



Speaker	Professor Thomas Bräunl
Talk title	The Next Big Things for Cars
Venue	Ivy & Jack
Time	Tuesday 29 October 2019, 7.00pm

Rosanna Marchesani

Good Evening everyone!

I hope you are enjoying this lovely venue and you have all managed to get yourself a drink before we start.

First, I would like to again acknowledge the Whadjuk Noongar people as the traditional owners of the lands and waters we are meeting today and pay my respects to the elders, past, present, and emerging.

As you know, tonight, twenty-two academics and they are speaking in ten bars across Perth.

At UWA, we are excited to make education a part of this city's popular culture, by transforming city bars like this one into a place that you can enjoy a drink whilst learning about the impact that our research has in the community.

Earlier this year, UWA launched UWA 2030, our vision for the next decade. A significant component of UWA 2030 is to harness and nurture the collective intelligence of our students and researchers to help tackle the grand challenges facing our society and our environment.

If you are sharing Raising the Bar on social media, please tag, @UWAresearch or #rtbperth19 so that we can share your posts, we love to do that.

Tonight's talks are being recorded and will be published as podcasts on our social media channels. Ticketholders, as you all are, will receive an email to let you know when that happens.

Professor Thomas Bräunl directs the Renewable Energy Vehicle Project (REV) as well as the Robotics&Automation Lab at UWA.

He has converted several road licensed cars to battery-electric drive and autonomous driving and operates one of Australia's largest EV charging networks with 24 AC and DC charging stations. Thomas has worked on Driver-Assistance Systems with Daimler/Mercedes-Benz and on Electric Vehicle Charging Systems with BMW.

Please join me in welcoming Thomas to the stage.

[clapping]



Professor Thomas Bräunl

Thank you very much, good evening everyone, thanks for coming.

This is a very unusual format for me, I have given plenty of talks on electric vehicles and autonomous driving but always with slides and lots of information in the background, so this going to be a new experience for me just talking and trying to get the message across.

I think cars are always a good topic to talk about because many people like cars, most of us have a car. Just a little pause here, how did you get here tonight? How are you getting home? Who is walking or here with a bicycle?

Okay?

Who is taking the train or the bus, public transport? And who is here with a car?

Okay?

Well, the CBD is probably easy to get to with public transport, other areas are not so easy.

I want to structure the talk as three different sections because what I see for the future of vehicles is three waves.

The three waves will be connected cars, electric cars and then autonomous driving cars.

We do research on all of these topics at UWA and I would like to talk about what that brings and what to expect over the next decade.

So, connected cars, you might have already experienced if you have purchased a new vehicle recently, middle to upper class, you probably have some connected features in there already.

Basically, cars now come with a SIM card like your mobile phone. They offer you a number of convenient features that you didn't have before. You will be able to use your mobile directly as Apple Car Play and as Android Auto, so you have a seamless transition from your address book, from your time table to your car. You don't have to re-enter the data as you may have used to in previous situations.

There are live maps, so you don't have to update your maps anymore, you always get the latest maps. You get live traffic information, so if there is a traffic jam, the system routes you to the next best road to get around and that's very convenient and you have what is called eCall, this is the new law in the European Union that every car has to be equipped with, so in case of an accident, automatically emergency services will be notified with the exact GPS location of the car, so if you are incapacitated of calling anybody, emergency services will automatically come and rescue you. This is something that will definitely save lives. Since there is no more car production in Australia, most likely cars equipped with the eCall will also be the standard in Australia and that we will get this feature as well.



There are more updates, over the air updates for your cars by a number of manufacturers now, so you don't have to come to the dealership anymore, they update your system. You can get this like your mobile phone updates directly on the car and what we will get in the future is services which are abbreviated as Vehicle to Vehicle Communications and Vehicle to Infrastructure Communications.

There is still some debate which network will be the dominant one. You might have heard about 5G that has been used for quite some time, superfast mobile network, so 5G is one of the contenders for vehicle networks but there is also an alternative based on the IEEE.11 standard and different manufactures backing different systems, so it is unclear how that is going to come out. It's again BETA against VHS all over again. Eventually, one network will service and that will be the communication network for future cars.

There is some exciting news coming on that front. What is almost there, are electric vehicles and that is something we have worked on for over twelve years now, so twelve years ago, we started at UWA on the renewable energy vehicle project. We have converted a number of road registered cars, the Hyundai Getz was the first we converted in 2008 and that car is still on the road. She is driving it.

I kept saying, converting a car to electric is not rocket science. You get components basically from electric forklifts, standard components, standard motors, standard batteries. If you are technology-minded, you could convert your own car and several people have done this. When we did this twelve years ago, we thought, "it's going to take a couple of years and then everybody is going to drive an electric car," and here we are twelve years later and there are hardly any electric cars on the roads in WA.

Things are improving slightly, but there are lots of EV sales going on in other countries but unfortunately, not yet in Australia.

Electric cars are not really anything new. You had electric cars basically, one hundred years ago. The first cars on the road were not electric but they didn't have the range and then petrol cars took and have dominated the car market for the last 100 years but now it looks like battery, electric cars are coming back and within, probably twenty years, most people will drive electric cars and nobody will have any petrol/diesel cars anymore.

In a certain sense, energy density, this is what's driving this and very realistically, the success of mobile phones and laptop computers have paved the way for electric cars, because the development of modern lithium-based batteries is what's required to drive electric cars and that's what makes it possible today.

Where are my slides? [laughing]

Okay, back to business.

I just want to point out the difference between all these electric hybrid cars because most people, I found out, even talking to my colleagues, don't really understand what the difference is.



You have basically petrol/diesel cars then you have what's called hybrid cars or mild-hybrids. Those cars have a very small battery inside and there is no way of getting energy inside the car except for putting petrol in. So, these are basically petrol cars which have a better fuel consumption, their electric-only range, is typically sixty seconds or one kilometre.

There is a lot of technology put in but you can't really go far with electric.

Next up, the category is "plug-in" electric vehicles.

A plug-in electric vehicle is a hybrid car where you can have a certain range, pure electric and then you can go any further distance on petrol. Unfortunately and with just one exception in the market and that was a vehicle that is no longer on the market, most hybrid electric cars have a very small electric-only, range? They can go basically, twenty to thirty kilometres electric and after that, it's all petrol and especially if you see the larger cars.

I am not really sure of what actual fraction, the actual users of these cars do, electric, probably the majority of all distance will still be driven on petrol, so not really that fantastic.

Then you have the pure electric or battery electric vehicles, so there is no petrol engine, there is only one drive system which is fully electric and those cars are the ones we want to support and another alternative which I am going to say a few more words after, is hydrogen cars or hydrogen fuel cell cars, which some people believe will come after that but I have some serious doubts that that's going to happen.

Why do we want electric vehicles?

If we look at the fuel consumption of vehicles in Australia, fuel consumption has actually gone up, per kilometre over the years, not just because cars have got worse but because larger and larger cars have been sold. More SUV's, more larger trucks so they have a higher fuel consumption so overall consumption is increasing.

You have probably heard a lot in the last month about CO₂ emissions and global warming, obviously, this is all very bad. Probably for the next generation especially but what is actually a lot worse is NO_x emissions and Particulate Matter (PM) emissions, because this is affecting all our health, every single day.

There has been statistics, you have probably seen fatalities, road fatalities which is a really shocking statistic but it has been proven that actually more people die from vehicle emissions than from road accidents so this is really serious, this is something that has to be addressed. I think everybody realises it is not healthy to work in the city area with lots of cars driving around, I sometimes ride my bike up and down the coast. You have a bike path and then you have four lanes of traffic with petrol cars going up and down, that exercise cannot be healthy, so something should be done there and I have a feeling in maybe ten years' time, people will have a look back at petrol cars and they will be saying the same thing as we say about smoking today.



Today we are saying, “I can’t believe people were smoking ten years ago in the pub” and this was going and it was a common thing to do, smoking has been reduced, petrol cars are still around I think people will look back and say the same thing about that one in the future.

Another good example, have you seen the London style taxis around Perth? Do you like them? Nice, convenient, big. The only reason these cars are here is because Australia does not have any emission laws. Here, you can register any car, there's no fuel consumption law, there is no emission law and those cars can no longer be licensed in England because of emission laws so they are being sent to Australia and they run on our roads, so ...

Coming back to electric cars, you probably know most of this, zero-emissions if charged from renewable energy, very silent at low speeds, significantly lower running costs, probably less than a quarter than what you pay for petrol and if you do have Solar PV you can run your electric vehicle virtually free provided you can charge it at the right time of day.

There is no immediate infrastructure required, you can actually charge your car at home and only for longer trips will you need a network and we are lobbying for this with the State Government that we get a state-wide fast-charging network which is not that expensive. We did a study, for \$30 million you could cover the whole state with EV Fast Charging Stations and that would allow a trip across the state and to neighbouring states.

In previous talks, I used to say, “Electric vehicles don’t work for everybody because they have a limited range and extended charging time.” None of this is true anymore.

All the modern electric vehicles you can purchase, they have at least a three hundred kilometre range which is equivalent to what you do in your petrol car and charging times on a modern EV charger is about three minutes for a one hundred kilometre distance. So, if you are charging for another three hundred kilometres, it is just about less than ten minutes charging. It's all there, it is all possible.

The negative aspects is currently the higher purchase price, so you are paying about twenty to thirty thousand dollars more for an electric vehicle than a petrol car. Obviously, you would have to drive many, many kilometres to make that financially work for you. I suppose everybody wants to do something good for the environment and everybody has a financial limit, so people would probably be wanting to pay, maybe \$5,000 extra for EV but not twenty or twenty-five thousand more, so the price still has to come down and the magic limit is considered to be US\$100 per kilowatt-hour of battery and I understand current production is very close to that so will probably have price parity in the next three or four years. At that stage, your electric vehicle will cost the same as a petrol car and then, of course, everybody will want one.

There are not that many vehicle models available in Australia. I have counted them all, there are currently ten vehicles available and of course there are not that many charging stations around either, so that doesn’t help. All of these models are quite expensive.



Now I am going to go to hydrogen cars, some people think, “Maybe we should skip electric vehicles and go straight to hydrogen because you can just go to a hydrogen filling station and fill up the car like you did with petrol.” I don’t see this happening for a number of reasons.

Number one, hydrogen is highly explosive, so you are riding a “bomb” if you have your car filled up with this one and I wouldn’t want to be in a collision in a hydrogen-fuelled car, I think that is really dangerous.

The economic argument is even more convincing. Driving a hydrogen vehicle will cost you four times the amount of energy than driving an electric vehicle, because if you go to one of these presentations, they always start with the same sentence saying, “Hydrogen is the most abundant element in the Universe,” which is probably true but you can’t just collect it, you have to use energy to collect or produce hydrogen and the best methods are about three to four times as much energy to generate hydrogen, to store it, to track it and then finally use it in a future vehicle. If you have a choice to pay X amount X dollars per kilometre or you should pay four times as much, I think it’s obvious what most people will do. The advantage that hydrogen vehicles have, which is longer range and shorter charging times has basically gone away because modern electric vehicles have the range, similar range and similar charging times, so that’s not going to happen, I think.

Also, electric charging stations are a lot cheaper to build and install than hydrogen fill station. A hydrogen filling station is anything between one and a half and five million dollars.

Electric vehicle stations, AC stations are a couple of thousand dollars, EV stations are up to eighty thousand, so it’s a different magnitude.

EV charging. How do you charge your vehicle? I was allowed to have one “prop” here and my assistant will take this out. Many people ask, “Well if I get an electric vehicle, how would I charge this at home? Is it difficult to install something special?” So, this is a home charging cable. Every car that you buy will have one its boot and you will notice on the one end it has regular 10 AMP socket so that just goes into your garage and the other connector goes into your car, that is what’s called a Type 2 connector and that little box inside the cable here, that’s a safety device that checks earth protection, overheating, over current, so it’s safe to use. If you use it regularly, there are other options you can have. You can have a fixed, installed charging station at home for maybe a thousand dollars or depending what speed you want but that cable is pretty much everything you need and it comes with the car and we expect that 90% of all chargers have them at home anyway, so you would rely on this one mostly and occasionally use a charging station, a public charging station outside your home. When you want to go a longer distance and you want to charge up quicker, it’s much better.

Charging stations, we know that people travel, 36 kilometres per day on average in WA, so if you charge at home, the average 36 kilometres, it will take you $2^{1/4}$ hours with this cable. That only draws 10 AMPs that pretty the same as your toaster draws if it was full on all the time, so it is not really excessive, it’s about five kilowatt-hours.



There are two types of charging stations, the public charging stations. We have a network in the Perth Metro area and most of the stations we have are AC stations because we installed them at the time when nothing else was available, almost ten years ago, AC stations are a lot faster, they have between seven and twenty-one kilowatt power, so your charging time is going to be a lot quicker but even that has been outdated, so the modern charging stations all deliver DC power directly to the vehicles and at UWA we have one which is 50kW DC, its open to the public and free of charge, so far. We are going to install a new one that has 150kW DC, so three times faster and you can even purchase now, 350kW stations which is the new standard, so, on these stations you can charge for five minutes and you get a 200 kilometre range charged to your account, so it is really there.

Another lack in Australia is the lack of charging standards or the law on charging standards, so we have now, a mix of different vehicles as Type 1 which is the US standard and Type 2 which is European standard. There are Type 1 Stations and Type 2 Stations and there are Type 1 cars and Type 2 cars but the automotive industry looks like they are now settled to Type 2 which is the European standard being introduced into Australia, which makes sense, because Type 2 is Three Phase Standard which doesn't work for the US of course because they don't have a Three Phase Network.

This will come. What will also come is inductive charging, so no more cable lugging around, even easier, you are going to have a plate in your garage or a plate in a public charging location and you only drive the car over this plate and then by Inductive Charging, the car will be charged. It is only a moderate loss in energy for this and much more convenient because you don't have to plug in a cable, you don't have to carry a cable around, so that makes things even easier.

There was a company called "A Better Place" some of you might remember them, their idea was, their business model was, battery swapping. The idea, like in a toy car, the battery is empty, you take the battery out, you put another battery in and you drive off again.

The idea, of course, you can do this in five minutes flat, so you are quicker in getting the cars back on the road. The company went bankrupt and that was predictable because if your business model relies on duplicating the most expensive part of the whole equation, that makes it very hard to survive because every battery you take out, you have to have another battery that goes in, even if it's only a fraction of the numbers of batteries driving around. That was not sustainable and with technology, we have with fast charging today, there is no need for battery swapping. The battery remains in the car, the battery will outlive the car and there is no need for battery swapping.

Clean energy is another important topic, so we have to make sure that the energy we put into the car comes from a renewable source so the car is not just locally emission-free, but completely emission-free.

I have seen some ideas of covering the cars in solar panels which will definitely help somewhat but you can't just use solar panels and drive the car for your regular distance. If you cover it completely the area that is given, you would get ... theoretically, maybe ten kilometres of range per day but that would require your car to be parked in the Sun for the whole day and banked at a 30° angle so, that's



not realistic. You would get a few kilometres and it would help a little bit but not all of your daily commuting needs.

The best idea is using Solar PV which, on a roof nearby or elsewhere, grid-connected so you can use the grid as a buffer and charge the car with that.

Global sales of EV's are on the rise, we have market shares in several per cent in most European countries and I think Germany has about two or three per cent, California has about 5%. Fifty per cent of all EV sales in the US go to California just because they have special subsidies, so subsidies help. Norway is always an example. Norway has a market share today of electric vehicles of over 60%, so more than 60% of all cars being sold today in Norway are pure battery electric vehicles and plug-in hybrids.

Heavy subsidies and also heavy penalties for petrol cars make this happen.

Several countries have announced an end to petrol vehicles. 2030 is the year for many countries that will have an impact and in the EU many countries give subsidies, I think about €4,000 per car purchased and that's about AUS\$6,500 and the US gives US\$10,000 which is about AUS\$15,000 per vehicle purchased. That makes a real difference if you are looking at buying a new car so that obviously brings up the numbers.

If Norway has 60%, what per cent do you think we have in WA?

Audience

.05%!

Professor Thomas Bräunl

.01%! It's close enough yes.

.2 % is Australia wide and .1% in Western Australia.

So, .1% it can only improve but unless there are any incentives, I think it is going to take a lot longer.

We calculated for the study for Main Roads that, we will reach 1% Australia wide probably in 2026, so that is another six years until we get to 1% let alone 60% as Norway has.

Another nice thing, once we have cleaned up the cars, there is no need to stop there because those batteries, current technology lasts a very long time so all the car companies give you an eight-year warranty on their batteries, internally they calculate that after ten years of use, these batteries still have an 85% capacity so they lose some capacity over time but after ten years they should still have 85% and after ten years, cars are typically being taken off the market, maybe not in Australia, but globally that is the limit when they calculate ten years. So, the batteries are still good after that and rather than recycling the batteries, the batteries can be repurposed. The batteries are being taken out completely, they are being repackaged in a different box and then can be used as home storage devices.



If any of you have Solar PV, you know the problem, you have excess solar in the middle of the day, Synergy pays you back seven cents per kilowatt-hour and then you buy it back in the evening for twenty-eight cents per kilowatt-hour. If you had some moderate battery storage, that would be much better for your energy needs and would reduce your energy bill.

Second life batteries could be used for home energy storage and they could also be used on a larger scale for stabilising the grid or even making the whole grid completely renewable.

In other countries, you have hydro so if you have mountains and a lake you can pump up water when you have excess energy and then your turbines when you need it at a different time of day but you can achieve the same thing with batteries. We had the first installation a couple of years ago, in the Perth suburb of Alkimos where Synergy installed a 1 MWh that is the size of a sea container to stabilise the grid or have a neighbourhood wide battery storage for its customers.

That's what I want to say about electric vehicles and moving on to the third wave which is self-driving cars.

Self-driving cars obviously, what a great idea, where all things are going to be a lot safer, there will be less accidents, more mobility for elderly people and younger children, cheaper taxis, everybody would like that, less congestion? Probably not. There was once a study with people thinking, "It going to be a lot more efficient with autonomous vehicles but the next study was revealing, well, number one, all these autonomous vehicles would actually abide by the law. They would never break the speed limit, they would keep the required distance from the car in front, so immediately you would have 30% more congestion just by doing that and then, of course, people want to avoid parking fees so if you drive to work, you wouldn't park your car at work you probably send it back home into your garage so you have all these empty drives. So the car is driving back empty and then it picks you up in the evening and suddenly you have a lot more traffic with this.

Research wise, not so much happening in Australia unfortunately, although we have, what people tell you, is one of the largest fleets of autonomous vehicles in the world because of all the autonomous mining trucks that the mining companies are now introducing, but if you have seen the autonomous shuttle buses that the RAC and Curtin University have, this is just a closed system. This is purchased technology from France. Those organisations can't even change the route that that bus is driving, they have to call France to tell them that we want the bus to go from a different building to wherever then they take a week and calculate a new route and install this into that bus and then the bus drives somewhere else. A lot more research could be done here.

Now, autonomous cars, obviously all the car companies are interested in this and doing research on this but what is also fascinating is that pretty much all of the IT companies are doing the research there as well. You have probably have heard about the Google cars which are driving around, not new, effortlessly working on autonomous cars so it looks like some interest coming from areas where we didn't expect that.



The question is, could you really build a car that is completely collision-free, that would never get in an accident?

I work for BMW and BMW has done such a research demonstration car that basically uses LIDAR for avoiding collisions with fixed objects.

You have to imagine you are sitting in this car, you have a wall in front of you, you hit the accelerator and the car will drive but will slow down and stop before that wall, so you could never basically hit anything. That works for reverse as well and besides, it's not practical yet because LIDAR is very expensive so that's probably twenty, thirty, forty thousand dollars' worth of LIDAR which is expensive sensors in this car, but at least with fixed objects, that would work. But then you still have a problem with other cars. Unless all of the cars are autonomous, another car could still hit you and then there are the laws of physics, so if you just drive at a certain speed and you have a pedestrian or bicycle just come up in front of you, there might not be any time to stop and you can't avoid this. If you can't see them coming then there is no chance to avoid them.

What you see in the market right now is basically two versions of autonomous vehicles. What I call Version A that is the one being developed by the automotive companies right now and if you are driving a high-end vehicle, you might have seen this as an option, if you are buying an expensive European car or a US car, you basically have this built-in. That works on highways or freeways, where there is no oncoming traffic, so it is a simple enough environment.

Until recently, all of these vehicles used the same supplier, Mobileye an Israeli company producing this for Fords, BMW uses Tesla and all of these companies. They were calling this a Driver Assistance System, you could run this on the freeway, you had to touch the wheel every ten seconds to make sure the driver is still there.

Tesla decided to call this autopilot and not have the ten-second rule, you didn't have to touch the wheel. Check out YouTube, you find all of the interesting videos, people sleeping in the back of the car, reading the newspaper while driving, doing other silly stuff and of course that lasted a couple of months until you had a couple of fatalities and then, okay, even with Tesla you have to touch the wheel every ten seconds to make sure you are paying attention and sitting there.

Tesla, has in the meantime, split with Mobileye so they are no longer being supplied, they now have their own system but I think there is still a difference between the Driver Assistance System and some fully autonomous system.

The best example for a fully autonomous system is what Google has done and now have a new daughter company called Waymo which does that. They are the first ones that can really drive in normal traffic, inner-city traffic and I have seen this in person, but they are combining two very expensive technologies, they are using LIDAR sensors, so very expensive sensor systems in the order between fifty and a hundred thousand dollars per car and they require where they drive, High Definition Mapping or HD Mapping and that costs hundreds of thousands of dollars for a small suburb and that was the reason that these Google cars, they can drive in Mountain View which is a



small suburb south of San Francisco but they cannot drive in the neighbouring Sunnyvale, they cannot drive in Cupertino, they cannot drive in San Francisco, they can drive where the whole environment has been mapped and it has to be remapped all the time, if anything changes.

It's nice to see that it's possible but it is not really financially viable at that stage.

To conclude, what are going to be the effects that we see from electric vehicles and autonomous vehicles? They are going to have a slow start in WA because there are no incentives, there are no models and cars are basically too expensive.

Over the years, there will be reduced income for petrol stations but then again, they make most of their money with the little "Marts" that they have in there anyway, so it will probably just be seeing a transition there.

It is going to be harder for dealerships because there are basically no service requirements for electric vehicles. The motor requires no service, even the brake pads will last twice as long because you break with the motor not with the friction breaks, so most likely half the dealerships, if not more will have to close because there is no more business for them.

On the autonomous vehicle side, it is going to take a lot longer, I think to be mainstream, probably another five to ten years until you can commit to really buy something.

There have been predictions that autonomous vehicles will reduce vehicle ownership by up to 40%. I personally don't see this coming, I think it really depends where you live. If you live in the inner-city where you have perfect public transport and not enough space to park but if you look in the rural areas or in Perth, which I would almost include into this one, I think we don't see that much change there, it is just places where you have to have your car and even if you had autonomous taxis, which would cost half of what a taxi costs today, I think personally I would still want to have my car and not just driving on transport provided by taxi or Uber, so I think is going to be seen and I don't think it is going to be as dramatic as some people think.

Thanks very much again, for coming out tonight.

[clapping]

I think we have lots of time for questions.

Audience

That was a very good talk.

Google has got about 1.5 million miles of real data, Tesla has got 5 million miles of real data. The talk about being "full self-driving feature complete" by the end of the year, I am just wondering what your comments are because big data is clearly going to drive it forward?

Professor Thomas Bräunl



I think having a lot of data is really important. The interesting thing is how they got the data? Because I know for Tesla, they basically just record everybody driving.

So, if you have a Tesla, all your data goes back to California. I work for BMW. BMW tried to collect some small usage data on their electric vehicles and it was almost impossible to add that clause into the purchase contract and do this legally correct. I think no everybody is paying attention to detail there but having a lot of data, is really the important thing. There are so many unusual themes that these AI system don't really anticipate, so unless you have covered all possible scenarios, you might come into a real traffic situation that is not really clear and the vehicle might act strangely.

Yes, getting lots of data is the key, legally correct or not, they have the data and Google is collecting this as well. I am still not sure how soon something will come out. If you listen to interviews with Elon Musk, I think he had an interview two years ago and he said we could have this in six months, I am sure he will deliver, but maybe not on time, not as quickly as he thinks it's going to come.

Audience

With the self-driving vehicles, are they able to cope with certain situations like, say an emergency services vehicle jumping the lights or going on the other side of the road, things like that, are they able to account for that sort of unpredictable interaction?

Professor Thomas Bräunl

I think at the moment, this is the largest problem. Whenever there is a construction site and something unusual going on, that's when these systems have the most problems

I think once suggestion that has been tried, is having basically, a remote control fall-back for these vehicles so if a scene comes where the car clearly cannot cope anymore, that goes back to an operator and then somebody remotely can steer the car through that construction site because everything is different and designs might not be compliant with what usually should be there, so I think, as I say, is the biggest obstacle for autonomous driving situations which are not the norm which are unusual and where there is no data, they can collect as much data as they want, the next construction site looks completely different and might be a bit unusual and you have to have a fall-back basically.

Audience

Sure.

Audience

On that one on emergency vehicles, if they are connected to the emergency connected to all its vehicles around it in the autonomous world, it can then tell the autonomous car what it's doing and separate it that way.

Professor Thomas Bräunl



Yes, I think that would work. If you have vehicle to vehicle and the emergency service has an override then you could stop all the autonomous vehicles, all the ones which were equipped, that would help.

But, if you have a construction site, where you have to do weird things, that makes it a lot more difficult.

Audience

Bosch in Melbourne are actually doing Tesla development work for the right-hand drive so they have got two vehicles that are licensed to drive around in Victoria, however, they have to go with a human override. So, they are developing that.

Driver monitoring, I was an auto mechanic at Frankfurt and I saw a very interesting radar system that actually goes through the clothing and monitors ... monitors the driver's vital function, so for example, if the driver was having a heart attack, the autonomous vehicle would take the driver to the hospital.

There is some clever stuff out there.

You talked about vehicles getting heavier, I think that is mainly driven by ANCAP. To get to the five-star safety rating, we have got a lot of high strength steel so we have had to make the cars heavier and stronger to reduce damage to the humans inside.

If you go onto the ANCAP website, there is a 1998 Corolla and a 2016, they put them through the same collision tests and the person in the 1998 Corolla would have died and the person in 2016 would have walked out and got away.

Vehicles are improving but slowly.

What do you think the next sensor system will be?

Professor Thomas Bräunl

That's a good question because so far, only the very expensive sensor systems have made a significant impact. What we are trying to do at UWA, we try to concentrate on vision, only because the idea is simple, every one of us here can drive a car with vision only. We don't have a LIDAR we don't have a Radar, we don't have a GPS built-in, so vision only, can do it.

So, if you have a computer system that is fast enough, if you have the right software, you will eventually be able to drive a vehicle just with vision only and cameras are one of the cheapest sensors you can get, so we are trying to concentrate on vision getting away from all the expensive sensors and do some research in that regards.

Audience



Until you get snow?

Professor Thomas Bräunl

You can drive in snow as well, right? Maybe a bit slower maybe?

Audience

Yes, but there are no white lines.

Professor Thomas Bräunl

Just regarding your comments of cars getting heavier and then having more fuel consumption, I think it's also cars getting bigger, so its people trying to ... or buying more larger cars, so people that may be used buy a smaller car are now buying a bigger car, an SUV, so the fleet consumption just goes up on average.

Audience

I was just wondering, what is going to happen to all of our cars that we have now? Will we be able to sell them, will someone want to buy them? Can we convert them?

Professor Thomas Bräunl

As I said it's going to take a long time, so unless the Government suddenly decides to give incentives, nothing is going to happen quickly, so our estimate, 2026 you will have 1% of electric vehicles and it will probably take another ten years until to get to 50% or so, so even if you buy a petrol car today, you probably don't see any adverse effects if you sell it again.

Then again, maybe in five or six years' time, you might want to think twice whether you buy another petrol car because in the end if you want to sell it, the residual value might be quite low. I think Australia might even be more influenced than we think by other countries, if the European Union will mostly go electric by 2030, that's only ten years away, China is probably doing the same thing, there might not be that many petrol car models around in ten years' time to buy, so the market will definitely change and if you are buying towards the end of the market, you would have the problem of driving the car until it falls apart or having a larger loss at the end when you sell it.

Audience

You talked about changing or converting your internal combustion cars to battery only, how much impact do you think that will have to change the market share in Australia or WA as well as new car battery sales.

Professor Thomas Bräunl



Sorry, that was the second half of your question. We have done this, several people have done this in WA as well as hobbyist groups that do this. It has zero impact globally. The cost for doing this is around \$30,000 but it basically makes no sense to do that, unless you have a vintage car that you want to keep and bring into a new era and then you can do it, but for any regular car, it makes no sense trying to convert it. You spend a lot of money and you end up with a car that's not as well-engineered as any mainstream electrical vehicle from a major car corporation, unfortunately.

Audience

In the UK, obviously where I am from, you can buy a two-year-old small electric car for about £5,000 to £7,000, the right-hand drive would be perfect in Australia but the tariffs here by the big oil companies and automobile companies are stopping equalising the market, shall we say.

Professor Thomas Bräunl

We had quite a discussion on the import of used electric vehicles because apparently, New Zealand had a deal with Japan and their EV market share is a lot higher than what we have in Australia and I understand the Government has changed the import laws as of this year for used or second-hand electric vehicles. Apparently, you can now import them without any duties, customs duties and as I said, you know, the UK is the perfect market for this because of right-hand steering. If you have contacts in the UK, look up their car sales. The Lotus that we converted at UWA is from the UK, the dad of a colleague of mine, checked out a couple of car dealerships, it cost half of what we would have paid in WA and shipping across from the UK was I think \$2,000. It's not all that much considering the price difference buying an electric vehicle here in Australia, here or in the UK.

Audience

How concerned should we be about self-driving cars being susceptible to things like hacking and cyber-attacks?

Professor Thomas Bräunl

That is another big issue, it's a major issue because of these vehicles are using AI technologies. Until today there is no really good measure to really verify these AI approaches. Because, traditionally all of these software developments were following basic engineering principles, so you did your image processing, you tried to find what we call edges and corners in an image and then construct as another vehicle or this is a traffic sign because we know it's going to be round, this, this and that but these days the success of AI methods have thrown the engineering approach almost out of the window. You can get so much faster, good results with AI methods that everybody is using them. But there is no telling what's really happening inside this AI. There is no verification, so it might work



very well, in 99.99% of cases but you are the one sitting in that car if that .01% happens and it's very hard to do that.

That's why the car companies are collecting massive test data so they can check for almost all eventualities.

There have been cases and you might have seen this in the news, somebody put a couple of very small stickers on the stop sign and then running this through a standard AI system that was doing traffic sign detection and it recognised it as a Speed Limit whatever sign. So you can really spoof these systems with very little effort if you know what you are doing there and there are potentially many, many things that we haven't seen where the system is not working correctly or not interpreting a scene correctly, so that is another step between something that works in the lab and that you would be comfortable selling to people and that people drive, but you have to develop the system, probably globally recognised that all these autonomous driving systems have passed a test that they are safe enough for people to drive.

Audience

Do you feel like we are close to that global benchmark based upon the information that you have collected?

Professor Thomas Bräunl

No I don't think so, I don't think there is an agreement on this or the car companies, they are protecting the data as well as their technologies, I think there has to be some global consensus, so probably some of the international car bodies have to agree that they are going to have a test benchmark as a minimum entry for that and only then could somebody, like a road authority approve a certain system for road usage.

Audience

I have more of a business type of question. You mentioned that a lot of dealerships may start closing down just because there is no maintenance required for the electric vehicles. The question is, is how do you see dealerships going forward, how the sale of the vehicles and all that kind of stuff, as well as, do you see companies finding other ways of creating repeat revenue that are not already available at the moment?

Professor Thomas Bräunl

I think, in the end, somebody has to lose if things are getting cheaper. So, people saving on service costs, that will be a consequence that dealerships would have to close down. It is probably hard to say what the percentage is going to be but my guess is probably half of the dealerships would have to close. I don't really know for a typical dealership what their income stream is, new car sales compared to There you go, then maybe two thirds will close down, and of course, some car companies are looking into direct marketing so they are going to sell cars over the internet. Tesla



has done this and I think if the US states have outlawed this so they can't do this but they are obviously pushing this and other car companies will follow and trying to do direct market there, I think it is inevitable, every positive side saving money has a negative side for those being employed in that sector but I think that is most likely how things will go.

Audience

You mentioned charging electric vehicles and you said I think, "I suppose 90% will be done at home" but then everyone charging themselves but then some charges are going up to 250kW which is a hell of a lot of draw, do you think ... in fact do you think they will have on electricity because then that's the new fuel these cars, is that back to a gridlock?

Professor Thomas Bräunl

Yes. At 1% no.

So the next six to ten years we are probably safe, after that, yes, that's going to be an impact. We have done the study for Main Roads which unfortunately has not been published yet, but there are going to be places in WA where you have a good grid connection where there is no problem. Our proposal was to have always two stations in one location so at least if you look what Tesla has done where they have six or eight stations in one location, so if come to a location and another car is charging you can use another bay. At 350kW that adds up quite quickly if you have four or six bays, you need several megawatt grid connections. It works in a number of locations, but other locations where the grid is not as strong, then you would have to go to what we consider the lowest level charging at 50kW and of course, there are places in WA where you don't even have that, where you don't have any grid connection. That is going to places up far north where you basically can't do this where you have townships or resorts that run on diesel generators, so there is no grid, there is nothing else. For those locations, you only have two choices.

Choice number one is just using a diesel generator for an EV charger and people have done that. We had a gentleman here from Perth has done this as a demonstration, using a 50 Watt charger and I think a 70kW diesel generator and they did a trial with the Tesla owners group and the diesel consumption of the generator was less per kilometre than using a standard diesel car, so it was more efficient doing it charging electric vehicles than driving a diesel car which is a nice result.

The other alternative, of course, you can go renewables, you could install, you would install, you have to install a lot of solar PV depending on the usage of that station plus you have to install battery storage with a station, so although you could do it until you have a large number of cars, that might be an expense that is too high for that purpose and to add this, once you have a large number of cars using it, the battery would do you no good anymore because you need more solar to have more renewable energy, so once it gets to 50% or more cars being electric, you have to adopt something else or maybe extend the grid or have more solar PV areas that fit into it, but that's going to be a problem, probably in ten years' time.

Audience



So, just on this, what is the loss of solar into a battery and that's charging other batteries, does it become non-economical anymore.

Professor Thomas Bräunl

I don't have the numbers on this but I think it is very small, it is probably less than 5%, I would say.

Only heat loss.

Audience

Speaking of the chargers with 350kW that sounds like a lot of power. Is there any danger to consumers using that type of equipment, especially if something went wrong?

Professor Thomas Bräunl

Obviously, 50kW is significant. To give you an idea, the actual charging cables, the cable itself is liquid-cooled because the excess heat from the current going through has to be cooled. I have not seen any case of any of these stations go wrong, we have a manufacturer in Australia of these stations, which is BeFill – brand name BeFill and the company name is Tridium in Brisbane, they have been very successful. They have been selected by Ionity which is the major European charging station operator, so they have several hundred stations now in the European market. I understand they are safe to use, they all have Safety Trip and Safety because they always check for over temperature, over current, they have protective earth with circuit tripping before anything hazardous can happen. Power can only flow once the system detects that it is actually plugged into a car. There is a communication protocol because DC charging, that's what makes this station so expensive they have to talk to the car first and find out what voltage the car wants. So the simple cars that once we converted first, the Hyundai Getz has 114 volts and our Lotus has 300 volts and the latest generation cars like Audi e-tron and Porche Taycan have 800 volts because the more volts you have the less current you need and the product of voltage x current gives you the power, so higher voltage systems are coming so these systems talk to the car and make sure there is a solid connection between the car and the station, only then the power can flow so, it's very, very unlikely not to be able ... how you could possibly electrocute yourself, I think it's pretty safe.

Rosanna Marchesani

Do we have any more questions?

Audience

Thanks for the lecture. Have you heard of the Osborne Effect like when the Apple iPhone was about to be released, the Nokia's and all the other phones of that generation, basically their sales died off pretty quickly as people were waiting for the new technology and how that applies to electric vehicles because apparently, from what I read, in about three or four years that just started reaching price parity between electric vehicles and fuel cars and there is going to be apparently a massive recession America and Europe etc., when it happens. What's your opinion?



Professor Thomas Bräunl

Yes, I think that could in fact happen. I mean, Kodak is another good example. Kodak was the leading company for film and they went bankrupt with not changing to digital technologies fast enough. I think the European market is quite slow. Besides Tesla, there is nothing really happening in the US. Ford is very slow, General Motors is slow, so I think the only danger they have to fear is coming out of China because China is gearing up for electric vehicles and pushing that and once the market gets flooded with Chinese or cheap Chinese electric vehicles, I think that is going to be real danger for the European and US manufactures and you are right that might happen to very big names if they are not changing quick enough.

Audience

Just on that, then how much do you see car manufacturers that do change to electric effecting what choice you have, so, for example even if you don't want to buy an electric vehicle and then you are going to have to, because there is just only going to be electric vehicles being produced, for example here, we just drive Japanese cars essentially.

Professor Thomas Bräunl

Yes, I think that is a possibility, so even if there are no laws being issued in Australia, maybe in ten years' time, the majority of the market will be electric vehicles and then you pretty much have very little choice of buying a petrol vehicle if you still wanted to. But, as I can tell you and everybody tells you who has driven electric vehicles you don't want to go back.

If you have driven an electric vehicle, you have experienced how nice it is, how convenient, no more petrol stations, so more exhaust fumes, I have not seen a single person that has driven and electric vehicle for more than a few days and who would want to go back to petrol driving, nobody wants to.

Rosanna Marchesani

Any more questions?

Audience

I was driving an electric vehicle and ...

Professor Thomas Bräunl

Were people jumping out of your way?

Audience

Well pedestrians especially in shopping areas there are people looking at shops and For Sale signs and they don't hear an electric vehicle coming and I had to stop a couple of times because ...



Professor Thomas Bräunl

As of the beginning of this year, it is the law that all new electric vehicles have to have a sound generator, I am not really sure if that's really needed. You obviously had and experience with it, most of it a benefit.

We have done experiments, electrical vehicles are silent up to about 30 km per hour from 30 km per hour you can't really distinguish a petrol car from an electric vehicle unless the petrol car accelerates. The acceleration where the engine revs up, that's something apart from that, you have the same wind noise, the same tyre roll noise, so there is no difference at 30 K's but say in a shopping centre, just parking in and out, there might be situations but all the new cars have to have now a sound generator so there is going to be some audible noise for people to pay attention.

Rosanna Marchesani

Just checking, any more questions from the audience?

We would like to thank you all for coming along tonight. I think we can agree it was a great talk, thank you very much, Thomas, very insightful.

[clapping]

As I said thanks a lot for coming along tonight, we hope you have a good evening.