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## Takeaways from RBC Auto Tech Conference

The inaugural RBC Auto Tech Conference pulled together various participants across multiple industries to get a sense of how four key secular themes are evolving: connected, autonomous, shared and electrification. The big picture takeaway is that these themes are all very real and quickly moving from the development phase to the production realm, but with that comes a new set of challenges. Autonomous hype was strong (and perhaps re-invigorated by [Softbank's investment in GM Cruise](#) and Waymo buying up to 62k FCA Pacificas). Participants indicated the pace of electrification is accelerating. Meanwhile, connectivity of vehicles and infrastructure makes that data explode and opens up whole new services, features and monetization opportunities. Please see inside for takeaways from the fireside chats hosted as well as the 3 panel discussions. But some overarching themes include:

**Scale is critical and achieving it is harder than it looks.** This goes for: 1) Making vehicles. Witness Tesla, though the company maintains they are on track to achieve 5k/week Model 3 pace around end of quarter. Start-up Byton also talked about the importance of some of their partners in order to scale quickly. We also believe this theme is at least in part behind Softbank's investment in GM Cruise given their integrated approach and manufacturing know-how. 2) Making components. On power electronics (DLPH and BWA) and motors (BWA) scale will help with profitability while on LiDAR (Velodyne, Innoviz, Leddertech) scale gets the sensor cost more affordable. Automotive grade, and the difficulty in achieving it was also a recurring theme among suppliers. BWA and DLPH view it as a competitive advantage that keeps new entrants at bay while the LiDAR players are striving to get the product performance and robustness to that level for use on production vehicles. Meanwhile, the security (BB) required for all this to occur is also critical and perhaps generally underappreciated by investors.

**Dawn of robo-taxi era; Will there ever be "owned" Level 4/5 cars?** The general consensus was "robos-taxis" will be here in ~2 years and only scale from there. There was some debate over whether owned Level 4/5 will ever happen and if that is even a good thing if it does. Meaning the shared autonomous model could become so prevalent and economical that it will never make sense to own a Level 4/5 car. Also clear, pretty much everyone hates the SAE levels of automation definitions.

**Business models still evolving.** Enthusiasm for robo-taxis and Transportation as a Service (TaaS) was emphatic. Many believe revenue/trip will be the new go-to-metric for mobility, which if true, means being multi-modal could be important. Consumer interface and differentiating service even more so. Ford highlighted a number of interesting mobility and services efforts. Still, there was no clarity from anyone on how the exact business model will evolve: transaction based, subscription, advertising or other. We continue to highlight APTV as very well positioned as they have seeds planted in a number of different business models from selling product or whole systems, to TaaS, to capitalizing off data from their connected services offerings.

**LiDAR a must.** Every participant that plays in and around the autonomous driving space save Tesla believes LiDAR is a critical sensor for L4/L5 autonomous vehicles. The form and type of LiDAR technology was up for debate, but there could be different LiDAR technologies for different purposes/use cases. Sounds like we should also be on the lookout for increased use of LiDAR for ADAS around the end of decade.

**Electrification inflecting.** Sentiment is that low hanging fruit of improving ICE engines via technology or lower levels of electrification is picked off and OEM plans are quickly moving to more complex electrification architectures (PHEV/BEV).

Please see our recent deep dives on [electrification](#) and [AV/robo-taxis/LiDAR](#).

## **Aptiv (Glen De Vos, Senior Vice President, CTO)**

### **Details of Las Vegas Lyft agreement and future plans**

- The Lyft engagement is important because it is a commercial pilot that allows APTV to refine operating model.
- APTV does not want to be a fleet operator or network operator but at this point is probably doing more than it would otherwise because it's so small and wants to demonstrate viability.
- On monetization, it believes the clearest path to revenue is \$ per mile. But can also make money in a "tech support model", vehicle analytics, support center, etc. Monetizing data is also big as the vehicle is a "sensor set on wheels".
- Thinks partnerships will be very important. But doesn't love formalized ventures because it almost marks something with exclusivity. It wants to provide autonomous to everyone.

### **Autonomous conversations and timelines**

- Two types of convos. In the commercial market, Aptiv plugs in its tech to its vehicle platform. Turnkey system. In the consumer market, almost all OEMs are interested in some level of co-development. Many reasons for that including security, technology IP, etc. German OEMs are deeply engaged. But PSA FCA not that engaged.
- Believes will see robo-taxis as early as next year. Inflection point is 2021-2022 timeframe.

### **2 stack strategy**

- Using both Ottomatika and nuTonomy. Recognized that there are two reasons for dual stack. First is to get some redundancy, and Aptiv wants full capability. Second is compounding performance. It's kind of like having a pilot and co-pilot and then having an arbitrator between the two. This optimizes safety and performance.
- If OEMs agree with the view that 2 stacks improve product, it is possible that even OEMs that appear to be "going alone" can take some stacks. OEMs have IP they want to contribute, and working with OEMs, need to figure out how to include their stuff with yours. This means you need modular architectures.

### **ADAS inflecting**

- There's been a refocusing of the OEM community away from level 4 and into L2-L3, for the consumer.
- If you are BMW/Daimler/Audi then you have a premium segment to sell more content into the vehicles. OEMs are struggling with right value prop between L2 and L3. But right now people are finding it really hard to sell the L3 platform because it's pretty expensive in relative terms and not much additional value to the end consumer (that they can see).
- OEMs can make a ton of money on ADAS. They can mark it up 4-6x and it's really sticky.
- ADAS has been growing fast driven by consumer adoption. We get the sense that there could be upside to numbers if the take rates remain high.
- Penetration rates are set to go from high teens to north of 80% over the next 5 years in some of the L1-L2 techs.



## BlackBerry Limited (Kaivan Karimi, Senior Vice President of Strategy and Business Development) – covered at RBC by Paul Treiber

*[SPARC](#) published by Paul Treiber yesterday:*

- **An end-to-end platform.** While BlackBerry's position in automotive is typically perceived only as its QNX operating system (OS), BlackBerry is best viewed as an end-to-end secure and connected platform for automotive and other vertical markets. BlackBerry's platform consists of its QNX OS, its hypervisor (virtualization), Certicom security solutions and related tools, its NOC-based cloud platform, and its Jarvis binary code scanning tool, among other solutions. BlackBerry Radar is an application of this end-to-end platform for the truck trailer telematics market. We see BlackBerry addressing other verticals over time, such as healthcare.
- **BlackBerry is targeting the "plumbing" of connected and autonomous vehicles.** The increasing complexity of vehicles (current vehicles have 100MM+ lines of code, more than the space shuttle and MS Windows) and connectivity of vehicles (full Level 5 autonomous requires V2X connectivity) are driving demand for next-generation automotive middleware. BlackBerry has the broadest portfolio of foundational and middleware software for automotive. CANBUS, the legacy connectivity protocol in vehicles introduced in the 1980s, is not secure and is poorly suited for connected and autonomous vehicles. The company provided an updated disclosure that its software is now in 100MM vehicles globally, up from its prior disclosure of 60MM vehicles.
- **Strategy to scale to \$20 or more per vehicle.** BlackBerry's QNX currently generates approx. \$2-3 per vehicle as the OS for infotainment systems. BlackBerry has partnered with chipset vendors like Qualcomm and NVIDIA, and expects to see higher revenue per vehicle from specific applications (like digital instrument clusters) along with the transition from ECUs to domain controllers in vehicles. Automakers are in the process of consolidating the 100+ ECUs and 6-8 operating systems per vehicle, which are becoming very difficult to further scale, with 10-12 domain controllers and 2-3 operating systems.
- **Linux is poorly suited to safety critical applications in vehicles.** BlackBerry does not see Linux (including AGL or Automotive Grade Linux) as a viable alternative to QNX in vehicles, given its security shortcomings. BlackBerry indicated that Linux has materially greater security vulnerabilities compared to QNX, according to disclosures at the National Vulnerability Database (NVD) at the U.S. National Institute of Standards and Technology (NIST). While several autonomous platforms are based on Linux while in development, BlackBerry does not expect Linux to be widely used in production mass market vehicles. According to Mathias Halliger, VP Automotive Products at NVIDIA, other than Google's Waymo, every autonomous vehicle platform using NVIDIA chips plans to port to QNX (which is POSIX compliant) for autonomous vehicles in production (originally disclosed at BlackBerry's Analyst Summit in April 2018).
- **Linux is not free.** Although Linux does not have licensing fees, its usage in automotive requires automakers to make significant investments in R&D staff. Automakers effectively end up "owning" their own operating system when they customize Linux, which entails significant fixed costs to develop and maintain.

## **Borgwarner (Stefan Demmerle, President and General Manager, Power Drive Systems)**

### **Product portfolio for EVs**

- BWA has worked to make sure they are powertrain agnostic. Targeted acquisitions have helped in this process as Remy provided the electric motor expertise, and Sevcon provided exposure to power electronics
- BWA's eGearDrive transmission can handle high input speeds of up to 14,000 rpm while providing smooth and quiet operation. BWA has had good success here.
- Their eDrive module, which integrates design of the electric motor and transmission, enables weight, cost and space savings. This product also highlights the synergies between the Remy acquisition and their in-house tech.

### **2025 industry outlook**

- When we asked for BWA's industry outlook by 2025, the company stated that any electric vehicle penetration forecast would no doubt be wrong. However, they believe there will be more hybrids and BEVs.
- Management noted that they believe that the low hanging fruit has been picked off, and architectures must become more complex in order to meet stricter emission standards and that space will play an important role. Electrification needs to fit seamlessly (weight, size, control, cooling, etc.).

### **What are you seeing in conversations with OEMs? What will be insourced vs. outsourced?**

- The conversation depends greatly on the customer and the region. China is at the forefront, which BWA sees as an advantage as the company has a history of executing on tight timelines.
- More generally, more OEMs are focused on their electrified strategy and are moving away from being flexible in regard to powertrain to being more dedicated to xEVs.
- Half of BWA's backlog is electrified, and 5% is related to BEVs. These numbers should move higher over time.
- As a supplier, BWA has a pretty good scope on needs by platform and region so that also helps deter insourcing because most OEMs don't know as much as they do on power electronics and motors.
- Ultimately, there will always be insourcers, but there are many opportunities going forward. BWA recently started working with a customer that sourced in-house but recently came to BWA.
- Competition is not much different for electric vehicles. Differentiation lies in functionality and integration abilities.

### **Content per vehicle**

- BWA generates \$700 for an electric motor, \$500 for a transmission, \$700 for an inverter, and \$200-300 for a heater.

## **BYTON (Dr. Carsten Breitfeld, CEO)**

### **Go to market strategy**

- BYTON's first public show was in Shanghai in September 2017, and their first product was revealed at CES in January 2018. The concept vehicle is very close to what the eventual production car will be.
- BYTON will go to market first in China in 2019, and then will expand to the US in 2020 and Europe in the second half of 2020.
- BYTON focuses on developing vehicles outside of the traditional stereotype. Essentially converting a car to a smart device on wheels.
- The company is targeting the taste of the younger generations, which is increasingly converging globally. The Chinese youth are the most open to testing new technologies, followed by the US youth, and then the EU (which is reflected in the timeline of market entries).

### **Vehicle production**

- BYTON appears focused on bringing vehicles to market that they know they can produce efficiently.
- The company noted that it is key to have one vehicle platform that is flexible enough that you can build multiple different models without having to make changes to the architecture.
- This kind of platform flexibility is what drives profitability in BYTON's view.

### **BYTON's plans for shared vehicles**

- Shared mobility is a large part of BYTON's future plans, as the company intends to generate 50% of their revenue from mobility services with the remaining coming from unit sales in 10 years.
- BYTON stated that consumers want individual mobility and to access it quickly. Consumers want certain levels of safety and luxury and to be able to express themselves. The key is that you need to have a car that feels like yours. BYTON will have a concept that a camera inside the car will recognize you as a customer and will download all of your content and preferences from their own cloud, allowing your shared vehicle to feel like your own.
- The company can build a purpose built vehicle for shared mobility. BYTON can increase the luxury in these vehicles and decrease the size to be more effective urban vehicles.
- BYTON emphasized that they do not want their cars to become commodities as ride sharing and autonomous changes the industry. As such, they are not selling their vehicles to ride-hailing companies and offer unique services to their consumers.

### **Electrification strategy**

- The powertrain will not be the differentiating factor as all will be electric. But it believes batteries need to have potential to upgrade to the latest technology.
- BYTON doesn't think about how long a battery will last in terms of years, but rather how you can change the battery once the tech is outdated.
- If you can figure out a second use case for some of the dated batteries and generate revenue (i.e. for in home batteries), then you can replace a customer's vehicle battery with the new technology and the consumer would only pay the difference.

**Autonomous strategy**

- The technology for autonomous driving will not be differentiated as it will be highly controlled by regulation and safety standards. Company is partnered with Aurora.
- In BYTON's view, only one to two suppliers within each region will provide the autonomous system. It comes down to how OEMs use the technology to differentiate your ride performance.

**What is your EV outlook, and when will we see robo-taxis and personal autonomous cars?**

- In China, 25% of new vehicles will be electric in 2025 and that could go to 50% in 2030/35; in the US a bit less; and Europe much less.
- In regard to personal autonomous vehicles, true L4/L5 will never be offered. While we could see robo-taxis in certain areas and conditions in 2020.

**Delphi Technologies (Mary Gustanski, Senior Vice President, CTO)****DLPH capabilities across the xEV spectrum**

- Delphi decided not to play in motors believing some customers would want to insource this. Decided to avoid batteries as they don't have the specialties and it's an incredibly hard business.
- However, inverters are Delphi's bread and butter. The inverter controls the electric output from the battery to the motor and are equally as complicated as the engine controllers in an ICE.
- Their flexibility in regard to vehicle architecture (P0-P4), along with their software and algorithm experience provides a competitive advantage. Their 35 years of engine management experience also helps.
- Thermal management will also be increasingly important as power requirements increase and the area underneath the hood becomes hotter and harsher.
- Delphi noted that they are not seeing OEMs look to insource the power electronics, the company has found that their integration capabilities and having a turnkey solution has created value for OEMs (especially in China).
- ~\$400mm in inverter business would be about breakeven, but would need to generate ~\$700mm in revenue to be on par margin-wise with their other businesses.

**Diesel trends**

- Delphi expects diesel vehicles to remain, especially in luxury vehicles, mostly in 2+ liter engines.
- For the diesel that is rolling off, GDi is gaining share, as 350 bar GDi system cuts down particulates and reduces costs for after/exhaust systems.

**Research & Development**

- DLPH spends 8-9% of sales on R&D, of which 40% is focused on power electronics in EVs, with the remaining 60% delegated to ICEs, including toward GDi which continues to grow.
- Delphi's Polycharge allows the capacitor, which stores energy within the inverter, to be 50% smaller than traditional capacitors. This allows Delphi to make their inverters 15-20% smaller than their competition.
- This new technology is something that their competitors haven't touched yet, and gives the company a competitive advantage.



### EV outlook

- The company expects BEVs to account for ~10% of global sales by 2025, with HEVs and PHEVs growing on par with 48V technology (so 48V won't be the clear share gainer).
- 2030 penetration will be driven by battery technology, consumer comfort, and the supporting infrastructure.

### Ford (Marcy Klevorn, Executive Vice President and President, Mobility)

#### Connected and data services

- Ford indicated that they will be announcing two new services for fleet operators that use the data generated from their vehicles. One of the services will be tailored for large operators, and the other will be targeted for small-to-mid size operators (such as police fleets).
- These data solutions are one way that Ford can monetize the data it generates from its fleet vehicles.
- For traditional Ford customers, they are using the Ford Pass App to provide services.
- Additionally, Ford is developing relationships with cities and bringing micro-transit (Chariot and GoRide, Ford's non-emergency transportation service). These trials help Ford to better understand how these vehicles function both before the adoption of autonomous technology.
- Ford will utilize the data generated from the cities with which they partner, and then provide the data back to them.

#### Ford and autonomous

- Ford appeared focused on how their customers, businesses, and cities interact with their autonomous vehicles and services. The company stated that AVs will not be one-size fits all, and through their partnerships (especially in Miami), they are learning more about how to tailor their offering.
- Ford's balance sheet should give them a position of strength in regard to developing autonomous vehicles, Chariot, and their Transportation Mobility Cloud (TMC). Additionally, the way Ford structured the Argo investment, provides them with increased flexibility.
- The Ford X team is also one of their strengths, as the team acts quickly to decide which new lines of business Ford should pursue.

#### The Transportation Mobility Cloud

- Ford and Autonomic are creating an open sourced platform to help cities manage the flow of information from connected vehicles and objects.
- The TMC provides the basic building blocks, which Ford referred to as commodities, to build any solution for a city. This creates a common language and eliminates the need for redundant investment and time in building a new code.
- Ford referred to the TMC as a virtuous circle as once more companies and cities begin using the TMC, the more data that will be held on it, and the more commonplace the system becomes and could solve a systems integration issue facing cities.



**When to partner, acquire, or go it alone**

- There is no cut and dry answer to this question as each situation calls for a unique solution. However, Ford stated that you need to address your own internal capabilities honestly to best understand what the best path is.
- It comes down to whether or not you have the speed and capability to develop your own technology, or, if it's a commodity like function, it may be better to move faster and pursue acquisition.
- Their partnerships with Dominos and Postmates provided Ford with new lessons that they would not have been able to get going it alone.

**When will we see robo-taxis, and advanced autonomous cars in our garages?**

- Ford stated that they continue to expect to introduce their robo-taxi solution by 2021.
- Ford autonomous in your garage, Ford thinks you will have to wait until 2025.

**Harman/Samsung (Sanjay Dhawan, CTO)****Strategy**

- Today, ~27% of the bill of materials in a vehicle is related to digital content (displays, electronics, control units, etc.), and Harman believes that this will increase to 40% over the medium term. Harman believes that they should participate in this industry growth.
- Since being acquired by Samsung, Harman rolled out its new Driveline product, which is intended to be a full solution to level 4-5 autonomous vehicles. Driveline is an open, modular platform that will allow OEMs to choose which hardware and software to use when developing their autonomous vehicles, providing flexibility to each OEM to choose which products provide the best solutions.
- Harman is also focused on driving into the telematics and sensor markets as those become increasingly important.
- Dhawan indicated that Samsung's strong balance sheet has provided Harman with more flexibility to increase investment and R&D to enter new markets and develop innovative products. One of the drawbacks to being a standalone company is that Harman was somewhat limited comparatively.

**Key trends**

- Human, machine interface will become increasingly important. Harman supports touch, gestures, buttons, but voice interaction is a focus. Additionally, Harman is looking at driver facing cameras to gather data on the condition of the driver and their emotional state. How can the car react to you and alter the environment to make you a better driver?
- ECU consolidation will be key as a typical car today has 100-120 ECUs which makes it hard to scale and maintain the vehicle. Harman will consolidate functions so you can make more tight coupling between some of the processes to make communication within the car more seamless and improve the driving experience.
- The Chinese market for high-end vehicles is accelerating and connectivity is becoming more important to consumers.
- Pricing trends have remained fairly static over the past ~18 months.



## Core areas of focus

- Want to be the number one supplier of digital cockpits
- Telematics and 5g is very important
- They want to be the tier 1 supplier of autonomous systems
- Create a connected cloud platform that coexists with android and other systems

## When will we see robo-taxis, and advanced autonomous cars in our garages?

- Robo-taxis, in a limited use case, will be introduced over the next 2-3 years, but broad use bases will take much longer.
- Autonomous cars (Level 4/5) will take 6-8 years to find themselves in your garage.

## NVIDIA Corporation (Danny Shapiro, Senior Director of Automotive) – covered at RBC by Mitch Steves

Extract from Mitch Steves' [note](#) published this morning:

- **The Takeaway:** Overall, we remain bullish on Nvidia. We were most impressed by the additional color provided on the simulation technology (ability to learn at a faster rate improving safety without the need for physical driving). We continue to believe the company is on track with its autonomous driving content wins and a ~20M unit estimate for 2035 was noted as a common number as we look out several years. Finally, the infotainment opportunity (while receiving less limelight as of late) could become more important once self-driving vehicles become common place (entertainment on wheels). Net: we remain positive on shares of Nvidia and think the company remains as a high quality asset to own for exposure to VR, AI and autonomous vehicles, three secular growth vectors.
- **TAM:** The company reiterated its \$60B TAM with \$20B coming from robo-taxis while the remaining \$40B will come from self-driving vehicles. Notably, the company stated that it has expanded its customer base (robo-taxi and self-driving opportunity) and is not able to announce them yet due to NDAs. We think this comment is a positive given that the company is seeing ASPs well north of \$1,000 for robo-taxis while low-end content starts in the low hundreds. Finally, the company notes that a common 2035 unit number for self-driving vehicles is 20M and we think a fair 2025 estimate would be ~400-550K units (RBC estimate, not Nvidia).
- **Simulation an important development:** We think the new simulation environment is a significant opportunity for Nvidia now that it is possible to re-simulate harsh weather environments such as snow, heat and rain. The ability to re-simulate environments likely accelerates the value provided by AI/Nvidia's graphic chips. Since it would be difficult to gather data by physically driving on a road, using these technologies allows the vehicle to learn at a faster rate. The end result is improved safety which Nvidia believes is the number one criteria when thinking about successful self-driving vehicles in the future.
- **Long-term return of infotainment?** While the focus remains on autonomous driving, we note that infotainment could see a resurgence once self-driving vehicles are commonplace. In this environment, we could potentially see voice recognition, gaming and more complex entertainment enter the car (video games in a car for example – PUBG, etc.).

## **Tesla (Martin Viecha, Senior Director and Head of Investor Relations)**

### **Model 3 production update**

- Tesla indicated that they have not experienced any bottlenecks as severe as the battery module issue that limited production early on. However, there have been slight issues in paint and general assembly, but those are on a significantly smaller scale.
- The company ultimately reiterated that they expect to hit 5k/week production by the end of June.
- In regard to planned downtime, management stated that the majority of the time will be taken to install the Grohmann line, which essentially adds an extra zone to battery module production, additional capacity.

### **What about Model 3 automation plans, ASPs, and gross margins?**

- Tesla stated that the step back in automation has been incredibly limited, indicating that ~90% of production is still automated, with just ~10% shifting to manual processes. Ultimately, they intend to automate the currently manual processes.
- Management also stated that their ASP assumption has grown significantly recently as more reservation holders are delaying their invite to wait for AWD, a performance package, or another higher contented option.
- This all leads to the company holding its 25% gross margin target for the Model 3. Management stated that the higher ASP models will help them achieve this target despite the higher manual processes.

### **Color on capex reduction**

- Tesla reduced its capex outlook in 2018 to less than \$3bn from ~\$3.5bn with 1Q18 earnings. Management stated that the majority of the reduced outlook was driven by the company going back to the drawing board to find cheaper ways to complete planned projects.
- However, some of the reduction in spending is delayed, though this is a much smaller portion. The delayed spending largely relates to lower spend on the Supercharger network. If they aren't making as many cars, then they don't need to build out the network as much.

### **Autonomous and shared**

- The introduction of autonomous vehicles beyond L2 will depend massively on the location. California could be one of the first regions to see the technology just because of the favorable driving dynamics in the state.
- Level 4 autonomy is much harder to predict, and could require a new chip that TSLA would replace free of charge.
- Turning to shared vehicles, management stated that it could help to reduce the burden of monthly payments. If you opt to allow Tesla to use your car during downtime, then your monthly payment could be offset by some of the revenue Tesla generates from your vehicle.

## Velodyne (Mike Jellen, President & Chief Operating Officer)

### LiDAR on your vehicle and economics

- Velodyne believe LiDAR is key and that 100% of Level 4 projects are using LiDAR. If you want to move slowly then a camera could pick everything up, but believe LiDAR is necessary for 30-40+mph. They feel very strongly about their competitive position on Level 4.
- Also working on LiDAR for ADAS. This market is a little different and more competitive. However, Velodyne is quoting \$100/unit levels but also has lower specs and performance.
- For their solid-state offering, not much on technical details but stated that their lasers and detectors are harmonized across their entire product lineup. They aren't tied to one beam-steering methodology and would be open to moving to a different wavelength (from 905nm).
- In terms of how much software they do, depends on use case. Everyone wants some help with the software, especially at consumer/ADAS level. Mobileye and a turnkey solution provided a nice model for the industry. Early mover OEMs feel responsible to develop the full stack, but a longer tail of not so far along OEMs who need some help.
- New Megafactory gives them good capacity, probably 50-100k units which is well ahead of the market place. For now they aim to stay 12 months in front of the market in terms of capacity in case of spot needs for the leaders in automation. New factory also added incremental levels of automation.
- Believe will see robo-taxis go from 10k to 100k units over the next 5 years. Level 4 vehicles to own timeframe is a lot tougher to gauge.

## Connected City Panel

**Participants:** Hagal Zyss, CEO, Autotalks Ltd.; Stephen Smyth, CEO, Coord (Sidewalk Labs/Alphabet); Peter Wengert, Global Chief Customer Officer, INRIX, Inc.; Mark Thomas, VP Marketing and Alliances, Ridecell

### Multi-modal transportation and implications

- The panelists see autos as just a single vehicle type in a chain of modes to transport a person or good, albeit an important one.
- Multi-modal is key as consumers become increasingly aware of the most efficient way to go from point A to point B given traffic, weather, accidents, so a consumer can choose the best mode of transportation given real time information.
- This capability requires cities to enable themselves to be connected so that they can optimize traffic, real estate (parking lots, curb space, etc.), and more. Additionally, autonomous vehicles will need a large amount of data from the city around them to operate.

### How will cities pay for the required investment?

- The investment is already beginning today as local governments are starting to see the benefits from connecting their cities.
- One panelist felt that the existing infrastructure is being underutilized in many cities, and stated that once cities start to realize the full potential of technology, it could be the catalyst to spur further investment (possibly with the extra revenue/savings generated from better utilizing their existing technology).



- Further, if governments begin to see new revenue streams from connecting their cities and autonomous vehicles, such as charging for time in loading zones, more efficient parking enforcement, they could be quicker to adopt.
- Our panelists also advocated for some stricter regulations that could accelerate adoption as well.

### How important is 5G?

- Near term, the bigger issue is expanding wireless coverage, not necessarily the bandwidth. Losing connectivity could become a big issue in autonomous vehicles and smart cities.
- Longer term more bandwidth will be critical to handle the amount of data generated by smart cities,

### In 50 years, will you be able to drive a personal car into a city center

- In general, our panel stated that new mobility will prevail. Increasing choices of transportation will likely decrease the need to drive a personal car.
- “Yes....but at a high cost”

## Sensor Suite & Sensor Fusion Panel

**Participants:** Aditya Srinivasan, General Manager – NA, Innoviz Technologies; Charles Boulanger, CEO, Leddartech Holdings; James Gowers, VP Strategy and Business Development, Perceptive Automata; Dr. Jy Bhardwaj, CTO, Lumileds Holdings

### What kind of sensor suite do you expect to see? Is LiDAR necessary?

- Redundancy is going to be key, especially for Level 4/5, which includes cameras, radar, and LiDAR.
- Cameras are good at classification at close range, radar is excellent for long distance but cannot classify items, and LiDAR gives you classification but does not operate well in poor weather. If radars were to gain the capability to classify objects then it could disrupt the industry, but this is unlikely.
- Once LiDAR comes down in cost, which is likely as volume begins to rise, then it is very likely to stay as a key sensor on an AV.
- Camera will likely always be a part of the sensor suite because they are cheap, and there is going to be a push within the industry to have a camera and one of either radar or LiDAR, especially for volume offerings.
- The first vehicles will have all three because they will likely be high end vehicles.

### Sensor fusion will be key

- The data from these systems mean nothing without being able to integrate the data and drive the vehicle safely, which is the biggest challenge.
- The sensors do not need have the ability to identify and synthesize the data built into the device, but the software to do this must be developed outside of the device.
- AI and machine learnings will likely be needed to identify objects rather than a rule based system. The downside here is that this means there will inevitably be some uncertainty and variance in how the machine identifies.
- Neural nets are already starting to be used and developed, but the questions becomes do you treat each sensor independently to categorize the output and statistically how confident are you in the output (false positives/negatives)?



- AI is going to have to take all the outputs to choose the right decision, which will take millions and millions of miles. Simulations will likely have to give way to on-road miles.

### **Challenges of executing at scale**

- Thus far, most of the autonomous rides we have seen have been in controlled tests in geofenced areas. Our panel appeared to believe that we were still far away from seeing a truly autonomous vehicle, comparing machine intelligence to that of a hamster. How long would it take to teach a hamster to drive? Our panel predicted 20 years.
- LiDAR costs are still restrictive as well, though the costs come down with scale. To help with this, LiDAR use cases, including in your phone for facial recognition, allow for some production costs to be taken out and could be translated to auto markets.
- The panel also noted that they saw much more “sobriety” at CES this year when it comes to autonomous vehicles as there are still serious problems to solve.
- However, there are other opportunities, as geofenced shuttles will likely be available in the near term.

### **So who is in the lead?**

- Our panel stated that Waymo is “way ahead” of anyone else and that their AI team is the world’s best, and their deep pockets allow them to invest heavily in future technology.
- Further, their millions of miles provides them with a substantial head start from the rest of the competition.

### **When will we see robo-taxis, and an advanced autonomous cars in our garages?**

- The consensus for robo-taxis appeared to be within the next 2-3 years.
- The panel was a little more varied when it came to autonomous vehicles for personal use. It appears that they expect to see some select offerings from premium brands by 2025 and beyond.



### VC Panel

**Participants:** Rick Bolander, General Partner, eLab Ventures; Jim Schienman, Founding Managing Partner, Maven Ventures; Shankar Chandran, Managing Director, Samsung Catalyst Fund; Timothy Wang, Principal, The Westly Group

#### How are you thinking about exit strategies?

- While there were varying views about whether the opportunity offered by autonomous vehicles is over or under hyped, we believe the general consensus was that it is too soon to be talking about exit strategies.
- The panel also generally agreed that OEMs are going to have to either invest or acquire in order to gain the knowhow if they have not begun to meaningfully develop their capabilities yet.

#### How will business models change?

- OEMs will have to rethink how manufacturing businesses are run as you merge the cultures of Detroit and San Francisco.
- Additionally, OEMs and other autonomous fleet operators will have to focus on how to reach the end user, especially within varying geographies. The panel appears to believe that market share will be an advantage as customer loyalty will be key.
- While traditional fleet operators, such as the Enterprises of the world, will have to meaningfully alter their strategy or they will be a thing of the past.
- What is working today is the autonomous shuttles that are currently running in Detroit.

#### Regulations

- In this case, the panel appeared to see regulations in a more favorable light as they are focused on making the streets safer for the community rather than pressuring business and investment. Mr. Shanker stated that regulations could be similar to laws that require seat belts and airbags.
- Autonomous cars are designed to make cars and driving safer, which in theory should work with the regulations that are in the pipeline.
- What could be the issue is whether regulations support the investment in infrastructure from both cities and corporations.

#### When will we see robo-taxis, and advanced autonomous cars in our garages?

- The majority of the panel believes that we will see robo-taxis come to market over the next year or two. Though one panelist stated that it could be 10 years before we see meaningful robo-taxi adoption.
- As for autonomous vehicles in our garages, two panelists expect to see AVs by 2023, while another stated that he hopes we never get to own personal autonomous vehicles.



## Companies mentioned

NVIDIA Corporation (NASDAQ: NVDA; \$252.19; Outperform)

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