The Rise of Autonomous Vehicle Technology

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2. Quantifying the size of, and surge in, AI technology
3. AV, why we should care now. Technology and the replacement of the incrementalists
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5. The AV opportunity: the user. Get ready for TAAS
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Themes

1. Disruption seldom comes from within

From Harvard Professor Clayton Christensen’s ‘disruptive innovation’ to McKinsey Global Institute’s ‘Disruptive Technologies: Advances that will transform life, business and the global economy’ much has been written and theorised over the relentless pace of technology innovation.

“Uber, the world’s largest taxi company, owns no vehicles. Facebook, the world’s most popular media owner, creates no content. Alibaba, the most valuable retailer, has no inventory. And Airbnb, the world’s largest accommodation provider, owns no real estate.” (TechCrunch 3rd March 2015 citing Tom Goodwin, SVP of strategy and innovation at Havas Media.)

Through innovation, the value shifts away from the products to the service interface. McKinsey estimates that, together, applications of 12 disruptive technologies could have a potential economic impact between $14 trillion and $33 trillion a year in 2025 (see below).

![A gallery of disruptive technologies](image)

*Estimated potential economic impact of technologies across sized applications in 2025. $ trillion, annual*

1. Mobile Internet
2. Automation of knowledge work
3. Internet of Things
4. Cloud
5. Advanced robotics
6. Autonomous and near-autonomous vehicles
7. Next-generation genomics
8. Energy storage
9. 3-D printing
10. Advanced materials
11. Advanced oil and gas exploration and recovery
12. Renewable energy

*Source: McKinsey Global Institute*

Disruption can lead to significant shifts in the returns of, and outlook for, both incumbents and new service models. A good example is to look at the period 2007 to 2012, spanning the first five years of the iPhone. During this time Return On Invested Capital (“ROIC”) at telecom network operators fell considerably despite the perceived need for contracts and hardware infrastructure and ‘owning’ the customer relationship. At the
same time, ROIC for content providers more than doubled because these providers were seen as benefiting from new distribution models, owning creatives, and a wave of innovation in applications and services at affordable prices.

Source: PWC, [https://www.pwc.co.uk/assets/pdf/valuations-index-aug13.pdf](https://www.pwc.co.uk/assets/pdf/valuations-index-aug13.pdf), S&P Capital IQ

We think the transportation industry is the next industry to be impacted by technology disruption. Why? Convergence of a number of mega trends and technologies relevant to the industry are now coming to the fore.

Source: International Insurance Society, Deloitte

Deloitte, in their study of "The Future of Mobility", suggests a new ecosystem will evolve around transportation and mobility in the future. We expect the shift will be far greater than a mere evolution and
has the potential to be significantly disruptive in a service led world. Our thinking is partly born of significant developments in ‘enabling technology’, in particular, artificial intelligence.

2. The size of, and surge in, AI technology

Artificial Intelligence (AI) traces its roots back to the Dartford College Summer Research Project on Artificial Intelligence in 1956 (Source: IEEE Annals of the History of Computing). But over recent years, the application of AI has exploded thanks to the combination of near infinite storage, a huge influx of big data and the wide availability fast, cheap and powerful processors.

Source: Nvidia

The size and value of the Artificial Intelligence (AI) market is difficult to accurately measure and forecast. Consultancy Research and Markets valued the global market for artificial intelligence at $900M in 2013. Data and research consultancy Transparent Market Research estimates the global AI market as $126B of annual revenue in 2015 and expects it to grow significantly; a36% CAGR from 2016 to 2024 rising to $3,061B.
So how can there be such a discrepancy, and does it matter? It is likely in our view that some (lower) forecasts for AI are confined to pure AI technology in application today. This may underestimate the overall impact and use of AI in embedded systems, artificial neural networks, automated robotic applications and digital assistance systems.

Across applications AI is classified as, and used in, deep learning, language processing, gesture control, context aware processing, smart robotics, speech recognition and image recognition. This has been made possible thanks to the success of Google’s MapReduce technology in our view. Over the last few years MapReduce has become a de facto standard computing model for big data applications owing to its reliability, scalability, fault-tolerance and robust computing framework for storing, processing and classifying massive datasets.

This big data framework has allowed for the rise in deep learning, and the application of deep learning to accelerate the progress of machine learning. Such is not lost on a disruptor such as Google, which has witnessed a significant increase in application of deep learning within the company, see chart below:

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**Global Artificial Intelligence Market Revenue, by Geography, 2015 (US$ Bn)**

<table>
<thead>
<tr>
<th>Region</th>
<th>Value (US$ Bn)</th>
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<tbody>
<tr>
<td>Total</td>
<td>126.24</td>
</tr>
<tr>
<td>North America</td>
<td>XX</td>
</tr>
<tr>
<td>Europe</td>
<td>XX</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>XX</td>
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<tr>
<td>Middle East and Africa</td>
<td>XX</td>
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<td>Latin America</td>
<td>XX</td>
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*Source: TMR Analysis, February 2018*
Advances in GPU technology have helped build cheap super advanced AI deep learning networks. In 2012 Google used a cluster of 1,000 servers, running 16,000 CPU cores, to operate a nine-layer neural network over one billion parameters to recognize images from ten million YouTube images. Two years later, Nvidia applied just three commodity servers and twelve GPUs to do the same and managed to achieve forty-seven times the throughput Google achieved while running 11.2 billion parameters (source: Nvidia).

Deep learning is a case study in the use of machines to do what people can’t. The role of GPUs in this leading edge computational power formula is critical because they work in parallel to tackle many tasks simultaneously. By formulating algorithms to specify complex goals it is possible to teach machines to teach themselves. A white paper published by Nvidia http://images.nvidia.com/content/tegra/automotive/images/2016/solutions/pdf/end-to-end-dl-using-px.pdf has, on an empirical basis, demonstrated that a form of AI in CNN (Convolutional Neural Network) can ‘teach’ a car to self-operate in diverse conditions on highways, local and residential streets in sunny, cloudy and rainy conditions in less than 100 hours. The software enablement from AI gives rise to the technology advances seen in hardware and semiconductors for the disruptive application into the transportation industry.
3. AV, why we should care, now. Technology and the replacement of the incrementalists

As presented above, AI, the fundamental cornerstone technology for AV, is ready. This is all very well but until now, the considerable cost of the technology required for AV vehicles has been a significant hurdle. “Google’s Self-Driving Cars May cost more than a Ferrari” ran the headline in Business Insider in September 2012 (Date: Sep 7, 2012). While Google didn’t reveal the full cost of the Lexus RX450 used in the self-driving car project, experts predicted that the massive array of sensors in each vehicle alone cost $250k or more (source: Business Insider).

The average American spends around $30,000 on a new car or light truck (Source: National Automobile Dealers Association). In 2014 Fast Company showcased a self-driving Toyota Prius, the price of which starts at around $24,000, optioned with a $75,000 to $80,000 Velodyne light detection and ranging (‘LIDAR’) system, visual and radar sensors estimated to cost about $10,000, and a nearly $200,000 GPS array. Fast Company reported “The staid-looking Toyota Prius costs more than a Ferrari-599. At $320,000, that’s an exclusive purchase, and well above the mean cost of a car, truck or SUV”.

For us, cost and the economic journey to commercialisation have been the biggest issues from a viability perspective. One of the biggest pushbacks we have had against the potential for AV is a perceived rise in costs associated with the technology, relative to non-smart vehicles. Technology innovation, scale and deflationary economics make this the wrong argument in our view. Progress on this very issue (cost) appears to be moving forward at breakneck speeds in our view, as evidenced below:

Quanergy Systems, a start up in LIDARs for self-driving cars, has a solid state sensor, the S3, which is focused on driving down the cost of LiDARs significantly. Quanergy plan a LiDAR that costs $250 at mass production compared to the $80,000 used in original Google self-driving vehicles (Source: Fortune).

Delphi in August referenced active safety, a key building block in the rise of autonomous vehicle technology, as the fastest growing segment for both the company and the auto industry, with 80% of Level 4 automation coming at just 20% of the cost of Level 2 automation. This suggests, perhaps, that technology-based deflationary economics (a positive driver of adoption and technology disruption) is about to play a major role in the technology disruption of the auto vertical.

Velodyne’s LiDAR solutions are capable of producing hundreds of thousands (in fact, up to 2.2 million!) data points per second, and they work like a radar over a range up to 200 meters at centimeter-level accuracy. LiDAR is a critical and essential part of the Advanced Driver Assistance Systems (“ADAS”) technology chain across all levels of automated safety. The key barrier (for adoption) here is primarily cost. In each of the 2012 Google AV vehicles, c. $75K was spent on Velodyne LiDARs. Today these LiDARs cost $8K (source: Electronic Design) and Velodyne see a path to these costing low $100s by 2018 (source: Fortune).

Within the move to advanced automotive solutions, ADAS is a key interim technology in our view. Several ADAS technologies are recommended by the NHTSA already and ten automakers have committed to the IIHS (Insurance Institute for Highway Safety) call for automatic emergency braking (“AEB”) ADAS technology to be made standard on light vehicles. AEB uses a number of on-vehicle sensors to detect an imminent crash, warn the driver and, if the driver does not take sufficient action, engages the brakes. AEB systems alone can reduce auto insurance injury claims by as much as 35% according to IIHS research. A typical ADAS system incorporates many technologies with four key areas of processors, sensors, software and algorithms and
mapping. Most of the ADAS functions are effectively redundant without the processors (ECUs - Electronic Control Units; and MCUs - MicroController Units) which are needed to process data in a multicore architecture at high frequency and low power consumption.

Source: McKinsey

Adoption studies by McKinsey suggest the key revenue opportunities within the semiconductor supply chain for autonomous vehicles and ADAS, will be in processors and optical (sensor) semiconductors. The two are expected to enjoy 65% of the automotive hardware semiconductor revenue pie by 2025 (see chart below).
Sensor numbers per vehicle increase rapidly as automation levels are increased, as captured in the chart by French technology company *Yole Developpement* below.
Sensor requirements per car are expected to increase from one to eight in semi-autonomous vehicles (2015 Euro-NCAP data) and 19 in full (level 5) autonomous vehicles over time. The average ADAS semiconductor content is expected to rise substantially and expand the semiconductor BOM by over five times.

Although ADAS applications are still in their early days, ADAS could eventually become the main feature differentiating automotive brands, as well as one of their most important revenue sources. The global ADAS market itself is expected to grow at anywhere from a 17% to a 30% CAGR through 2020 and could reach $30B in revenues per year (source: McKinsey) by the end of the decade. Even these projections are likely based on a slower technology progression and adoption rate than is being made possible by regulation changes, technology deflation, and quicker AV capabilities we believe.
Autonomous and ADAS systems will need to link to a vehicle’s communication module directly to enable fully autonomous driving. Although these modules have intrinsically secure connections, additional protections will be needed. Advanced hardware firewalls, incorporated network-level security elements such as crypto encryption on the chip layer and support of virtualization technologies could see opportunities for semiconductor companies embedding security on the silicon.

In April this year Nvidia, at their Analyst day, suggested that ADAS could be present in some shape or form in 100% of cars by 2020 and that the chip solutions are the key enabler of the resulting complexity.
In our view, forecasters are struggling to keep up with the pace of change. An independent research report "Emerging Technologies: Autonomous Cars—Not If, But When", by IHS Automotive (January 2014) forecast that the price for self-driving technology will add between $7,000 and $10,000 to a car’s sticker price in 2025, a figure that will fall to around $5,000 in 2030 and about $3,000 in 2035, the year when the report says most self-driving vehicles will be operated without control intervention from a human occupant. The original thesis estimated 230k autonomous vehicles would be sold in 2025 and 11.8M (or c.9% of the world’s auto sales) in 2035. These estimates have been revised to 600k in 2025 and 21M in 2035 by IHS (June 2016). But the figures in our view, on both the pace of adoption and the pace of technology led reduction in costs, both appear too ‘incremental’. IHS only expects the tipping point to occur - when autonomous vehicles outsell conventional cars - in 2050. That would likely represent the slowest-ever technology adoption in history in our view and seems highly improbable to us. It is helpful to compare the figures from an extensive Navigant Research Study on Autonomous Vehicles which differ enormously from IHS statistics. This shows once again how difficult it is to accurately forecast the pace of disruptive technology adoption. Navigant’s report (“The Evolution of Self
Driving Functionality”) estimates that 85M autonomous capable cars will be sold annually by 2035, more than seven times the IHS estimate. That many vehicles would represent c.65% of the annual world’s auto sales volumes and would mean the “tipping point” referenced taking place at least 15 years earlier than projected by IHS. For us, the point is that while it’s safe to predict incremental adoption, it’s also likely the least accurate. We know from other technologies that rates of adoption can easily reach exponential growth, examples being cloud computing capacity, smartphone performance and data consumption) and that they are hard to forecast. We think it even harder to predict in respect of the disruptive consequences on incumbent industries and companies.

Incremental automotive innovations such as the use of self-tensioning seatbelts, anti-lock braking (ABS meaning Anti-skid Braking System) and airbags took several decades from being introduced in premium cars to all cars. We suspect many market participants assume that autonomous driving will also be a long burn. We think there are good reasons why the diffusion process for self-driving cars will be to a different pattern. For one, AV is not incremental technology in the way those listed above were. AI technology is revolutionary and progressive (see above) and now is reaching a cost tipping point in our view. Clearly as a technology is adopted more and more the cost benefit in itself from scale economics turns positive for more and more potential buyers. The increased safety is one benefit for the user (and a key driver of regulation change, more on the same in section four below) but the potential for ROT (Return on Time) is likely a key adoption factor.

Autonomous car passengers, rather than today as drivers, can increase time for other productivity activities let alone reduce lost potential income. Urbanization continues to drive increased congestion in urban areas and drivers in London now waste an average of 101 hours a year in gridlock (INRIX 2015 Traffic Scorecard). In the U.S. the average commuter now wastes 50 hours per year in traffic congestion. Based on average hourly wages (U.S. Bureau of Labor Statistics - $21.64/hour August 2016) this equates to theoretical average lost income of $1,082 each year for a US commuter from sitting in traffic alone. This doesn’t even factor in the potential benefit from cost per mile when moving away from the TCO (total cost of ownership) model to a move to true TAAS (Transport as a Service) or MAAS (Mobility as a Service) as an alternative to car ownership (more on this later).
Time is a scarce resource and this is perhaps best represented in the logistics industry. The annual “Analysis of the Operational Costs of Trucking” report published by the ATRI (American Transport Research Institute) in the 2015 report referencing 2014 data, covering 5.3 billion accrued miles driven by fifty-four thousand trucks and tractor units. The survey shows that driver costs account for 35% of motor carrier costs for trucking. It is therefore easy to see how the adoption of fully autonomous technology in the trucking industry could
increase the return on investment and lead to a virtuous circle of rapid adoption.

Table 10: Share of Total Average Marginal Cost, 2008-2014

<table>
<thead>
<tr>
<th>Motor Carrier Costs</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tbody>
<tr>
<td><strong>Vehicle-based</strong></td>
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<tr>
<td>Fuel Costs</td>
<td>38%</td>
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<td>31%</td>
<td>35%</td>
<td>39%</td>
<td>38%</td>
<td>34%</td>
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<tr>
<td>Truck/Trailer Lease or Purchase Payments</td>
<td>13%</td>
<td>18%</td>
<td>12%</td>
<td>11%</td>
<td>11%</td>
<td>10%</td>
<td>13%</td>
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<tr>
<td>Repair &amp; Maintenance</td>
<td>6%</td>
<td>8%</td>
<td>8%</td>
<td>9%</td>
<td>8%</td>
<td>9%</td>
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<tr>
<td>Truck Insurance Premiums</td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
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<tr>
<td>Permits and Licenses</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
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<tr>
<td>Tires</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
<td>2%</td>
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<tr>
<td>Tolls</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
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<tr>
<td><strong>Driver-based</strong></td>
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<tr>
<td>Driver Wages</td>
<td>26%</td>
<td>28%</td>
<td>29%</td>
<td>27%</td>
<td>26%</td>
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<tr>
<td>Driver Benefits</td>
<td>9%</td>
<td>9%</td>
<td>10%</td>
<td>9%</td>
<td>7%</td>
<td>8%</td>
<td>8%</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>100%</td>
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<td>100%</td>
<td>100%</td>
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</table>

Source: American Transportation Research Institute

4. Economic and human impact

The extended automotive industry is a $2 trillion revenue industry today. This factors in not only auto sales and incremental revenue opportunities from insurance, advertising and energy usage but also elements such as healthcare costs from accidents and the public sector expenses of traffic enforcement.
Nearly 1.3 million people die in road traffic related crashes each year, on average 3,287 deaths each and everyday. Road traffic crashes account for 2.2% of all deaths globally. It ranks as the ninth leading cause of death. Road traffic injuries are predicted to become the fifth leading cause of death by 2030. (Source: ASIRT, Association for Sage International Road Travel).

Source: Deloitte University Press
In 2010 in the U.S., almost thirty-three thousand people were killed, almost four million were injured, and twenty-four million vehicles were damaged in motor vehicle crashes (Source U.S. Dept. of Transport). The economic costs of these crashes totaled $242 billion according to the NHTSA, which included lost productivity, medical costs, legal and court costs, emergency service costs (EMS), insurance administration costs, congestion costs, property damage, and workplace losses in its calculations. The $242 billion cost of motor vehicle crashes represents the equivalent of nearly $784 for each of the 308.7 million people living in the United States, and 1.6% of the $14.96 trillion real U.S. Gross Domestic Product for 2010. Unfortunately this trend is not declining. Data released in August 2016 showed that 2015’s automobile death rate was higher, with more than thirty-five thousand people dying in motor accidents. This represents an increase of 7.2% YoY which was the fastest single year percentage increase in 50 years since 1966. The NHSTA estimates c. 94% of crashes can be traced to human error. Almost half of those killed were not wearing a seatbelt, one in three fatalities involved drunk driving or speeding and one in ten involved distraction.

Source: Hexagon “Shaping Change”
5. The AV opportunity: the user. Get ready for TAAS

The ‘holy grail’ for transportation is a safer, cheaper and more convenient alternative. The Uber model today is a precursor to what could be THE revolution, namely an AV-Uber type service offering where the convenience of a taxi is enjoyed for the price of mass transport.

![AV technology will lower TaaS prices and increase access and usage](chart.png)

*Source: Ford CMD, September 2016*

If a new world of accessible autonomous car sharing (true TAAS, Transportation as a Service) comes to fruition the potential benefit of the cost per mile economics alone could spur adoption. Deloitte, for example, calculates almost a dollar as the current costs per mile of ownership. In a shared accessible autonomous world this same cost-by-mile falls dramatically to c.$0.31/mile, see chart below.

![Cost breakdown chart](chart.png)

*Source: Deloitte*
The estimated average cost of a new car or truck sold in the U.S. is $33,560 (Kelley Blue Book data, May 2016). IHS Automotive predicts that autonomous technology will increase the sticker price by between $7-$10k in 2025, by $5k in 2030 and c.$3k in 2035. Now this is, of course, based off very conservative penetration rates of autonomous vehicles as discussed above and scale could bring the technology cost down rapidly. But even assume, for now, the IHS estimates and plug in the various cost inputs of vehicle ownership and it seems clear to us that as you increase the utilization rates of vehicles the cost per mile equation drops dramatically. We have applied the current ASP of a car, assumed a 5% CAGR through to 2025 ($52,063) and then added in the mid-point of the IHS autonomy cost estimate for 2025, $8.5k in the equation. Clearly there are many variables and this is just for illustration purposes but if cars in this autonomous world were utilized 50% of the time, 18 hours per day and carried on average two passengers per journey, the break-even charge per passenger mile could be as low as $0.29.

Even this estimate of the CAGR increase of the ASP of the vehicle may be too high given the current trends of technology pricing/substitution; something that is already proliferating in the premium auto segment. For example, the total price of a Mercedes E-Class car with the 2015 digital package is just €1,654 more than the 2010 model, despite the addition of more than €7,000 in connectivity options, most of them substituting previous features that have now become standard (Source: PWC Connected Car Study 2015).

What happens if we take the previous assumptions and now apply a significantly lower AV cost curve going forward to be baked into a 4% total CAGR price increase for the average cost of a vehicle and take utilization rates in an autonomous efficient metro area to 70% and increase efficiency of usage to 20 hours per day and keep all other factors equal? The break-even charge per passenger mile falls to just $0.18.

Source: Northern Trust Securities
Under this scenario it becomes increasingly clear that not only would people not need to drive a car but would beg the question, why own one? Perhaps in tandem with a rise in car sharing and car automation comes the collapse in car ownership and a future of where scale service operators maintain the control. The hotel industry could serve as a blueprint, in the sense that cars could be securitized via a REIT model (manage versus own). The exploration of a related theme ‘Peak Car’ will be presented in a later primer.

If you can get the same convenience of a car (on demand), efficiency of time used and a better economic cost the scale service provider seems likely to emerge victorious in the battle. Uber, or the future Uber equivalent, could easily begin to aggressively press the cost/mile economics and wipe out the rental car model, the car sharing schemes of the future that OEMs are wedded to (Daimler, Ford, BMW) and the existing OEM model itself in one transformation leap. The illustrative cost per mile and potential revenue per mile dynamic below is one the technology leaders have likely figured out in our view:

![AV cost ($) vs. mpg](image)

**Source: Northern Trust Securities**

At 50c revenue per mile but just a 24c per mile cost, the ROI is 20% using a 12% cost of capital (all NTCM estimates).

The rise of EV (Electric Vehicles) is moving in tandem with this shift in auto technology. Electric Vehicle technology can now demonstrate a superior automotive product in terms of driver performance, safety, comfort an even convenience in our view. In August, the WSJ reported that the mass adoption of EVs (Electric Vehicles) is coming much faster than people expect. Part of the reason is an elimination of ‘range anxiety’ - the fear of a vehicle running out of ‘juice’ - and this is happening due to technology change. Average range is expected to double in the next year and a U.S. DoE survey suggests that when a workplace installs a charging station, employees are twenty times more likely to buy a vehicle with a plug. MIT, in a study published in “Nature Energy”, shows a technical potential of 87% penetration rate of electric vehicles in the U.S. taking into account battery life, cost, availability of charging stations, consumer appetite etc. While giving no timeline of when, it is worth pointing out that EV today is just 0.7% of all vehicles on the road today (Source: MIT, Bloomberg).

The perception is that until electric vehicles can actually drive a reasonable distance without charging they will have limited appeal. That perception is changing; on September 14th 2016, Fortune stated that the Chevrolet Bolt EV is “blowing away expectations”. It can travel an impressive 238 miles on a single charge. The Bolt EV has a superior range to Tesla’s Model 3 (238 miles to Tesla’s 215 miles) and it will beat it to market. The Bolt is
due on the market before the end of 2016 whereas the Model 3 will ship (if, and it’s a big if, on schedule) late 2017. The Bolt EV is aimed at the mass market with a MRRP of under $37K and is eligible for government subsidies of up to $7,500.

One of the big questions relates to demand - do consumers want autonomous vehicles? The young certainly appear to want them as do Chinese consumers. Chinese demand too, is likely to be significantly higher than elsewhere in the world if an August 2015 survey by the World Economic Forum is to be believed. Chinese consumers’ propensity to use autonomous vehicles is among the highest in the world with c.98% of Chinese individuals (across the age spectrum) willing to use autonomous vehicles, far in excess of Germany or the USA, according to CB Insights.

It’s little wonder the Chinese seem to be most receptive to AV. The headlines of ‘Chinese carpocalypse’ and ‘carmageddon’ over China’s national holiday’s last October saw thousands of vehicles stranded on the Beijing motorway for example. According to China’s National Tourism Administration, more than three-quarters of a billion Chinese people were on the roads during the holidays between October 1 and 7 across the country. On that scale, AV has the opportunity to be one of the greatest ROTs (Return on Time) ever.

In July Uber announced it had served two billion rides in only six years, across 73 countries, in over 450 cities. Incredibly, one billion of those have been served in just the last six months.

Now recall, in this new on-demand economy, the main reason people use ride-hailing apps such as Uber and Lyft. The most common reason, as defined in the recent PEW Internet research report is not what you might expect (cost versus taxi). For 86% of people it is primarily that it saves users TIME and stress.

Which begs another question - who wins the race to scale, the race of the apps in a software-led world? The size of the market is huge and will likely be dominated by two to three players. This is typical in any technology at scale. Autonomous vehicle ownership in of itself, for the technology companies, is of no appeal in the long term in our view but the companies will need to ‘seed’ the market. It is a land grab we think.

There are many payment platforms that may come to fruition across freemium, premium subscription, unlimited, pay per mile and sharing are all possible. Comparing the size of five global public technology companies, which could easily provide a TAAS service offering to an existing scale user base, to the global auto OEM market is revealing. The market cap of these five companies is twice the size of the combined market cap of all listed global auto OEMs for a similar level of net income (see chart below). The size of the prize is very large and the shift means participants must be prepared to lose money first.

Source: CB Insights, Roland Berger
A July Forbes article pointed out TrueCar’s development of a modelling technique based on ownership mix, occupancy and vehicle lifespan which suggests that the global car fleet could fall by 50% by 2030 and (even with a faster replacement cycle) would imply a 26% drop in vehicle demand. Even in their best case scenario for the car industry over the next 15 years, they fail to see any growth in vehicle demand by 2030. That seems too optimistic in our view. Consultancy PwC calculates “…the use of autonomous vehicles could:

- shrink the US car fleet of 250 million cars to only 2.5 million, through a transportation sharing model.
- Reduce 8 million traffic accidents to 1.1 million.
- Reduce fuel consumption from nine BILLION gallons to 190 million gallons.”

They calculate the potential impact could be as high as a $1.3 trillion benefit for the US economy from the introduction and implementation of autonomous vehicles and including the expansion of electrical cars (Source: PwC, Hexagon, Geospatial world).

We know which side of the battle we would pick to be the eventual winners.

Source: Deloitte, The Future of Mobility
6. **The AV opportunity and Regulation**

The 1968 Vienna Convention on Road Traffic was amended in March 2016 to allow for automated driving. The result is that technologies which permit vehicles to drive themselves are now admissible in traffic, provided they are in line with UN regulations and can be overridden or switched off by the driver. Automated driving is "the next revolution in the field of mobility," according to the UN Economic Commission for Europe (UNECE) which administers the 1968 treaty.

The Obama Administration’s proposed guidelines for self-driving cars were unveiled in September 2016. Included in the proposal were fifteen benchmarks automakers will need to meet before their autonomous vehicles can hit the road. In other words the regulations are catching up with the technology; the future has arrived. We think this excerpt from a NY Times article sums it up well;

"**In long-awaited guidelines for the booming industry of automated vehicles, the Obama Administration promised strong safety oversight, but sent a clear signal to automakers that the door was wide open for driverless cars.**"

The main components of the policy as outlined by the NHTSA are:

- **Vehicle Performance Guidance for Automated Vehicles**: The guidance for manufacturers, developers and other organizations outlines a 15 point “Safety Assessment” for the safe design, development, testing and deployment of automated vehicles.

- **Model State Policy**: This section presents a clear distinction between Federal and State responsibilities for regulation of HAVs, and suggests recommended policy areas for states to consider with a goal of generating a consistent national framework for the testing and deployment of highly automated vehicles.

- **Current Regulatory Tools**: This discussion outlines DOT’s current regulatory tools that can be used to accelerate the safe development of HAVs, such as interpreting current rules to allow for greater flexibility in design and providing limited exemptions to allow for testing of non-traditional vehicle designs in a more timely fashion.

- **Modern Regulatory Tools**: This discussion identifies potential new regulatory tools and statutory authorities that may aid the safe and efficient deployment of new lifesaving technologies.


There is widespread progress among other regulators too. There have been a range of notable policy endorsements and advances across the globe in recent months.

**South Korea**, often ahead of the tech adoption curve (in our view), eased regulation on autonomous vehicles in May 2016. The government approved the test operations of self-driving cars, which had previously been allowed only in limited regions, can now be conducted across the entire nation. Small AV and electric cars and other future vehicles will also be allowed to run on local roads should they meet safety requirements. Where Korea leads others will follow.
Japan’s government is looking to reduce deaths from traffic accidents by 90% and is considering a proposal for regulatory reform for a detailed course of action for driverless technology. According to the Nikkei, the government is looking to have one of every five cars autonomous by 2030 (too slowly in our view). The Japanese government listed autonomous driving systems as a cross-ministerial Strategic Innovation Promotion (SIP) program in May 2015 which created a nationwide project plan. In term of autonomous driving system development, the Japanese Government targets four primary areas which are:

- V2X (vehicle to everything) communication;
- dynamic mapping;
- localization enabled by GPS, sensors and maps; and
- transfer of driving authority.

Japan’s government has focused on the use of driverless taxis for the Tokyo Olympics of 2020, which suggests to us, Tokyo will need to become an AV metro of excellence well before this date.

In August, the Energy & Environment Ministry of France proposed a decree to allow semi-autonomous, driverless vehicles to circulate on public roads for experimental purposes. The law change would allow France to become a test area for AV vehicles and center of excellence for embedded intelligence.

To date, we have counted eleven companies who have been granted permission to test autonomous vehicles in California: Volkswagen, Mercedes-Benz, Google, Tesla, Nissan, BMW, Honda, Cruise, Baidu, Bosch and Delphi.

The German Transportation Ministry has drafted legislation to allow self-driving cars. Vehicles would be allowed to drive autonomously for a certain time and under certain conditions in legislation presented by Transport Minister Alexander Dobrindt in July.

The UK allows driverless vehicles to be tested on public roads today. Those wishing to test vehicles in the UK are not limited to the test track or certain geographical areas, do not need to obtain certificates or permits, and are not required to provide a surety bond (provide they have insurance arranged). (Source UK Government Department of Transport.)

In August China (NDRC & Ministry of Transport) issued a plan which encourages carmakers to install anti-collision warning systems and develop the technology essential to autonomous driving through the use of big data and cloud computing. It incorporates the Beidou system, which is China’s own satellite positioning system which can complement (and replace) traditional GPS (which, of course, was developed using U.S. Defense department technology).

Beijing limits the distribution of license plates to control vehicle population. The odds of winning roulette (37/1) are higher than winning the lottery for a license plate (80/1) (Source: Bloomberg) in Beijing and use of vehicles are further restricted to select licence plates on certain days of the week. CAAM (China Association of Automobile Manufacturers) highlight that eight Chinese cities are considering similar curbs. Perhaps it is little wonder that 96% of Chinese consumers (Source: Roland Berger study) would consider using a driverless vehicle for day-to-day transportation.
In August China’s transport ministry declared that online car-booking services can operate lawfully. The government now encourages private auto-sharing, car-pooling and the development of sharing economy. (Source: Bloomberg). Vehicles will be required to install safety features and new regulations are expected to take effect from 1st November this year.

China’s auto industry regulator in July said it’s working with police to formulate rules governing the testing of autonomous cars. MIIT and police have a preliminary draft of the rules, She Weizhen, head of the ministry’s autos department, said in a forum in Beijing. She didn’t give a detailed time frame on when the regulations will be finalized, but the admission that this is being formulated is progress indeed.

Chinese regulation may be difficult to piece together given the available information relative to other countries. However putting all these pieces together and then adding in information from related companies our view is China is a leader, not a laggard, in this move to AV in our view.

7. Where will AV rise first?

Our contention has always been that if driverless cars are indeed to become reality it will happen first in China, for a number of reasons. Beijing has the ability to command the resources to implement change on that scale and they have history in aggressively rolling out chosen technologies. There are lower hurdles for Chinese innovation (infrastructure synergies, driver concentration and insurance structures), the lack of technological cannibalism that is becoming a feature of the Western technological outlook and the environmental payback for China versus Western markets.

While the pace of AV and EV technology advances is a well-known global trend, it is our belief that secular change in this area will happen far faster than current expectation. That’s particularly so in China. A combination of government policy, technological advancement and environmental regulation are driving China’s efforts to significantly reduce the cost of applicable technologies (such as batteries) over the next two to three years.

Recent company commentary enables us to piece together the parts of the ‘jigsaw’ which suggests China is progressing at breakneck speed. Yutong earlier this year successfully sent a self-driving city bus on a 32 km long circuit on an intercity road between Zhengzhou and Kaifeng in Henan Province. The bus drove the whole route in regular traffic without any human assistance, attained a peak speed of 68 km/h, passed 26 traffic lights and was able to change lanes and overtake autonomously.

Baidu plans to have autonomous vehicles on China’s roads by 2018 (source: WSJ). AutoBrain, the core of Baidu’s autonomous driving technology, includes Highly-Automated Driving (HAD) maps, positioning, obstacle detection, and smart decision-making and control. Advanced automotive vertical technologies, with cutting-edge big data and advances in artificial intelligence is being led by Baidu which expects to reach autonomous vehicle production scale by 2020.

The head of MobileEye in China (Su Shuping) expects demand for their ADAS could surge 100-fold over the next three years once Chinese regulations are in place (expected by year end). A Bloomberg report cites ADAS sales estimates in China of $30B by 2020 and local broker Citic expects ADAS installation to be mandatory by
2018. These estimates are significantly more bullish than those from independent forecasts, e.g. those from IHS, which only expects $4B revenues a year by 2020. As such, it’s possible the opportunity currently being assessed in most analyst models is grossly underestimating the potential.

8. AV Risks

The continued challenges to autonomous vehicle deployment include potential technology risks for software reliability and cybersecurity, though both of these are showing improvements as technology evolves and the industry recognizes the threat. As mentioned in the technology discussion above, there are developments on silicon to incorporate security protocols. The implementation of local, state, federal, international guidelines, regulatory standards and legal frameworks are undoubtedly complex and challenging. However, as evidenced above there has been significant progress in our view of the same. But clearly questions remain.

- Who is liable should a crash-less car crash?
- Will they be hack-proof?
- How long before consumers really trust the product?
- Will the physical product developed appeal to people?
- How will industry jobs be re-positioned?

Clearly there are risk factors which can not be answered today. However with every technology disruption where there are many unknowns, the pace of change eventually overtakes perceived barriers if the benefits far outweigh the risks.

We see autonomous vehicles as another technology innovation to follow the same path as the proliferation of personal computers, the internet, the smartphone and cloud computing.
Stocks

1. AV Basket Version 1 promotions out: ARM, Nvidia, Bizlink

We launched our original autonomous vehicle basket on June 30th 2016.

In keeping with our process to remain dynamic and act according to change we now make a number of changes to our basket constituents.

First ARM has been promoted out of the basket due to the delisting of the company after being acquired by Softbank. ARM is a major disruptor in our view. With its dominance in mobile processors at the foundation, all things connected should drive significant growth in its total addressable market. ARM owns an unassailable library of IP processor designs based on chip performance, size and power performance across all IoE (Internet of Everything) applications. ARM is increasingly the glue that binds the disruptive forces of the entire digital world but will not offer meaningful stock performance within Softbank due to the dispersion of assets within the Softbank portfolio.

Nvidia is also promoted out of the basket. Nvidia’s Drive PX2, the artificial intelligence computer for self-driving cars that uses deep neural networks to process data from multiple sensors and cameras, is being deployed as the in-vehicle car computer for Baidu’s cloud-to-car HD-map based self-driving system. This latest Drive PX2 consumes just 10 watts of power and is palm sized, half the size of the original version launched in January. For sure NVidia’s technology lead in deep learning, the opportunity in eGaming, the rise of AV technology and the QCC metrics (three year average CROIC of 12.8%) haven’t changed. But the risk/reward and the alpha opportunity from here, in light of the significant rise in the stock price, has we think.

Bizlink is ejected from the basket. Put simply, Bizlink is a geared play on Tesla in providing the cable assemblies for the company and we remain skeptical of Tesla’s ability to scale EV having already missed numerous production targets. As a niche cable maker of cable assemblies, connectors and wires Bizlink could see margin risk as a rise in the proliferation of EV component companies increase competition in the future.

As a result we feel that a Taiwanese component company trading at a c.20x F12M P/E is too rich a multiple and there are better enablers to be found.

2. The Global AV Basket Version 2

As we expect a surge in the opportunities AV will present in the next 18-24 months we have extended the size of our basket with a deliberate skew in the types of companies which are represented. First, there is a larger representation of Asian names in the basket now compared to v1. This is partly to reflect the geographic exposure of where we expect AV to rollout first, namely China and parts of Japan. Second, this is to reflect where we feel the second wave, the service led offerings, are easier to quantify the potential scale winners more so than in the West. Third, many of the enabling technologies in Asia would appear to reside in publically listed companies whereas many in the U.S. remain private (see chart below) or in Europe are being acquired (ARM, Haldex).
Source: CB Insights August 2016

There are 22 global stocks in our Global AV Basket with six in Europe, six in the U.S. and ten in Asia.

**Europe:** Continental, Imagination, Infineon, Melexis, ST Microelectronics, Valeo

**U.S.:** Delphi, InvenSense, Littlefuse, Mobileye, NXP Semiconductor, Sensata

**Asia:** Baidu, DeNA, Denso, Jiangsu Protruly, Mando, Nexteer, Renesas, Sunny Optical, Tencent, Tung Thih

**European Autonomous Vehicle Basket Stocks:**

**Continental:** Continental has the #1 market share in LIDAR/RADAR systems. The ADAS revenue growth has been growing at +50% and been profitable for nearly 18 months. The rise of technology as part of the modern car is a trend for which Continental is well positioned. The firm spends over €2.4bn a year in R+D across offerings to increase performance and comfort in their client’s products. The firm is a rare compounding in the auto sector and has a trailing CROIC of 11.2%. Continental is shifting R&D towards software as evidenced by the 13k headcount in software engineers and is a big customer for Melexis (more below).

**Imagination:** ADAS and security are two focused new growth areas for ‘new’ (new CEO and CFO) Imagination. With a broad range of silicon-based intellectual property, Imagination IP processors are used across mobile communications, consumer, automotive, enterprise sectors and in the IoT and embedded electronics industries. The company’s IP is focusing on delivering complete solutions to licensees to build platforms for multimedia rich, secure, connected, autonomous cars. These can be scalable technologies from low cost, low power, code efficient systems all the way up to graphics and processing intensive high-end systems.
Imagination’s quad-threaded interAptiv CPU acts inside Mobileye’s EyeQ4 SoC as the brain of the chip for example.

**Infineon:** We continue to see Infineon as a winner from the megatrends in automotive silicon. The company is already positioned as #2 market share globally in auto semis with market share gains in power and sensors. According to Strategy Analytics, Infineon’s auto market share is #1 in power semis, #2 in sensors and #3 in microcontrollers (within which, Infineon are #1 in powertrain on Infineon’s estimate). We continue to see the long term model driven by the rise of silicon content in autos and the surge in ADAS and AV applications. At the last set of results (F3Q16) Infineon’s ATV segment enjoyed revenue growth +9% YoY and segment margins rose 200bps YoY, thanks to the strength in ADAS and electro-mobility. While Infineon expect c.2% vehicle production growth, semiconductor content per car should grow at 4x this rate.

Infineon’s purchase of International Rectifier (deal closed January 2015) bought Infineon expertise in power conversion and expansion into compound semis to drive greater economies of scale in production. With silicon reaching its material limits in switching frequency, IRF technology of using gallium nitride on silicon based power semis allows Infineon to shrink transistors on its chips to consume less power. Similarly Infineon’s deal to buy Wolfspeed (due to close by the end of the year) is a power focused acquisition with Wolfspeed’s focus on silicon carbide chips smaller, thinner and lighter than alternatives and lowering power losses in the process. The same are expected to be in high demand for on-board charging in electric and hybrid cars. Infineon has a strong portfolio position to capitalize on the opportunity ahead in AV and EV in our view.

**Melexis:** The rise of ADAS, the precursor to fully autonomous vehicles is leading to huge growth in the number of sensors per vehicle required to enable the advance in technology within cars. Melexis is the purest play on auto sensors (90% of their business). It benefits from years of R&D (typically 5-7 years lead development time per product), a leading position/reputation in some of its product lines (global top 3 in several product lines), and long-standing customer relationships which drive the product development process and repeat business. Meanwhile, they generate extremely impressive cash returns on capital of 30%+, making it a genuine cash compounder.

**ST Microelectronics:** APG (Automotive Products Group) already make up 25% of STM sales but there are additional content growth opportunities for the MEMs & Sensors division (c.14% of sales) given the increasing proliferation of the same in autonomous vehicles. STM is a top four (Source: IHS Markit Data June 2016) supplier of auto ICs and leading MEMS provider. In autos STM are focusing on connectivity, processing platforms, infotainment, ADAS technologies, and sensor fusion in future smart cars. STM have refocused R&D to automotive and smart industries with both digitization of the car and electrification of the car offering significant opportunities. Book-to-bill is above one (as at F2Q16) and STM is enjoying a wave of microcontroller wins from automotive complexity.

**Valeo:** Valeo is one of the highest quality global suppliers (measured in ROIC terms). It claims to be an ADAS global leader in revenue terms, although revenue is not disclosed. ADAS is reported in the Comfort and Driver Assistance division, made up of Driver Assistance, Interior Controls and Interior Electronics (20% of sales, 23% of EBITDA) and is seeing the highest growth in the group currently (mid-teens growth on a LFL basis). More specifically, Valeo has strong positions and is seeing good growth in surround cameras, from cameras (partners with Mobileye), ultrasonic sensors and radars, with laser scanners to come. The company has also
acquired Peiker, a relatively small company (2015 sales €310M) which is a leader in connected vehicle solutions. Given we are still early in the development of ADAS at OEMs and that ADAS will be a critical component of AVs over the next decade, Valeo is well-placed to win business in the AV sector (no matter who builds them) as well as from OEMs looking to aggressively introduce ADAS technology.

**U.S. Autonomous Vehicle Basket Stocks:**

**Delphi Automotive:** Delphi is disproportionately well positioned in high margin automotive electrification technologies and an early lead in AMoD (Automated Mobility on Demand) relative to peers in our view. The company has a plethora of partnerships with technology leaders including Nvidia, Mobileye, Texas Instruments, Nuance and Quanergy, and QNX. Delphi has technologies from automated driving software algorithms (Ottomatika) to full surround Radar and LiDAR sensors. In a partnership with Mobileye the combination claims to have the most cost effective and an unmatched Automated Driving solution which will be production ready in 2019. Delphi’s high-tech, high margin Electronics Architecture division (55% of group sales) made up 60% of operating income in F2Q16 results. The company is an investor in 3D LiDAR leader Quanergy and it has made seven acquisitions or investments in the last two years to expand offerings in electronic architectures and software for safety and automated driving capabilities. With a strong complement of OEMs as customers and a hedge on the multitude of partnerships with technology leaders we feel Delphi are well positioned from the impending rise in ADAS technologies.

**InvenSense:** small cap InvenSense’s focus on highly integrated MEMS (Micro-electromechanical systems) gyroscope and accelerometer is well placed for sensor performance integration in automotive chip solutions. The company also has proprietary software solutions for obstructed conditions in GPS technology tracking and MEMS for ADAS, safety, camera image and vehicle stabilization

**Littlefuse:** Automotive sales make up c.40% of group revenues and rose 15% YoY organically (F2Q16) thanks to sensor demand (sensors +21% YoY in 2Q16) and the company mix shift is towards high margin auto sensors and fuses with a current exit of low margin non-core sensor products. The company is a leading supplier of circuit protection products for the electronics and automotive industries and is expanding in power semis and automotive silicon from the asset acquisition from On Semi announced in August 2016.

**Mobileye:** is working with 30 OEM candidates on Level 4 autonomous vehicle collaboration. The company has also won contracts with three Chinese OEMs and it is in China where we see the most pressing need and, given the recent comments from Baidu, suggest AV solutions could appear in that market before most of the Western world. Mobileye’s recent collaboration with Delphi for a full end to end autonomous vehicle solution brings the company’s EyeQ 4/5 SoC with sensor signal processing, fusion and REM (Road Experience Management) system for real time mapping and localization to a much wider scale of opportunity in our view. And EyeQ chip volumes (EyeQ is c.75% of sales) are already growing at c.45% YoY.

**NXP Semiconductor:** NXP PMICs (post the Freescale acquisition) portfolio is well positioned in highly integrated, high-performance solutions across Auto, Industrial and consumer markets. The new PF series of PMICs brings advanced levels of configurability and programmability in a system level PMIC solution, key to integrating the various components in the rise of AV technology. The NXP BlueBox technology module handles sensor fusion, analysis and complex networking in a connected car. It runs at 90,000 DMIPS (millions of
instructions per second), generating huge volumes of data. NXPI believe that fully autonomous vehicles could have as many as 20 radar sensors alone per vehicle. In radars alone the value per vehicle is expected to increase by as much as 13-fold from level one autonomy on low driver assist to fully autonomous level 4 (as per NHTSA definitions). We continue to see NXPI as a winner from the megatrends in automotive silicon especially from a position of strength as the #1 market share globally in auto semis.

**Sensata:** Automotive (c.45% of revenues) growing at 6% organically (3x car volume growth) and performance sensing is likely to benefit from the position in mission critical automotive sensors, particularly in LIDAR. To this end Sensata has a strategic partnership with Quanergy, providing component level solid-state LIDAR sensors, and a seat on the board of the disruptive start-up. Sensata should we think benefit from the content growth opportunity in China given the relationship the company has with every OEM.

**Asia Autonomous Vehicle Basket Stocks:**

**Baidu:** has big ambitions in autonomous vehicles, has partnerships with BMW and Samsung, has been testing self-driving cars in China for some time, and has ambitious plans to launch commercially available driverless production vehicles in 2018. Baidu invested in laser sensor company Velodyne in August and Velodyne’s LIDAR solutions are capable of producing 300K to 2.2 million data points per second with a range up to 200 meters at centimeter-level accuracy. Baidu also announced, in September 2016, a complete end-to-end solution for autonomous vehicles in partnership with Nvidia, which will deliver a cloud-to-car architecture platform. Significantly this will be a completely open platform which would enable other companies to move onto the platform (shades of Android, and Linux). Such a collaboration could help accelerate AI and AV technology. AutoBrain is the core of Baidu’s autonomous driving technology and includes highly automated driving (HAD) maps, positioning, detection, and smart decision-making and control. Advanced automotive vertical technologies, with cutting-edge big data and advances in artificial intelligence is being led by Baidu in China who expect to reach autonomous vehicle production scale by 2020.

**DeNA:** the company’s key strength lies in it experience of the mobile market, their ability to handle large amounts of traffic and in servicing and optimization. This grounding is leading to ambitious developments in the AV world. In July 2016 DeNa announced plans to join Preferred Networks in an artificial intelligence venture, splitting ownership of PFDeNA to develop applications of deep learning for industries ranging from games to autos and healthcare. DeNA also has Robot Taxi, the JV with ZMP which has essentially been ‘underwritten’ by the Japanese Government’s commitment to driverless Taxi’s for the Japanese Olympics. And according to the Nikkei, DeNA is also joining forces with Yamato Transport (Source:Nikkei) to conduct field-trials of an autonomous vehicle door-to-door parcel delivery service.

**Denso:** Denso’s ability to provide key electronics for powertrains for all of gas engine, electric or hybrid the company is insulated from whichever format becomes the future mainstream powertrain technology. Denso is already providing key Engine ECU (engine control unit), battery ECU, battery sensor and electric compressor across the Toyota hybrid range. Denso’s proprietary software also combines with its own millimetre wave radar and LIDAR radar systems with a proclaimed advantage in bad weather conditions (which could be a significant differentiator in the future given this has been a bottleneck for LIDAR in the past). Today we
calculate Denso already has 20% of sales (4x the level of rival Aisin Seki) from EV related technologies and this could be become a significant business driver in the next few years.

**Jiangsu Protruly:** Electronic vision products are key to auto ADAS systems and Protruly has been leveraging bionic intelligence algorithms and precision OME (optical mechanic electronic) imaging into advanced displays. Protruly’s expertise has historically been in night vision and nearly half of passenger vehicle fatalities occur at night time (49% according to NHTSA Traffic Safety Stats) where ADAS systems could provide significant improvements.

**Mando:** The company owns a proprietary self-driving ADAS technology that appears to be making waves in ambient driving conditions. Increased cooperation with VW, Tesla, GM and Ford (Source: Bloomberg) could show the technology has global appeal rather than a reliance on historical success with Korean local vendors Hyundai and Kia. Pure ADAS sales may be 5% of the mix today but growing at 79% YoY (Source: Bloomberg, 2Q16 numbers) is indicative of the opportunity for the technology. New Hyundai models and blind spot detection technology success is expected to grow sales and the success of the technology is expected to accelerate growth markets of China, India and Europe for the company.

**Nexteer:** Nexteer’s recent 2Q results were c.25% above consensus estimates (Bloomberg data). Such serves, in our mind, as a reminder of how both investors and analysts are likely behind the technology curve of the implications of the rise of AV and semi-AV vehicles. ADAS functionality is jointly developed by Nexteer with key OEMs and a focus on software and integration between steering and braking systems should lead to higher pricing and profitability for Nexteer. Nexteer focuses on intuitive motion control using EPS (electric powered steering) rather than traditional hydraulic as an enabler of ADAS. Nexteer has seen an appetite among OEMs, particularly those in China, to adopt ADAS and get autonomous vehicles on the road. They see ADAS as the next frontier of the conventional steering business. And to really be successful an OEM needs both longitudinal control primarily governed by powertrain and braking, and lateral control primarily governed by steering; both are required to have 360 degree vehicle control. Nexteer are well positioned to provide this enabling technology.

**Renesas:** Renesas enjoys c.38% market share in automotive MCUs and c.70% share in navigation SOCs. Automotive is close to 50% of group sales (47% in FY15) and Renesas’s R-Car SoC has cognitive computing technology with the potential to become a leading autonomous automotive computing platform. The company has lagged in analog and power semis in our view but such which will be solved with the pending acquisition of Intersil which will give Renesas complimentary positioning in both analog and power semiconductor segments. The acquisition creates a higher synergistic complementary suite of semi solutions focused on IoT, industrials and autos and the ‘new’ company expect to expand the addressable market by $7B (to $42B) by 2020. Key Renesas customers include Continental and Bosch who are leading the ADAS revolution while Intersil count Google and Harman amongst its leading customers.

**Sunny Optical:** Sunny seems well placed in our view to enjoy first mover advantage in VLS (Vehicle Lens Sets) over key rival Largan precision. 2016 VLS shipment guidance from the company is for 30-35% revenue growth which seems ultra conservative in our view given the 44% YoY 1H VLS growth. The company is seeing strong demand from ADAS clients across the globe and there is a rising penetration of high ASP front view sensing cameras in the mix. The likes of Delphi, Autoliv, Mobileye, ZF, Bosch, Continental are all auto customers for
SO. SO remains a beneficiary of the rising importance of lens technology in the IoT world and will be a key enabler of the rise of AV.

**Tencent:** 55% of all time spent on mobile phones in China is spent on Tencent services (source: KPCB) with users spending on average 110 mins per user per day on their platforms, visit on average 10x a day and already accounts for 55% of all eCommerce transactions in China. In other words it has the mobility platform and the involvement within the AV market will allow internet companies to collect huge amounts of end user and traffic data, further underwriting the strategic value held by the data generators. Tencent’s partnership with, and stake in, Didi Kuadi we see as one of the most valuable assets in the Tencent portfolio remains unvalued by consensus. Despite seeing growth 16X that of Uber last year (according to the FT), still less than 5% of the urban population in China use this service. The FT reports Didi has an 83% market share in one of the fastest growing taxi markets in the world and the opportunity for synergies with an IoT movement heavily supported by the Chinese government remain vast. Coupled with Tencent’s investments in AV tech, takeaway delivery, home and beauty services etc the upside for this division could be substantially greater in time, particularly with such a large market share, the onset of big data and last year’s $1b investment from Apple (its largest yet).

**Tung Thih Electronics (TTE):** a rare Asian pure play on ADAS, PAS (parking assistance system) and auto camera system technology company. The company is well positioned in China (c.75% of group sales) having already secured 40% PAS market share and 25% auto camera market share in China. The company is also developing automatic emergency braking systems and signal recognition technology to complement existing technologies in PAS, auto-parking and lane departure prevention technology. Exposed to the rise in TTE related content the company should benefit from automated order growth. A 27% increase in 2015 R&D was a strategic bet by TTE to focus on the increased penetration in entry level ADAS are the company is seeking to increase average content per vehicles from NT$1,500 to NT$5,000.
RESEARCH CONTENT
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Where we refer to ‘Sell’ we mean ≤20% downside relative to local index (STOXX Europe 600, S&P 500, MSCI AC Asia Pacific) over a 6-12 month period.

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