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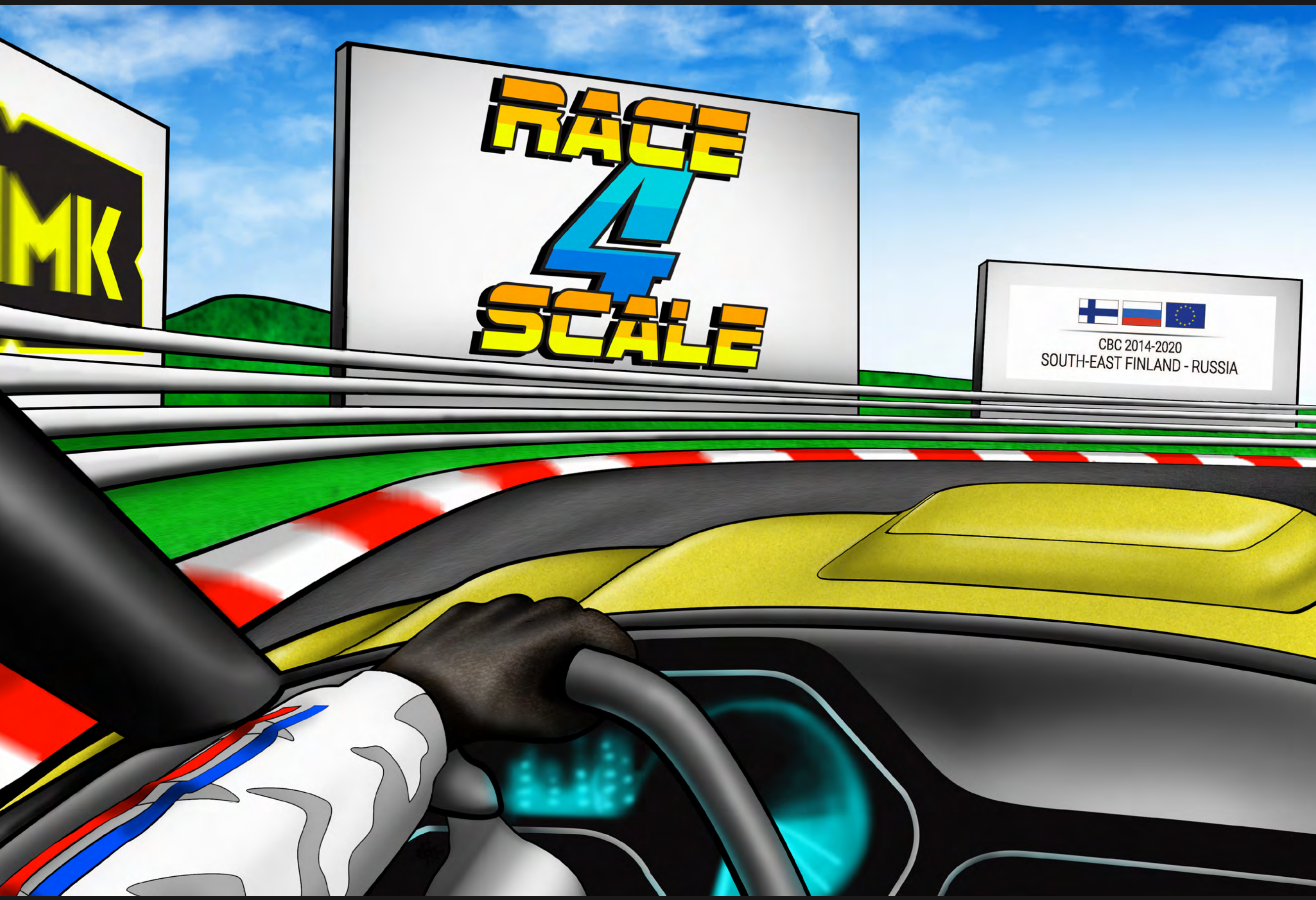


# RESEARCH ON CURRENT AND DEVELOPMENT NEEDS IN THE AUTOMOTIVE AND MOTORSPORT INDUSTRY

Mikhail Nemilentsev, Jarmo Kujanpää & Jan Kettula (Eds.)

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# PREFACE

Mobility is under transition. We can see much evidence for this in our everyday life and surroundings. Vehicle charging facilities are building up, electric scooter services are popping up in many cities, cycling is becoming a true alternative for many and is being promoted by cities building new and enhanced cycle paths. In the larger view, we see that sustainability is driving much of the transition. Car manufacturers are facing strict regulation in several markets, which puts stress on achieve low levels of $CO_2$ emissions. Electro-mobility is a relevant option for different types of vehicles and mobility needs, from small and short range (e.g., electric assist bicycles, urban distribution vans and trucks) to larger and longer range (buses, heavy goods vehicles). Reaching road transport with zero exhaust emissions requires a system-level change and renewal of the whole mobility ecosystem. As passenger cars are the dominant mode of transport in many countries, including Finland, the sustainability transition can be considered as a game changer for the industry.

The Sustainable Development Goals (SDGs) are at the heart of the United Nations' 2030 Agenda for Sustainable Development. Sustainable transport is a key issue among the SDGs and the sustainability transition that is called for. Sustainable transport relates to, for example, health, energy, infrastructure, economic growth and cities and human settlements, which is why the development needs a multi-sectoral approach as well as multi-faceted actors to be involved. With all SDGs, partnerships are extremely important, and actors should be working tightly together at the local, regional, national and international levels. Cross-border co-development must also be realised, which in Finland's perspective takes place in the EU, Nordic, Baltic and Russian contexts. To gain considerable results, the actors representing businesses, associations, local, regional and governmental authorities as well as education, research and development should all be involved.

Digitalisation can be considered as an engine for the mobility transition. New services and business models which make use of the digital environment are being innovated. There is more and more data and information available, and increasingly in real time. This provides possibilities for planning and managing operations and reducing the environmental load e.g., by optimising our mobility and use of vehicles. For a traveller, especially a city dweller, the opportunity to fulfil one's mobility needs with many alternative modes and their combination can offer a freedom which has traditionally been connected to car use. As Finland has been a leading country in introducing Mobility as a Service (MaaS), it will be interesting to see how this concept will be adopted. Simultaneously, technology is progressing based on a broad offering, for example, with increasingly intelligent functions providing driver assistance and paving the way for more automated functions. For instance, as technology develops communication is becoming one of the key factors for future road transport.

The value of the data and information increases when they are shared, and actors, for example those in an ecosystem, can gain competitive advantage by sharing high-quality data with each other. Even greater value can be obtained when there are platforms for refining common knowledge and understanding, especially on future possibilities. Therefore, I see the Race4Scale project and its objectives as highly important. For the project and the partners involved, I would like to stress sustainability as the key future development need and as the number one trend influencing the automotive ecosystem in the current decade, and likely for long beyond.

This publication has three parts. Development director, PhD Tuija Arola presents an outlook on the motorsport industry and especially career opportunities. RDI Specialist and Futures Researcher Tero Villman highlights future perspectives for the passenger car in Finland. Both studies build on expert interviews and deliver up-to-date prospects. Even if sustainability is generally recognised as an important issue, it might come as a surprise to some readers that the motorsport industry is also addressing the issue, as Arola depicts. However, the need to do more in terms of sustainability is recognised and was also an issue raised by Lewis Hamilton while securing his seventh Formula 1 World Championship title at the Turkish Grand Prix 2020. The third part of this publication documents findings from two workshops in autumn 2020. The workshops tapped into the studies by Arola and Villman. The student participants of the two workshops wrote learning diaries, which are compiled to present the ideas raised in the workshops, focusing especially on competence development and future professions in the Finnish automotive ecosystem.

When considering the future and new possibilities and opportunities for individuals and different businesses, the need for new knowledge and continuous learning can be clearly recognised. The transition described in this publication calls for the renewal of businesses and educational and other institutes as well as all of us, working now or in the future, in this field. As Tero Villman concludes in his study, there is a need for both new and old skills, and skills that cover a broad spectrum as well as specialised and expert skills. The career possibilities offered in the automotive sector, and more generally in the mobility sector, call for motivated people, eager for lifelong learning.

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Pirkkala, 8 December 2020

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AWD | All-wheel-drive. |
| CBC programme | Cross-border co-operation programme supporting the EU's external actions with financing from the European Union, the Russian Federation and the Republic of Finland. |
| CNG | Compressed natural gas. |
| $CO_2$ emissions | Carbon dioxide emissions. |
| DAS: Dual Axis Steering | Changing the alignment of the front wheels. |
| ECTS | European Credit Transfer and Accumulation System – Standard for comparing academic credits. |
| EV | Electric vehicle. |
| FIA | Fédération Internationale de l'Automobile – The governing body for world motor sport and the federation of the world's leading motoring organisations. |
| ICE | Internal combustion engine. |
| JOT | Just-On-Time, or JIT, Just-In-Time. Management philosophy. |
| Lean | Business methodology for eliminating waste of productivity. |
| LPG | Liquefied petroleum gas. |
| MaaS | Mobility as a service. |
| NASA | National Aeronautics and Space Administration (USA). |
| NEDC | New European Driving Cycle. |
| R&D | Research and development. |
| RDI | Research, development and innovation. |
| SDG | Sustainable Development Goals. |
| SUV | Sports utility vehicle – A car classification that combines elements of road-going passenger cars with features of off-road vehicles. |

| | |
|---|---|
| Traficom | The Finnish Traffic and Communications Agency. |
| Trafikverket | The Swedish Traffic Administration. |
| UNECE | The United Nations Economic Commission for Europe. |
| VAT | Value added tax. |
| WLTP | Worldwide Harmonized Light-Duty Vehicles Test Procedure – The new standard for $CO_2$ emissions and fuel consumption. |
| WRC | World Rally Cars. |

# CONTENTS

# 1 INTRODUCTION

This book consists of two applied research studies in the field of the automotive and motorsport industries and two subsequent reflections on the Race4Scale CBC-ENI project and Future Professions Workshop conducted in Finland in 2020.

Chapter 2, "IN TRANSITION: PASSENGER CARS IN FINLAND 2020-2030" is written by M.Sc. (Econ.) Tero Villman, who serves as a RDI expert on the Race4Scale project. The study is mainly focused on the present and future state of passenger cars in Finland and contains a variety of quantitative and qualitative data, reporting the results of the semi-structured interviews on an anonymous basis due to the sensitive nature of research.

Chapter 3 "MOTORSPORT INDUSTRY: INTERESTING AND CHALLENGING CAREER OPPORTUNITIES" is conducted by Doctor of Philosophy (Education) Tuija Arola, Development Director of Adult Education Taitaja. Ongoing trends in the motorsport industry, issues of sustainability and an educational perspective on motorsport and future-oriented education are the focal areas of the research.

Chapter 4 RACE4SCALE – DEVELOPMENT OF AUTOMOTIVE AND MOTORSPORT ECOSYSTEMS: REFLECTIONS FROM THE PROJECT PERSPECTIVE is developed by M.Sc. Jarmo Kujanpää, who is the Project Manager of Race4Scale project. Jarmo considers the project's international and intercultural contexts as well as historical aspects of automotive development.

Chapter 5 TOWARDS NEW PROFESSIONS AND PROFESSIONALISM: CONSIDERATION OF THE FUTURE PROFESSIONS WORKSHOP IN FINLAND is written by D.Sc. (Econ.) Mikhail Nemilentsev who acts as the RDI expert on the Race4Scale project and brings aspects of transnational project work and digital learning in relation to the Future Professions Workshop in Finland as part of the project's first work package (WP1).

# 2 IN TRANSITION: PASSENGER CARS IN FINLAND 2020-2030

Tero Villman, M.Sc. (Econ.), RDI Expert, Race4Scale CBC-ENI project, "Creative Industries" RDI Unit, South-Eastern Finland University of Applied Sciences

## 2.1 INTRODUCTION

Passenger cars have an integral role in everyday life in Finland. Currently, they are the dominant mode of transport, as 60% of daily trips and 76% of distances travelled are done by passenger cars (Finnish Transport Infrastructure Agency 2018). In addition, they are embedded into the fabric of culture, from the values they are used to represent to the design of society and its habitat, the built environment. Nevertheless, passenger cars are on the verge of a transformation with a significance relatable to the transition from horse-drawn carriages to horseless carriages. According to the Ministry of Transport and Communication (Tieliikenteen päästöt laskussa 2020-luvulla – uusia toimia tarvitaan yhä), in Finland, traffic counts for a fifth of greenhouse gas emissions, out of which 95% is the result of domestic road traffic and half of that is caused by passenger cars. Therefore, a significant portion of the greenhouse gas emissions in Finland are caused by passenger cars. As the number of cars and the distances travelled by car have increased and are projected to continue to increase (Lapp, Iikkanen, Ristikartano, Niinikoski, Rinta-Piirto & Moilanen 2018), and the main energy sources are currently fossil-based petrol and diesel fuels (Traficom, Vehicles in Traffic), the powertrains used in vehicles require a transition towards emission and carbon-free alternatives.

While at the time of the previous transition to the automobile, the powertrain changed from muscles to engines, both were human-operated, and humans remained in command as the operators. Nonetheless, the role of humans as operators may be about to change drastically. The change has been on its way for a long time, as the cognitive abilities of the operator, i.e., the driver, have been augmented with indicators and driver-assistance systems lowering their cognitive load, and outsourced to on-board safety systems to reduce the risk of accidents and minimise potential damage in situations where the operator is unable to handle the vehicle safely. Moreover, in order for traffic safety to increase technologically, vehicles must gain total awareness of their surroundings, more advanced sensors and processing capabilities are required, and thus the cognitive load is evermore shifted from the human operator to the vehicle. For many years already, there have been cars able to manoeuvre independently in traffic to some extent, but many issues must be resolved and new issues are discovered before autonomous cars are to roam the streets in numbers. Especially if autonomous cars are to be widely adopted and the total of vehicle-kilometres grow as result, the question of alternative energy sources and powertrains becomes increasingly important.

Despite the technological advancements, it takes time for any changes to be realised on a large scale; that is, the current vehicle fleet of nearly 2.8 million passenger cars in traffic on 30 June 2020 (Traficom, Vehicles in Traffic). Although new cars enter the roads and old cars are recycled, the overall size of the vehicle fleet is an issue that affects the renewal rate remarkably. With that in mind, what kind of changes – technological and otherwise – may be expected within the next ten years?

Based on a series of eleven expert interviews conducted between August and October 2020, this research aims to identify and discuss trends, driving forces and weak signals regarding and around passenger cars in Finland from 2020 to 2030, especially focusing on technological change. As the experts represent a wide array of expertise and actors, from public office to interest groups and research organisations to private business, technology to business, environment to social and regulation, the interviews consider a broad variety of topics and issues but the research does not claim to be exhaustive. In addition, to best discover differentiating and intriguing results, all information regarding the interviews is represented anonymously.

The report is structured as follows. Next, the current state of passenger cars and the vehicle fleet in Finland and the related views expressed in the interviews are presented. Then, the trends, issues, plans and projections described by the experts are introduced, and potential questions and implications are discussed and presented in separate thematic sections.

The research considers the Framework Foresight (Bishop & Hines 2012; Hines & Bishop 2013, 36; Hines 2020) as the foundation for its theoretical framework. Mainly, as an environmental scanning exercise, the Framework Foresight phases of Framing and Scanning are considered essential for the research. Framing entails defining the domain of the exploration, including the key topic, description of the topic, geographical scope, time horizon and a domain map, and assessment of the current situation, including the identification of current conditions such as hot topics of the domain, stakeholders that could affect the future of the domain and significant events in recent history. Scanning involves identifying any signals of change and research concerning trends, issues, plans and projections. In addition, drivers may be identified and used as a means to synthesise large sets of inputs to the research to describe key drivers influencing change in the domain. According to the Framework Foresight model, the next phase after Scanning would be Forecasting/Futuring, i.e., describing alternative futures scenarios, which is considered out of the scope of the research. (Hines 2020). In addition, to provide an effective scope, motorsport, heavy vehicle traffic and public transport are considered out of scope, although issues and implications presented by the experts may be briefly discussed.

In the report, the terms passenger car, car and vehicle are used interchangeably unless otherwise specified in the context. Together with the motorsport research presented by PhD Tuija Arola, the reports form an informational foundation for further activities in the Race4Scale project. Mainly, in the Future Professions workshops organised during October and November 2020, the participants, for example, students, teachers and business community member interpreted the information to analyse competence development issues and opportunities, and furthermore map future professions in the Finnish automotive ecosystem.

## 2.2 RESEARCH METHODS, DATA COLLECTION AND DATA ANALYSIS

The research approach used in this study is qualitative and the data presentation method is descriptive (McTaggart & Kemmins 2007). Based on a series of eleven expert interviews conducted between August and October 2020, the research aims to identify and discuss trends, driving forces and weak signals regarding and around passenger cars in Finland from 2020 to 2030, especially focusing on technological change. Therefore, the research may be described as an environmental scanning exercise. The interviews were semi-structured, which allowed for more informative dialogue with the interviewees and adaptation to each interview situation (Bhat 2018).

An initial list of interviewees was created based on familiarisation with publications. Then, at the end of each interview, the interviewee was asked to identify potential interviewees with relevant expertise related to the research, i.e. snowball sampling was used in the recruitment of interviewees. In order to provide an effective sample for the research, the selected interviewees were assessed to represent a range of interests from public office, interest groups, research organisations, and private business, and a range of expertise from political, economic, social, technological and environmental perspectives. To best discover potentially differentiating and intriguing views, the interviews were kept anonymous and thus the interviewees' names or organisations are not specified.

The interviews were semi-structured. Since the scope of the research includes multiple perspectives and each interviewee is an expert in their subject matter, a list of central topic and questions related to change assisted in the interviews. The questions were open-ended and designed to give space for the interviewees to answer based on their expertise and views. In addition, answers led to further, more specific questions and discussions often went deeper into the interviewee's own area of expertise. Although the research considers a broad range of topics and issues, it does not claim to be exhaustive.

The interviewees were recorded and transcribed. The resulting material was used to identify key topics and groupings, i.e. perform thematic analysis in accordance with the content analysis method (McMullin 2014). All information regarding the interviews is reported anonymously. The framework and interview questions used in the semi-structured interview are described in Appendix 1.

## 2.3 THE CURRENT STATE OF PASSENGER CARS IN FINLAND

Passenger cars and mobility in general are important for a sparsely populated country with long distances. Finland as one such country is an excellent example. We will discuss the current state of passenger cars in Finland based on statistics and impressions provided by the interviewees.

### 2.3.1 MOBILITY

Based on statistics and the interviews, the role of the passenger car in the Finnish transport system is essential. It is the dominant mode of transport and currently there are no clear contenders to compete with it. According to the Finnish National Travel Survey 2016 (Finnish Transport Infrastructure Agency 2018), on average Finns made 2.7 daily trips with a total distance of 41 kilometres, of which on average 1.6 trips and 31.1 kilometres either as the driver or a passenger in a passenger car. In total, Finns made 5.1 billion domestic trips and travelled 76 billion kilometres per annum, from children and young people travelling 69% of their daily kilometres by car, to the 81% of parents with children, and 89% of young pensioners. Undoubtedly, there are regional differences as, for example, the infrastructure and public transport options vary. While in the Helsinki region 47% of trips are made in a passenger car, in Salo and the western Uusimaa region it is 70%. Based on the distance travelled, 69% of kilometres are travelled in a passenger car in the Helsinki region, and from 83% to 86% in the regions of eastern and western Uusimaa and Salo. In addition, according to the survey, there is a significant prominence of passenger cars for longer trips, as 78% of trips over 100 kilometres are made either as the driver or a passenger in a passenger car.

In addition, while the situation with the COVID-19 pandemic has affected commuting and travelling significantly, it has put more emphasis on private transport options, including passenger cars. The use of passenger cars has increased, as has the demand for different services providing cars for shorter periods, e.g., car rental services, too.

### 2.3.2 THE VEHICLE FLEET

While there are considerable variations in the distances travelled and the modal shares of different transport modes based on life situations and regions, the passenger car is arguably the most used mode of transport throughout the country and across demographic groups. Therefore, the kinds of passenger cars that are used is an essential issue in many regards, for the travellers, for the environment, and for the economy.

According to Traficom, the Finnish Traffic and Communications Agency (Vehicles in Traffic), the number of vehicles in Finland has increased significantly since 1960 (see Figure 1). The Finnish Transport and Communications Agency, Traficom, is an authority for permit, licence, registration, approval, safety and security matters. In total, there were 2 788 271 passenger cars in traffic on 30 June 2020 in mainland Finland: 70% of which powered by petrol and 28% by diesel, while 1.2% were either petrol or diesel plug-in hybrids, 0.4% gas-fuelled and only 0.23% battery electric vehicles. In addition, as a curiosity, currently there is one registered hydrogen-powered fuel cell passenger car in Finland. Based on the statistics, the average passenger car in use on the Finnish roads is 12.2 years of age and powered by petrol, and it is scrapped after 21 years (Finnish Information Centre of Automobile Sector, Average scrapping age of passenger cars; Traficom, Vehicles in Traffic). In the European Union, the average age of passenger cars is 10.8 years and 95.9% are petrol or diesel powered (European Automobile Manufacturers' Association, Average vehicle age; European Automobile Manufacturers' Association, Passenger car fleet by fuel type). Thus, in Finland, the average age of a passenger car in use is higher and the share of alternatively-powered vehicles lower than the averages in the EU fleet.

By the end of 2019, the average $CO_2$ emissions for passenger cars in traffic in Finland were 155.4 g/km and for newly registered cars 116.9 g/km based on the New European Driving Cycle (NEDC) measurements (Finnish Information Centre of Automobile Sector, Average carbon dioxide emissions (NEDC) of new registered passenger cars, g/km; LiikenneFakta, Hiilidioksidipäästöt). According to the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) measurements, the average $CO_2$ emissions of newly registered passenger cars in 2019 were 139.3 g/km (LiikenneFakta, Hiilidioksidipäästöt). Due to the change from the NEDC measurement model to the WLTP, the statistics are not comparable, and during the transition, both measurements are reported.

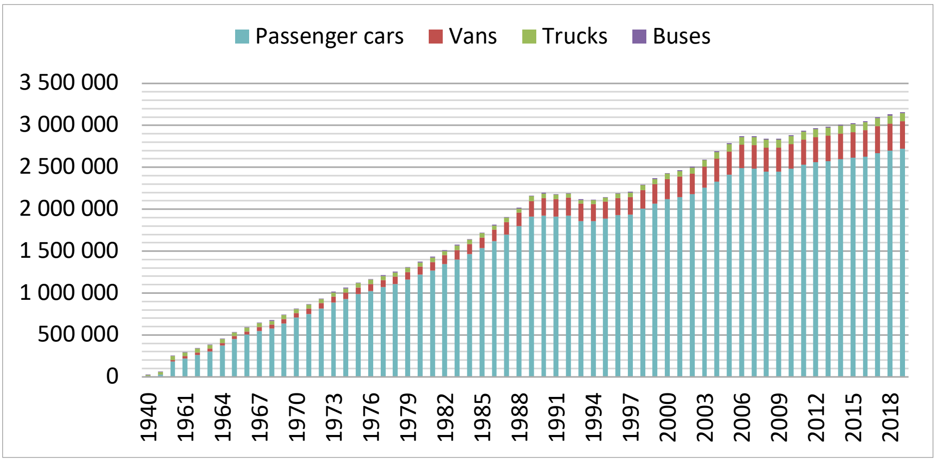


**Figure 1** - Vehicles in Traffic (Traficom, Vehicles in Traffic)

### 2.3.3 RENEWAL OF THE FLEET

According to estimations, the latest cars provide their driver with 10% to 20% better protection than ten-year-old cars (Räty & Kari 2017). Therefore, it is clear that the renewal of the vehicle fleet does not only reduce emissions but also improves traffic safety. However, the vehicle fleet changes slowly. The main methods of renewal are through the market of new and used cars, including the import of used cars, and the scrapping of older vehicles.

Between 2009 and 2019, the yearly average of new registrations has been 111 882 passenger cars ranging from the 90 574 cars registered in 2009 to the 126 123 of 2011 (see Figure 2). The major decline from 1990 to 1993 was the result of the Finnish Great Depression. To recognise the scale, sales of used cars were approximately 600 000 to 634 000 passenger cars per year between 2015 and 2019 (Finnish Information Centre of Automobile Sector, Statistics of Sales of Used Cars). In addition, the number of imported used passenger cars grew almost 44% between 2003 and 2019: from 31 944 to 45 912 cars (Traficom, Imported Used Vehicles). Passenger cars have also been scrapped in increasing numbers. From 2008 to 2019, the number of certificates of destruction issued regarding passenger cars rose from 38 487 to 71 424 (Finnish Information Centre of Automobile Sector, Number of Certificates of Destruction 2008-).

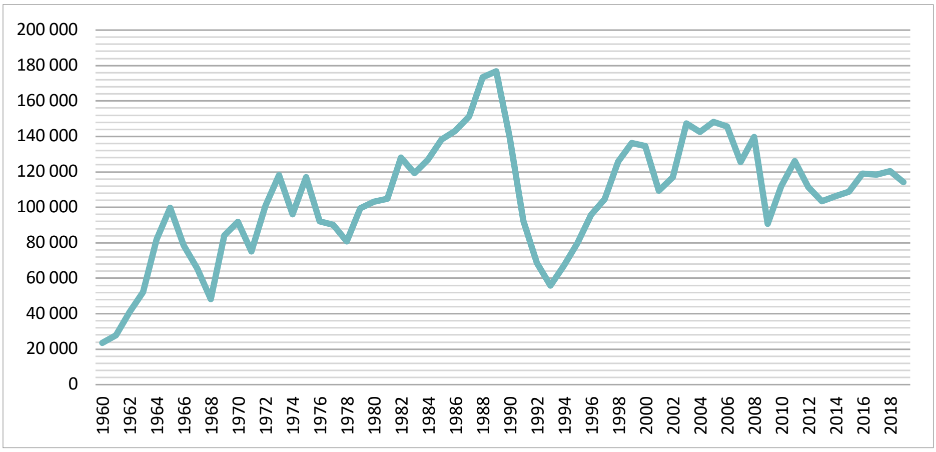


**Figure 2** - First registrations of passenger cars between 1960 and 2019 (Official Statistics of Finland, First registrations of motor vehicles)

## 2.4 TOWARDS 2030 (AND BEYOND)

It has been claimed that cars are in a state of constant change. In fact, the current state may be described as a confluence of many shifts and disruptions. To understand potential changes, it is important to examine how the situation is already changing, what kinds of issues have an effect on the development, the directions or plans for different actors, and how projections are viewing the change. As one interviewee said, "maybe we are on the verge of a very rapid change, where we cannot really anticipate how fast it will hit, and how it will change the vehicle fleet and the ways of using cars, especially on the passenger car side". In general, it is challenging if not impossible to project the rate of change, nevertheless, during times of disruptions and transitions, and an expressed projection might sound preposterous or, on the contrary, be outdated very soon. In the next sections, we will present and discuss the trends, issues, plans and projections described by the experts.

## 2.5 ALTERNATIVE POWERTRAINS TO REDUCE EMISSIONS

The traffic volumes and demand for traffic in Finland are expected to increase, and in part this will be on the passenger car side. Conversely, the number of passenger cars is not expected to grow, at least not significantly. Distances travelled will continue to increase as urban areas grow. According to an interviewee, while urbanisation is advancing, it might not shorten trips to the extent that the traffic performance of passenger cars, i.e. the total number of kilometres driven typically in a year, reduces. Public transportation, biking and walking are expected to grow, and measures for their advancement are needed, but passenger cars are expected to continue as the dominant mode of transportation. Urbanisation allows for shorter journeys, the promotion of walking, cycling and public transport, but then, for example, individual lifestyles, shrinking households, an ageing population and the regional and urban structure in Finland create conditions that maintain car use and the passenger car as the main mode of transport, by which the majority of trips are made. Furthermore, if urbanisation slows down and migration even turns in some aspect, this will pose even greater challenges for public transport.

One of the most important drivers of change is the elimination of greenhouse gas emissions from transport and the transition towards a carbon-free future. The long-term plan of the European Union is to achieve carbon-neutrality by 2050 (European Commission, 2050 Long-Term Strategy). The Government of Finland is working to ensure that Finland is carbon-neutral by 2035 and carbon-negative soon after by "accelerating emissions reduction measures and strengthening carbon sinks" (Finnish Government). There are four primary measures to reduce emissions by 2030 (Andersson, Jääskeläinen, Saarinen, Mänttäri & Hokkanen 2020):

- Using alternative power sources
- Improving the energy efficiency of transport means
- Improving the energy efficiency of the transport system
- Pricing methods

According to the interviewees, the climate policy of the European Union, and especially the binding emission targets set for European car manufacturers, are considered the most important factors driving the change. EU legislation has set mandatory emission targets for new cars since 2009 (European Commission, Reducing $CO_2$ Emissions from Passenger Cars - Before 2020). The first emission target applied set the bar at "130 grams of $CO_2$ per kilometre applied for the EU fleet-wide average emission of new passenger cars between 2015 and 2019." (European Commission, Reducing $CO_2$ Emissions from Passenger Cars - Before 2020), which had already been reached in 2013. From 2021, the average emissions of all newly registered cars of a manufacturer will have to be below 95 g $CO_2$/km, from 2025 15% less than the 2021 starting point, and from 2030 37.5% less than the 2021 starting point.

To reach the emission targets, manufacturers have both improved the energy efficiency of their internal combustion engine models and developed alternative powertrains utilising, for example, electricity, gas, hydrogen or the aforementioned in various combinations as hybrids. For any alternative to succeed, there needs to be an energy source or a fuel that can be used, a vehicle than can use it, and distribution between them. If any of these are missing or lacking, the alternative may be unattractive or even unattainable. Next, we will discuss the alternative powertrains presented by the interviewees.

### 2.5.1 INTERNAL COMBUSTION ENGINE VEHICLES

Although in Finland the percentage of petrol and diesel cars of new registrations has declined from 97% in 2017 to 81.1% in 2020 (between January and September), they make up most of the current vehicle fleet (97.7%) and with the current average scrapping age of 21 years, the renewal of the vehicle fleet takes a long time. However, with the internal combustion engine, the main issue relates to the fuel, and for that reason, better alternatives to fossil fuels are needed. As the current vehicle fleet need fuel for their lifetime, the demand for petrol and diesel fuels will continue as long as they are used and new ones are sold. Therefore, the best option is to use already available renewable or low-emission alternatives and develop even better ones, at least for the transition period. Currently, as described by an interviewee, the best alternative for petrol vehicles is E10, with up to 10% of renewable ethanol. E85 with up to 85% ethanol is available, too, but it requires a specific flex-fuel vehicle or the ethanol conversion of a regular petrol vehicle. As petrol vehicles make up most of the vehicle fleet, this is definitely an issue that needs to be addressed. The popularity of diesel has decreased due to the diesel emissions scandal, but while the movement has been towards alternatives, too, it has also increased the sales of petrol cars. From the perspective of renewable fuel alternatives, diesel presents wider possibilities as it can be mixed with renewable ingredients in any ratio up to 100%, and used without any modifications to the vehicle.

In addition, a new alternative fuel for internal combustion engine vehicles could be the so-called synthetic fuels (electrofuels or Power-to-X fuels, P2X ) as they can be produced from, for example, hydrogen from water and carbon captured from the air through the process of electrolysis and synthesis. Synthetic fuels typically burn cleaner as they contain fewer impurities than their oil-based counterparts, and they could be produced locally in small communal facilities with excess renewable energy. However, since the process requires significant amounts of renewable energy, currently the production of synthetic fuels is many times more expensive than using renewable materials, but when there is a surplus of renewable energy available, synthetic fuels may provide a form for storing the energy for later use.

When fossil fuels can be replaced with sustainable renewable or low-emission alternatives, there could be a brighter future for the internal combustion engine, as there are plenty of cars and a wide distribution network in use. For example, Neste has developed Neste MY Renewable Diesel and continues to develop new solutions "based on scalable renewable and circular raw materials that have been difficult to utilize so far, such as forestry or agricultural residues, municipal waste, algae, waste plastics and carbon dioxide" (Neste). In addition, LUT University, the technology company Wärtsilä and the energy company St1 have examined how Power-to-X solutions can benefit Finland on the road to carbon-neutrality by 2035 and in establishing a new area of growth in exports for the Finnish technology industry (Laaksonen et al. 2020).

### 2.5.2 NATURAL GAS VEHICLES

One of the alternative energy sources for passenger cars is compressed natural gas (CNG) or compressed biogas (CBG). Vehicles using gas have been around for decades, but they have become more popular during the last five years since, in addition to having more car models on the market and the distribution network having grown, there has been a financial incentive to purchase one: the purchase price is lower because of lower emissions, and the fuel is more affordable than petrol or diesel. Despite the potential, more major consumer interest has not followed and manufacturers such as Volkswagen have announced that although they are still producing currently available natural gas vehicle models, they will not be developing new models. It is important to consider that while natural gas is a fossil fuel, biogas is renewable, as this affects the potential role of gas vehicles in the future. While in Finland there have been significant investments in the production of biogas, Central Europe utilises natural gas, and biogas may seem only a gas that is more expensive. More importantly, since the European Commission has set binding emission targets for manufacturers, the way gas vehicles are measured against other alternatives has a huge impact on the decision manufacturers make.

According to an interviewee, a gas vehicle is considered to be only 20% better than a petrol vehicle, but an electric car is 100% better, because the emissions are calculated based on the exhaust emissions of fossil natural gas, instead of the better alternative, renewable biogas. If the emissions of gas vehicles were calculated using a better valuation, there could be more interest in manufacturers producing them. However, it is also important to consider the production complexity: with fewer alternative powertrains, fewer different production lines are required.

In addition to the production of new gas vehicles, there is also an option to convert an existing petrol or diesel car to run with natural gas. Still, despite the financial subsidy provided by the Finnish Transport and Communications Agency (Traficom, Conversion subsidy), consumer interest in conversion has been low. For the above reasons, the interviewees expect the role of gas be more important for heavy vehicle traffic, to make use of biogas production in Finland and to further develop the distribution network along major trade corridors. That being said, the use of biogas in transport reduces Finland's dependence on oil and improves the country's current account, and there are plans to support the expansion of the gas distribution infrastructure (Ministry of Transport and Communication, Fossiilittoman liikenteen tiekartta; liikenteen päästöjen puolittaminen vuonna 2030). Thus, the current and new gas-operated passenger cars will have access to fuel in the future, too. In addition, synthetic fuels may also be produced in the form of gas, providing another potential energy source for gas vehicles in the future.

### 2.5.3 ELECTRIC VEHICLES

The push towards the electrification of passenger cars is significant and the transition has started gaining increasing momentum. The percentage of new registrations of electric cars has grown remarkably since 2017 (see Figure 3). During 2017, plug-in hybrids and battery electric vehicles made up 2.6% (3055) of new registrations, but in 2019 the percentage was 6.9% (7863 vehicles). Between January and September 2020, the percentage of plug-in hybrids and battery electric vehicles of new registrations was up to 16.7% (12 278 vehicles). (Official Statistics of Finland, First Registrations of Motor Vehicles.)

More and more car models are available, and the pricing is affected by the tax benefits for acquiring and owning electric vehicles and the purchase incentives offered in 27 member states of the European Union, including Finland (European Automobile Manufacturers' Association, Electric vehicles: Tax benefits & purchase incentives in the European Union). Electric vehicles are mainly either battery electric vehicles or plug-in hybrids with an internal combustion engine accompanying the electric motors and batteries, which are recharged from an external electric power source. There are other types of hybrid electric vehicles, for example, full hybrid, where an internal combustion engine produces the energy that the electric motor requires, and mild hybrids, where a small electric motor is used to reduce fuel consumption.

As one interviewee pointed out, electric cars are more energy-efficient than internal combustion engine vehicles, but the reason is that electricity as a form of energy is already more refined when stored in the batteries. Hence, in order to understand the energy efficiencies and emissions related to different alternative energy sources, there is a need to examine the whole chain, starting from the raw material or primary energy up to the actual use. To not only ensure the reduction of exhaust emissions, but to transition towards carbon-neutrality, the energy used to charge batteries should be generated from renewable instead of fossil sources.

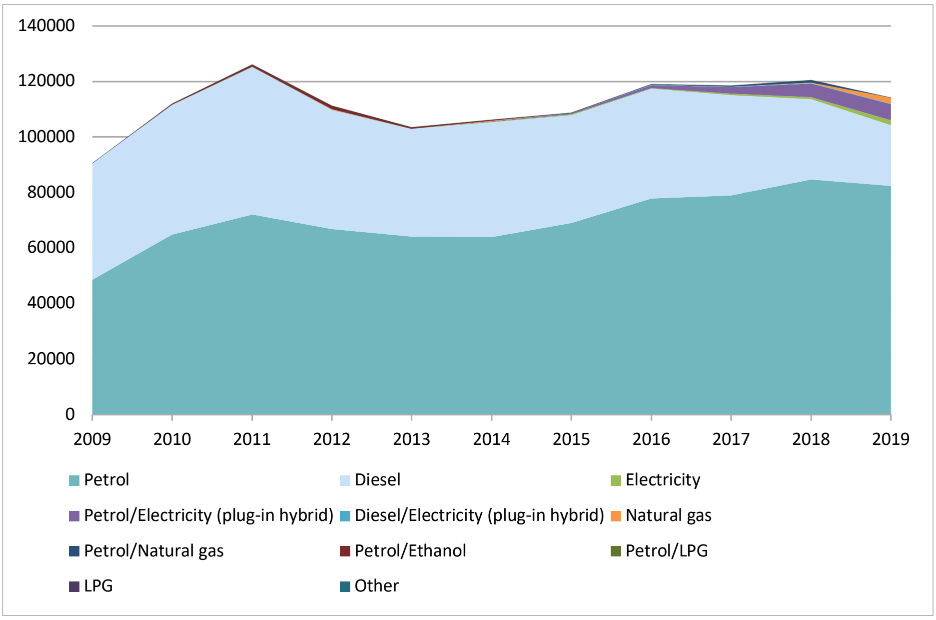


**Figure 3** – First registrations of passenger cars by driving power (Official Statistics of Finland, First Registrations of Motor Vehicles)

Regarding the sufficient distribution of electricity for use in electric cars, much has been done to develop a network of charging stations, both public and private, but much remains to be done. While the possibility for private charging points within private residencies and condominiums is definitely an advantage of electric vehicles, the installations may require other alterations and electrical work as well, or there may simply not be space for charging points. Apartment buildings may have fewer parking spaces than residents have cars, and street parking is used. Since half of the population in Finland (Official Statistics of Finland 2019) live in apartment buildings and terraces, the electrification of transport requires the development of other infrastructure, too.

To promote the development of the charging infrastructure, there will be an obligation "to build a charging infrastructure for electric cars whenever a large-scale renovation is completed in a housing company or on business premises" (Finnish Government). In addition, petrol station chains will be obligated to provide specific numbers of charging points. As a method for further increasing the number of electric cars, there are multiple proposals related to company cars, since approximately a fifth of newly registered cars are company cars, and these will enter the used car market after company use. The interviewees see that the electrification of the powertrain as a trend will continue and strengthen further.

### 2.5.4 FUEL CELL VEHICLES

Fuel cell vehicles powered by hydrogen have been and are still seen as a potential solution for reducing emissions. Although there are a few car models available, currently hydrogen fuel cell cars are very expensive and there are no public refuelling stations in Finland. The interviewees do not see hydrogen as a likely alternative for passenger cars. There are not that many manufacturers interested in the technology, as the focus is on electric cars, the fuel cell system is relatively heavy and takes up space, and the distribution infrastructure requires heavy upfront investments compared to the number of customers, as opposed to building or installing charging stations for electric vehicles and connecting to the existing electricity grid. Similarly to gas, the future of hydrogen will most likely be in heavy vehicle traffic, because fuel cells provide a pathway towards carbon-neutrality (European Commission, Hydrogen Strategy), and the electrification of traffic is not enough alone, as the current batteries do not provide enough energy, for example, for a full trailer combination truck for a long distance, and recharging takes time.

### 2.5.5 FROM ALTERNATIVES TO CHOICES

While over time there have been many alternative energy sources and powertrains for cars, petrol and diesel have dominated for a long time, and they will continue as the majority at least for the timescale of the research, until 2030. Granting that there is a movement to phase out fossil fuels entirely, it is not a straightforward path. As the majority of motorists are currently tied to their petrol or diesel cars, the shift towards alternatives potentially increases inequalities, as those who can afford to buy a new car can choose, and those who cannot are stuck and have to cope with rising costs. In addition, increasing the production capacity of renewable alternative energy sources and the development of sufficient distribution infrastructure requires resources, and should be achieved in a sustainable manner. For example, renewable diesel is an excellent alternative for reducing the emissions of the current vehicle fleet, but there should be enough biomass available and the production capacity should meet the demand sustainably. In addition, in order not to lock future potential, decisions and control should be technology-neutral to allow technological solutions to be developed freely and from there, possibly, the most energy-efficient means of reducing emissions can be discovered.

For some time, it seemed that there were many upcoming challengers for the internal combustion engine: it now seems that the electrification of passenger cars is progressing strongly as the manufacturers are investing in the development of new electric car models and production lines. Due to significant investments, there might not be an interest in changing direction, and thus the trend may grow even stronger. According to the interviewees, the direction for passenger cars might be from one powertrain system, the internal combustion engine, to another, electric solutions, despite other powertrains also being present in small numbers. Natural gas and hydrogen will most likely fuel heavy vehicle traffic and the developing distribution infrastructure may serve some minority of passenger cars as well. According to various projections, the number of electric cars (including both plug-in hybrids and battery electric vehicles) in 2030 will range from 22 800 to 850 000, or about 8% to 30% of the vehicle fleet (Finnish Information Centre of Automobile Sector, Autokannan tulevaisuuden käyttövoimat; Kalenoja 2019). Natural gas vehicles are expected to reach 1% to 2% and hydrogen even less, if any.

However, it is crucial to understand that the projections depend on many issues, and the estimates provide only a limited perspective based on the information available at the time. The projections may change drastically if the reasoning behind them changes. In particular, the economic crisis caused by the COVID-19 pandemic has already had and is expected to continue to have severe consequences globally. In addition to the health and mental effects, the economy and employment are widely disturbed. Consequently, the automotive industry is affected, too. For example, the registrations of new passenger cars in 2020 are expected to drop near the levels of new registrations during the Finnish Great Depression in 1991 and the financial crisis in 2009 to approximately 91 000 cars from 2019's 114 200. The current estimate for 2021 expects increased sales, with 103 000 new registrations, but the crisis may disrupt the curves for a long time to come. (Finnish Information Centre of Automobile Sector, Käytettyjen autojen kauppa kannattelee tänä vuonna autoalaa). In addition to new registrations, it is important to consider the import of used cars, as this replaces the purchase of a new vehicle and imports of used cars have increased in numbers. While previously the typical imported passenger cars were larger diesel-powered vehicles with higher emissions than registered new cars in Finland, more and more vehicles with alternative powertrains have been imported in recent years – even more than the corresponding share of the new cars registered in Finland. (Andersson et al. 2020, 40-41.)

Informed decisions and impactful actions are required to reduce emissions and achieve carbon-neutrality in Finland by 2035. As an interviewee stated, if we make decisions and put them into action, then change can be vast, but if we do nothing, hardly anything will happen – "it is up to us depending on what we want and what we decide".

## 2.6 AUTOMATION FOR SAFETY, COMFORT AND PRODUCTIVITY

From before the 1970s until the 1980s cars included mostly mechanical components, such as the handbrake, steering wheel, control and gears. The first big step was taken when some of the systems were converted to electric in the most expensive cars in the mid-1980s. In the 1990s, the same development increased in the mid-priced category. Today, virtually all vehicles even in the low-price category include electronic steering control, which has enabled the development of vehicle automation development. In addition to technological development, driving automation needs a functioning infrastructure, enabling legislation and social acceptability (Rilla 2020). Next, we will discuss what is meant by 'driving automation', the development of driving automation, and some of the issues related to driving conditions and regulation. In addition, the perspective of full driving automation as a vision is described.

### 2.6.1 DEFINING DRIVING AUTOMATION

Often, when discussing the automation of vehicles, the conversation actually refers to fully autonomous vehicles. According to the widely referred to standard SAE J3016™ (SAE International 2018), there are six levels of driving automation (see Table 1), starting from Level 0, where there is no driving automation and the driver must perform all dynamic driving tasks (DDT), to Level 5, in which the automated driving features manage driving everywhere and under all driving conditions autonomously – without any need for human interference ever. The levels in between describe the various degrees of the driving automation system being able to perform parts or all of the dynamic driving tasks on a sustained basis and the operational design domain (ODD), i.e. the "[o]perating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics" (SAE International 2018, 14). Therefore, it is important to recognise that driving automation systems and features are already widely used with humans in the driver's seat, and there are many possibilities even before full driving automation.

**Table 1** – SAE J3016™ Level of driving automation, adapted (SAE International 2018, 19; SAE International 2019)

| **Level** | **Level 0** | **Level 1** | **Level 2** | **Level 3** | **Level 4** | **Level 5** |
|---|---|---|---|---|---|---|
| **Name** | No driving automation | Driver assistance | Partial driving automation | Conditional driving automation | High driving automation | Full driving automation |
| **What does the human in the driver's seat have to do?** | You are driving whenever these driving support features are engaged – even if your feet are off the pedals and you are not steering | | | You are not driving when these automated driving features are engaged – even if you are seated in 'the driver's seat' | | |
| | You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety | | | When the feature requests, you must drive | These automated driving features will not require you to take over driving | |
| | **These are driver support features** | | | **These are automated driving features** | | |
| **What do these features do?** | These features are limited to providing warnings and temporary assistance | These features provide steering OR brake / acceleration support to the driver | These features provide steering AND brake / acceleration support to the driver | These features can drive the vehicle under limited conditions and will not operate unless the required conditions are met | | This feature can drive the vehicle under all conditions |
| **Example features** | Automatic emergency braking, blind spot warning, lane departure warning | Lane centring OR adaptive cruise control | Lane centring AND adaptive cruise control at the same time | Traffic jam chauffeur | Local driverless taxi, pedals / steering wheel may or may not be installed | Same as level 4, but feature can drive everywhere in all conditions |

### 2.6.2 TRAFFIC SAFETY

The renewal of the vehicle fleet has been noticed to have a positive effect on traffic safety. Passive safety features in particular, for example, deformation zones in the vehicle structure, seatbelts, airbags and headrests, which aim to mitigate the consequences of accidents to passengers, pedestrians, cyclists and other road users, have had a positive impact on the reduction of accident victims. Although the passive safety features continue to be important, the next leaps are to be gained with active safety features. While passive safety features are benefitted from during accidents, active safety features aim to prevent accidents from happening, or at least reduce their impact. For example, Level 2 systems provide partial driving automation in the form of adaptive cruise control and lane centring.

According to a study (Innamaa, Kanner, Rämä & Virtanen 2015) considering the effects of increased automation on Finnish traffic, when the majority of cars are at Level 2, it is estimated that there are 10-15% fewer fatalities as adaptive cruise control reduces the number of rear-end collisions and pile-ups, and lane centring reduces encroachment accidents and head-on collisions. In addition, adaptive cruise control may further reduce accidents, as a vehicle driving in accordance with the speed limit may prevent those behind it from speeding (Innamaa et al. 2015, 59). According to the same study, when the majority of vehicles are equipped with Level 3 driving automation, the fatalities could be lowered by 40-70% on roads where automated driving is possible. On the other hand, poor weather and road conditions can affect the performance of the systems, cars may drive faster and closer together, drivers' attention may be compromised, and when the drivers' role moves from active driving to standing by to take control of the vehicle only in times of system failure or changing conditions, accidents may even increase.

The role of the driver is expected to become more of an issue when vehicles reach Level 3 conditional driving automation. Essentially, the driving automation system is in control of the vehicle until it requests the human to take over. The request may come in advance when the operating conditions are about to change, or suddenly in the case of failure. As it turns out, humans are not particularly good in activities which most of the time do not require active doing, but then suddenly due to a demanding situation one needs to gain awareness, understand the problem, and take control safely – quickly. Hence, driving automation might require reaching Level 4 for safety reasons: the system must work reliably in all situations without human inference such that, in the event of a problem, it can safely reduce speed, drive to the side of the road or park in a safe place. The challenge is that the system must be able to handle a wide range of situations in all conditions.

The research and development requires significant investments at the same time as the industry must develop solutions for reducing emissions. In addition, there are currently no test methods by which a car manufacturer could show that the developed system works reliably in all possible conditions and situations that can be encountered in traffic. Developing such methods is challenging, as the environment in which cars operate has almost an infinite number of combinations of conditions, situations and characteristics, and there is still the possibility of something unexpected or random occurring. Essentially, the reliability of the driving automation system should be almost 100%.

Although safety is a crucial aspect regarding driving automation, it may also be seen as a mandatory foundation after which the main selling points for consumers is driving comfort and, for businesses, productivity. Driving comfort is increased by, for example, having the option to drive on monotonous roads in the automated mode and being able to focus on other matters such as work or entertainment. Regarding commercial vehicles, businesses aim to have the unit production volumes as high as possible and the costs of labour and fuel as low as possible. For example, platooning, i.e., multiple trucks driving automatically in a convoy close to one another, reduces fuel consumption and emissions.

Smaller automated buses or taxis could operate in a limited area, as Waymo started offering fully driverless rides to their customers within specific areas of Phoenix (Krafcik 2020; Lee 2020). However, the interviewees believe that the advances in driving automation during the next decade will come in the form of specific features such as advanced driver-assistance systems, and there will possibly be cars functioning on Level 4, but it will take a considerably longer time – even decades – until there are fully autonomous cars on roads in Finland, if it is even possible. As with every new technology or feature, an interesting question is, how do people view driving automation? What is required in order to use the automated features? Do people know what is expected of them when using specific driving automation features? What kind of personal and social barriers may there be, for example how do people feel about becoming a passenger and not being in control of the vehicle? How will the cost of increased driving automation features change car prices and sales? What completely unexpected issues will arise?

### 2.6.3 DIGITAL INFRASTRUCTURE

If the car was a new invention entirely, we might directly develop driverless cars, contemplated one interviewee. Furthermore, if all cars were autonomous and interconnected, there would be less or even no need for traffic lights and such. However, since this is not the case, it will take a long time until such dramatic changes may be considered. Still, there is a need to support the digital infrastructure, which, as a digital twin, constantly signals and updates the condition of the road, where there are accidents, where detours are, and so on. The digital infrastructure makes it easier to plan automatic driving routes. Currently, the information collected originates from the mobile phones of road users or specific cars, and goes to the private providers of the services for further use. A question presented by an interviewee is does the reliance of commercial services providers enable the required level of self-sufficiency and security of supply, and should there be a public digital infrastructure available as an alternative?

### 2.6.4 DRIVING CONDITIONS

Poor weather and changing seasons, for example winter conditions in Finland, are currently an issue for automated features to function reliably, as they affect how visible the road and road signs are, or how much dirt accumulates on the surface of the vehicle and over the sensors.

Current solutions, for example for lane centring, rely heavily on cameras providing information regarding the location of the lane lines, which may be covered in snow. Therefore, they are more sensitive to problems. In addition, with the exception of Sweden, the share of the traditional car industry is quite low in northern Europe, as the major brands in the industry, especially on the passenger car side, are concentrated in Central Europe. Perhaps partly for that reason, the wintry and snowy conditions in the north have been overshadowed compared to what is currently being developed for the mass market. There is also discussion there of difficult weather conditions, but more of fog, heavy rain and so on. However, in the future, driving automation solutions are expected to utilise multiple different means, such as radar, laser scanning, camera and acoustic sensor systems in conjunction. Hence, the challenges regarding the weather and road conditions are expected to become less of an issue.

### 2.6.5 REGULATION

In terms of legislation, in principle there are no obstacles in Finland in regard to driving automation, especially if private car traffic is being considered. That is, there is no explicit requirement that the driver of the vehicle should be inside the vehicle, holding the steering wheel, or anything that would prevent from testing or even using more advanced automation. However, road traffic regulation is largely affected by the United Nations agreements regarding road traffic, road signs and road signals. Article 8 of the Convention on Road Traffic states, "[e]very moving vehicle or combination of vehicles shall have a driver" (UN 1977, 24). This has been interpreted differently and hence, in some countries it is specified in national legislation that the vehicle must have a driver and the driver must hold the steering wheel. In such countries, the issue has been identified. In Finland, too, the current interpretation of the law is similar. In 2016, the Convention on Road Traffic was amended by stating, "automated driving technologies transferring driving tasks to the vehicle will be explicitly allowed in traffic, provided that these technologies are in conformity with the United Nations vehicle regulations or can be overridden or switched off by the driver" (UNECE, UNECE Paves the Way).

### 2.6.6 FULL DRIVING AUTOMATION AS A VISION

Introduced in Sweden in 1995, Vision Zero put forward the aim that no one should die or be seriously injured in traffic (Trafikverket). It also emphasises the notion that the road transport system should be seen as an entity, in which different components, for example, roads, vehicles and road users, must interact with each other to ensure safety, and the roads and the vehicles must be adapted to the capabilities of road users. Vision Zero has spread from Sweden to other countries around the world, and the European Commission has set the long-term goal to zero fatalities and serious injuries by 2050. Level 5 full driving automation may be viewed as a vision similar to what Vision ZERO is for traffic safety. According to one interviewee, there is sort of a prevailing understanding amongst experts in the field that although many estimates and bold statements have been made about the timescale, ranging from years to decades and even a century, it may never be achieved in full and Level 4 may be as high as the solutions succeed. Still, however, it is a vision that should be aimed for.

## 2.7 CHANGING BEHAVIOURS

The alternative powertrains and the related political guidance, the introduction of new car models with new technology in increasing numbers, the changing attitudes related to ownership and the general economic situation create uncertainty and knowledge gaps in the car market. Some could argue that acquiring a vehicle is not as straightforward as it used to be. There are more and more options regarding the various car models, and the different alternative powertrains have introduced the important consideration regarding the energy source: does the energy source meet the customer's needs now and in the near future? While previously the majority of customers selected between petrol and diesel cars, now the options are broader and their implications wider. Customer-centric organisations will benefit in this situation by recognising customers' actual needs and finding the best solutions for them in the constantly evolving market. Next, we will discuss the importance of understanding the behaviours new technology, business models and environmental factors bring forth.

### 2.7.1 REMOTE WORK

With regard to mobility, digitisation and remote working are a big question mark with remarkable potential. As early as the early 1990s, there was discussion that remote work would revolutionise commuting and work travel. According to an interviewee, very little has happened in recent years, with the exception of the COVID-19 crisis, i.e. when there has been no external pressure or need for social distancing. Now, remote work practices have been introduced wherever the tasks allow, and many organisations have found additional value from them.

In addition, the systems and services enabling remote co-operation and meetings have taken major leaps within months, instead of years. If remote work becomes a widely adopted practice and a form of employment for knowledge work, this may have significant effects on the mobility system and more. Even before the COVID-19 pandemic, remote work was a normal practice in many industries. While there are distributed organisations with no offices and digital nomads working remotely from anywhere, in many organisations remote work included visiting the office at least once or twice a week. Hence, people may live further from their place of employment, and commute when the work requires. In such an example, the traffic performance may actually increase compared to the situation in which people live nearer and commute every day. If, for example, a longer commute of 150 kilometres is travelled back and forth even once a week, the traffic performance is more than with a 20-kilometre daily commute. In contrast, the time spent in traffic may decrease, as potentially the slowest kilometres are travelled less.

The pandemic has introduced a new level of uncertainty. Nevertheless, a variety of the work practices are likely to stick for a long time to some extent, but the question is, how do they affect mobility? At least previously, according to an interviewee, the time people usually spent on daily trips was found to be relatively constant, and it was typical that missed trips were compensated by some other activity that requires travelling. In other words, if an hour is saved from commuting, something else, such as a hobby or social activity, requiring travelling may take its place. Therefore, even the reduced commute may not directly reduce the need for transport and the overall traffic performance. In addition, there are many professions for which remote work is not an option due to the nature of the work – although technological developments are likely to expand opportunities in the future.

### 2.7.2 NEW AFFAIRS WITH ALTERNATIVE POWERTRAINS

While a vehicle's fuel economy and driver's driving style impact the range of an internal combustion engine vehicle, the general notion of filling the tank is understood and service stations are available around the country. Natural gas vehicles are refuelled in a similar manner at a filling station, but there are approximately 60 stations and they are mainly near larger cities (Kaasuautoilijat ry). Hence, it is not uncommon to drive tens of kilometres to a filling station, when preferring gas. Depending on the active use of the vehicle, a potential buyer has the option for a gas-only operated vehicle or alternatively a bi-fuel or dual-fuel vehicle, in which the gas system is accompanied by a separate fuel system enabling it to use either petrol or diesel in addition to gas. Still, as noted by one interviewee, the actual filling station and operation are somewhat different than people are used to when dealing with petrol and diesel cars. It would be useful to have a refuelling nozzle at the sellers so that it is possible to demonstrate the refuelling operation. More importantly, it is valuable for sellers to be familiar with the differences and to help potential buyers assess whether a gas vehicle will fit their needs now and in the future.

Electric vehicles are unlike internal combustion and gas vehicles. Currently, as electric vehicles are new and increasingly in the spotlight, people need guidance while looking for a vehicle, assessing whether an electric vehicle is a suitable alternative, and on making the best of it after the decision has been made. Although typically early adopters of a technology are deeply interested and informed, the followers might not share the same connection and curiosity. There are many kinds of electric vehicles with different specifications, characteristics and features. In addition to the car itself, potential buyers need to assess their possibilities for recharging: is it possible and convenient to recharge at home, at work or at public recharging points? The users of electric vehicles adopt a new way of operating the vehicle. When the refuelling of a petrol vehicle might occur a couple of times a week or a month, or even less often, the recharging of electric vehicles might be a daily (or nightly) operation depending on the battery capacity and use. According to an interviewee, as there are many options regarding recharging depending on the vehicle and the charging station, people might have only a vague idea about how charging takes place, what kinds of cables are needed and how the payment policies work.

### 2.7.3 PURCHASING AND UNCERTAINTY

According to an interviewee, one of the main explanatory factors regarding the aged vehicle fleet is taxation, which keeps the purchase prices of new cars relatively higher and in turn affects how long a car is kept for purely financial reasons. When acquiring a new car in Finland, in addition to VAT, the consumer is charged a registration tax, the amount of which depends on the carbon dioxide emissions (g/km). In addition, there are taxes on ownership and motoring. First, on ownership, the yearly vehicle tax consists of a basic tax based on the vehicle's $CO_2$ emissions and a tax on driving power "imposed on vehicles that are powered by some other force or fuel than motor petrol" (Traficom, Structure and quantity of vehicle tax). Second, on motoring, based on the fuel used, the excise duties depend on the energy content and the $CO_2$ emissions of the fuel, and a strategic stockpile fee (Tax administration, Tax rates on electricity and certain fuels; Tax administration, Tax rates on liquid fuels).

Table 2 illustrates an example of the taxation on cars with a tax-free list price of 25 000€ and different emission levels. As shown, the price of a new car with low emissions benefits from lesser taxation, and the advantages continue during ownership. However, the value of a new car may include new uncertainty.

**Table 2** – Price formation of a new passenger car from 1.1.2019 (Finnish Information Centre of Automotive Sector, Registration tax of passenger cars new-registered in Finland)

| $CO_2$ emissions (g/km) | 0 | 50 | 100 | 120 | 145 | 160 | 200 |
|---|---|---|---|---|---|---|---|
| **Registration tax** | 2.70% | 3.90% | 6.80% | 9.50% | 15.30% | 20.00% | 30.60% |
| **Consumer price without car tax** | 25 000 | 25 000 | 25 000 | 25 000 | 25 000 | 25 000 | 25 000 |
| **VAT** | 4 839 | 4 839 | 4 839 | 4 839 | 4 839 | 4 839 | 4 839 |
| **Registration tax** | 649 | 949 | 1 705 | 2 454 | 4 222 | 5 844 | 9 875 |
| **Price with taxes** | 25 649 | 25 949 | 26 705 | 27 454 | 29 222 | 30 844 | 34 875 |
| **Share of taxes** | 21.40% | 22.30% | 24.50% | 26.60% | 31.00% | 34.60% | 42.20% |
| **Taxation value** | 24 024 | 24 324 | 25 080 | 25 829 | 27 597 | 29 219 | 33 250 |

The development of a car's value has been almost linear until recently, according to an interviewee. For the past decades, it has been relatively easy to estimate that the value of a newly registered car will halve in three years, and during the next three years, it will halve again. However, now the development of technology and the introduction of new car models affects these assessments, because already after three years there are more advanced cars with batteries of higher capacity and broader range available at a lower purchase price. For example, if one purchased an electric vehicle for 50 000 euros in 2017, the estimated value would be 25 000 euros in 2020, but there may already be new models with better specifications available for the same or a slightly higher price.

In addition, the purchase incentives provided by governments make estimation even harder, although in the longer term, the incentives may also benefit buyers of used cars if they increase the supply of electric cars to the market. As noted by an interviewee, the incentives, especially in car-producing countries, fuel the local economy and employment. The income from sold cars remains in the country of origin and maintains or even creates new jobs. For this reason, countries may grow interest in introducing limitations regarding the export of used vehicles purchased originally with incentives, and hence possibly focus exports on older models, although the treaties of the European Union must be taken into account.

As evaluated by the interviewees, this uncertainty may reduce the willingness to purchase new cars until the technology has matured. In addition, this slows the renewal of the vehicle fleet without company cars and alternatives to purchasing. Different types of leasing and long-term rental options provide an alternative if the risk regarding the residual value is balanced properly. According to an example provided by an interviewee, when electric cars were not as common as nowadays, the residual value of a vehicle could be priced at almost zero after the leasing period, which pushes all of the risk to the customer and is essentially a very expensive agreement. Now, the aftermarket values are finding a balance and more affordably priced alternatives are not hard to find. A fixed-time agreement enables the customer to know the costs in advance, pay a monthly fee, and not worry about the resale price, making it an interesting option especially in periods of transition.

In order to make informed decisions, potential car buyers have to know or get to know the different alternatives in the market and how these options fit their needs. Alternatively, informed and educated car sellers are able to help customers amidst all of the options and uncertainty in finding the right options for their needs. By understanding and providing fitting solutions for changing customer needs, they not only reduce the risk of annulments, but more importantly create more satisfied customers and a good reputation.

### 2.7.4 TOWARDS SHARED CARS

As an alternative to purchasing a vehicle for one's mobility needs, there is also the option to use different services providing cars for shorter periods. For example, the interviewees see that car-sharing services may provide an alternative to a family's second car or for a specific transport need, when the need is not constant, or a car owner may place a vacant vehicle available for rental on a digital platform. In addition, Mobility as a Service (MaaS) – a combination of different types of transport options available through a single service for a subscription or with a pay-as-you-go model – is a promising concept. However, they see that for a car-sharing service to work, both the price point for the customer and the cost for the operator must be low.

After all, such a service can be affordable only if it has large customer potential and number of customers. However, car-sharing services have not been turned into profitable services, even in the capital region in Finland. According to an interviewee, it may even take 5 to 10 years before car-sharing services are available in Finland on market terms. In addition, a major issue with a shared car is that typically people need to use the car at similar times. Furthermore, doubts are expressed regarding the condition and cleanliness of shared vehicles in general, and in particular during a pandemic. Therefore, the interviewees mentioned that shared cars may be well-suited for groups of people who know each other before commercial car-sharing services become largely available. For example, in the shorter term, there are possibilities for shared cars amongst housing companies or even residential areas, where car-sharing also reduces parking space requirements and costs. In the case of housing companies, the vehicles may be seen as an extension of the common areas and are typically kept in good condition.

As stated by an interviewee, owning a car is not likely to disappear, but especially in cities, there will be an increasing move towards shared vehicles in the longer term. Furthermore, while in the shorter term, electric cars are expected to reach the same price level as internal combustion engine vehicles, in the long term, the prices of passenger cars are expected to increase. The most important reason is financial. Research and development, for example of new powertrains and driving automation, include substantial investments by manufacturers and require more expensive parts – both hardware and software – to be installed in the vehicles. Another perspective is the change in vehicle utilisation, possibly due to driving automation. Currently, passenger cars are mostly stationary, even 95% of the time, as mentioned by an interviewee. If or when the higher levels of automation are achieved, it is expected that a car will be utilised more, by more people, and throughout the day. For example, additional people without driving permits or with restricted mobility may use fully autonomous cars. This in turn may lead to fewer cars being sold, and companies instead of individual consumers may own the cars. If this is the case, the change will affect the automotive industry at scale, as it will need to adapt production and supply chains. An interviewee mentioned that manufacturers are expected to make do with fewer production plants as result.

## 2.8 NEW AVENUES WITH TECHNOLOGICAL DEVELOPMENT

Technological development is commonly seen as a key source for innovation. Next, we will discuss the potential of cars as developing platforms for innovations and for entirely new possibilities.

### 2.8.1 THE CAR AS A DEVELOPING PLATFORM

The longevity of passenger cars may be examined analogously to the development of mobile phones. While especially electric cars have the potential for an even longer lifecycle, now, at a turning point as technology is rapidly taking leaps and bounds, this is yet to be realised, only when the technology is at the same level as, for example, on an iPhone, whose users do not see the need to purchase a new one as the current model is technologically sufficient to receive software updates and thus improvements and new features after purchase.

While previously a car was considered as a finished product when it left the factory, it is becoming more of a platform developing over time. In addition, while previously the software used in a vehicle was updated through physical cables or USB drives during maintenance, currently remote and wireless Over-The-Air updates directly from the manufacturer are becoming more common. However, as pointed out by an interviewee, there is debate regarding the regulatory aspects of Over-The-Air updates as according to legislation in certain countries, the vehicle must always behave in the same way as it has been accepted in the type approval and the functionalities cannot be changed afterwards. This is certainly an issue that needs to be resolved, as in addition to e remote software updates, vehicles are expected to utilise more data and machine learning to improve and adapt to changing and new conditions every day. Thus, servicing a vehicle will require a proficient level of information technology and software skills, and this may become an expertise of its own.

While currently it may seem unlikely, if in the future there are standardised vehicle batteries and battery replacement systems, the lifecycle of electric vehicles may be extended. Then again, with new battery technologies, a car battery may last two million kilometres and 16 years (Bloomberg). However, as vehicle technology develops over time, it is clear that in the future a 16-year-old electric car will be old technology. Especially when the development of electric cars is expected to take important leaps within the next decade, the lifecycle of the first generations of electric cars may be shorter than that of future generations. Now, according to an interviewee, this can be seen in the used car market in Norway, where first-generation battery electric vehicles or plug-in hybrids are not the most sought-after models; instead, larger battery capacity and technologically more advanced models gain interest. Furthermore, in the future, the batteries may even outlast the car, and thus may be reused in a second vehicle or repurposed for storing energy from, for example, solar panels.

### 2.8.2 THE CAR AS PLATFORM FOR NEW INNOVATION

Similarly to mobile phones, cars may become something completely different to what they were initially used for: the transportation of people and goods from one place to another is but one feature that they have in addition to all the other features that come with them. That is, just as with phones, the basic feature remains just one of the wide range of potential use cases. With time, the possibilities of cars have the potential to grow significantly from what they are now. As an example provided by an interviewee, if someone thinks that they cannot go to their summer cottage in an electric car, because they cannot charge it there, in the future the situation may be the opposite: the electric car is used for that exact purpose because it is possible to bring both the electricity and communications networks with it.

In addition, a vehicle with sensors and communication capabilities may gather data on its surroundings which in turn can be harnessed for various purposes, for example, creating a real-time data-gathering network for weather, driving and road conditions, and a parked vehicle may act as a house and garden monitoring system. Furthermore, the potential with full driving automation to extend the use cases for vehicles is immense. This potential has raised many questions. For example, since the value of data is immense and increasing day by day because of constant development of data analysis and utilisation, questions regarding data ownership and distribution of benefits must be resolved. For what purposes and how can data be collected and used? Who owns the data? Who benefits from it?

As the spectrum of infrastructure and uses for cars grows, users are likely to become customers of a specific ecosystem rather than the car itself – similarly to mobile phones. Looking to the future, cars are becoming more and more software-based all the time, thus in the future one could assume that car brands will even start to fade a little. The most important factor may be what kind of ecosystem they have. What if people cannot recall the brand of their car, as not all even remember what brand of phone they have, but they are guaranteed to remember whether it is an Android or an iOS device?

As an interviewee described, in the future, the greatest value added will probably be in the software and data, and new business and work opportunities are likely to surface. Hence, there will be significant and growing opportunities on the software side of the previously hardware-oriented passenger car.

### 2.8.3 ENTIRELY NEW POSSIBILITIES

Although many of the electric vehicles today are not remarkably distinct from their sibling models with different powertrains, battery electric vehicles have the potential to change car design. For example, the bonnet of the car may be significantly shorter as without an engine in front of the vehicle, less space is needed to increase crash safety and meet the safety standards. The design could also change how cars are viewed. As one study commented on the design of a previous Waymo Firefly: “The cars evoked a friendlier world, where cars were not things to be feared, nor the harbingers of thousands of deaths across the world” (Murphy 2017). New car manufacturers in particular may unlock the full potential, as the electric powertrain is their only powertrain and the design of a new model may start from the ground up.

Established manufacturers have invested in their current models and their designs adhere to the specifics of internal combustion engine vehicles. However, when established manufacturers design electric cars as completely new models, they have the advantage of additional experience from everything beside the electric powertrain. Currently, the range of passenger car designs is vast, from small ‘pods’ to traditional sedans, sporty family saloons and large SUVs. The potential for the automotive ecosystem in Finland is enormous, as an interviewee explained, but the future as subcontractors within the automotive industry may not be the best possible for the next 10 years. However, with expertise from all areas required in the processes of making cars and around them and access to raw materials, the renewal of the vehicle fleet could be sped up and the economy stimulated by developing and producing affordable electric cars designed for the Nordic conditions in Finland.

When technology becomes cheaper, as an interviewee described, possibilities for something entirely different may present themselves. Already different types of last-mile services and solutions, such as small self-driving buses, are being piloted in order to increase efficiencies in public transport. How about when batteries become more efficient, smaller and cheaper? For example, could there be electric one-person mini-cars, which could function similarly to the commercial electric scooters that have become widely available in a relatively short time? Available through an app for a small fee, the mini-cars could be safely driven within a specified region with low speed limits. While self-driving capabilities are not mandatory, through the development of advanced driving automation, the mini-car could operate as a robotaxi, transporting the passenger to their destination, thus being able to cater to the needs of larger customer groups. How would mobility, street views and car ownership change if someone could provide such a service as widely and affordably as the electric scooters?

## 2.9 WORKING WITH THE OLD, THE CURRENT AND THE NEW

During its lifecycle, the vehicle must be maintained and when needed repaired in order to ensure safety both inside and outside the car and the general operational efficiency and reliability of the vehicle. Technological development, for example, in regards to alternative powertrains, active safety features and the overall digitalisation of passenger cars brings many considerations both as new technologies enter the market and as at the same time the existing vehicle fleet remains to be serviced. There is a vast number of both independent and brand maintenance and repair shops providing services – even more than fast food restaurants, as one interviewee described it – while at the same time the competence requirements widen and deepen. Still, the level of expertise in the field should be as good as possible across the board. This works as a driver from general car mechanics towards more specialised skills, such as car electricians, and places new requirements on both educational institutions and companies and continuous learning. In addition to the previously mentioned competence development directions, such as information technology and software skills in regards to cars themselves, next we will discuss service development, electrical safety, business skills and recycling.

### 2.9.1 RE-EVALUATING SERVICES AND COMPETENCES

Since the internal combustion engine has been the dominant solution for powertrains, both consumers and people working in the automotive domain are most accustomed to it. However, in the current situation where vehicles with alternative powertrains are growing in numbers, there is an urgent need for service and competence development, since the maintenance requirements are considerably different between different powertrains, especially between internal combustion engines and battery electric vehicles, and this will be reflected in the entire aftermarket. For example, the powertrain of battery electric vehicles consists of fewer mechanical parts, the maintenance processes are simpler, there is no need for oil changes and the maintenance interval could be longer.

The maintenance, inspection and repair needs are more related to the battery, i.e., battery operation and capacity. For example, damaged battery cells are replaced during maintenance, which can then maintain the battery capacity close to the original level. Since batteries are valuable, both in price and raw materials, identifying and replacing faulty battery cells is becoming a valued new skill. According to an interviewee, the process is not complicated, but requires following the manufacturer's instructions and documenting what specifically was done. If a battery needs to be replaced, heavy tools are needed to handle the 300 to 500 kilograms which a battery in an electric passenger car may easily weigh.

Still, many factors are expected to remain more or less the same, since passenger cars include similar mechanical and other wearing-out parts. Common faults relate to the axles, suspension and braking systems. In addition, for example, tyres need to be changed based on deterioration and driving conditions, and windscreens need to be replaced when damaged. Electric vehicles may even bring forth new kinds of wear. Since the car is heavier due to the batteries, there is more load on the chassis. Moreover, when vehicles use regenerative braking systems instead of brake pads, the brakes experience less wear and may lock up, requiring maintenance. Therefore, cars will require maintenance in the future, too, but the maintenance programmes and processes must purposefully consider the new characteristics of the vehicles. For example, with electric cars, it is important to ensure the faultless condition and safety of the electrical system, thus regular inspections are warranted.

In addition, the development of vehicle self-diagnostic and reporting capabilities, i.e. on-board diagnostic systems, have already reduced and continue to reduce unnecessary maintenance visits and extend service intervals because of the ability to indicate actual maintenance needs. Furthermore, remote maintenance, i.e. inspecting vehicle information from a distance, is expected to become common in all cars, including lower price range models, since it enables manufacturers, repair shops and insurance companies to improve efficiencies and reduce costs. For example, if a limited fault is identified before an incident or a maintenance visit occurs, the required parts can be ordered just in time for the specific need, the work can be planned and prepared for in advance, and a potentially safety-threatening accident may be avoided.

When the cars are physically serviced, considerations regarding electrical safety are increasingly topical. As estimated by an interviewee, repair shops may currently work on one electric car per week, but within five years, there will be enough electric cars to be serviced every day. When high-voltage vehicles are on the service floor, there is a risk of electrical accidents. Thus, general understanding of electrical systems and safety is expected to become a basic requirement for car mechanics: everyone needs to know, for example, how to work safely when there are high voltages present. There is also a need to understand how the current may lead to the chassis and what kind of errors this may cause. In addition, the skills of vehicle electricians are expected to increase in demand. Moreover, working with electric cars requires safety measures and preparations in the repair shops. Currently, both brand-specific and general training, for example SFS 6002 safety at electrical work courses, is organised regularly.

### 2.9.2 DIGITAL AND BUSINESS SKILLS ON THE RISE

The expectations of consumers are increasing and digitalisation is changing the sales and marketing processes. Digital presence is mandatory and digital commerce is developing fast. More and more cars are purchased without seeing, which requires more advanced digital services. In some cases, for example with Tesla, digitalisation has provided the means to sell online directly to consumers. For car-sharing services digital platforms and accessibility are crucial. Thus, information technology competencies are a requisite for all businesses.

If vehicles are more and more owned by companies, aftermarket actors should start to focus on business-to-business business models and services and competence development, since a potential customer may control a fleet of hundreds or thousands of cars and decide centrally where the fleet is serviced. This may be a driver towards market consolidation, centralisation or chaining, or stronger business networks, as both the technical expertise required to service the extensive range of vehicles in the current vehicle fleet and the new cars with the latest technology, and the business know-how required to succeed in the changing operational environment is getting wider and deeper. As one interviewee described, it feels utopian that a two- to five-person repair shop could say with a clear conscience that they can service any make and model. Alternatively, for example, repair shops may increasingly focus on specific makes and models, a specific vehicle technology, e.g., diesel powertrains, car electronics or software, or a specific age range, such as 20- to 40-year-old models, as some have already done. However, due to the market size in Finland, options may be limited compared to larger markets such as Germany. In any case, business networks are and will become of greater value.

### 2.9.3 RENEWING AND RECYCLING

The most prominent approach of renewing the vehicle fleet is through scrapping and recycling. Currently, according to the interviewees, the average scrapping age of passenger cars in Finland is too high, even troubling, and recently it has been getting even higher. This is important to consider since the yearly kilometres driven with 15-year-old cars are easily 14 000, and only with cars more than 20 years old do the kilometres decline considerably. More cars, effectively from the oldest end, need to be removed from the cycle altogether, i.e. taken into the official recycling system and not for example be exported. For that, there are different means for expediting the renewal. For example, providing a scrapping premium was seen as a useful measure in a previous experiment, and it has been continued since. Another more high-flying idea would be to include a recycling pledge in the price of a new car. When the last owner of the vehicle returned it to an official take-back point, they would receive the pledge, similarly to refundable bottles and cans in Finland.

The good news is that according to the interviewees, once a vehicle is destined to be scrapped, the recycling systems is well thought-out and functioning. For example, there are almost 300 hundred take-back points in Finland, recycling a car is free, and a significant amount of reusable and other materials are collected in the process. Through the development of driving automation, cars entail much more electronics, and thus the recycling of electronic components is becoming increasingly important. However, recycling electronics may come as a by-product, a secondary effect, from the recycling of electric cars, which include batteries with valuable precious metals and other reusable materials. As described by an interviewee, particularly regarding the recycling of batteries, the situation is approaching a turning point. The mining of lithium and other minerals has been cheaper and more effective than recycling, but due to the development of technology and increased volumes, recycling is starting to become an economically feasible option, too. This is important, since many of the issues regarding electric vehicles aside from the technical capabilities revolve around the batteries, from the excavation or procurement of the raw materials to the energy-intensive production and related environmental, ethical and health considerations, especially when there are strong incentives for manufacturers to produce and consumers to select electric cars.

In addition, if the emission measurements change from inspecting the exhaust emissions to measuring lifecycle energy use and emissions, recycling becomes even more important. Thus, the expectations regarding the recycling of batteries are vast and so is the potential for Finland. According to the interviewees, this potential has been noticed and acted upon already. In Finland, the recycling of electric car traction batteries began in 2019. Finnish Car Recycling Ltd is responsible for organising recycling operations, and current operators include, for example, Fortum Waste Management, uRecycle and Stena Recycling. Furthermore, as the European Commission prepared a Strategic Action Plan on Batteries and requested, "Finland has assumed responsibility for the development of battery recycling in Europe" (Business Finland). In addition, the Ministry of Economic Affairs and Employment has commenced the formation of a national battery strategy "to enable Finland to strengthen its role as a pioneer in sustainable battery manufacturing and recycling" (Ministry of Economic Affairs and Employment). As an interviewee explained, this opens up many new avenues for business and in terms of national competences.

## 2.10 CONCLUSION

Ten years, from 2020 to 2030, is a relatively short time for change in the vast landscape that, for example, the vehicle fleet, value chains, infrastructure and people form around passenger cars in Finland. However, a time of transition is significant from the perspective of future directions. The conditions, decisions and actions of today affect the development of tomorrow. Furthermore, it is necessary to understand and consider the effects of past decisions and actions as they have formed the current conditions. In many cases, the effects will be present for years and decades. For example, the current vehicle fleet will not suddenly renew itself, but renewal takes time. Based on the current statistics, passenger cars registered between 2000 and 2010 will still be in use in between 2020 and 2030.

Similarly, based on current trends, a vehicle registered in 2025 will still be in use in 2045, although close to its recycling age. Certainly, changes will occur, but during times of transition, a high level of uncertainty is present. The lifespan of a technology may end up being short or the adoption scale small for one reason or another. A solution may be rejected or start a new niche with a small but invested community. On the other hand, the adoption scale may expand rapidly, or the lifespan of a previous technology may prolong even beyond expectations and projections. In any case, the world of tomorrow needs to be anticipated today.

As passenger cars change from what they used to be, how do consumers know what the best solutions for them are? Technological development brings possibilities and uncertainty, but service design may assist in tackling uncertainty and knowledge gaps. Understanding both the new technology and possibilities and the consumer's situation and needs is crucial for providing fitting solutions and services in the changing situation. In addition, attitudes regarding ownership are changing. The shift from product sales to services has been happening for a long time. Rather than asking whether the servitisation and business models of the sharing economy will become profitable in a sparsely populated country such as Finland, better questions might be how, where, when and what kind of services create new opportunities? Some business models are especially useful for the transition period, for example if they remove uncertainty, while other models may be needed when the transition is well underway.

While internal combustion engine vehicles are expected to reduce in sales numbers, they will remain dominant for a long time. In order to reduce emissions, electric cars are the centre of attention and there is a clear push towards them. Currently, plug-in hybrid vehicles are becoming increasingly popular, but some see them as a temporary solution until the prices, availability and ranges of battery electric vehicles develop in their favour. If so, is the transition from internal combustion engine vehicles towards battery electric vehicles a move from one-solution state to another one-solution state? Furthermore, are battery electric vehicles a solution for the transition towards fuel cell electric vehicles? What does the future hold for other alternative powertrains? What kinds of decisions and actions pave the road towards carbon-neutrality in Finland by 2035 and what will be the responses of consumers?

In addition, the typical image of greasy garages could use an update. It is clear that the knowledge and skills needed in the automotive industry require both width and depth, and need to consider the old, current and new technologies. Since the average passenger car in use on the Finnish roads is more than 12 years old and the average scrapping age is around 21 years, there are plenty of cars with present-day or yesterday's technology to be serviced. However, new models arrive with new technologies and features. Modern passenger cars are sophisticated products integrating hardware and software. How does education and on-the-job training need to evolve and the industry develop to function proficiently amidst the change and in the future, too? What are the possibilities for education and training regarding alternative powertrains, digital competences and skills, and safety and driving automation systems? What are the possibilities in Finland for smart specialisation? What kinds of jobs and skills may surface and flourish in the transition towards carbon-neutrality and beyond? One thing is certain: learning should be continuous and life-long.

The transportation of people and goods from one place to another describes only a single use for passenger cars: mobility. In the same way as mobile phones, cars are developing into platforms for novel innovations and new possibilities. Whether it acts as a communications hub, an energy storage and delivery system, an individual cell of a larger real-time data-gathering network or a self-driving service provider, the potential for the car to enable something completely new are growing with technological development and software. In addition, as passenger cars are a central part of the mobility system in Finland now and expectedly in the future, manufacturers are producing lower-emissions vehicles, and the government guides the national development of, for example, vehicle use and infrastructure development to advance carbon-neutrality, the image of passenger cars need to develop, too. Furthermore, since there is expertise in Finland for the whole vehicle lifecycle and around cars, how can that potential be recognised, experimented and harnessed to provide new energy for the economy and to give rise to solutions fit for the Nordics and the environment at large? What types of business models and networks enable a future fit for the automotive ecosystem in Finland? Furthermore, as a domain of constant development and a confluence of shifts and disruptions, it could be of great value to explore how the automotive ecosystem and its actors are anticipating the future, and especially how the capabilities for using the future in the present could be developed further.

In regard to many of the discussed themes, the report only scratches the surface. While the scope of the research is relatively specific, it is considerably wide. All of the presented themes could warrant research of their own. As observed, many questions remain and many new ones have emerged. The regulatory requirements continue to guide the design of cars and reduce emissions; vehicles will be equipped with more advanced hardware and software for safety, comfort, productivity and environmental reasons; the expectations and behaviour of consumers are changing; the market needs to develop new services and find new business models for the digital world; and both new and old skills – wide and deep – are required in the automotive industry.

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# 3 MOTORSPORT INDUSTRY: INTERESTING AND CHALLENGING CAREER OPPORTUNITIES

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## 3.1 INTRODUCTION: OVERVIEW OF THE MOTORSPORT INDUSTRY

Motorsport and motor racing is a global term used to cover the group of competitive sporting events which mainly involve the use of motorised vehicles, whether for competition or non-competition. Motorsport competitive events take place worldwide and use highly optimised and customised motor vehicles for racing competitions. Competitions are arranged on race tracks, temporary circuits, on streets and off-road. Different types of motor vehicles are used in the competitions, such as cars, bikes, go-karts, boats, trucks, snowmobiles, etc. The most popular form of motorsport is car racing. Motor racing is currently promoted through series such as WRC (World Rally Cars), MotoGP and Formula Racing such as Formula One, Formula V6 Asia, Formula Nippon, GP2, Formula Three, Formula Palmer Audi, F2, Formula Atlantic. (Market Data Forecast.)

The Fédération Internationale de l'Automobile, FIA, is the governing body for world motorsport and the federation of the world's leading motoring organisations. Founded in 1904, with headquarters in Paris, the FIA is a non-profit-making association. It brings together 243 international motoring and sporting organisations from 146 countries on five continents. Its member clubs represent millions of motorists and their families. (FIA Activity Report 2019.) The governing body of motorsport in Finland is the AKK-Motorsport registered association. It is the rights holder of FIA in Finland. The aim of AKK-Motorsport is to promote responsible motorsport and its acceptability and appreciation in Finnish society and to participate in the development of road safety and road safety education through motorsport. The association consists of 320 motorsport clubs and 29 000 members. The member associations of AKK-Motorsport arrange approximately 350 national motorsport competitions in various disciplines. (AKK Motorsport.)

In Finland there are a several different motorsport disciplines, such as car slalom, car navigation, cross-karting, drag racing, drifting, ecorun, e-motorsport, endurance, historic, folkrace, ice track racing, karting, off-road, rally, rally cross, rally sprint, course race and regularity rally, also called time-speed-distance or TSD rally. In addition to competitions, the main branches of activity of AKK-Motorsport are sports club activities, education and training as well as lobbying. (AKK-Motorsport.) In addition to AKK-Motorsport, one of the key actors in the Finnish motorsport is the Association for Hobby motorsport, Hamu (Harrastemoottoriurheilun Keskusjärjestö Ry). Hamu is targeted at amateur drivers and the rules of the competitions are more flexible, except for the safety rules. The classes of Hamu are Classic cars, HR 2 wd based on cubic capacity, Proto, V1600, H20504 WD and LiteR, Beginners, Underage < 1650cc and < 2050cc, Women and Seniors. According to Kahelin (2020), both Finnish umbrella organisations, AKK-Motorsport and Hamu, co-operate closely to facilitate and support Finnish motorsport.

According to Market Data Forecast, the global motorsport market is set to cross USD 8.55bn by 2025, expanding at a compound annual growth rate (CAGR) of about 10% during the forecast period of 2020 to 2025. The growth in the motorsport market can be attributed to the increase in advertising deals and motorsport sponsorships. Social media platforms such as Facebook and Twitter have become popular platforms for promoting motorsport racing and attracting more viewers and increasing the market. The global motorsport market is mainly categorised by channel and race series. By channel, the global market is divided into broadcasting, ticketing, advertiser/sponsorship, race host fees, merchandising, etc. Of these, the broadcasting channels account for a substantial portion of world business and this trend is likely to continue in the coming years. By race series, the worldwide motorsport market is divided into Formula Racing, MotoGP, Rally Racing, Off-Road Racing, Motorcycle Racing, etc. Among these, Formula Racing is the most popular and accounts for a leading proportion of the overall revenue share. MotoGP bike racing and others are also expanding at a notable growth rate in the global business. (Market Data Forecast.)

According to IndustryArc, motorsport has reached more than 194 countries and this is set to increase as the connectivity of technology continues to grow in the modern world. One of the most important factors impacting the motorsport market is the revenue generated from the participation fees which are paid by the participating motorsport teams. For instance, for Formula 1 (F1) racing series, participants such as Mercedes, Ferrari, Red Bull Racing, McLaren, Renault and others pay a huge amount to test their vehicles and participate in the racing series. (IndustryArc.)

The European motorsport market has the largest share in the global business in terms of revenue because of the presence of Formula Racing in the area. European nations were the first to host such events. These events received significant support from the high-end car manufacturers, most of which originate from European countries. Europe occupied a 46% share in the review period of the global motorsport market. The Asia Pacific motorsport market is following Europe in the global business and contributed about a 23% share, facilitated by the large fan base in its countries, particularly in China, Japan, South Korea and Australia. (Market Data Forecast.)

## 3.2 RESEARCH AIM AND OBJECTIVES, AND RESEARCH METHODS OF DATA COLLECTION AND ANALYSIS

The research aim is to describe the current situation and potential future developments of the motorsport industry. Because the motorsport industry is very comprehensive, the research mainly focuses on the fields of formula and rally in the Finnish and European context.

The objective of the research is to focus on the motorsport industry as a potential career, excluding professional formula and rally drivers as well as the personnel in marketing, sales, accounting and administration. The research is part of the Race4Scale project and therefore the aim is to form an informational foundation for further actions, such as the recognition of skills needed in the motorsport industry as well as the development of teachers' professional and pedagogical skills.

The current research is based on the qualitative approach (Creswell 2013).

### Acquisition of secondary data

To form an overall picture of the research subject, the researcher collected and analysed data from reports, research articles and other relevant documents related to the motorsport industry (Yin 2014). The foundation of the research was constructed based on content analysis and the objectives defined in the Race4Scale project plan.

### Semi-structured interviews

The interviews were based on a set of semi-structured questions related to the motorsport industry and its future development. Semi-structured interviews were chosen because having key questions make it possible to define the explored area, but also allow the interviewer or informants to elaborate an idea or response in more detail (May 2002). The questions were designed based on the content analysis and conclusions made during the first phase of the research process.

The five informants are all experienced specialists in the field of motorsport and represent both educational institutions and the motorsport industry. Four of the oral interviews were conducted face to face and one on the telephone. The interviewer took notes during the interviews. Each interview was analysed individually and then jointly to form an overall picture of the motorsport industry as well as the career opportunities and skills requirements in the industry.

The interview results were considered according to thematic and content analysis (Braun & Clarke 2006). The subsequent sections include the researcher's professional reflections as well as analysed themes derived from the semi-structured interviews. The interviewees' considerations are presented in the subsequent sections of the current study. As a result of the research process, a synopsis of the necessary soft and hard skills of a motorsport mechanic was created. The current state and future development paths of the motorsport industry were also identified and described in the survey. Descriptions of the informants can be found in Appendix 2.

## 3.3 HOW MOTORSPORT TECHNOLOGY HAS CHANGED ROAD CARS

Competitive motor racing provides an ideal environment and race teams ideal capabilities for the automotive industry to rapidly develop and test technological innovations in the harshest environments. For automotive manufacturers, motorsport can be seen as a platform to demonstrate the capability of their products on the global stage. New innovations can then be directly applied to the vehicles sold to everyday consumers. (Powis 2016, 4.) The 'trickle-down effect' means that technology developed by experts in, for example, Formula1 eventually finds its way into road cars.

Formula 1 in particular has throughout its history been the forerunner of technological innovation with advancements that have directly benefitted the wider automotive industry. Aerodynamic innovations, safety developments, energy recovery systems, navigation tools and composite materials from F1 have been adopted by road cars and other industries. F1 has been one of the key actors in developing aerodynamic improvements. Rear wings, spoilers and other additional car body parts play an important role in generating large amounts of downforce in high-performance cars at high speeds. Spoilers were invented by Lotus and were originally used only in F1 cars. (Teknosuomi 2018.)

Motorsport has also been a forerunner in developing sensor and information technology in cars. A F1 car has 150–300 sensors which collect an immense amount of information during the race. The computers collect and analyse information to enable the technicians and designers to improve the cars. Formula 1 engineers have also developed a number of thermal sensors that are now used in road cars. Pirelli took this technology even further; by using the thermal sensors that define in which temperature the tyres have optimal adhesion, they were able to develop better and safer tyre compounds. In addition, anti-lock brakes and traction control are examples of improvements that were originally developed for race cars but are now common road car accessories. Bugatti, Ferguson, McLaren, Williams and Lotus have played a significant role in the development work of these innovations. The combination of anti-lock brakes, traction control and four-wheel drive was used in one of the McLaren F1 cars in 1993, and as a result the car was banned because it was regarded as too overpowering. (Teknosuomi 2018.)

Lawrence (2018b) lists seven innovations that are widely used in road cars due to the trickle-down effect:

**Table 1.** Seven innovations used in road cars (Lawrence 2018b)

| | |
|---|---|
| **Semi-automatic gears** | The direct shift gearbox was developed for the Porsche 962 in 1984. Enabling clutchless shifting, it was the progenitor of the paddle gears that are now used in F1. Combining the performance of manual transmission with the simplicity and mono-tasking of an automatic, the direct shift gearbox and its various un-gated semi-automatic offspring found their way into road cars. Today flappy paddles are a popular optional extra in many road car brands. |
| **Disc brakes** | Originally premiered by Porsche for the 24 Hours of Le Mans, disc brakes began infiltrating road cars in the 1980s. Enabling fast braking without locking the steering, disc brakes were a clear performance-enhancing technology and were marketed as a breakthrough in road safety. The technology continues to develop: road cars are now making an F1-inspired switch from steel disc rotors to lighter, more heat-resistant ceramic versions. F1 cars remain a lap ahead in terms of technology and have mostly already moved on to using carbon fibre. |
| **Carbon fibre chassis** | Super light, flexible and 10 times stronger than steel by weight, carbon fibre is the go-to construction material for high-speed vehicles from F1 cars to hypersonic planes. The high costs of manufacturing and moulding carbon fibre means that we are a long way from seeing fully carbonised mainstream road cars. However, many manufacturers are incorporating it into carbon fibre reinforced plastic (CFRP) bodies and carbon fibre is also used in the chassis and car body. It is especially popular in electric vehicles, where weight management is important to offset the bulk of the battery. |
| **Rear-view mirror** | Perhaps not the most thrilling development but definitely the most ubiquitous. Motorsport engineers realised that a handily placed mirror would allow drivers to see when rivals were approaching from behind, enabling easier blocking and brake checking on corners. This little accessory then went on to be one of most significant safety features in road cars. |
| **AWD (All-wheel drive)** | Originally introduced by the Audi rally team, and rapidly diffused into their Quattro road car in 1980, AWD aids smooth handling on both flat and rough ground. Refining the simplicity of 4WD, it varies the power relayed to each wheel depending on its individual needs, making rally cars as small as a Mini, but still as powerful as 300 hp. AWD is now conventional in road cars such as Suzuki SX4, Subaru Impreza and Nissan demonstrate. |
| **Joypad steering wheels** | The average F1 steering wheel has more buttons than a laptop keyboard. Each of these has a function essential to maximising performance. The various buttons on the steering wheel of a road car fulfil somewhat more pedestrian functions, mostly focused on controlling the media player and enabling hands-free phone calls. But by centring these functions in the driver's eye-line, button steering wheels aid safety alongside convenience. |
| **Active suspension** | Regular suspension is passive, which means it just does what the road tells it. Active suspension, on the other hand, actively raises and lowers the chassis at each wheel to ensure better handling, improved traction and a smooth ride. Early active suspension simply adjusted the stiffness of the shocks, but F1 took this to extremes, embedding sensors throughout the car to feed data into an on-board computer. Toyota was the first brand to take the technology to the road, with the 1983 Soarer, and such road cars as the Citroën Xantia, and Volvo S60R have ensured its continued rise. |

In addition to technical innovations, motorsport has also significantly contributed to the testing and development methods used by the automotive industry. The wind tunnel was originally designed to study the aerodynamics of F1 cars. A wind tunnel is a structure used for studying the interaction between solid or gel bodies and airstreams. It simulates interaction by producing high-speed airstreams which flow past a model being tested. The model is fixed inside the testing area of the tunnel so that lift and drag forces on it can be measured by measuring the tensions on the fixing structure. Today all major road car manufacturers are using precisely the same wind-tunnel technology pioneered and perfected by Formula 1 ten years earlier. (Collins.)

## 3.4 THE LATEST INNOVATIONS AND REGULATORY DEVELOPMENTS

Innovations in motorsport are forcefully directed by the FIA technical, safety and sporting regulations for the various disciplines. For example, in Formula 1, the very detailed technical regulation document is 111 pages long and the sporting regulations 83 pages. Owing to the availability of significant amount of funds for research and development activities and a dedicated infrastructure for these operations, the major innovations are from the key players in the industry such as Ferrari, Mercedes, McLaren and Red Bull (Market Data Forecast). According to Kahelin (2020), the new innovations in each motorsport discipline are strongly defined by the FIA regulations but teams are also testing the 'grey area' boundaries of the regulations. Kahelin (2020) also points out that not all of the latest innovations are totally new; some of them were discovered even tens of years ago but at that time the materials and manufacturing techniques were not advanced enough to enable the innovation to be instituted. According to Kahelin (2020), the forthcoming major innovations in motorsport will be related to energy recovery, battery technology and high-speed recharge of batteries.

Koiranen (2020) says that eventually electric cars will take over and combustion engines will step aside in all the motorsport disciplines. Koiranen (2020) forecasts that during the coming years hybrid motors will also come to the smaller formula series. However, the main driver of the steps and speed of development is the financial capability of the teams in the smaller formula series. Koiranen (2020) also recognises the grey area of motorsport development and says that all teams try to get competitive advantage by testing the borders of the technical regulations.

Dual Axis Steering (DAS) is an innovation designed by Mercedes and introduced in 2020 during the first round of pre-season testing in Barcelona. Gray (2020) explains how DAS works: F1 cars are ordinarily set up with the front tyres pointing very slightly outwards, because under braking the tyres are pushed slightly inwards. With this set up, the tyres straighten up under braking. However, that means that aerodynamically the tyres have slightly more drag on the straights, which both loses the car speed and heats up the inside rim of the tyre, which affects the wear on the rubber. By using DAS on the straights, Mercedes appears to be able to straighten up the front wheels, removing that aerodynamically troublesome patch on the inside of each tyre, increasing speed and reducing tyre wear. (Gray 2020.)

Motorsport teams have also been active in developing top-speed data transfer between the car and the engineers. Over the course of a race weekend, a Formula 1 team will collect around 2 terabytes (TB) of data from each car. A whole web of sensors collect information on forces, temperatures, displacements and pressures, allowing the engineers and drivers to build a more complete picture of how the car is performing and helping them to cut elusive extra split seconds. In the all-electric Formula E series, 150 sensors monitor each car's vital statistics during testing, although only a fraction of them can be used during the race. This kind of technology relies on the transfer of data between the car and the server, which Formula 1 teams are also pioneering. The majority of what is collected can only be transferred when the car is in the pit, but, as with everything in motorsport, time is of the essence. Since 2017, teams have used two wireless standards to transmit the data. It starts as soon as the car enters the pit lane, but, when it is within four metres of the garage, it switches to a faster 1.9 gigabit-per-second upload, meaning that a gigabyte of data can be transferred in less than five seconds. As more and more road cars become connected, transferring large amounts of data in real time is going to be crucial, particularly if human drivers are removed from the equation. (Do, Thi Nguyen, Le & Lee 2020.)

The launch of 5G technology will be essential in facilitating this, with range, latency and speed all increased over what is possible with current 4G networks. V2X is the two-way communication between the vehicle and other devices around it that will really change how we drive. V2X means 'vehicle-to-everything' and is fundamental to the viability of self-driving cars, enabling each vehicle to navigate a network of streets full of traffic, pedestrians and other hazards through constant communication with almost everything it must share the road with. (Sherwood 2019.) V2X networks are expected to facilitate various applications of emerging and promising technologies in the Internet of Things (IoT). V2X communication will play a vital role in safety-critical and delay-sensitive services because it can provide low latency and high reliability. (Do et al. 2020.)

The World Rally Car (WRC) series has also significantly promoted the progression of rally cars. The WRC is a top-category vehicle designed for rally competitions. Although extensive modifications have been made to maximise rally performance, the body is based on that of a production vehicle. Essentially derived from a production vehicle, the car even has a number plate to allow driving on public roads. WRC regulations were introduced in 1997, and cars were initially fitted with 2.0-litre turbo engines. However, with technological advances resulting in engines that were able to produce the same performance with smaller displacements, from 2011 WRC cars have been limited to 1.6-litre direct-injection turbo engines. In 2017, the WRC regulations were significantly revised with the goal of further improving performance: air restrictors, which limit engine air-intake, increased in size from 33 mm to 36 mm, leading to a boost in maximum output from 320 hp plus to 380 hp plus. This massive amount of power is effectively transmitted to each of the car's four wheels through a full-time four-wheel drive system featuring active centre differential. In addition, the revised 2017 regulations permit aerodynamic parts to be fitted with greater freedom, and WRC cars have evolved to feature bold, aerodynamically efficient exterior designs. (Toyota Gazoo Racing 2019.)

According to the FIA World Rally Championship official website, the next generation of Rally1 Cars – formerly known as World Rally Cars, will have a strong focus on cost management and sustainability, while making the sport's pinnacle more accessible to incoming manufacturers. New for 2022 Rally1 Cars, the first to incorporate hybrid technology in the WRC, will continue to bear a close resemblance to the road cars from which they were born, while incorporating significant regulation changes. When the FIA ratified the latest rules, the first big changes since the current cars were introduced in 2017, a key message was that cars will continue to look and sound assertive. It confirmed that the cars will retain their aggressive and aerodynamic styling, albeit with no aero effect from hidden ducts and changes to the devices at the rear of the car. The cars will remain four-wheel drive, but with a more simplified transmission system running five gears and without an active-style centre differential. A maximum of six transmission units per car per year will be permitted. The suspension will also be less complex and feature shorter wheel travel and more straightforward dampers, hubs, hub carriers and anti-roll bars. Liquid cooling of brakes will no longer be allowed, and the car's fuel tank will be simplified in shape in a more economical solution. (WRC FIA Rally World Championships 2020a.)

"The accessible nature of the Rally1 regulations will quickly allow manufacturers to fight for victories, while the performance parity will help to deliver strong competition between the world's best drivers," says the FIA. "These (new regulations) are the result of months of rigorous analysis and investigation by the FIA's team of expert personnel in close collaboration with the WRC manufacturers, with every design cost required to demonstrate a real benefit, without losing the ethos of maintaining top-line performance." Further detail on engine regulations, hybrid technology specification and implementation following the current tender processes for the 2022-spec cars will be discussed at the WRC Commission meeting in 2020. (WRC FIA Rally World Championships 2020a.)

While developing the current WRC race cars, manufacturer teams are also developing their 2022 cars and the testing will start in 2021. The hybrid system, the E-motor, power electronics and the drive system will be provided by German company Compact Dynamics, that has a strong knowledge in supplying electrical solutions to motorsport at all levels, including Formula 1, endurance racing and the Formula E all-electric race series. The battery, which delivers around 100 kw (approximately 130 bhp) when fully charged will be supplied by the leading battery innovator Kreisel Electrics from Austria. At the first stage, battery power will be used in the transition of the race cars through built-up areas, but deployment in competition is something the FIA is investigating . (WRC FIA World Rally Championship 2020b.)

The automotive industry has received a significant amount of attention from researchers worldwide in improving the aerodynamic features of various types of vehicles, starting from high-speed race cars to heavy load carriers. Due to the advancement of information technology, it has become possible to simulate the proposed design changes and modifications before implementing into the final design. One of the major objectives of research has been in reducing drag and lift forces affecting the vehicles in motion. This has resulted in some exceptional aerodynamic designs that are nowadays utilized in the motorsport industry. The very high speed of race cars, cause a tremendous amount of lift forces and therefore the front and rear wings are fitted to generate downforce to maintain the overall stability at high speeds. The problem comes to prominence especially when the race cars have to negotiate turns and twisty sections on the racetrack. Centrifugal force affecting the car is directly proportional to the square of velocity during turn. Consequently, the driver is forced to slow down the car to maintain the stability. In this situation the driver must be able to rely on the downforce generated by front and rear wings and tire friction to successfully negotiate the turn. (Roy & Dasgupta, 2020.)

## 3.5 SUSTAINABILITY IN MOTORSPORT

In the public debate, motorsport has repeatedly been accused of being pollutant, uneco-logical and a waste of limited natural resources. The message and the public pressure have been taken seriously and the FIA environment and sustainability commission was created in 2017 in order to:

- Ensure that sustainability is integrated into all strategic elements of the FIA's work plans and agendas for the Sport and Mobility pillars.
- Support all relevant programmes, projects and initiatives of the Sport and Mobility divisions that promote sustainability and corporate social responsibility agendas.
- Define and elaborate strategies that will work towards strengthening the FIA's reputation as a leader of the global sustainability agenda. (FIA, 2020a.)

The FIA has introduced an Environmental Accreditation Programme (2019 b) that is aimed at helping motorsport and mobility stakeholders worldwide to measure and enhance their environmental performance. By introducing an environmental management system, the programme provides stakeholders with a three-level framework against which to accredit their activities. It is organised around three levels:

1. One-Star – Basic practice: Demonstrate basic environmental performance and a commitment to improve.
2. Two-Star – Good practice: Demonstrate good environmental performance and be close to follow internationally developed roadmaps toward environmental management.
3. Three-Star – Best practice: Demonstrate best practice and commitment to seek continual improvement through the implementation of an environmental management system. (FIA Environmental Accreditation Programme 2019 b.)

The most important Finnish rally event, Neste Rally Finland, achieved the highest 3-Star level in 2017. This level is based on several internationally recognised environmental standards and guidelines, including the standards of the International Olympic Committee (IOC) and the ISO 14001.

Also Formula 1 has recognized the need to pay attention to the environmental impacts of the sport. In year 2019 Formula 1 released an ambitious sustainability plan to reach a net-zero carbon footprint by 2030. The key actors of the initiative are FIA, sustainability experts, Formula 1 teams, promoters and partners. In addition to eliminating the carbon footprint of the F1 car and the on-track activities, the initiative includes actions to ensure the use of ultra-efficient logistics and travel and 100 % renewably powered offices, facilities and factories. According to the plan, the carbon reduction projects must begin immediately. Being at the forefront of technological innovations give the Formula 1 development teams a global platform to promote progress and to develop technologies that reduce and eliminate carbon emissions of the current internal combustion engine (ICE). The present F1 hybrid power unit, that delivers more power and uses less fuel than any other car, combined with new sustainable fuels and energy recovery systems presents an immense opportunity to provide a net-zero carbon hybrid power unit. (Formula 1 ® 2019.)

According to SportBusiness (2019) FIA wants to ensure that by 2025 all the motorsport events are sustainable. This means the use of sustainable materials at all events, eliminating single-use plastics and reusing, recycling or composting all waste. Additionally, FIA plans to offer every fan a more sustainable way to reach the race event and wants to ensure that circuits and facilities enhance wellbeing of the motorsport fans and nature as well as provides opportunities for local people and enterprises to get more involved in the action during a motorsport event. (SportBusiness 2019.)

## 3.6 FORMULA E – VISION FOR THE FUTURE OF MOTORSPORT

The Formula E -series is a significant step towards sustainability in motorsport and Formula E aims to represent a vision for the future of the motor industry and motorsport events, serving as a platform for research and development of the electric vehicle, increasing public interest in these cars and promoting clean-energy and sustainability. The Formula E -series championship is based around three core values of energy, environment and entertainment and is a combination of engineering, technology, sport, science, design, music and entertainment to promote the change towards an electric future. Based on the technical specifications defined by the FIA, teams will focus on improving and developing powertrains and battery technology with the aim of filtering the new technology into the electric vehicle market of passenger cars. (ABB Formula E FIA Formula E Championship.)

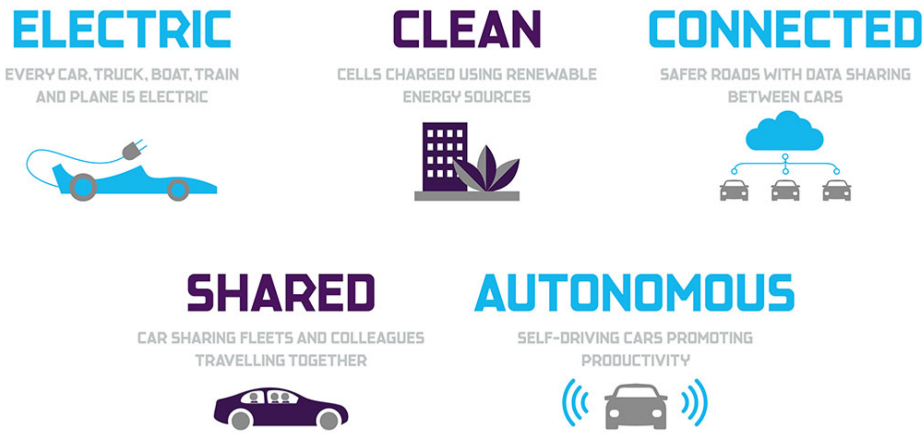


**Figure 1.** The vision of Formula E. (ABB Formula E. Our Sustainability Objectives 2020)

In Formula E each race takes place on a temporary circuit on city streets. All teams are supplied with the same chassis and battery, on top of which they can mount their own electric motors, gearboxes, etc. Comparing the aerodynamics there are a lot of differences between the Formula 1 and Formula E. A Formula E race car is designed to be efficient by reaching the lowest possible drag factor, whereas a Formula 1 race car concentrates on aerodynamics. Contrary to the Formula 1, the design of a Formula E race car is the same for all the competing teams and manufacturers are not allowed to adjust it to gain a competitive advantage. The SRT05e (aka Spark Gen2) all-electric vehicle made by Spark Racing Technology (SRT) runs on a 54 kW battery pack and has a Formula 1-style Halo cockpit protection system. (WhichEV 2019.) According to Redfern (2019) all teams also use the an identical Spark-Renault SRT 01E chassis, with batteries supplied by McLaren Advanced

Technology. Teams are allowed to supply and develop their own electric powertrains, but the rules are kept strickt to ensure the racing is as close on track. (Redfern 2019.)

According to WhichEV (2019) the 2018-2019 season saw the first all-electric race car complete an entire race without having to change vehicle. Before the SPark Gen2 cars, drivers had to swap cars during the race. Made for street racing, the SRT05e's single all-electric motor has a peak power of 250 kW (335 hp), which launches the Gen2 car to 99,78 kph from standstill in 2.8 seconds and has a top speed of 280 kph. In comparison, a Formula 1 race car has around 1,000 hp, accelerates from 0–100 kph in under 2.7 seconds and reaches a top speed in excess of 338 kph. Due to this, the Formula 1 street circuits must be much wider, and tracks have to be longer and need have wide run-off areas. The most observable difference between Formula E and Formula 1 is the noise of the car. A Formula E race car sounds like all-electric road cars, such as the Tesla. In fact, what can be heard most in a Formula E race car is its racing transmission and tyre noise. Also the regulations regarding the tyres differs; in F1 there are almost a dozen compound types to choose from, while in Formula E, all cars have to use the 18 Michelin Pilot Sport all-weather tyres, and two sets of tyres must last the entire race weekend. Since Formula E race cars do not require warm up like an F1 race car, drivers pull up to the grid in the respective order of their qualifying times. Unlike other motorsports, Formula E has a 45-minute time limit and doesn't resort to the number of laps a driver completes. Once the timer runs out, there is an additional lap that drivers must complete to finish the race. The last lap is activated when the leader car crosses the finishing line. (WhichEV 2019.)

In a Formula E race cars are not allowed to pit, cannot recharge and have to rely on active regeneration only, where approximately 30 % of power is transferred back into the battery pack. This creates interesting scenarios, and drivers have occasionally been caught out by the undefined number of laps and run out of power before reaching the finishing line. During the race, drivers have access to 200 kW (270 hp) of power which is 50 kW less than in the other sessions. However, drivers have the ability to activate two lots of 25 kW during the race – giving them an extra boost in power. (WhichEV 2019.)

The first 25 kW of power comes from a feature called 'Fanboost'. The feature is determined by the driver's popularity and lasts for five seconds. Viewers can vote for their favourite drivers six days prior and up to 15 minutes into the race and voting is done via the Formula E application, online through ABB Formula E website or via Twitter using hashtags #FANBOOST + #DriverName. Once the voting time has elapsed, five drivers are given a single-use Fanboost, which can be triggered after the 22-minute mark. The second power boost comes from 'Attack Mode', which gives any driver 25 kW of extra power if they run through a designated area of the track. This area is off the racing line, so it is disadvantageous to the driver. The number of seconds granted by driving through the Attack Mode area(s) is released by the FIA during the race and therefore teams cannot plan their racing strategy beforehand. The two 25 kW modes can be used in sequence, so theoretically five drivers could utilize the full 250 kW power unit. Spectators can see if the driver has access to additional powers, as the Halo cockpit protection system above the driver lights up in blue if Attack Mode is activated, and purple if Fanboost is initiated. (WhichEV 2019.)

Formula E is set to introduce its third-generation race car design for the 2022/2023 season, with the aim to improve the performance over the current Gen2 cars by increasing power and reducing weight. New fast battery charging will also be introduced, meaning that racing time could potentially be increased. The FIA has revealed the first specifications for the new Gen3 car in a series of tender invitations sent out to suppliers. The tenders cover the areas of chassis, batteries and tyres for the three seasons starting from 2022/2023. The length and width of the chassis will moderately be reduced to 5,000 and 1,700 millimeters, and the target weight of the complete car including the driver will be reduced from the current 900 kg to 780 kg. The chassis will still have an open cockpit with a halo protection system. The aim is also to reduce the weight of batteries from current 385 kg to 284 kg. Fast battery charging will be limited to 600 kW and will be allowed for 30 seconds in the race. This is expected to provide an extra 4 kWh of power. The cars will remain rear-wheel drive, with peak output limited to 470 hp. A new front axle energy recovery system, common to all race teams, will be introduced. The FIA has also brought up a cost cap of 340, 000 € excluding battery and spare parts for the cars. (Vijayenthiran 2019.)

## 3.7 CAREERS IN MOTORSPORT – CAN DO, WILL DO, DONE!

According to the Career Guide of the British Motorsport Industry MIA (2021) the Motorsport Industry is mainly made up of small to medium- sized companies supplying products and services to the motorsport teams which participate in various series of events around the globe. These companies are involved in research and development, testing, race car construction and supply of products/components such as gearboxes and composites. In larger organizations, roles of the technical staff can be specialized to focus on a particular area of discipline, often demanding a high level of skills, expertise and specific knowledge. In smaller companies, roles usually demand wider, multi-skilled capability and knowledge. Manufacturing consists of several different areas:

- composite materials
- model making and testing
- machining
- fabrication
- quality and inspection (Motorsport Industry MIA 2021.)

Components of race cars  are complex, low volume, high precision, and high value. The roles of motorsport engineers are related to one or more elements of the manufacturing process e.g. programming, setting or operating machinery, painting, welding, assembling, and the use of materials such as carbon fibre or specialized weight-saving metals and alloys. Typically motorsport engineers work with some of the most advanced technologies in the world and motorsport is often utilized as the 'test laboratory' for proving components and systems that have applications not only to motorsport, but also in other engineering sectors e.g., defense, marine, aerospace and general automotive industry. Therefore, career opportunities exist in a wide range of organizations  related to design, development, manufacture, supply and preparation. The motorsport industry moves at such a pace that today's 'specialism' is tomorrow's 'norm'. (Motorsport Industry Association MIA 2021.)

The race engineers interpret the telemetry and instruct the mechanics and their professional route usually  includes completion of a university degree course in a relevant subject. Most employers favour a qualification in  mechanical engineering but qualifications in electrical, aerodynamics or aeronautical engineering also appeals to certain employers. Whatever the chosen academic learning path, it is essential to complement the qualification with practical work experience. The technician route is suitable for individuals who wish to become motorsport mechanics or fulfil machining and fabrication manufacturing roles. The educational path can be built through vocational programmes or apprenticeship both combining academic study with practical work experience. (Motorsport Industry Association MIA 2021.)

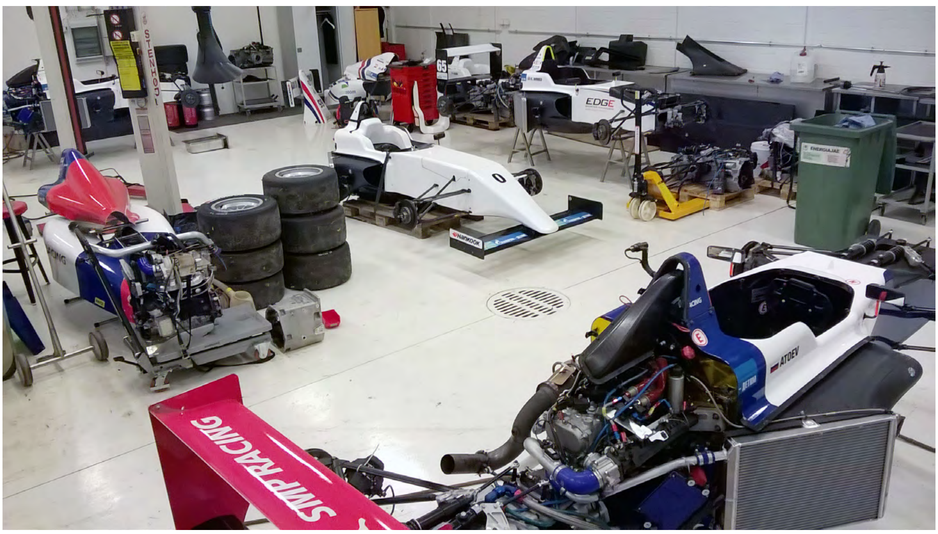


**Figure 2.** Maintenance of Formula 4 cars before a race (Photo made by Pasi Kahelin).

According to Pekkanen (2020), in Finland, technology-based careers in motorsport can be divided into four specialist groups:

- technology: testing and measuring performance
- craftspeople: welding, roll cages, car bodies
- import and sales of competition and race tyres and wheels
- transmission: design and production of race gear components

To work as a professional of the above mentioned specialist groups, skills are typically obtained through some basic training and extensive activity in the motorsport hobby. Especially in engineering and design, the studies at University of Applied Science e.g. Metropolia and SeAmk form a solid ground for a career in motorsport. The typical features of these specialists are ambition and resilience. Usually the work also includes close-knit collaboration with other specialists, drivers and motorsport teams. The motorsport industry in Finland consists of numerous small enterprises. They do not usually publicly advertise their services but are well- known in the motorsport circles. One important business area of the motorsport teams is to provide services for drivers; it is possible to rent a car, mechanics, logistic services and even get the insurances. (Pekkanen 2020.)

CEO Riku Seppä (2020) describes the operations and services of his company: for some motorsport disciplines Kymen Septec, Dynamo, builds race cars including design and production of parts. The production process requires craftmanship and inventiveness. In some motorsport disciplines car parts, the necessary ICT- software and materials are available. Seppä (2020) states that in order to be able to acquire them on good terms, good contacts and networks are indispensable. Dynamo offers full-service packages for both professional and amateur drivers. For young drivers and their parents, Seppä also gives valuable advice on purchase of suitable and cost effective vehicles. He says that it is not always sensible to buy new parts but utilize used and repaired parts.

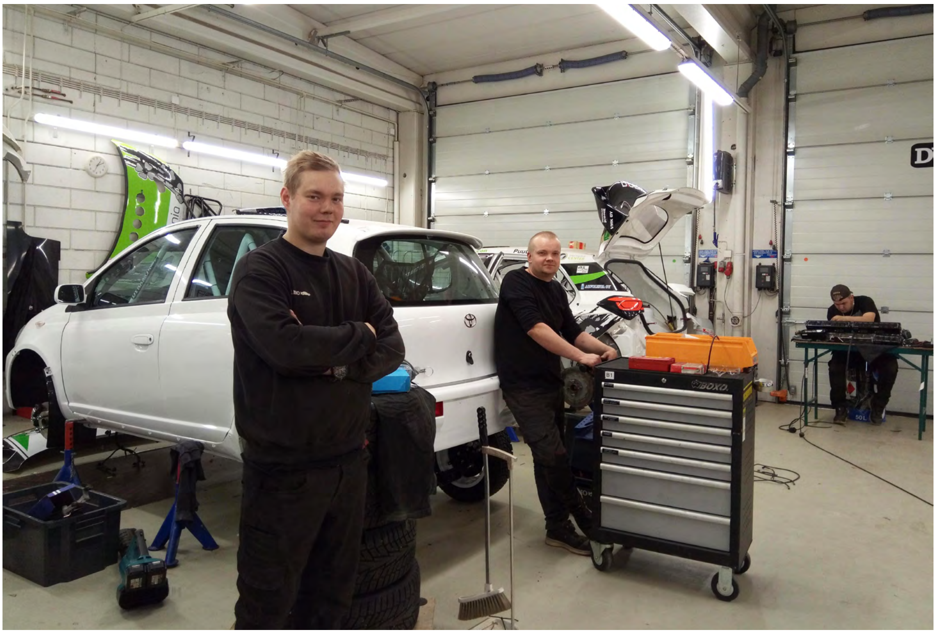

**Figure 3.** Entrepreneur Riku Seppä (right) and motorsport mechanic Vili Liukkonen (left) at the premises of Kymen Septect, Dynamo (Photo by Tuija Arola).

In Finland only a small part of the motorsport mechanics work full-time. The bigger teams have some full-time mechanics and according to the need in competitions and tests they recruit temporary mechanics from a trusted network. (Pekkanen 2020.) Pekkanen also says that working in a motorsport team is not just a career but rather a way of life and it is important, that team members also have good support networks e.g. family.

Pekkanen (2020) and Kahelin (2020) describe the skills needed when working as a member of a motorsport team. A good mechanic should

- have good nerves and good physical and mental health
- be resilient and able to cope with stress
- be able to cope with strict timetables and pressure as well as demanding working conditions
- be precise
- be motivated
- be enthusiastically interested in motorsport and able to constantly learn
- be self-confident in their own skills
- be able to work in a team and to understand the entire operation
- speak up if they notice errors made by other mechanics
- promote solidarity and co-operation in the team: “We win and lose as a team!”

Seppä and Liukkonen (2020) say that a good motorsport mechanic must be inventive. A good mechanic is able to prioritise their work and has resilience. Liukkonen reminds, that it is also important to ask for advice if you do not know something. He emphasises that a motorsport mechanic should never trust on good luck. In a motorsport team bad luck is a forbidden phenomenon; it indicates that the team has not done its work properly. Liukkonen underlines that your speech and actions must be consistent. A good mechanic is proactive and a combination of creativity and discipline. Liukkonen says that it is important that the team also reflects and constantly develops its work and co-operation. Challenging situations during the race must be analysed and improvements made. The head mechanic in particular must take responsibility for operations and be able to make decisions rapidly in the hectic operational environment.

Koiranen (2020) says that building a career in motorsport is a long path and usually runs from the very bottom to the top. According to him, international teams are constantly looking for good mechanics and make good job offers, especially abroad. Koiranen says that a good motorsport mechanic knows what they are doing and has a passion for the work. A good mechanic should also be skilled in languages, calm and not mess up during the long and hectic workdays. Koiranen says that he usually recognises the promising mechanics as early as during the on-the-job training period.

The most visible and celebrated jobs in motorsport belong to its drivers, engineers and mechanics. But the racing world depends on a vast array of specialist skills, including experts from some surprising branches of science. Lawrence (2018a) introduces seven of motorsport's most specialised scientific roles:

**Table 2.** Motorsport's most specialised scientific roles (Lawrence 2018a)

| | |
|---|---|
| **Fuel chemist** | The objective is to fine tune the chemical composition of fuel, optimizing octane levels to match the individual characteristics of the vehicle, correcting for its weight, acceleration, and the architecture of its engine.<br>A perfectly tailored fuel can add 40 bhp to a F1 car. The profession also includes the development of new additives, which have to be in compliance with the rules of each discipline. |
| **Aero-dynamicist** | The objective of aerodynamics is to ensure that the front end of vehicle slices through earth's atmosphere as easily as possible. But it's a field that encourages micro-specialization; members of an F1 aerodynamics team will be assigned a single component from the front wing to the radiator inlet or brake cooling duct to work out how it can be improved with either imperceptibly tiny, or wholly radical, changes in its shape. The aerodynamics team need to work closely with the telemetry crew and fluid dynamicists to turn their feedback into physical reality. |
| **Telemetry modeller** | Telemetry is collecting and collating data on the activity of every component, analyzing its interactions, and finding innovative new ways to exploit its behaviour.<br>It's a trickle-down science which involves fitting test cars with a vast amount of sensors to monitor what each part is doing and how it responds to extreme conditions. The role attracts specialists in complex systems science, an emerging branch of research which aims to make sense of systems with multiple inputs. |
| **Materials scientist** | The aim of materials scientist is to develop new materials or find new ways to use the existing ones by monitoring their performance under the stresses of a race. One example of this is inventing new carbon-fibre composites for F1 cars.<br>In a sport where cars must conform to one of only 30 permitted body shapes and the chassis has to be made of steel, even the choice of material for wires and welds can confer a genuine competitive advantage. |
| **Lubricant specialist** | Lubricant specialists are the protectors of valuable, fragile parts which are put under extreme stress and constant friction. Lubricants need both a viscosity and thermal stability which can cope with massive, rapid temperature changes in engines that produce up to 1 750 kW of heat per minute. |
| **Surface finishing** | Getting a smooth finish on motor components uses a lot of the same technology as rocket science. The high-tech world of superfinishing produces components with a surface roughness as low as 0.02Ra. To put that measurement in context, that's more than twice as slick as the Teflon NASA uses for heat shielding.<br>Superfinishing vastly reduces wear from grinding and friction heat, which is essential for parts whose extreme operating environment means a long life is simply making it to the end of a race. |
| **Fluid dynamicist** | Despite the slightly misleading name, fluid dynamics covers the study of gaseous interference specifically the way air circulates around the car. One of their key responsibilities is increasing downforce to keep the car on terra firma. |

The National Automotive Technical Education Foundation in the United States of America has identified a set of important working life skills related to automotive technology. These so called vocational hard skills are divided into engine repair, automatic transmission, manual drivetrain and axles, suspension and steering, brakes, electrical/electronic systems, heating and air conditioning, engine performance and alternative fuels and vehicles. The other section of skills is related to the employability and possible transferability of acquired skills because in the current industrial environment, people typically have many different employers and various professions during their careers. The automotive sector also includes technologies transferable to other industries, such as defense, aerospace, energy, and transport. One such skill is welding, which can be transferred to a wide range of industrial jobs in various sectors e.g. metal and construction industry. Other transferable skills include aerodynamics, lightweight structures, electronics, embedded systems, and general onboard car systems.  Innovation is a key asset of a successful motorsport team and teams  invest a significant amount of resources on research and development of high-end engineering systems,  that have to be adopted under strict deadlines.  There are several examples of new motorsport technology applications, which are transferred over to the defense sector, such as the development of more efficient engine-cooling systems, radiators and filter systems for armored vehicles that  are usede in very hot and dusty conditions.(Jovanovic, Tomovic, Verma, Luetke & Branch, 2015, 25.)

In Finland, the path to becoming a professional motorsport mechanic is long. According to Kahelin (2020), in Finland a career in motorsport is usually built upon an active hobby, by working with a motorsport team in Finland and then gradually progressing into international tests and competitions and getting a daily allowance during trips abroad.


**Figure 4.** Set-up of a Formula 4 car at the Pit Box (Photo by Pasi Kahelin).

Kahelin (2020) says, that as a head teacher at the Taitaja Motorsport Academy it is his responsibility to encourage students and to promote and help them to build networks in the field of motorsport. According to Kahelin, Finnish motorsport mechanics are hesitant to use a hobby as a reference in job-seeking. Kahelin emphasises the importance of active marketing of your skills and building networks. Motorsport teams are actively headhunting good mechanics and hardworking mechanics are recognised. Motorsport mechanics working with successful drivers are particularly sought-after. The positive assessment of the team chief is essential and references are always requested when recruiting new team members. There are many possibilities for career opportunities if you are proactive. There are also possibilities for career progression; mechanics typically head towards work in the competition organisations, for example as a chief of a competitive section of a rally. Mechanics trained at Adult Education Taitaja are currently working at MP Racing, the Motopark Racing Academic Team, Formula 3 and Formula 2. (Kahelin 2020.)

In motorsport knowledge of car technology is also important if you are aiming to become a professional driver in some of the motorsport disciplines. According to Kahelin (2020) several talented young drivers are currently being trained in Finland. In track racing motorsport disciplines, for example karting, the youngest drivers are only 5 years old. In rally, systematic training and coaching is started with 13-year-old drivers and goal-oriented competing starts at the age of 16 to 17. The use of simulators supports track racing disciplines best but in rally the circumstances are more demanding to simulate. Drivers are usually not technically oriented. According to Kahelin, it would strongly benefit the team and the dialogue between the driver, mechanic and engineer if the drivers also had some knowledge of the technology of the race car. Seppä and Liukkonen (2020) also say that it is helpful if the driver has some technological knowledge and is able to describe their perceptions of the performance of the car. Some of the top rally drivers are even trained to perform some repairs during the race if needed. Kahelin (2020) describes the development process of a race car. Using the data received through numerous sensors, the team develops a fast race car. After that the fine adjustments are made based on the preferences of the best driver of the team. The driving style of the driver defines the adjustments of the race car. Because the adjustments are made according to the needs of the best driver, the other drivers have to adapt to the set-up.

## 3.8 EDUCATIONAL OPTIONS IN MOTORSPORT IN FINLAND

Although Finland is known as an important actor in global motorsport, there are only a few educational establishments that offer specialised training to become a professional in motorsport. The Finnish training and qualifications system does not include a distinct qualification in, for example, Motorsport Engineering or Motorsport Mechanics, but the orientation and specialisation to become a professional in motorsport is facilitated through individual study plans, projects and on-the-job training. All the training programmes have been designed and are executed in co-operation with professional motorsport companies and organisations. Usually the individuals aiming at becoming motorsport professionals take a qualification in

- Mechanical Engineering (Automotive and Work Machine Engineering)
- Automotive Engineering (Automotive Electronics Engineering, Automotive design)
- Basic, further and/or specialist vocational qualifications in car technology

Seinäjoki University of Applied Sciences SeAMK offers Motorsport Engineer training. The training programme is run in co-operation with RSD Racing Finland. It is a Degree Programme in Mechanical Engineering (Bachelor of Engineering, 240 ECTS) and the specialisation is in Automotive and Work Machine Engineering. The University of Applied Sciences Metropolia offers Automotive Engineering training (Bachelor of Engineering, 240 ECTS). To specialise in motorsport, students can apply for membership of the Metropolia Formula team (10–30 ECTS). The Metropolia Formula team designs and manufactures an electric Formula race car to compete in the international Formula Student competitions every year.

Vocational College Omnia offers training to become a motorsport mechanic in co-operation with AKK-Motorsport. The motorsport-oriented training is based on the basic qualification in automotive technology, and in addition the students will get to know the rally, rallycross, karting and track racing disciplines.

Adult Education Taitaja offers motorsport mechanic training, which has been executed in co-operation with formula and rally teams such as Koiranen GP and Toyota Gazoo Racing. The further training programme, Taitaja Motorsport Academy, is aimed for persons who already have good basic knowledge, practical skills and a previous suitable degree, and who are interested in working in the hectic and exiting world of motorsport. An on-the-job training period is organised in co-operation with the formula and rally teams and requires preparedness to travel in Finland and abroad. The on-the-job periods give students a great opportunity to get acquainted with the real world of motorsports and to network with professionals. Motorsport Mechanics education combines two strong Finnish brands, motorsport and vocational education.

## 3.9 CONCLUSION

Motorsport is a worldwide sport industry with a substantial growth potential both financially and technologically. In addition to being significant business, competitive motor racing provides an ideal environment and race teams ideal capabilities for the automotive industry to rapidly develop and test technological innovations. For automotive manufacturers, motorsport is a platform to demonstrate the capability of their products on the global stage. (Powis 2016, 4.) Formula 1 in particular is and has been the forerunner of technological innovations that have directly benefitted the automotive industry and road cars. In addition to technological innovations, motorsport has also contributed to testing and development methods such as wind tunnels, sensor technology and data transmission. According to Kahelin and Koiranen (2020), the forthcoming major innovations in motorsport will be related to energy recovery, battery technology and high-speed recharge of batteries.

In the public debate, motorsport has forcefully been accused of being pollutant, unecological and a waste of limited natural resources. These messages and the public pressure have been taken seriously and the FIA environment and sustainability commission and the FIA Environmental Accreditation Programme are aimed at helping motorsport and mobility stakeholders worldwide to measure and enhance their environmental performance. In 2019, Formula 1 announced an ambitious sustainability plan to have a net-zero carbon footprint by 2030. The initiative will include the Formula 1 cars, on-track activities, and the rest of the sport operations. The key actors of the initiative are the FIA, sustainability experts, Formula 1 teams, promoters and partners.

The Formula E series is an important step towards sustainability in motorsport and it aims at representing a vision for the future of the motor industry, serving as a framework for research and development around the electric vehicle, accelerating general interest in these cars and promoting clean-energy and sustainability. The three core values of the Formula E championship are energy, environment and entertainment and it is an innovative fusion of engineering, technology, sport, science, design, music and entertainment to promote the change towards an electric future. Teams will focus their efforts on improving and developing powertrains and battery technology, with the aim of filtering the new technology into the everyday electric vehicle market. (ABB Formula E FIA Formula E Championship.) Formula E is also taking a substantial development leap in facilitating viewers to participate in the events by voting and giving their favourite drives extra power through the Fanboost.

The motorsport industry is predominantly made up of small to medium-sized companies supplying products and services to teams participating in various motorsport disciplines.

These companies are involved in research and development, testing, race car construction and supply of products/components such as gearboxes and composites. In larger organisations, the roles of employees can be specialised to focus on a particular area of discipline, often demanding a high level of skills, expertise and specific knowledge. In smaller companies, roles usually demand wider, multi-skilled capability and knowledge. (Motorsport Industry Association MIA 2021.)

In Finland only a small number of motorsport mechanics work full-time. The bigger teams have some full-time mechanics and according to the need in competitions and tests they recruit temporary mechanics from a trusted network. (Pekkanen 2020.) Koiranen (2020) says that building a career in motorsport is a long path and usually runs from the very bottom to the top. According to him international teams are constantly looking for good mechanics and make good job offers, especially abroad. Koiranen says that a good motorsport mechanic knows what they are doing and has a passion for the work. A good mechanic should also be skilled in languages and calm during the long and hectic workdays. Kahelin (2020) emphasises the importance of active marketing of your skills and building networks. The positive assessment of the team chief is essential, and references are always requested when recruiting a new team member. According to Liukkonen (2020) a good mechanic is able to prioritise their work, has resilience and never trusts on good luck. A good mechanic is proactive and a combination of creativity and discipline. Liukkonen says that it is important that the team also reflects and constantly develops its work and co-operation.

The skills of a successful motorsport mechanic can be divided into hard and soft skills. Hard skills, also called technical skills, are specific professional abilities that can be learned through education and training. Soft skills are subjective skills that relate to the way individuals interact with each other. Usually, they are not taught but are rather the natural result of emotional intelligence and life experience. (Opetushallitus 2019.) Based on the table presented in the first results of the Finnish National Forum for Skills Anticipation's anticipation work (Opetushallitus 2019, 19) and the interviews with experienced motorsport professionals, the division of the hard skills and soft skills of a motorsport mechanic can be described as follows.

**Table 3.** Division of hard skills and soft skills of a motorsport mechanic (adapted from Opetushallitus 2019, 19)

| | **Hard skills**<br>Technical, job-specific skills that are usually easily observed, measured, trained and closely connected with knowledge | **Soft skills**<br>Non-job-specific skills, which are usually intangible, hard to measure and closely connected with attitudes |
|---|---|---|
| **General skills**<br>Skills applicable in most companies, occupations, and sectors | **Generic hard skills**<br>· motor technology<br>· car body technology<br>· electrical science<br>· information technology<br>· welding<br>· machining<br>· English language<br>· work safety and first aid | **Generic soft skills**<br>· teamwork and promotion of solidarity<br>· resilience<br>· motivation<br>· ability to constantly learn<br>· ability to ask for help and share information |
| **Specific skills**<br>Skills applicable in a small number of companies, occupations, and sectors | **Specific hard skills**<br>· competition car electrics<br>· composite and carbon fibre structures<br>· metal failures and analysis<br>· competition car structures<br>· competition car set-up<br>· regulations of the motorsport discipline | **Specific soft skills**<br>· precision<br>· creativity<br>· ability to prioritise<br>· ability to work under time pressure<br>· ability to work in demanding work conditions<br>· ability to make quick decisions |

In the Finnish educational system, motorsport professionals are always trained in co-operation with motorsport teams to facilitate the growth of both hard and soft skills. This approach will also better prepare the students for the hectic and extremely demanding profession and facilitate networking with the industry to promote employment. The close co-operation between the educational institutions and motorsport teams will also make sure that the teachers always have the latest knowledge, and the curriculum is up to date.

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# 4 RACE4SCALE – DEVELOPMENT OF AUTOMOTIVE AND MOTORSPORT ECOSYSTEMS: REFLECTIONS FROM THE PROJECT PERSPECTIVE

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## 4.1 THE RACE4SCALE PROJECT IN THE FINNISH-RUSSIAN INTERNATIONAL CONTEXT

The regions of Kymenlaakso and Saint Petersburg have prioritised the development of education and lifelong learning and the facilitation of innovation and R&D projects as success factors for the regions' development. The Race4Scale project involves students, teachers and managing staff of the secondary and tertiary educational partner institutions and business representatives of the automotive and motorsport industry in Russia and Finland as the key target groups that will drive the socioeconomic performance of the cross-border region.

The Kymenlaakso region provides strong international potential in the field of motorsport. The regional adult education centre co-operates with well-known motorsport brands and teams, for example, by training specialist mechanics for them. The latest motorsport investment in the region is the KymiRing racing track opened in 2019, which fulfils all the standards for arranging international motorsport competitions (KymiRing 2021).

The St. Petersburg region in turn provides strong automotive industry know-how while famous automotive companies such as Ford, Nissan, Renault and Nokian Tyres have manufacturing facilities in the area. One of the Race4Scale partners represents an association formed by these companies. Other project partners include secondary education organisations, and applied and research universities.

The project's overall objective is to increase the level of education by studying and defining future professional requirements and developing/proposing new educational paths respectively. The Race4Scale project consists of six work packages (WPs) which all include varying activities. These activities are, for example, workshops common for all participants, theme days, the development of educational personnel, innovation camps for students, seminars and above all research projects dealing with automotive industry and motorsport (Race4Scale 2021). The results of the two above-mentioned studies and the Future Professions Workshop can be presented visually (Figure 1).

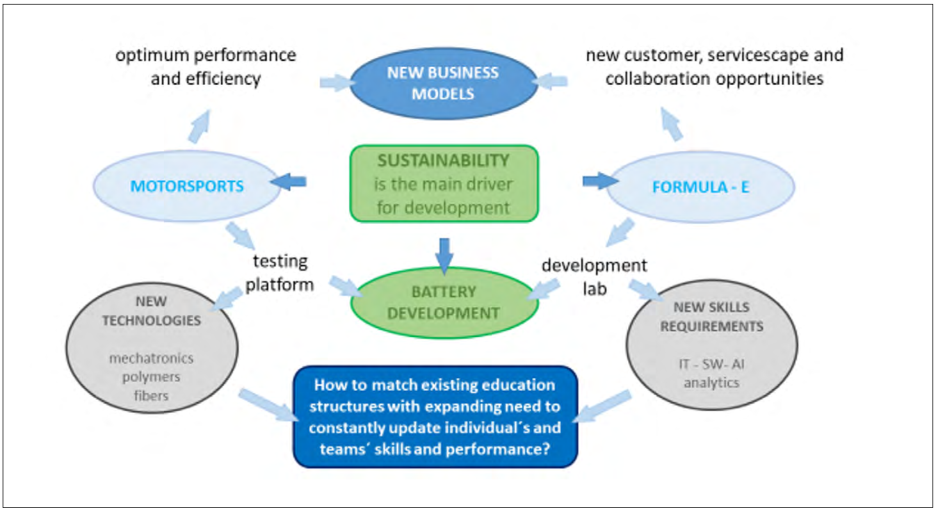


**Figure 1.** Towards new business modelling in the automotive and motorsport industries (Kettula 2020).

This publication represents the results and findings of Work Package 1 (WP1) comprising two independent research studies about the car industry's future and a series of (hybrid) workshops based on the above-mentioned studies respectively. WP1 also includes an identical research and workshop package organised by the Russian partners. A separate publication will be launched about the Russian workshop by the Russian project partners in due course. The execution of the Race4Scale project was enabled by the South-East Finland–Russia CBC 2014-2020 programme funding.

## 4.2 START GRID

In 1910, the world's largest manufacturer of wagons, George Milburn (1820-1883) had a vision that the electric car could be made lighter, lower and cheaper (Milburn Light Electric 2008). He opted to get into electric car manufacture. During their eight years of production, from 1915 to 1923, Milburn Wagon Company produced over 4,000 electric cars.

Milburn was one of the more successful producers of electronic automobiles. Powered by batteries, these cars provided an exhaustless and almost silent ride. The Milburn was the lowest-priced electric of the time and much lighter than its competition. While easy to drive and elegant, it was also slow, achieving a top speed of only 20 miles per hour. It could not also go very far even on a full charge with only a 60 to 75 mile range. By the early 1920s, electric cars had lost their popularity to gasoline-engine cars. (Milburn Light Electric 2008.)

**Figure 2.** Milburn Electric – Electric Car (USA-1916) Museo Automovilistico, Malaga, Spain. (Photo by Jarmo Kujanpää).

George Milburn was an automotive industry visionary as early as over one hundred years ago, like Elon Musk today. His visions also included the aim to be able to both manufacture and sell electric automobiles cheaper than competitors do. Yet a more famous historical character obviously is Henry Ford whose major innovation was cost-effective serial manufacturing of (combustion engine) automobiles (Ford Motor Company 2021).

Later on, about 50 years ago, the Japanese car industry developed serial production to a new apex, based on which many new business models and concepts like 'Lean' and 'JOT' were created. The common denominator for all these innovators has been to strive for cost-effective production and the opportunity to offer cars for consumers cheaper than the competitors can.

This is problematic when it comes to the current electric cars, due to their high purchase price. As Tero Villman concludes in his research, why would someone buy a used electric car when they could get a similar new electric car with a similar price? The reason for this development has among other things been the development of battery technology and the cost benefits of mass production. On the other hand, this development has had an impact on first registrations of new passenger cars. Nowadays the share of private leasing is steadily growing in Finland (Autoalan Tiedotuskeskus 2020). In other words, consumers want to shift the risk of price reduction to vendors.

Legislation also plays a significant role in consumers' purchase decisions. Taxation of fuels and other means of control guide consumers´ interest towards low-emission vehicles. In a sense, it is a question of a kind of forced market mechanism. Accordingly, the legislation also creates new business models for automotive industry. Tesla sells emission allowances to other manufacturers while Tesla's cars are emission-free in use (Beresford 2020). There are a number of related questions: How about other power supplies and new innovations in the automotive industry and travel? Will fuel cell cars be part of the future? Today there is only one such vehicle in Finland (Leino 2020). There has been much discussion about hybrid cars being only the products of a period of transition – transition to where? How about the development of the charging and filling infrastructure, a critically important factor? It can be stated that Race4Scale is on the cutting edge, as the automotive industry is now changing faster than over one hundred years before when combustion engine vehicles took over electric automobiles – i.e. we are back to Square One!

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# 5 TOWARDS NEW PROFESSIONS AND PROFESSIONALISM: CONSIDERATION OF THE FUTURE PROFESSIONS WORKSHOP IN FINLAND

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The search for a future profession begins long before receiving the coveted diploma or certificate of qualification. Working together at the levels of the high school, college and adult colleges, university of applied sciences, research university and industrial cluster, goals, processes and outcomes are synergistic. With the trend of overproduction of economists and marketers, as well as in the period of impoverishment of Europe of qualified personnel, we – the South-Eastern Finland University of Applied Sciences and the Race4Scale project consortium – have a large bonus, a unique option: we offer professionals, working intelligence, quality of crafts, the highest level of working creativity, even professional postgraduate study. In the entire post-Soviet space, the middle link of qualifications (i.e. secondary education) dropped out. In our project consortium in particular, we propose to restore the chain of professional DNA, to heal society with new educational and professional programmes, new standards, new forces of new people. We are forming a matrix of intellectual labour reserves.

## 5.1 THE NEW ONLINE REALITY FOR TRANSNATIONAL PROJECT CO-OPERATION

Due to the closure of borders and the impossibility of holding joint events face to face in Finland or Russia, the need for high-quality and effective online training, seminars and workshops is increasing. All research, development and innovation (RDI) activities are moving online: for example, interviewing can only be carried out through Zoom, Teams or other similar applications. For some, this is a real shock: not only for the older generation, but also for the young people themselves. New first-year college and university students have some difficulty learning online as well. Somewhat more fortunate were senior students who had the opportunity of both contact and non-contact learning from the beginning of the new academic year. In general, there is an urgent need for teachers and students to improve their technical skills, as online applications take over the leadership in formal (school, secondary special and higher) education and in informal training aimed at increasing overall work efficiency and developing creative (non-standard, innovative) solutions and working methods.

## 5.2 A NEW DIGITAL LANGUAGE OF LEARNING

Language must be mentioned briefly. The modern generation of students use their new universal language – the language of digital awareness. It can be assumed that the older generations of students and teachers devote more time to self-study, reading original books, articles and other publications, while modern youth learn almost instantly from digital sources, preferring visual solutions, photo and video images to classical forms of knowledge. In addition, popular social networks (Twitter, Facebook, Instagram, TikTok, Snapchat, etc.) have taught users to use the most concise information to convey the essence of events and processes, even when describing innovative solutions. One can, of course, appeal that, in pursuit of brevity, the depth of the sought-for solutions is missed, and also as that the modern generation 'jumps' over the headlines without plunging into the details of the information presented (in the form of newspaper articles, online textbooks or manuals). To this, one could object that the volume of open information over the past decades has grown so much that it can be overcome only through a brief acquaintance with various information modules. So is education and the professions of the future: they consist of many complementary modules, but never form a single whole. The overall illustration of the alternative future with application of education, business and social domains can be seen in Figure 1.

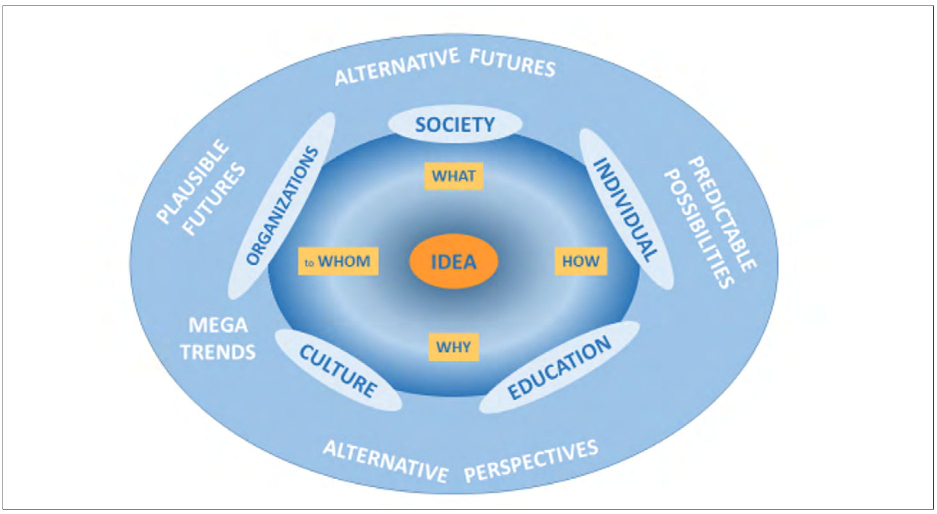


**Figure 1.** The alternative future prospect and its domains (Kettula 2020).

## 5.3 REFLECTIONS ON STUDENT LEARNING DIARIES: FUTURE PROFESSIONS WORKSHOP IN FINLAND – 28.10.2020 AND 4.11.2020

After the Finnish workshop, the XAMK students were asked to write learning diaries in addition to their participation. First, they had to present their group idea in about ten sentences. Second, they described their biggest insight during both days of the workshop. Third, each student provided at least one suggestion for improvement. Fourth, the students presented major concepts that, in their opinion, would feature in the future automotive and motorsport industries by 2030, in relation to business, culture, education, society and students themselves. Fifth, the students gave their personal feedback.

The following series of students' comments and suggestions deserves attention. Learning is a matter of fitting to the new (or renewed) world. Regular re-education of the workforce is the absolute must. To strengthen the latter statement, learning can and should be activated through re-educating oneself. Step by step, classical degree education will switch to a modular education, in which every student may fit the most relevant study modules on a continuous basis, and numerical grading will cede to competence-based verbal assessment. By means of the simplification of products and services in the market, frugal innovations could be worked out. Innovations will be sooner or later measured by their 'smartisation' – i.e. an ability to self-develop and become self-efficient in such development. Sustainability of product/service solutions will be achieved through more ecological solutions. However, it remains unclear by which criteria ecology will be assessed in the future. As artificial intelligence (AI) becomes more sustainable, a new type of digital culture is currently being generated. In such a culture, the significance of soft skills comes to the front as the modern generation possesses hard skills by default. Learning itself acquires new features of simulative testing as students and employees learn mostly intuitively by experiencing (i.e. inductively) rather than through the (applied) theory (i.e. deductively).

The students also created mind-maps – thus explaining their vision of the motorsport's and automotive industry's future. They mentioned, for instance, the non-human nature of communication in the recent future – e.g. cars with cars. The culture itself will acquire elements of AI as well as turning completely 'green'. The logical question would be then what such 'green' means – by which standards it could be measured more completely.

In addition to this, the automotive future can be fully realised only through education, or a remodelling of education – to put it more correctly. Learning also becomes more shared – by the analogy of crowdsourcing and crowdfunding platforms. The traditionally used European Qualification Framework (EQF) with its levels of knowledge, skills and competences for each level of formal education in EU, needs to be transformed into the 'digitalised EQF' – thus reflecting the needs of digitalised education and the digitalised labour market (The European Qualification Framework 2020).

Finland's sustainability should be tailored at a national level and will result eventually in global effective solutions. The message could be the following: "Local Sustainability – Global Feasibility". Such a sustainable aspect of learning could be applied to the lifelong learning concept. In other words, learning becomes even more inclusive and achievable by means of digital technologies and sustainable educational solutions.

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## APPENDIX 1(1)

### Framework and questions of the semi-structured interviews conducted by M.Sc. (Econ.) Tero Villman

**Haastattelurunko**
**Nykyhetki 2020 (10min)**

- Miten kuvailisit henkilöautoja ja –autoilua Suomessa tällä hetkellä? (2020)
- Miten Suomen alueelliset ominaisuudet, kuten vuodenajat ja etäisyydet, vaikuttavat henkilöautoihin ja –autoiluun?
- Mitä muita ominaispiirteitä liittyy henkilöautoihin ja –autoiluun Suomessa, ja miten ne vaikuttavat tällä hetkellä?

**Trendit ja muutosvoimat (10min)**

- Minkälaisia trendejä ja muutosvoimia olette havainneet henkilöautoihin ja –autoiluun liittyen?
- Miten megatrendit, kuten ilmastokriisi, väestön ikääntyminen, taloudellinen ja yhteiskunnallinen eriarvoisuus, kaupungistuminen ja digitalisaatio, vaikuttavat henkilöautoihin?

**Muutos**

- Seuraavaksi voisimme luodata tulevaisuutta erityisesti teknologian näkökulmasta, ajatella viiden ja kymmenen vuoden päähän eli vuosiin 2025 ja 2030.

**2025 (10min)**

- Miltä Suomen autokanta voi näyttää 2025? Mikä on muuttunut ja mikä on pysynyt ennallaan?
- Minkälaisia autoja on liikenteessä silloin?
- Mistä nämä muutokset tai muuttumattomuudet johtuvat ja miksi?
- Miten nämä teknologiset muutokset vaikuttavat autojen elinkaaren aikana, esimerkiksi autojen myyntiin, huoltoon ja kierrätykseen tai elinkaaren loppuun? Osaamiseen ja koulutukseen?

## APPENDIX 1(2)

### 2030 (10min)

- Miltä Suomen autokanta voi näyttää 2030? Mikä on muuttunut ja mikä on pysynyt ennallaan?
- Minkälaisia autoja on liikenteessä silloin?
- Mistä nämä muutokset tai muuttumattomuudet johtuvat ja miksi?
- Miten nämä teknologiset muutokset vaikuttavat autojen elinkaaren aikana, esimerkiksi autojen myyntiin, huoltoon ja kierrätykseen tai elinkaaren loppuun? Osaamiseen ja koulutukseen?
- Mitkä mainitsemistasi teknologisista muutoksista ovat mielestäsi merkittävimpiä ja miksi? Mikä on mielestäsi suurin yksittäinen teknologinen muutos kymmenen vuoden aikana?
- Mitkä ovat mielestäsi merkittävimmät teknologiset haasteet Suomessa henkilöautoihin liittyen?

### Muuta (10min)

- Mistä emme ole vielä keskustelleet? Mitä haluaisit vielä lisätä tai korostaa?
- Ketä suosittelisit, että kysyisin haastateltavaksi?

## APPENDIX 2(1)

**Informants of Tuija Arola's research**

**Pasi Kahelin,** oral interview 21.8.2020 at Adult Education Taitaja.
Pasi Kahelin is a Bachelor of Motorsport Engineering and Design from Swansea University, Wales and has over 30 years of experience in motorsport as a mechanic, driver and member of competition organisations. As a driver Kahelin has experience of race track driving and rally sprint and he has also been a map reader in rally racing. Kahelin has also built motors for racing cars. Kahelin is the head teacher of the Motorsport Mechanic training at Adult Education Taitaja.

**Jorma Pekkanen,** oral interview 4.8.2020 at Adult Education Taitaja
Jorma Pekkanen has been an active actor in Finnish motorsport for more than 55 years. He has three Finnish Championships, and more than 60% of the competitions in which he participated ended on the podium. During his career in motorsport, in addition to competitive driving, he also built his own racing cars. Pekkanen specialises and is well-known especially for building racing motors and transmission. His ambition is to create innovations that improve the car´s performance. In international circles he has had a specimen car contract with Nissan Motorsport (1400 m²) for the Finnish Championships. Pekkanen has also acted as a pit manager in testing of rally cars.

**Riku Seppä,** oral interview 15.9.2020 at Kymen Septech Oy,Dynamo
Riku Seppä, entrepreneur and CEO, started his business Kymen Septech Oy, Dynamo in 2005. Dynamo builds and maintains vehicles for drivers/competitors in the Rally Finnish Championships and Rally Cross Finnish Championships as well as for national competitions. The business idea of the company is to offer an overall package for customers. Dynamo mainly operates in Finland but has also participated in some competitions in the World Championship series. Before starting his business, Riku Seppä was a successful rally driver in national series for 10 years.

**Vili Liukkonen,** oral interview 15.9.2020 at Kymen Septech Oy,Dynamo
Vili Liukkonen is a professional motorsport mechanic at Dynamo. His career started through hobby activities as a rally driver in the junior series and subsequently as a volunteer mechanic. Liukkonen has worked at Dynamo for 3 years and his role is as the head mechanic for the client teams.

**Marko Koiranen,** telephone interview 8.10.2020
Marko Koiranen is the owner and CEO of Koiranen GP. He has been in the motorsport industry for 25 years. From 2015 to 2018, Koiranen was the promotor of the SMP F4 NEZ Championship series. Currently, he is the promotor of the national Formula 4 series and the Formula Academy Finland.

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1 *Srujal Shah - Kari Dufva:* CFD modeling of airflow in a kitchen environment. Towards improving energy efficiency in buildings. 2017.

2 *Elias Altarriba:* Öljyn leviämisen estimointi arviointitaulukoiden avulla osana operatiivista öljyntorjuntatyötä Saimaalla. 2017.

3 *Elina Havia - Jari Käyhkö (toim.):* Fotoniikkasensori- ja korkean teknologian kuvantamisen demonstrointi metsäbiojalostamon hallintaan (FOKUDEMO). 2017.

4 *Justiina Halonen - Emmi Rantavuo - Elias Altarriba:* Öljyntorjuntakoulutuksen ja -osaamisen nykytila. SCAROIL-hankkeen selvitys öljyntorjunnan koulutustarpeista. 2017.

5 *Veli Liikanen - Arto Pesola:* Physical fun: exercise, social relations and learning in SuperPark. 2018.

6 *Timo Hantunen - Petri Janhunen (toim.):* Sote-alan videoneuvottelujärjestelmien käytettävyys ja käyttöönotto. 2018.

7 *Pekka Turkki:* Selluloosa ja selluloosajohdannaiset elintarvikkeissa. 2018.

8 *Elias Altarriba - Minna Pelkonen - Jukka-Pekka Bergman:* Laadullinen tapaustutkimus opetusresurssien nopean ja voimakkaan vähenemisen vaikutuksista korkeakouluopetukseen. 2018.

9 *Sari Tuuva-Hongisto:* Nuorten syrjäytyminen ja alueellisen eriytymisen vähentäminen. Tutkimuskirjallisuuteen ja –raportteihin pohjautuva kartoitus. 2019.

10 *Susan Eriksson:* Digitalisaatio nuorisotyön opetuksessa. 2019.

11 *Susan Eriksson – Sari Tuuva-Hongisto:* Nuorisotyön digitalisaatio 2030. ”Meidän tulisi osata tarjota nuorille työkaluja maailmaan, jota me emme vielä itse tunne.” 2019.

12 *Susan Eriksson:* Digital applications in youth employment services. 2019.

13 *Hilla Sumanen – Jaakko Harkko – Jouni Lahti – Eeva-Leena Ketonen – Olli Pietiläinen – Anne Kouvonen:* Nuorten työntekijöiden työkyky ja työterveyshuollon palvelujen käyttö. 2020.

14 *Marja Moisala (toim.):* Paikkariippumattomuus nuorten tulevaisuuden palveluissa maaseudulla. 2020.

15 *Hilla Sumanen:* Experiences and impacts of the post critical incident seminar among rescue and emergency medical service personnel. 2020.

16 *Marja-Liisa Neuvonen-Rauhala (ed.).:* XAMK BEYOND 2020. At Your Service – Business Development, Co-operation and Sustainability. 2020.

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