valeo SA designs, produces, and sells components, integrated systems, and modules for the automotive sector worldwide. The company operates in four segments: Comfort & Driving Assistance Systems, Powertrain Systems, Thermal Systems, and Visibility Systems. The Comfort & Driving Assistance Systems segment develops interfaces between the driver, the vehicle, and the surrounding environment. It offers driving assistance, interior electronics, and interior control products. The Powertrain Systems segment develops powertrain solutions, including electrical systems, transmission systems, combustion engine systems, and electronics that are used for reducing fuel consumption, CO_2 emissions, and other pollutants. The Thermal Systems segment develops and manufactures systems, modules, and components for thermal energy management and in-vehicle comfort during various phases of vehicle use, as well as for various types of powertrain. Its products comprise thermal climate control and powertrain products, thermal compressors, and thermal front

end modules. The Visibility Systems segment designs and produces lighting systems and wiper systems, which support the drivers and passengers in various weather, day and night, and on-board activities. In addition, it offers a range of after-market products and services through Valeo Service, which supplies original equipment spares to automakers, and replacement parts to the independent after market; manufactures on-board chargers for passenger cars and commercial vehicles; and provides on-board telematics mobile connectivity solutions, as well as air conditioning systems for buses. Valeo SA was founded in 1923 and is headquartered in Paris, France.

Herman Int.

Harman International Industries, Incorporated designs, engineers, manufactures, and markets audio systems, visual products, enterprise automation solutions, and connected services for automakers, consumers, and enterprises worldwide. It operates through four segments: Infotainment, Lifestyle, Professional, and Services. The Infotainment segment offers infotainment systems for vehicle applications to be installed primarily as original equipment by automotive manufacturers. The Lifestyle segment provides car audio systems for vehicle applications; mid- to high-end loudspeaker and electronics for home, multimedia, and mobile applications; home audio and theater systems, and distribution systems for home applications; headphones, computer-embedded audio, and portable wireless speakers for multimedia applications; and mobile products, such as speakers, amplifiers, and digital signal processors under many known international brands as JBL, Bowers & Wilkins, Bang & Olufsen and others. The Professional segment provides loudspeakers, power amplifiers, digital signal processors, microphones, headphones, mixing consoles, lighting, video, and control and automation solutions for commercial, enterprise, and public space applications;. The Services segment provides software solutions to automotive, retail, mobile, healthcare, media, and consumer electronics markets. Harman International Industries, Incorporated was founded in 1980 and is headquartered in Stamford, Connecticut.

Google

Under the main brand name Google, Alphabet Inc., through its subsidiaries, provides online advertising globally and is engaged in multiple additional fields of activity. The company offers performance and brand advertising services. It operates through Google and Other

Bets segments. The Google segment includes principal Internet products, such as Search, Ads, Commerce, Maps, YouTube, Apps, Cloud, Android, Chrome, and Google Play, as well as technical infrastructure and newer efforts, such as Virtual Reality. This segment also sells hardware products comprising Chromecast, Chromebooks, and Nexus. The Other Bets segment includes businesses, such as Access/Google Fiber, Calico, Nest, Verily, GV, Google Capital, X, and other initiatives. X (previously Google X) is the research and development facility that started up in 2010 with the development of a self-driving car. Alphabet Inc. was founded in 1998 and is headquartered in Mountain View, California.

Subaru

Subaru is the brand name under which Fuji Heavy Industries Ltd. manufactures, repairs, and sells passenger cars and their related components in Japan and internationally. Fuji Heavy Industries Ltd. operates through Automobile, Aerospace, and Industrial Products segments. The last includes manufacturing of generators, engine-equipped machinery, agricultural machinery, construction machinery, and other machine tools, as well as their components. The company is also involved in real estate leasing, shopping mall management, and travel agency operations; and the lease of various facility equipment, rolling stocks, and garbage trucks, as well as the sale of insurance. Fuji Heavy Industries Ltd. was founded in 1917 and is headquartered in Tokyo, Japan.

Bosch

Bosch Limited manufactures and trades in automotive products in India and internationally. The company also manufactures and/or trades in industrial equipment, consumer goods, and energy and building technological goods. It offers gasoline and diesel systems, chassis system controls, electric drives, starter motor and generators, and car multimedia products; commercial vehicle and passenger car steering systems; and drive and control technologies comprising industrial and mobile hydraulics, pneumatics, linear motion and assembly technologies, and electric drives and controls. The company also provides microelectronic products, such as semiconductors and sensors; electronic control units for body electronics, brake control systems, and engine management, as well as electronic manufacturing services; and sensors for consumer electronics, and eBike systems. In addition, it offers automotive spare parts and accessories; vehicle diagnostics services; and technical after-

sales service for its automotive products and systems, as well as providing packaging machines for the pharmaceuticals, food, and confectionery industries. Further, the company provides solutions and services in the fields of energy generation and energy efficiency services; power tools, such as cordless screw drivers, drill machines, impact wrenches, rotary hammers, surveying equipment, and range finders; industrial boilers, and solar and gas water heaters; and home appliances comprising refrigerators, washing machines, dishwashers, and dryers. Additionally, it offers security and communication products, such as closed circuit television, access control, intrusion detection and control, fire alarm, public address/voice evacuation, conference, paging and personal security, and social alarm systems, as well as IP-solutions; and engineering and IT services. The company was founded in 1951 and is headquartered in Bengaluru, India. Bosch Limited is a subsidiary of Robert Bosch GmbH.

Autoliv

Autoliv, Inc., through its subsidiaries, develops, manufactures, and supplies automotive safety systems to the automotive industry worldwide. It operates through two segments, Passive Safety and Electronics. The company offers a range of products, including modules and components for passenger and driver-side airbags, side-impact airbag protection systems, seatbelts, steering wheels, inflator technologies, and whiplash protection systems, child seats; and automotive radars, night driving assists, camera-based vision systems, brake controls, positioning systems, electronic control units, and other active safety systems, as well as passive safety electronic products, such as restraint electronics and crash sensors. It primarily serves car manufacturers. The company was founded in 1953 and is headquartered in Stockholm, Sweden.

Source: Team's analysis

Exhibit 17 – ADAS Competitors

Company	FCW/LDW/AEB	DSCW	Signs recognition	PCW	Small Animals	Surround view	Night/Weather
MOBILEYE	X		X	X			
VALEO		X				X	
HERMAN INT.	X						
FORESIGHT AUTO	X		X	X	X		X
GOOGLE	X	X		X	X	X	X
SUBARU	X			X			
BOSCH	X		X	X			
AUTOLIV	X		X	X			

FCW = Forward Collision Warning, LDW = Lane Departure Warning, AEB = Automated Emergency Braking, DSCW = Dead Spot Collision Warning, PCW = Pedestrian Collision Warning

Source: Company data

Exhibit 18 – ASAD Technologies to be Mandated as a Standard Fitment in Europe by 2019

Source: Frost & Sullivan

Exhibit 19– Global Automotive Industry Forecast, 2013-2018

Source: Calculated from HIS automotive estimates and Marketline forecasts

Exhibit 20 – Top 20 Largest Global Producers of Motor Vehicles – 2013

Rank	Group	Country	Total	Cars	LCV	HCV	Heavy
1	Toyota	Japan	10,324,9	8,565,1	1,481,7	272,41	5,686
2	General	United States	9,628,91	6,733,1	2,890,9	4,762	
3	Volkswagen	Germany	9,379,22	9,259,5	119,723		
4	Hyundai	South Korea	7,233,08	6,909,1	242,021	67,290	14,575
5	Ford	United States	6,077,12	3,317,0	2,667,2	92,858	
6	Nissan	Japan	4,950,92	4,090,6	837,331	22,916	
7	Fiat	Italy / Unite	4,681,70	2,163,0	2,350,6	124,13	43,836

30

Rank	Group	Country	Total	Cars	LCV	HCV	Heavy
8	Honda	Japan	4,298,39	4,263,2	35,151		
9	Suzuki	Japan	2,842,13	2,452,5	389,560		
10	PSA	France	2,833,78	2,445,8	387,892		
11	Renault	France	2,704,67	2,347,9	356,762		
12	BMW	Germany	2,006,36	2,006,3			
13	SAIC	China	1,992,25	1,685,3	231,374	74,431	1,053
14	Daimler	Germany	1,781,50	1,631,5	150,005		
15	Mazda	Japan	1,264,17	1,175,4	88,730		
16	Dongfeng	China	1,238,94	642,092	226,319	357,41	13,123
17	Mitsubishi	Japan	1,229,44	1,090,5	135,306	3,564	
18	Changan	China	1,109,88	873,794	166,056	70,039	
19	Tata	India	1,062,65	650,708	279,511	117,42	15,010
20	Geely	China	969,896	969,896			

https://en.wikipedia.org/wiki/Automotive_industry

Exhibit 21 – Disruptive Trends That Will Transform the Auto Industry

1. Driven by shared mobility, connectivity services, and feature upgrades, new business models could expand automotive revenue pools by about 30 percent, adding up to $1.5 trillion. Connectivity, and later autonomous technology, will increasingly allow the car to become a platform for drivers and passengers to use their time in transit to consume novel forms of media and services or dedicate the freed-up time to other personal activities. The increasing speed of innovation, especially in software-based systems, will require cars to be upgradable. As shared mobility solutions with shorter life cycles become more common,

consumers will be constantly aware of technological advances, which will further increase demand for upgradability in privately used cars as well.

2. Despite a shift toward shared mobility, vehicle unit sales will continue to grow, but likely at a lower rate of about 2 percent per year. This drop will be largely driven by macroeconomic factors and the rise of new mobility services such as car sharing and e-hailing. A detailed analysis suggests that dense areas with a large, established vehicle base are fertile ground for these new mobility services, and many cities and suburbs of Europe and North America fit this profile. The remaining driver of growth in global car sales is the overall positive macroeconomic development, including the rise of the global consumer middle class. With established markets slowing in growth, however, growth will continue to rely on emerging economies, particularly China, while product-mix differences will explain different development of revenues.

3. Consumer mobility behavior is changing, leading to up to one out of ten cars sold in 2030 potentially being a shared vehicle and the subsequent rise of a market for fit-for-purpose mobility solutions. Changing consumer preferences, tightening regulation, and technological breakthroughs add up to a fundamental shift in individual mobility behavior: individuals increasingly use multiple modes of transportation to complete their journey; goods and services are delivered to rather than fetched by consumers. As a result, the traditional business model of car sales will be complemented by a range of diverse, on-demand mobility solutions, especially in dense urban environments that proactively discourage private-car use.

4. City type will replace country or region as the most relevant segmentation dimension that determines mobility behavior and, thus, the speed and scope of the automotive revolution. Understanding where future business opportunities lie requires a more granular view of mobility markets than ever before. Specifically, it is necessary to segment these markets by city types based primarily on their population density, economic development, and prosperity. Across those segments, consumer preferences, policy and regulation, and the availability and price of new business models will strongly diverge.

5. Once technological and regulatory issues have been resolved, up to 15 percent of new cars sold in 2030 could be fully autonomous. Fully autonomous vehicles are unlikely to be

commercially available before 2020. Meanwhile, advanced driver-assistance systems (ADAS) will play a crucial role in preparing regulators, consumers, and corporations for the medium-term reality of cars taking over control from drivers.

The market introduction of ADAS has shown that the primary challenges impeding faster market penetration are pricing, consumer understanding, and safety/security issues. Regarding technological readiness, tech players and start-ups will likely also play an important role in the development of autonomous vehicles. Regulation and consumer acceptance may represent additional hurdles for autonomous vehicles. A progressive scenario would see fully autonomous cars accounting for up to 15 percent of passenger vehicles sold worldwide in 2030.

6. Electrified vehicles are becoming viable and competitive; however, the speed of their adoption will vary strongly at the local level. Stricter emission regulations, lower battery costs, more widely available charging infrastructure, and increasing consumer acceptance will create a new and strong momentum for the penetration of electrified vehicles (hybrid, plug-in, battery electric, and fuel cell) in the coming years. The speed of adoption will be determined by the interaction of consumer pull (partially driven by total cost of ownership) and regulatory push, which will vary strongly at the regional and local level. In 2030, the share of electrified vehicles could range from 10 percent to 50 percent of new-vehicle sales. Adoption rates will be highest in developed dense cities with strict emission regulations and consumer incentives. Sales penetration will be slower in small towns and rural areas with lower levels of charging infrastructure and higher dependency on driving range.

7. Within a more complex and diversified mobility-industry landscape, incumbent players will be forced to compete simultaneously on multiple fronts and cooperate with competitors. A paradigm shift to mobility as a service, along with new entrants, will inevitably force traditional car manufacturers to compete on multiple fronts. Mobility providers (Uber, for example), tech giants (such as Apple, Google), and specialty OEMs (Tesla, for instance) increase the complexity of the competitive landscape. Traditional automotive players that are under continuous pressure to reduce costs, improve fuel efficiency, reduce emissions, and become more capital-efficient will feel the squeeze, likely

leading to shifting market positions in the evolving automotive and mobility industries, potentially leading to consolidation or new forms of partnerships among incumbent players.

8. New market entrants are expected to target initially only specific, economically attractive segments and activities along the value chain before potentially exploring further fields. Many more new players are likely to enter the market, especially cash-rich high-tech companies and start-ups. These new entrants from outside the industry are also wielding more influence with consumers and regulators. Similarly, some Chinese car manufacturers, with impressive sales growth recently, might leverage the ongoing disruptions to play an important role globally.

Source: McKinsey&Company reports, 2016

Exhibit 22 – Global Car Start-up Map, 2016

Connected Car Start-Ups: Where They're From and What They Do