A Work Project, presented as part of the requirements for the Award of a Master Degree in Management from the NOVA – School of Business and Economics.

WHAT ENVIRONMENT IS NEEDED FOR AN AUTONOMOUS INNOVATION HUB, AND IF HUNGARY CAN BECOME ONE?

MÁRTON ERDŐSI – 24676

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03.01.2017

Restricted Note

As this thesis contains confidential information it will be inaccessible for the public for the five years after submission to the Examinations Office.

Acknowledgements

I would like to express my special thanks to Katrin Merfeld, Prof. Dr. Sven Henkel and Luis Manuel da Silva Rodrigues for guiding me through the research. Besides, I would like to state my thankfulness for my family and friends, who supported me through my whole Masters program. Last but not least, I would like to express my gratitude to the interviewed industry experts, who shared their experience with me and gave the chance to speak with them.

Abstract

The automotive industry is facing with great disruption and change nowadays, which it has not seen before. One of the most significant change will be brought by autonomous driving technology. Since, it is a relatively new market with huge potential, the competition to leveraging on this field is enormous. Most of the researches done regarding autonomous driving, is about the economical and social effects of it. This research intends to investigate the environmental needs of an autonomous technology innovation hub, where this technology can be developed, besides the chances of the automotive industry-centralized Hungary becoming such hub.

Keywords: innovation, R&D, hub, environment, autonomous, technology, vehicle, Hungary, ZONE, test, track, automotive,

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List of Abbreviations

ABS - Anti-lock Braking System
AI – Artificial Intelligence
AV – Autonomous Vehicle
BME – Budapesti Műszaki Egyetem (Budapest University of Technology)
BME HIT - Budapesti Műszaki Egyetem, Hálózati rendszerek és szolgáltatások Tanszék (Budapest University of Technology, Department of Network Systems and Services)
BME KJIT - Budapesti Műszaki Egyetem, Közlekedés- és Járműirányítási Tanszék (Budapest University of Technology and Economics, Department of Control for Transportation and Vehicle Systems)
BME KJK – Budapesti Műszaki Egyetem, Közlekedésmérnöki és Járműmérnöki Kar (Budapest University of Technology and Economics, Faculty of Transportation Engineering and Vehicle engineering)
BME VIK – Budapesti Műszaki Egyetem, Villamosmérnöki és Informatikai Kar (Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics)
CoC – Centres of Competence
DARPA - Defense Advanced Research Projects Agency
DGPS - Differential Global Positioning System
DM – Deutsche Mark
EC – European Commission
ELTE - Eötvös Loránd Tudományegyetem
ELTE IK - Eötvös Lóránd Tudomány Egyetem, Informatikai Kar (Eötvös Lóránd University, Faculty of Informatics)
EMS – Engineering Manufacturing Services
ESP - Electronic Stability Programme
EU – European Union
FDI – Foreign Direct Investment
GCI – Global Cities Index
GDP – Gross Domestic Product
GE – General Electric
GERD – Gross Expenditure on Research and Development
GNSS – Global Navigation Satellite System
GVC – Global Value Chain
HIPA – Hungarian Investment Promotions Agency
HQ – Headquarter
IMF – International Monetary Fund
IoT – Internet of Things
IP – Intellectual Property
IT – Information Technology
KSH – Központi Statisztikai Hivatal (Central Statistical Office)
M&A – Mergers and Acquisitions
MNC – Multinational Company
MTA – Magyar Tudományos Akadémia (Hungarian Academy of Sciences)
MTA SZTAKI – Magyar Tudományok Akadémi, Számítástechnikai és Automatizálási Kutatóintézet (Hungarian Academy of Sciences, Institute for Computer Science and Contol)
NFM – Nemzeti Fejlesztési Minisztérium (Ministry of National Development)

NMHH - Nemzeti Média- és Hírközlési Hatóság (National Media and Infocommunications Authority)
ODD – Operational Design Domain
OECD - Organisation for Economic Co-operation and Development
OEM - Original Equipment Manufacturer
PISA – Programme for International Student Assessment
PR – Public Relations
QC – Quality Control
R&D - Research and Development
RDI – Research, Development and Innovation
RECAR - Research Centre for Autonomous Road Vehicles
SAE – Society of Automotive Engineers
SME – Small and Medium size Enterprises
TFP - Total-Factor Productivity
USA – United States of America
V2I – Vehicle to Infrastructure
V2V – Vehicle to Vehicle
V2X – Vehicle to everything
VC – Venture Capital
WHO – World Health Organization
WIPO - World Intellectual Property Organization
WW2 – World War 2.

1.Innovation and R&D

This section gives an overview about innovation, it's typologies and characteristics. It is followed by the topic of R&D theory, internationalization, structures, tendencies in R&D, innovation hub and eventually, R&D collaboration.

1.1 Innovation

1.1.1 Define

Originally, innovation comes from a Latin word, "innovare", which means "into new". One of the first explanations' basis for innovation was Schumpeter's (1934) important work. He described it as the very first addition of a new method, product, system or process. Schumpeter points out that the definition has a two-fold nature. Firstly, innovation as a process, secondly as an outcome. As a process, it is defined as "introduction and application" (West & Farr, 1990), "bringing into use" (Kanter R. M., 1984) or "development and implementation of an idea" (Van de Ven, 1986). In case of innovation as an outcome, it could appear as a concept, idea, product, method etc., which is new in the given environment (Damanpour, 1991; Dougherty, 1992; Howell & Higgins, 1990; Marcus, 1988; Pennings & Harianto, 1992).

1.1.2. Innovation as a process.

By allowing to say that innovation is a process, it gives the opportunity to researchers to explore the creating activities of innovation (Greve & Taylor, 2000; Myers and Marquis, 1969).

Baregheh, Rowley & Sambrook (2009) introduced a definition for innovation. They say, "innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace".

Researchers usually explore the creation of community ties, which lead to innovation (Adner, 2006; Obstfeld, 2005). They are able to group the sequence of activities into different phases, which are necessary for innovation. Usually, at least two stages can be found in an innovation process, the idea generation and its implementation (Axtell, Holman, Unsworth, Wall, Waterson, & Harrington, 2000; Clark & Guy, 1998). The first

stage includes actions from the very beginning such as the idea formulation to the decision making plus implementation (Amabile, Conti, Coon, Lazenby, & Herron, 1996). This step is regularly perceived as a new service or new market opportunity (Garcia & Calantone, 2002). The second phase is an experiment, where trying and failing is repeated effortlessly in order to accomplish an innovation (Eisenhardt & Tabrizi, 1995).

It can also be described as an approach and technology for acquiring a new market or new product process and classifying new customer groups. Innovation is also called an action where firms solve challenges by merging knowledge (Fri, Pehrsson, & Søilen, 2013).

1.1.3. Innovation as an outcome

There is an additional phase added to the ones mentioned in the "innovation as a process" part by Eisenhardt (1995). This phase is the commercialization step (Kanter R., 1988; Rogers, 2003; Strebel, 1987). It refers to a product or service for which a commercial gain is the expected outcome of the innovation. Innovation as an outcome is defined by being novel, useful, in use, or non-trivial. The listed definitions are useful for identifying what constitutes an innovation, besides helping to categorize innovation (Jaffe, Trajtenberg, & R., 1993; Levitt, 1960; Utterback, 1971).

Novelty is also presented as a definition which considers innovation as an outcome. Essentially, this outcome is something new (Greve & Taylor, 2000; Gupta, Tesluk, & Taylor, 2007; Obstfeld, 2005; West & Farr, 1990). However, the innovation's intensity is not elemental to the idea itself, but it is decided by the person who is judging that particular novelty (Damanpour, 1991; Dougherty, 1992; West & Farr, 1990). Marcus (1988) also defined innovation in a similar way "ideas, formulas, or programs that the individuals involved perceive as new". However, it may happen that the given innovation is new for a certain pool of people, but not for the remainder of them. Hence, Van de Ven (1986) proposed his definition of innovation "as long as the idea is perceived new to the people involved, it is an 'innovation', even though it may appear to others to be an imitation or something that exists elsewhere." Correspondingly, Daft (1978) explain innovation as "the idea can be old with regard to other organizations so long as the idea has not previously been used by the adopting organizations."

The above mentioned models, descriptions and definitions clearly overlapping with each other. Besides the number and the variance of these definitions, it makes it

harder to end up with a clear and solid definition of innovation. Firstly, in 1984 Ettlie et al. (1984) mentioned this problem and lately, Zairi (1994) and Cooper (1998) said that a crucial problem of innovation is the lack of a strong, widely accepted definition which would enable us to grasp the essence of innovation. A widely used explanation would help to adopt different practices and cover various forms of innovation, because "the term 'innovation' is notoriously ambiguous and lacks either a single definition or measure" (Adams et al., 2006). Scientists and researchers pointed out this issue that the lack of a coherent explanation and definition of innovation will lead to a situation where it is tough to be able to build-up plan of actions to be innovative (Baregheh, Rowley, & Sambrook, 2009).

1.1.4. Innovation in the knowledge literature

Innovation also appears in the knowledge-literature. There are several definitions and models regarding the knowledge-based process of innovation (Galunic & Rodan, 1998; Nonaka & Takeuchi, 1995). For instance, the study of Tsai and Ghoshal (1998) and Tsai (2001) introduce models describing the managerial innovativeness in organizations. They show the connection among innovation and knowledge creation. Although the models expose the importance of different processes of knowledge creation, they often break down when it comes to deciding if the new knowledge can be considered an innovation or not.

Information, knowledge, skills and ideas are regularly associated with each other (Woodman & Griffin, 1993). To be able to conceptualize innovation processes, this vagueness makes it difficult to be able to differentiate between existing knowledge, new information or ideas. If knowledge is well described, we can still find various approaches in the literature. Knowledge could be seen as an objective commodity (Bohn, 1994) (Bollinger & Smith, 2001) or a culturally created process (Blackler, 1995) (Cook & Brown, 1999).

Nonaka (1994) for example, uses an individual model for innovation, in which the basis of his model is the relationship between tacit and explicit types of knowledge. Nahapiet and Ghoshal's view is a social capital angle. They stress cumulated interactions in innovation which is a more complex aspect of knowledge that consists more forms of corporate knowledge. In the knowledge literature, the scope of knowledge investigation differs from the traditional innovation process methods. Machlup (1962, 1980) introduces

an innovation process method consisting of four stages that allows the stream of ideas.: research, invention, development, and application.

1.1.5. Typology of innovation

According to the innovation literature, the studies of Daft (1978) as well as Kimberly and Evanisko (1981) present typologies by explicit differences between administrative and technical innovations. On the other hand, Dewar and Dutton (1986), Ettlie, Bridges, and O'Keefe (1984) investigate another aspect of innovation, namely the difference between incremental and radical innovation, while Marino (1982) and Zmud (1982) isolate initiation and implementation phases of innovation. However, due to the page limitation, I would like to present the two most complete typologies, one from Damanpor (1991) and one from Thompson J. (2004). They cover all the above-mentioned typologies.

The first typology by Damanpour (1991) shows three pairs of innovation types, such as administrative innovation - technical innovation; process innovation - product innovation and radical innovation - incremental innovation.

The first part of the pairs, technical innovation, indicates service, product, and technology in the process of production, which are related to key activities of a firm. (Damanpour & Evan, 1984, Knight, 1967). Technical innovation is coming with a low level of formality, low level of centrality and a high level of professionality. The second piece of the pair is the administrative innovation, which is an indirect relation to the key activities of a firm and a "more direct relation to the management of the activities" (Damanpour & Evan, 1984; Kimberly & Evanisko, 1981). This type of innovation is coming with high level of formality, high level of centrality and low level of professionality.

The second pair is the product-process innovation, from which product innovation happens when a new product or service is introduced in order to fit into the market and meet its needs. The effect of this type of innovation is the gained benefit for the customers. (Utterback & Abernathy, 1975). Process innovation affects the organization itself and production level where it has been introduced to. The adoption of the mentioned innovations differs in the different stages of the organization. (Knight, 1967).

The first part of the third pair, radical innovation is considered, when a crucial reconceptualizing is presented in a business (Markides, 1998). This innovation is reachable

on three different levels. In a product level where a significantly new idea or technology is introduced. In a process level, where major changes can be found in the methods of how product or service is delivered. Thirdly, in a level where the two above mentioned levels are combined (Tushman & Nadler, 1986). Whereas, the incremental innovation refers to an improvement in products or services and on the existing processes (Leonard & Rayport, 1997).

The second typology of innovation is created by (Thompson J. , 2004) defining the creative innovation and the adaptive innovation. By creative innovation, he means the ability to achieve innovation within the organization's own system where the output is more likely a new product or service. Adoptive innovation means the capability to use a given idea or solution from outside of the organization and implement them in it, hence reaching a change of the system.

1.1.6. Characteristics of innovation

The characteristics of innovation can be identified based on its suitability for various organizations. In this sense, secondary characteristics of innovation take place, when a certain innovation might be different regarding the suitability in various organizations. Secondary characteristics can be complexity or costs. These are characteristics which could be seriously different in different kind of organizations (George & Mohr, 1976; Meyer & Goes, 1988).

On the other hand, primary characteristics of innovation do not vary based on the kind of organization, what's more, where innovation appears, it is closely associated with its context. Researchers like Damanpour (1991) or Dewar and Dutton (1986) identified another type of characteristic of innovation, namely the degree of the innovation and how it affects the firms' competencies. Whereas Tushman and Anderson (1986) classify innovation's characteristic based on how it affects competence.

Duplicability can not be avoided when it comes to the characteristics of innovation. It could give an understanding, how the innovation has been created, hence, it should allow the reproduction of the innovation process's result, without going through it again. For instance, if a product is created, the ones who created it, should achieve the knowledge and skill during the process, to be able to create another product. Moreover,

it should be replicable in other organizations by just transferring the knowledge. Nelson and Winter's (1982) opinion is that an innovation can always be duplicated by at least the innovator itself. To be able to replicate an innovation, it has to have duplicable knowledge about how the product should be created.

Conceptualizing is also a type of character that an innovation can carry. The availability of knowledge is the key here because this makes the difference in adoption or creation. If the knowledge needed to adopt the innovation is available beforehand and this knowledge was used before, the players replicated or adopted the given innovation. If the knowledge was not available or not used before in a certain context, the players have to go through the creation process, therefore they create an innovation which existed in another context or did not exist at all.

Usefulness shows the degree of how an innovation can improve on a given situation (Dosi, 1988; West & Farr, 1990). This characteristic is useful for making a difference between innovation and invention. The main difference is that while an invention is new, it is not necessarily improving a given situation. Usefulness also helps to show the decision of implementation. Machlup (1962) says that an entrepreneur needs to invest in an invention, which needs to be turned into an innovation, hence the entrepreneur expects a return on the investment he or she made. Of course, an innovation alone does not guarantee any success on an investment if the invention is useless or perceived to be useless.

Dougherty and Hardy (1996) highlighted that "the generation of multiple new products, as strategically necessary over time, with a reasonable rate of commercial success". The latter part indicates the idea of usefulness. Besides, usefulness not automatically refers to a product or an idea. It can be something generated through the innovation's application. It involves a social perspective since the players have to make a decision to make a use of it (Rindova & Petkova, 2007).

1.2. Research and development

1.2.1. Theory

The importance of R&D in the occurrence of innovation is highlighted in several studies, mostly in the theories of the endogenous knowledge-based growth (Romer 1990; Gross-

man & Helpman 1991; Aghion & Howitt 1992) and in the knowledge models (Etzkowitzand Leydesdorff 1995; Carayannis & Campbell 2009).

In order to achieve new innovative products and services, business R&D is crucial to have. Furthermore, it is also important to have an R&D relationship with other companies, organizations from other fields of the economy and share the knowledge within this network (Carayannis & Campbell 2009; Carayannis & Rakhmatullin 2014). The endogenous growth literature shows that innovation drives growth as a result of R&D activities (Grossman & Helpman 1991). An important part of this literature says that the rate of innovation depends on the previous amount of knowledge and the weight of the R&D input. Empirical studies suggest that the new sources of economic growth are R&D, education, and innovation. Large part of the above mentioned researches have discovered a positive equivalence within R&D capital and the degree of total-factor productivity(TFP) (Coe et al. 2009; Teixeira & Fortuna 2010).

The most widely used indicators of R&D factors are R&D expenses and the number of researchers. Empirical researchers find that the number of patents indicates the innovation performance, too (Porter & Stern 2000; Bilbao-Osorio & Rodriguez-Pose 2004; Bottazzi & Peri 2007). Other researchers mention the inefficient side of this concept to understand innovation, because it is not fundamental to patent all innovations. There is the increased price of patent protection process, thus there is a negative impact on companies' tendency to file a patent (de Rassenfosse & van Pottelsberghe de la Potterie, 2012). Therefore, the approach presented above will show a false picture of a falling R&D efficiency. Consequently, other indicator of innovation has been presented, like the one which considers given inputs and outputs from the innovation structure (Carayannis & Grigoroudis, 2014).Yet, because of the absence of widely available data, still, the number of patents is the most commonly used index to measure innovation.

The sum of workers in research operations has a positive effect on innovation (Porter & Stern 2000), while it is influenced by the R&D expenses (Bilbao-Osorio & Rodriguez-Pose 2004). Researchers widely accept that the cumulative R&D efforts makes the contemporary stage of knowledge, hence in long terms, the input of R&D is a critical aspect in the degree of innovation. According to Porter and Stern (2000), every country is able to improve its innovation by using other countries' knowledge stock, but the capability of a country to copy and use other countries' knowledge depends on its

human capital and R&D activities. Having said, a larger country's increase in R&D activity leaves a positive effect on other countries' innovation which then reaches a peak in 5 to 10 years thereafter (Bottazzi & Peri 2007).

In the long run, the elasticity of the applied patents versus increase in R&D expenses is expected to have an average of 1,5 rate (Rassenfosse & Pottelsberghe, 2012).This number is parallel with previously done researches, for instance, Jaffe (1986) finds that if every firm increases the R&D expenses by 10%, the business sector's innovation would rise by 20% and 50% of this rise would be assigned to research externalities. Zahra and Gerald (2002) investigated R&D capability, which they say is a dynamic competence in order to create and use knowledge and let firms to gain and keep their competitive advantage.

Cassiman and Veugelers (2006) agree on the positive correlation between firms' internal capabilities and the rise in research or development investments, besides having technological cooperation with external institutions.

Regarding the role of governments in R&D, Lerner (1999) show his results from his study that compared 1,435 US companies' performance, who received support from a governmental program called Small Business Innovation Research program (SBIR). The companies were compared to businesses that received no aid. He found that the ones, receiving a grant from the government grew at a faster rate, hence governmental R&D funding could be very useful for companies through enhancing their performance.

1.2.2. R&D internalization

Several, mostly multinational companies have changed from a centralized R&D to an international R&D architecture from the 1980s, in order to gain knowledge from other countries. The first-movers were technological firms, mainly from smaller countries where R&D resources were limited, as a result of the home country's market size. Firms like Novartis (Switzerland), Philips (Netherlands) or Ericsson (Sweden) and Belgian companies brought away at least 50% of their R&D from their home country. Companies with a bigger market share and larger R&D resources had no such pressure to move their R&D abroad. Such companies were GE and GM from the USA, Fujitsu, and Toyota from Japan or Daimler–Benz from Germany. They had to make the step to be internationalized after their market and industry faced greater competition, so they had to gain knowledge

from outside their home country on a global scale. We can speak about R&D internationalization as a trend from the 1970s, yet, it became a widespread phenomenon in the 1980s (Cantwell, 1995). The 50 largest R&D spenders in the mid-1990s in the world had an accountable spending in the triad countries which shows the importance of R&D internalization.

In the year 1986, Swiss and Dutch firms possessed more R&D labs abroad than within their home countries (Pearce & Singh, 1991). In the USA, during the period of 1985-1993, R&D investment in overseas countries was triple the amount than within the countries, reaching an overall 10% of all investments related to R&D investment abroad (National Science Board, 1996). During these days, European companies had 1/3 of their R&D expenses outside of the continent (Buderi et al, 1991). However, internationalization of R&D can not be performed without changing the R&D structure.

1.2.3 R&D structures

Based on the combination of Perlmutter's (1969) categorization and an empirical observation of his own, Gassmann (1999) created 5 structural forms of internalized R&D organizations. In the following section, I elaborate on the 5 different structural forms further.

1) Ethnocentric centralized

The ethnocentric centralized R&D structure is the one that utilizes the complete R&D concentrated in a domestic market. This structure expects that the home market is superior to the other countries regarding the knowledge stock and the level of technological development. It is also called the firm's protected "think tank", where new products are created which is then produced in other regions, other countries and sold worldwide. The crucial knowledge and technology which is the basis of maintaining the long-term competitive advantage of the firm, stay in the home country as a "national treasure". This structure enables the firm to protect an undesired technology transfer, besides it also helps running the R&D activity at low costs, due to the scale of the activity. Therefore, such R&D needs a given amount of capital and human resource. The flow of information is provided by the one location of R&D unit, the common understanding of the system and the standardized management system, hence a strong control can be used. (Gassman, 1999)

Regarding its disadvantage, the main problem with this centralized structure is the very limited amount of sensitivity to signs coming from outside of the market. Moreover, the structure of these organizations is very inflexible. Multinational companies should keep this type of structure just in the case of having all the necessary knowledge and technology within the R&D unit. For smaller MNCs, this structure is the most common one, due to its advantage in specialization, scale, and scope (Quinn, 1985).
Microsoft had a centralized R&D unit back in the 90's and it could compete with the other companies in the industry successfully both in domestic and foreign markets.
Furthermore, a company with a widely known, the well-established design does not need to internationalize its R&D activity. If a market originally had been provided centrally, there have to be special motives to relocate the R&D outside of the previous operation range (Utterback, 1994).

2) Geocentric centralized R&D

If a firm is planning to get involved in foreign markets and is facing a higher level of competition domestically, the geocentric centralized approach would overcome the ethnocentric centralized structure. This organizational structure can maintain the efficiency coming from centralization while opening doors to international R&D knowledge. It needs an increase in human capital investment in order to be internationally aware. They can opt for this with a centralized R&D site where technology and knowledge are gathered, however, R&D employees are sent abroad in order to collaborate and contact suppliers, manufacturers, customers and other R&D labs. This international presence can be enhanced by recruiting international or multilingual engineers or engineers with international experience. (Gassman, 1999)

Nissan, for instance, implemented this structure in the 1990's successfully when they were developing the Primera, for which the target market was Europe. They created a team of engineers who had European cultural experience due to previous visits to Europe. This was Nissan's first successful model introduction in Europe.

3) Polycentric decentralized R&D

The structure of polycentric decentralized R&D has been used from the 1980s by mostly European MNCs who had intense desire to be present in regional markets. In this structure several locally organized R&D units are operating, to achieve a more effective response

to local needs for product adaptation. There are companies created by M&A activity where the companies did not reorganize their original R&D units and did not make a use of the potential synergy. A structure like this is decentralized without any superior R&D unit. Within these units, the flow of information is more limited, mostly reports are made regarding the ongoing operations. These reports are than sent within the network. This process is followed by an evaluation form each director of R&D units, who report to the local management. On one hand, it can respond to regional requirements, besides it is capable of using local resources. Nevertheless, limited information is shared with the additional units, because the regional units' strong independence. It can also have the effect that the company loses focus from the crucial technology. (Gassman, 1999)

4) Integrated R&D network

Controlling all the units in the network, in case of the integrated R&D network approach, is no longer available for the home country. R&D competence centers can be found along with other interdependent units closely working together. Each unit has its own role in the R&D network, where the R&D competence units make the strategic and business development-related decisions, besides they are serving a "sensor" role, sensoring for possible changes all the time. Here, the essential characteristics are the expansion of each unit's competency and the enhancement of authorization of the competence center. For this, there is a need of creating a network where the importance is to boost the potential synergy among the units. A precondition of such network is a highly advanced IT infrastructure. Polycentric decentralized units are also able to reach a local market share, however, the integrated network allows to use the gained knowledge and skills for all the R&D units' to benefit from (Howells, 1990; Boutellier et al., 1997).

There are flexible connections among the units, which enables better use of skills and competencies. It helps the units to be specialized and lower the risk of duplicate developments. Every unit is specialized in a given technology or product, hence due to the gained knowledge, a given specialized unit can be considered as a leading center in its area. This unit is responsible not just for the related product R&D, but for the whole value creation process. It has the most solid knowledge of the given market and it coordinates the product creation and the introduction of the product world widely (Pearce, 1989).

For instance, Nestlé had around 21 R&D units in ten countries in the 2000s. The

coordination of the network was managed by 20 people from a legally independent company, besides they were responsible for the best synergy among the units. (Gassman, 1999)

5) R&D hub model

This model is centrally tight, reducing the danger of not using resources effectively while it also avoids the chance of duplication. Here, a given unit is responsible for the whole R&D operation and it keeps the leading role in some given technologies internally. The units in other countries are mainly working on already specified technological area(s). The center tightly manages the decentralized units. It has planned R&D programs for the long run and plans for the allocation of knowledge and human resources within the network. The structure allows the technology transfer to be efficient and provides a stable assistance for the network. It might happen that the main unit is established as a separated constitutional entity which owns all the technological expertise, hence IPs, too. (Gassman, 1999)

For example, Daimler-Benz's research and technology department was in Stuttgart, with five other R&D units in Germany, then in 1995, the first R&D unit outside of Germany was opened. They had two motives for internationalizing their R&D activities. Firstly, searching for innovation centers around the world. They had a unit in Palo Alto, USA, which was close to the biggest IT firms and Stanford University. With the help of this unit, they introduced a prototype car with features like integrated communication system, navigation, and internet, back in 1997. Their Indian unit in Banglore was created because of the high software productivity, hence they required input for their telematics, multimedia and manufacturing systems. Secondly, they wanted to locate the R&D units close to local markets, like in Shanghai, where they created a joint-venture unit that supported a subsidiary working on microelectronics. These activities were coordinated by given departments in Germany, therefore, researchers were traveling between Germany and China. (Gassman, 1999)

The positive side of this design is the quick responsiveness to local needs, while it keeps the R&D units' integration together. The innovativeness is coming from the various competencies and the different inputs of the units. Regarding the disadvantages, it has a higher amount of costs, due to the coordination needs and the possibility to suppress

creativity. The foreign units' size should be big enough to reach a critical mass of operation, but should not be too big, as to avoid unnecessary activities. In addition, the management level in the units should be consistent, for letting the fast information flow (Kuemmerle, 1997).

1.2.4. Tendencies in Research & Development

An international R&D organization is always about to change, in Grossman's (1997) research, he identifies four trends in the field of R&D.

The first trend is that the majority of the companies with centralized structure will adapt their organization to the international examples because they realize that their original R&D system has to be aligned with the international requirements. To be able to achieve this, they acquire knowledge from foreign innovation centers and are open to feedbacks and external information.

Secondly, if the firms feel that the product adaptation was pure or if the foreign development of technologies pressure is high, they create a so-called "listening posts". Usually, these are established in the technologically advanced countries. In this case the major input of know-how is coming with the mentioned form of knowledge gathering.

The third trend is coming from the technologically strengthened and more competent decentralized R&D units. Hence, the companies whose strategy included tight control, now give higher autonomy for them. The units' flexibility is increasing and their creativity is blooming while information freely flows and the units prosecute a given and well-defined mission.

In case of the fourth trend, a merged or acquired firm who had strong local R&D activity, after the M&A keeps its barely independent R&D. If the created firm recognizes the positive effects of integrating it, centers of expertise can be created resulting in an efficient international R&D mechanism.

1.2.5. Innovation hub

The presence of cities has been progressively rising regarding the new hubs of technological innovation. A shift can be seen towards an entrepreneurial activity in cities with various players. Studies investigating venture capital (VC) investments in the US show that it moves from suburban areas to city centers (Martin Prosperity Institute, 2014). Nowadays, San Francisco, for instance, has more VC investments than Silicon Valley,

which was the innovation scenery's main area, becoming a very large start-up environment in the US. It had $3.1 billion VC investments in 2013 (Endeavor Insight, 2014). This trend is not limited only to the US., it can be seen all around the world. The trend is the combination of indicators like density, proximity, diversity of people. What innovation parks were before, now organically growing cities become that (Athey et al 2008).

1.2.5.1 Indicators of innovation, competitiveness in cities.

In the upcoming section, indexes, indicators and main factors will be highlighted by different institutions and researchers. The most common ones are business activity, finance, human capital, government, social/cultural, infrastructure and information/knowledge. The following section reviews the indicators, which are driving innovation to cities that is followed by models for innovation ecosystem in cites will be presented.

Various research organizations have investigated the best measurements of competitiveness in cites. Hot Spots 2025 created a ranking of 120 cities, with the help of 32 indexes of theirs, which includes mostly qualitative factors and uses a grouping of 8 categories. These are the following: human capital, physical capital, institutional character, social/cultural character, economic strength, global appeal, financial maturity and environment/natural hazards (The Economist Intelligence Unit, 2013).

A.T. Kearney (2014) introduced the Global Cities Index (GCI) which is based on 26 factors, leading to five main categories such as human capital, information exchange, cultural experience, business activity and political engagement.

Solidance (2013) made the list of the most innovative Asia Pacific cities, where they used six categories in order to create this list about the area. Their factors were technology, society, government, global integration, human talent and knowledge creation.

The New York innovation index, which is using six elements, regarding resources towards innovation and the effect of innovation on the city. These elements are finance, R&D, human capital, high-tech gross city product, entrepreneurship/employment dynamics and IPs (NYCEDC, 2011).

1.2.5.2 Frameworks to better understand innovation ecosystem in cities

There are several studies that help in explaining innovation in cities through frameworks and through the review of those. In the upcoming section, I present 6 of the most important papers briefly.

Winden et al's (2007) framework was dedicated to find out what influences the

knowledge economy in cities. It was found that the cities' foundation quality and the organizing capacity highly affect the human capital generation and the knowledge-based industries, which transform into innovation afterward. As it is mentioned previously, this model investigates how to increase the knowledge economy of a city, which is divided into seven categories such as industrial structure, quality of life or leisure activities, infrastructure, scale, social equity, and diversity.

The framework done by Schaffers et al (2011) considers smart cities where all city-related economic activity and utility create the innovation ecosystem. The players of this framework include organizations and inhabitants who create the supply and demand for products and services.

Crowley's (2011) approach consists of three parts such as institutions, human capital, and urban firms or entrepreneurs. The core of these three elements is the firms and entrepreneurs, which are responsible for creating the demand and supply for innovation. Universities, governments, research centers compose the element of institutions. They are responsible for creating and spreading knowledge which is the basis of innovation. Regarding human capital, he comments "The concentration of highly skilled people in one place promotes the exchange of ideas and learning, facilitating the process of innovation.". By providing appropriate environment cities will be able to attract talents. The flow of this ecosystem starts with companies and entrepreneurs connecting with institutions and people as well as creating networks eventually. These networks make it easier to collaborate and help to create ideas and knowledge. Consumer and public procurement will push the demand towards new products and services.

Innovative city ecosystem in the eyes of the European Commission (EC) (2013) is processed linking together the people with places (built environment), public (public organizations/policymakers) through private (business). EC noticed how important it is to promote innovation and reach an economic growth in cities because more than 2/3 of European citizens live in an urban environment.

According to Bell (2014), there are nine factors transforming cities to an innovation ecosystem. Talent, right skilled human capital with passion; customers, who are buying products globally and locally; available capital, which helps to finance the developments of new products; academic institutions, who are the supply of skilled labor and the promoter of creating new ideas; heroes, who are the successful startups, being an example; guides, the ones who give help and advice; provide advice; support services, such as

governmental officers, lawyers, marketing firms, PR firms etc. ; gathering places, where the creation of ideas can happen and which promote "collisions" ; comparative advantages, which stands for the uniqueness of the given city.

The research, done by Katz and Wagner (2014) focuses on innovation districts, not cities, but some factors could be applicable to cities becoming innovation ecosystems. Three assets were identifiable in every innovation districts they examined. These are the physical, networking and economic assets. They call organizations, institutions, and firms, which somehow drive and support innovation as economic assets. Physical assets are allowing the collaboration and connectivity, which are the public and private buildings and infrastructure. As for them, publicly reachable spaces can serve as labs, where new products can be tested. Regarding private assets, start-ups can rent affordable office spaces. In case of the infrastructure, public transportation, the presence of sidewalks, bike lanes can connect the districts to cities. Lastly, the networking assets expression stands for the relation among the actors of the ecosystem. Due to the information or idea exchange and collaboration, these networks enhance the innovation, besides they can create conferences, workshops, informal events as well as hackathons.

Through the literature review on indexes and frameworks related to innovation in cities and innovation ecosystems in urban environments, four main categories can be indentified: Human capital or people; Physical assets or infrastructure; Economic assets and Government and policy or enabling environment. It also showed that an innovation hub could consist every type of R&D structured companies, governmental, financial and education institutions.

1.2.6. R&D collaboration

The increasing level of competition among companies makes knowledge creation and commercialization time to be cost consuming. This trend is more visible for tech intense firms where the pace of development is raising, the life-cycle of products is shrinking and the expense of capital equipment is increasing. As a reaction to these pressures, companies can replace their in-house R&D with an inter-firm R&D. In this case, companies can achieve R&D scale, share expenses and risk, get access to complementary resources and enter into new markets while dividing the development cost and risk (Tyler & Steensma 1995; Albors 2002; Ryall & Sampson 2003; Mariti & Smiley, 1983; Powell, 1990). According to Mowery (1988), the use of R&D collaborations is raising, however, studies

found a very high rate of failure in case of R&D cooperations where less performance was expected (Brouthers et al. 1997; Spekman et al. 1998; Madhok & Tallman 1998). Various reasons can cause failure when parties engage in cooperation. It can be caused by the wrongly selected co-partner(s) (Beamish & Inkpen, 1995) incorrect management structure (Sampson, 2004) or miscalculated need of communication and the level of management issues (Kelly et al., 2002).

In case of an R&D alliance, sharing knowledge between the partners is a huge coordination issue. Fortunate transfer of knowledge is not guaranteed, especially in case of complex and tacit information or knowledge. However, there is a huge dilemma, firms coping with, the level of incentive to share given knowledge or preserve that knowledge. The form of collaboration affects how profitable it is for a firm to collaborate because the structure of such alliance can affect the willingness and ability to share knowledge. What makes knowledge transfer more difficult is the difference in the partners' capabilities. The higher the gap regarding capability pool of the firms, the less favorable one partner's capacity for transferring knowledge and resources. According to Sampson (2007), who surveyed 463 R&D cooperation in the telecommunication industry, finds proof for these arguments. This type of cooperation has a deep influence on firms' ability to benefit from other partner(s) resources. Besides of the importance of effective knowledge transfer mechanics, it is also important to have a common aim of the alliance, so the incentives of partners to pool the necessary resources remain constant.

1.2.6.1 Partner characteristics and performance in cooperation

Ahuja (2000) argues that cooperation plays a role as the source of resource and information, besides it gives a positive effect on the partners' patenting activity and innovation capability. Baum, Calabrese, and Silverman (2000) investigated start-ups in the biotech scene and found that they were way more innovative through collaboration, hence alliances are contributing to a firm's knowledge stock. Obviously, the organizationally fixed resources are hard to transfer, even when partnering takes place. The characteristics of an ally have a strong impact on how smoothly partners can learn from each other. Lane and Lubatkin (1998) examined pharmaceutical and biotech companies and found that the greater the technological similarity and knowledge base, there is a greater chance of the cooperation's success. Ahuja (2000) for example says that technological similarity among

partners raised the number of patents after the cooperation. Even though the above-mentioned studies observed different industries and used a different way of measurement, the results are comparable. Therefore, high diversity in partner capabilities may reduce a firm's benefit of being in an R&D cooperation. Yet, if partner firms are very similar, they might also see lower benefits from the collaboration. In case innovation is coming from current capabilities but from a new perspective of combination, then besides a minimum level of R&D activities, the aggregation of similar knowledge and capabilities does not raise innovation.

On the other hand, according Keller (2001), partners with various capabilities have more to learn from each other. Combining different angles and competences leads to an increase in creativity and the ability to find novel solutions to existing issues. Empirical researches found similar results, hence supporting these arguments, although slightly in different contexts. Companies with different kind of alliances in their portfolio, like cooperation for manufacturing, R&D or marketing are more likely to get a central position in the industry network and reach a higher growth rate than others (Powell et al., 1996) Baum et al. (2000) had similar results, after analysing biotech companies. The ones cooperated with various partners like universities, pharma companies, and government labs were more successful than other biotech firms cooperating with only one type of partner.

These findings suggest that companies in an R&D collaboration benefit from the alliance if the competencies differ, hence allows the firms to combine their knowledge in various ways. However, the difference should not be so big in order to have an effective assimilation. The outcomes of such alliances can be direct and indirect. Firstly, regarding direct benefits, an example can be the gained capabilities from the partner firm to develop given products or services. Indirect benefits, for instance, can have a smaller learning curve or gained knowledge, which can contribute to non-alliance activities.

2.Autonomous driving

This section aims to provide an insight into autonomous driving, starting with it's history, levels of automation, which is followed by the it's benefits and disadvantages and ends with the future market possibilities of this technology.

2.1. Definition and history

The National Highway Traffic Safety Administration, which is a governmental department in the USA describes self-driving vehicles as in which "…the control of the vehicle occurs without direct human interaction towards controlling the steering, breaking, acceleration. The vehicle is designed in a way that the driver is not expected to constantly monitor the road while the vehicle is in autonomous mode." (NHTSA, 2013). The beginning of autonomous driving technology's development was around the 1970s and 1980s and showed the feasibility of cars that they are capable of controlling their own movements in different environmental conditions such as highway and urban streets (Dickmanns, 2002; Thorpe et al., 1988).

In Japan in 1977 a team led by S. Tsugawa showed the first truly autonomous car, meaning it could process data gathered from the road through cameras. It could direct itself recognizing white markers on the road (Forrest & Konca, 2007). California Partners for Advanced Transit and Highways in 1997 revealed a project called "DEMO 97". In this project, there were eight autonomous cars involved which drove 7,6 miles on an empty highway A famous German aerospace engineer in the 1980s called Ernst Dickmanns with the help of his team could reach more than 90km/h with their autonomous car, which was installed with cameras (Anderson et al., 2014). The project was so successful that he earned the nickname "the pioneer of the autonomous car" (Vanderbilt, 2012). In 1995, researchers of Carnegie Mellon University announced a trip called "No hands America". This was a series of autonomous cars every year presented by them and in their 5th year, the model called NavLab5 was capable of driving through the country with a 98,2% autonomy and for as long as 70 miles without human interaction (Vanderbilt, 2012). Developments in computing and sensing technologies further increased due to a series of races/competitions, starting in 2004, backed by the Defense Advanced Research Projects Agency (DARPA) in the USA. (DARPA, 2014)

There is a race course during which autonomous cars had to be able to navigate on their own and reach the finish line. The prize of the competition was one million dollars. The winner of the first year "only" reached 7,3 miles with its car from the 150 miles of the race. Next year both the prize and the number of applicants have doubled. University of Stanford won the competition by completing the whole course with a VW Touareg. In 2007, DARPA added a 4-mile urban part into the course with congested traffic. Several competitors have completed this complex part of the course. After adding the urban environment to the contest, the competition got huge exposure and brought high attention to autonomous technology (Vanderbilt, 2012). Companies like General Motors (GM) or Volkswagen (VW) started to cooperate with universities and established research centers in order to develop advanced autonomous technologies following the competition (Anderson et al, 2014)

The first big entrant to this market was Google, who hired the best engineers in this field and started working on autonomous technology solutions. In 2015, it seemed their effort put in is successful. Their autonomous cars have crossed the one-millionth mile on public roads in 2015 (Google, 2015). In the period of 6 years, while the cars were out on the roads, they were involved in 16 minor accidents from which all were the other driver's fault (Google, 2015).A new player in the automotive industry also stepped into the market, called Uber, who established its self-driving car lab in 2015, in order to create autonomous taxis (Kiss, 2015). Tesla is also well-known for its intentions in autonomous driving as they have been working on autonomous technologies for several years and in 2015 they released a software update with autopilot mode. Nowadays, all the bigger original equipment manufacturers (OEM) are working on their own autonomous car technology or cooperating with other companies to do so (Thompson C. , 2015).

2.2. Levels and current technology

Automation levels

The Society of Automotive Engineers (SAE) created the levels of automation, which is a scale from 0 to 5 (SAE International, 2014) (See Figure 1.).

Level 0

In a level 0 car, the driver is the one, who has the responsibility is over the car and for monitoring the environment. It is called "no automation", however, two systems which do not require human input still classified at this level. Firstly, warning systems like lane change assist departure warning and parking distance control. Secondly, emergency systems such as emergency breaking or anti-lock system can be found in level 0 cars (SAE International, 2014).

Level 1

Some parts of the driving process (lateral=steering or longitudinal=acceleration/breaking control) are executed by automated systems at this level. For the remaining part, the responsible is the human driver, who interacts in case of an object or event occurs, reacts and is able to switch on or off as well as overwrite the actions of the automated systems 3. These assistance systems are similar to automated steering and lane parking assistance and adaptive cruise control (SAE International, 2014).

Level 2

A car with of level 2 can execute parts of both longitudinal and lateral control. Human driver's responsibility is to monitor and respond to the environmental conditions besides that, supervise and switch on or off the systems when it is needed. In this case, the driver can put his or her hands off the steering wheel, however, needs to pay attention all the time and take back the full control in case it is needed. Advanced traffic jam assist can be a good example of level 2 automation (SAE International, 2014).

Level 3

Systems of level 3 can perform one or more driving task which includes the monitoring of the environment. Human driver, in this case, does not need to monitor what the automated systems are doing, however, he or she needs to be able to overtake the control within a certain response time. The automated system has to inform the driver asap if adaptation is required. Level 3 systems are for instance highway and traffic jam chauffeur systems (SAE International, 2014).

Level 4

Level 4 vehicles are designed to execute all driving tasks for the whole trip, but it is limited to the so-called "operational design domain" (ODD) of the given car, which means it does not work in every driving environment (SAE International, 2014).

Level 5

Lastly, level 5 is the one where full automation is reached. The systems are able to execute all aspects of the driving tasks in each environmental condition. They are created for running without any human interaction, where steering wheel would be an optional feature of the car. According to the definition in the beginning of this chapter, this level of automation is fully autonomous. (European Parliament's Committee, 2016; SAE International, 2014)

2.3. Benefits

1) Safety

According to the World Health Organization (WHO), around 1,24 million people die on the roads every year in the world (World Health Organization, 2010). The cost of these traffic accidents adds up to $260 billion per year, besides the cost of the injuries due to the accident adds more than $365 billion yearly. All in all, the result of traffic accidents reaches $625 billion in total, not mentioning the loss of lives (Morgan Stanley Research, 2014).

According to Eno Center for Transportation (2013), the main reason for death in the USA for citizens between 15 and 27 years, is traffic accidents. In the USA, 93% of accidents are caused due to human factors such as distraction, speeding or alcohol. If autonomous cars are adopted, it would offer the opportunity to lower these numbers. It is said that ultimately self-driving cars can reduce the rate of fatal accidents below 1%. However, the crashes would not be eliminated fully as some drivers would still prefer to control their vehicles.

2) Mobility

Nowadays, there is a huge ratio of people, who are not able to drive due to disability or being too young or old. For instance, just in the USA, there are 36 million disabled people, for whom it is very difficult to travel within cities by their own (U.S. Census Bureau,

2011). In case of autonomous cars, these people's mobility and wellbeing could be further increased. Moreover, thanks to autonomous cars, there will be higher space utilization because parking facilities would be moved to less costly spaces. Logistic companies would also benefit from this technology in different ways, but most importantly it will cause an increase in efficiency due to the vehicles running all day long. (Litman, 2017)

3) Reducing Cost of Congestion

Congestion is a huge problem in all of the larger urban areas. US citizens, for example, stay in traffic jams around 40 hours in a year with an estimated cost of $121 billion (U.S. Department of Transportation, 2015). In cities like Istanbul, Mexico City, Moscow and Rio de Janeiro this rate can reach more than 100 hours per year (Weindelt, 2016). In China, for example, 35 cities have more than one million vehicles and 10 cities have more than two million automobiles on their roads. In the bigger cities, more than 75% of all the roads are suffering from traffic jams during rush-hours. Generally speaking, the number of cars in China increased by 15% which amounts to 126 million cars, of which Beijing has 5,6 million (Shufu, 2016; Buckley, 2016).

A study done by Daniel Shoup (2006) shows that urban traffic's 30% is due to drivers are circling around business areas to find a parking space. Furthermore, it is estimated that around 23-45% of urban traffic congestion is caused by traffic intersections (West D. M., 2016). The static traffic lights or stop signs are not efficient anymore because they are not taking into consideration the flow of traffic. When a large number of autonomous cars would be presented on the roads, V2I communication could allow an optimized traffic flow in urban areas (Shoup, 2006).

4) Reducing air pollution

The use of cars is one of the biggest air polluting factors. Autonomous technology could reduce fuel consumption by 4%-10% than human drivers due to smoother acceleration and break according to a RAND study (Anderson et al., 2014). The study did not calculate with electrified autonomous cars, which obviously would further decrease fuel consumption. After analyzing their trips, Uber found out, that 50% of San Francisco and 50% of Los Angeles based trips were pooled rides with several passengers. Worldwide, this number is 20% (West D. M., 2016). Naturally, the more shared vehicles are on the roads, the less traffic congestion and air pollution will be seen. Eventually, there will be a move from the one driver per car, which would be beneficial for the environment. (West D. M., 2016)

2.4. Disadvantages and Challenges

1) Technological Challenges

Fully autonomous technology is not available up until now. Firms like Audi (Drew, 2013), Google (Scott, 2013), BMW (Stephen, 2013), Nissan (White, 2013) and Mercedes (Garvin, 2014) said that in 2-3 years they will commercialize level 3 autonomous cars, but to reach level 5, where the car can manage to drive itself in every weather and road situation, needs additional 10-15 years (Moore & Lu, 2011). The most important issue to be solved for OEMs regarding technology is to avoid that the system misidentifies obstacles and/or misclassifies situations which could lead to fatal accidents. In order to solve this challenge, the best tactic could be to start testing the technology in real life situations and conditions, hence having huge amount of usable data, from which by analyzation, OMEs will be able to identify problems before the commercial use of these vehicles. (DiClemente, Mogos, & Wang, 2014)

2) Cost

Currently, the cost of the technology used on the researched vehicles is enormous. In case of the Google Car, just the AV module costs around 80.000 dollars (Knight, 2013). It is estimated to be halved by the time of commercialization. So, for around an additional 40.000 dollars, cars could be equipped with AV technology, however, this price tag would limit the reach of these kind of cars in the early phase. According to Tannert (2014) to have such technology under 10.000 dollars, an additional 10 years is required. Moreover, a large positive network effect would require huge investments in the V2I and V2V infrastructure. After a critical mass is reached, these systems will be beneficial. It will lead to a more efficient traffic coordination and accident prevention. Therefore, the early adaptors will have less beneficial effect due to high costs, which would set back the pace of market penetration. (Tannert, 2014)

This challenge can also be seen as an opportunity, because if somebody can manage to achieve the same technology for lower cost, they would have the advantage to penetrate the market. A disruptive innovation can reshape the market before the launch. An example of these is the innovation of a 19 years old student called Lonut Budisteanu, who designed and created a fully autonomous car that costs 4000 dollars (Jaynes, 2014).

3) Labour Force Implications

A downside of fully autonomous cars could be that it will replace millions of workers' job. If we look at the economy as a whole, it may have a positive effect regarding efficiency or productivity, however, it may cause an economic shock and negative anticipation of the affected parties. The most affected industries are trucking, marine freighting as well as taxi, and it is estimated to have 1.701.500 truck drivers, 1.600 workers in water transportation and 233,000 taxi drivers, just in the USA (Bureau of Labour Statistics, 2012). For firms manufacturing AVs, need to realize this and start the discussion with the unions of the affected industries, to have a smoother launch of products. It is expected that Unions will achieve that similar to trains where engineers are needed onboard, operators will remain in the mentioned vehicles close to the controls. (DiClemente, Mogos, & Wang, 2014)

4) Security & Privacy

One of the biggest challenge to be solved is to avoid the possibility of hacking an AV, hence somebody else could take over the control. Other side effect is that if a car is hacked, the hackers could localize the owner when being on the way, and would be able to create patterns from the movements.

Steven Shladover and Jonathan Petit (2015) present various security issues related to connected cars, like hacking, data theft, jamming, sensor manipulation, or ghost vehicles. These actions could disturb communication and generate false readings for the system. Their research finds that the most dangerous attack on autonomous cars would be global navigation satellite systems (GNSS) spoofing and inserting fabricated messages (Petit & Shladover, 2015). Such manipulation could have huge risk for the passengers leading to serious accidents.

Since autonomous driving is based on V2I (vehicle to infrastructure) and V2V (vehicle to vehicle) conversation, it is very important to have a secured pathway in these systems, besides the other personal devices that include phones (Greenberg, 2015). For instance, cybersecurity professionals could remotely hack a Jeep Cherokee according to Wired magazine. They were able to influence the steering, radio, climate control, brakes and showed how easy it is to hack a car like that, and drew attention for the designers of autonomous cars how important is to create a secure system in self-driving car. All in all,

autonomous technology requires a much higher level of privacy and security in case of onboard solutions and personal devices. For this, manufacturers need to invest in the related fields of R&D.

5) Liability

In case autonomous cars hit the roads, liability from drivers will fall to the manufacturers or the companies supplying the autonomous technology. This means further costs for these companies in case of an accident, where a lawsuit with medical expenses is around $1-2 million dollars in case of non-fatal incidents. This means companies will minimize the liability risk by either improving the technology and delaying the market entry or putting some pressure on legislation (Miller, 2013).

6) Insurance

When speaking about liability, insurance immediately comes to mind. It is not sure yet, what happens with insurance companies, however, the expectation is that they would not see any significant change to the bottom line, hence they will remain neutral. Monthly insurance costs are expected to decrease since fewer accidents are forecasted to happen. Price of insurance can affect the decision-making process of buying a car. A CarInsurance.com's survey showed that without any decrease in insurance price, 20% of the respondents were willing to buy an autonomous car, while with an 80% discount on insurance, 90% of them were willing to consider buying a self-driving car (Mearian, 2013).

7) Bad weather

Weather can merely influence visibility and road conditions. In case of bad weather with heavy rain, snow or smog the visibility of road signs and lane marks are bad, therefore autonomous cars could make bad decisions, hence there is higher risk in these conditions since the technology relies on cameras and sensors. Rob Grant, Senior Director of Public Policy from Lyft says that self-driving cars "don't behave well in certain weather conditions or poor road conditions." (West D. M., 2016). Professor Mary Cummings strengthen this statement, by saying that fog, dust or precipitation make problems for Lidar systems by blocking the laser and interfering with the image detection competence. Due to this, the car would not be able to measure the distance between cars, identify signs, pedestrians or bicyclists (Cummings & Ryan, 2014).

8) Poor highway infrastructure

The lack of sufficient infrastructure in order to implement autonomous cars, affect several countries. For instance, 38% of the Indian roads and 16% of in Chinese roads are unpaved (Bhattacharya et al., 2014). While road conditions are not good enough or poorly engineered, either for a semi-autonomous car, it is hard to travel through those conditions. Again, the possibility of accidents arises, due to the poor decision making by the autonomous algorithm. Until it is not solved, the responsibility of autonomous cars should be limited. An analyst at Minzu Securities called Cao He, says that due to the various diverse road condition all around the world, it is very unlikely for any firm to be able to present a sizable solution within 5 years (Bloomberg News, 2016). Special cases for autonomous cars are bridges, because they represent very few environmental input, without any buildings, hence autonomous cars would have a hard time to find out where they are exactly, says Raffi Krikorian from Uber (Chafkin, 2016).

9) Public acceptance

Lastly, everything depends on how the consumers and public will feel about autonomous cars since it is a huge shift from common transport solutions. A survey among US citizens done by the University of Michigan concludes that 46% of their respondents still prefer traditional cars, 39% of them say that they prefer semi-autonomous cars and 16% prefer fully autonomous cars. When acceptance by genders is compared, 19% of men preferred fully autonomous cars, while 12% of women said the same. Division by age shows that 19% of young people (18-29), 22 % of people between 30 and 44, 12 % of people from 45 to 59 prefer self-driving cars, while in the group of people above 60 years old it is 10%. As for the features in autonomous cars, the majority (95%) of them said they still want to have the steering wheel, brake and gas pedals. 37% of the respondents were concerned to travel in a fully autonomous car, 29% were moderately, 24% were slightly concerned and 10% had no concern about it. (Schoettle & Sivak, 2016).

Asians, especially Chinese drivers show higher openness to self-driving cars. Results of a survey done by the World Economic Forum show that 75% of Chinese people are willing to travel in autonomous cars (Reuters, 2016). Roland Berger found similar results when investigating the same question. They measured that 96% of Chinese people

would consider autonomous cars as everyday drivers. On the contrary, for the same question, 58% of Americans and Germans answered in favor of the autonomous vehicles (Girault, 2016).

2.5. Future/market

The market of semi-autonomous and fully autonomous cars is estimated to be expanding from around 2020. According to Mckinsey and Co. (2016), in a progressive scenario, 50% of cars sold in 2030 could be highly autonomous and around 15% could be fully autonomous. BCG suggests that autonomous cars will need 15-20 years to reach a global 25% market penetration and if we take that, autonomous cars will hit the markets around 2020, for 2035-2040 autonomous cars will account for 25% of cars on the roads. For instance, just in China, forecasts say that 8,6 million autonomous cars will be on the roads by 2035, from which 3,4 could be fully autonomous. Hence, the automotive revenue pool will experience a huge increase, with the additional services like on-demand and data-driven services. With these additional services the pool can reach 6,7 trillion dollars, and without these services, the estimation is 5,2 trillion dollars. (Boston Consulting Group, 2016)

As mentioned before, the cost of autonomous technology, in the beginning, would be high, due to the extra cameras, sensors, and software in the car, so the adoption of autonomous cars for typical consumers will be slow. It is more likely that businesses and niche businesses will be the early adopters of this technology, such as ride-sharing firms, public transportation companies, delivery firms, taxis and industrial applications.

3. Hungary

This section is devoted to present Hungary's history, labour market and education, innovation and automotive industry, in order to understand the environment Hungary has.

3.1. History

Hungary's economy was mostly based on agriculture before World War 2, however, after that, the country started an aggressive industrialization. This period was under the communist regime, hence the majority of the firms were governmentally owned. From 1968 decentralization have been started and the number of private companies have raised.

Agriculture contributed around 50% to the country's GDP before WW2, which declined to 4% nowadays. Yet, 50% of the land in the country is arable and it keeps trying to be self-sufficient in terms of raw food (Tarsoly, 1997). In the 1960s, the country became a very dominant and advanced economy in the Eastern European region, however, in the 1970s, investments in both agriculture and industry have declined, even though the deficit of external sources have raised from 1 billion dollars (1974) to 15 billion dollars (1993) (U.S. Department of State, 2010). For the sake of boosting the economy, it asked for help from the World Bank and the IMF. The movements have done due to these collaborations, Hungary laid the basis of the post-communist' market-oriented economy. When the Soviet Union collapsed in 1990, most of the Eastern European countries lost their biggest export partners. József Antall was the first, democratically elected president of the country, who started market reforms, however eventually he caused a 10% budget deficit. In term of unemployment, 1/3 of the jobs were gone in the period of 1990-1995. It is also caused by the double-digit inflation rate. From 1990 to 1992, GDP decreased by 20% and the inflation rate experienced an over 160% increase, while unemployment reached 12%. Within the period of 1990 and 1992, the GDP decreased by around 22% while the inflation rate raised by more than 160%. (Spalovsky, 2008) Under the leadership of Gyula Horn from 1994, the economy faced a turnaround. He enforced aggressive privatization and as a result, more than 50% of the country's output was from the private sector. In addition, economic growth appeared with a yearly 5% increase rate after 1995, moreover, inflation decreased from 30% to around 9% (2000). Budget deficit of the country in 2000 was 3%. The economy's transition was so successful that more countries attempted to copy the process. In the period of 2000 and 2007 an average 4% GDP growth

could be seen. In 2014, the country has joined the EU, which opened the country's economy. This opening was successful, because 82,1% of Hungary' GDP was coming from foreign trade, while FDI accounted to 60%. (Szél, 2010)

3.2. Current Economy

Regarding the current economy, Hungarian and International organizations both agree that the growth will continue this year. In 2016 the real GDP growth was 1,8% (Portfolio, 2017). As for the 2017 year IMF predicts 3,2 % GDP growth (IMF, 2017), World Bank predicts 2,6% (Budapest Business Journal, 2017) and OECD expects 3,76% (OECD, 2017). Speaking about the unemployment rate, in the EU-28 it was 8,5% in 2016 (Eurostat, 2017) and it is expected to decrease to 7,5% in 2017 (Eurostat, 2017), while in Hungary it was 4,4% in 2016 (KSH, 2017) and expected to be 4,2% in 2017 (Világ Gazdaság, 2017). It is the effect of the economic growth, besides the retirement age was lowered and the government enhanced the inactive people to step back to the labour market.

One of the highest global value chain participator in the OECD, is Hungary (OECD, 2016) (See Figure 2.) This results from the high number of foreign firms presented in the country, mostly electrical and transport equipment producers. These segments of the economy require huge investments, hence the FDI coming to Hungary, is also high (OECD, 2016) (See Figure 3.) Behind the inwards FDI is usually MNCs, which use a high proportion of intermediates in the production of their products. However, these intermediate products are mainly coming from foreign-owned and not domestic companies. This is the reason, why domestically-owned firms, who are producing intermediate products are not successful integrating themselves into the global value chain, hence domestic value-added activities in the export products is relatively small. Moreover, domestic companies' contribution in other countries' export is also low (known as low "forward participation" in GVCs). In addition, domestic service providers could not contribute to the manufacturing segment as much as the other European countries' service providers (OECD, 2016), (See Figure 4.). Hence, domestic service providers missed a huge slice of the pie, with being unable to provide communication, design or marketing solutions for foreign-owned companies (OECD, 2013). Inward FDI concentrates on few segments as mentioned above. This is why, for instance, vehicle production segment accounts for 13%

of the total export, while 22% of all industrial production. However, little investment can be found in intangibles like digital economy or R&D, which are more knowledge-based activities. These activities are needed in order to enhance growth and contribute more in the GVC (OECD, 2015). Lastly, in Hungary, SMEs are dominating the market, but they are not competitive and the lack of innovativeness retains them from engaging in GVCs (See Figure 5).

3.3. Labour market and education

As the economy has changed in the last decades from being manufacturing focused to sectors with more technology focused, the required skills of the labour market has changed too. Hungary is catching up to the wealthier OECD countries when it comes to labour force, besides, as stated by the European Commission, it will climb in the GVC, which would require new well-educated professionals (European Commission, 2015). Employees with poor or dated skills (will) suffer from high unemployment rate (ManpowerGroup, 2015). Yet, the Hungarian education system could not respond to these needs quickly. While the number of enrolment to high schools increased, the graduates find it hard to get a job. Unemployment rate between 20-24 year is higher than the OECD average. The number of university students has also increased in the last decades, however, it is still low compared to other OECD countries. However, the ones who have tertiary education, earn a higher salary than the average OECD employee with a similar educational background (OECD, 2016) (See Figure 6). What is more, the number of graduations are increasing in fields, where there is no employment growth forecasted, which leads to an increasing mismatch between companies and the labour force. This creates an environment where employees end up in companies or fields that are not directly related to their study, thus this situation has a negative effect on their salary and productivity (OECD, 2014; OECD, 2015).

Hungarian labour market suffers from the emigration of young and skilled workers. From 2008 the number of these emigrants has tripled and now reaches 3% of the total labour market of Hungary. The government tries to address this issue and trying to mobilize through a new program called "Come Home, Youth!". This program includes covering settlement costs and a monthly 320 EUR wage for one year (Hungarian Spectrum, 2015). Other countries also granted the resettlement of skilled workers. Denmark, Finland

or Ireland gives tax concession for these workers (OECD, 2011). If Hungary could make visa and work permit processes easier, it might help by attracting foreign skilled labour from outside of the EU.

Speaking of education, the 2015 PISA tests' outcome is under the OECD average in all the assessed subjects. What is missing from the current education system is the required skills from today's labour market, like manage to solve non-routine issues in unfamiliar situations. Namely, the problem-solving skills of Hungarian high-school students are one of the worst in the OECD. The main reason behind this result is that the education is still content oriented and there is no space for knowledge application (PISA, 2015). Empirical research says that the better problem solvers are being employed quicker and for better positions (OECD, 2014).

R&D in the higher education concentrates natural, health and technical sciences. Businesses role is crucial when speaking about development through collaborations with Universities. The Hungarian Academy of Sciences (MTA), with several research institutions, is a dominant player in this sector, with an estimated 167 million euros of RDI allocated budget. The major collaborations between higher education and firms mean a long-lasting cooperation, where firms are supporting undergraduate and Ph.D. training (HIPA, 2014).

3.4. Innovation

According to The Hungarian National Economic Strategy, one of the primary priorities for the country is innovation and R&D. Investments in this field are increasing every year and the government also supports these activates by grants. In 2014, the total Gross Expenditure on R&D (GERD) was 1.429 million EUR, which was 1,37% of GDP. In 2008 this contribution was 0,9% (KSH, 2015), (See figure 7).

Smart Specialization Strategy (S3) was also made by the government, along with every other EU member state in a framework defined by the EU. Hungary's S3 was approved in 2014, which shows the direction of the country with six sectorial and two horizontal RDI priorities. These were created based on activities where the country has an advantage or has the ability to make knowledge-based growth (Nemzeti Innovációs Hivatal, 2014).

"Sectorial priorities:	"Horizontal priorities:
• Healthy society and wellbeing	• ICT (info-communication technologies) & Services
• **Advanced technologies in the vehicle and other machine industries**	• Inclusive and sustainable society, viable environment"
• Clean and renewable energies	
• Sustainable environment	
• Healthy local foods	
• Agricultural innovation"	

(Nemzeti Innovációs Hivatal, 2014)

Barely 50% of the domestic RDI expenses came from the business sector in 2014, with 690 million EUR spent in this field. The commitment towards R&D from companies in different sectors heavily varies. "The proportion of companies engaged in innovation is significantly different among the various sectors" (Deloitte, 2015).

According to Bloomberg's Innovation Index, released in January 2017, Hungary has jumped 3 places from last year, reaching an overall 27th place and 13th in Europe. According to Bloomberg, this jump is the result of the R&D and manufacturing sectors' increased performance (Bloomberg, 2017). The co-published Global Innovation Index, from WIPO, INSEAD and Cornell University shows that according to their measurements, from out of 127 analyzed countries, Hungary ranked 33. (WIPO, 2017) As for the Bloomberg's index, Hungary is ahead of its regional peers, such as Croatia, Slovakia, Romania and the Czech Republic. It also ranked better than Hong Kong or Luxemburg. In the EU, according to Bloomberg, Hungary has made the greatest advances (Bloomberg, 2017).

3.5. Automotive industry of Hungary

From the 1990s, vehicle production was shifted to developing or post-communist countries. It is represented by the increased production in Central Europe, in countries like Slovakia, Poland, Czech Republic and Hungary. This area has become a great production hub for the automotive industry because automotive manufacturers and suppliers are well

integrated into a global value chain here. Central Europe is close enough to Western Europe to be able to fulfill just-in-time systems run by OEMs (Havas, 2000; Jürgens & Krzywdzinski, 2009; Kaminski & Ng, 2005; Pavlínek, 2005; Sass & Szavaletz, 2013). Automotive is an indigenous industry, so Hungary remains to be a dependent "attachment" in the European production systems (Van Biesebroeck & Sturgeon, 2010).

The position of the country helped to become a strong production and logistic center in Europe, hence there are many logistics companies in the country. They are providing supply chain services, which enhances other fields of the ecosystem, too. The automotive industry of Hungary is flourishing, mainly because of the strong presence of manufacturing plants of vehicles and parts.

The country hosts over 600 automotive-related firms and in the industry-related sectors, more than 100.000 people are working. 100,000 people (KSH, 2016)

3.5.1. Hungarian Achievements in the Automotive industry

Hungary has contributed to the spread of automobiles with many discoveries. The earliest example could be that in the 14th century, the wheelwrights made in Kocs, a Hungarian city were used to make a construction of a horse-drawn vehicle with steel-spring suspension. Hungarians called this vehicle "kocsi", which eventually become very popular in Europe and this led to the foundations of the foreign names like the English "coach", the Portuguese and Spanish "coche", the Slovak and Czech "koč" and the German "Kutsche" Coach-and-four was also invented by Hungarian inventors. (Bödők, 2003).

Jenő Farkas (HUN), József Galamb (HUN) and Childe Harold Wills (US) were the ones who designed the Ford T-model. Two Hungarians Donat Bánki and János Csonka have created the first petrol carburetor and patented in 1893 (Plesz & Kuti, 2013). Dr. Ferenc Anisits played an important role in developing the first eight-cylinder diesel engine (Katona, 2013).

3.5.2. Hungarian Automotive players in Hungary

Nowadays the automotive industry has a very important role in the life of the country. The sector's 90% is owned by foreign companies, however, the export and the manufacturing industry accounts for 4% of the GDP and around 10% if the parts and accessories are taken into account. In 2015, Automotive industry gave more than 30% of the total

manufacturing sector. With an approximately 17,8% growth rate (2015), automotive industry became one of the priorities to the Government. (KSH, 2016) (see figure 8.)

3.5.2.1 OEMs in Hungary

In this section, four OEMs will be presented, who are are operating in Hungary.

1) General Motors

In 1990, GM invested around 250 million Deutsche Mark (DM) to build an assembly plant in a town called Szentgothárd. They were assembling 13.000 Opel Astras, but the biggest part of the production was the 1,6-litre engine, from which 200.000 were made. Another 257 million DM investment resulted in the duplication of the engine production to 460.000 engines in 1996. Two years later, from 230 million DM, Opel built a gearbox factory, where 250.000 units were made annually. In 2008, Opel started the production of the 1,6 and 1,8-litre standard, EURO 5 petrol engines. Opel's latest investment was in 2011. The goal of the 500 million investment was to enlarge the engine factory and be able to produce 500.000 engines yearly. Due to this investment, the number of employees reached 1.500 by the end of 2015. The latest investment enabled the factory to produce small and medium size petrol engines, and medium size diesel engines, from which all of them can fulfill the EURO 6 emission standard. (Opel, 2017)

2) Suzuki

Suzuki Motor Corporation has established the Hungarian Suzuki operations in 1991, with a 45 million EUR investment. They choose Esztergom to be the place for the factory. Initially, the production was done in a 350.000 m2 place, which for nowadays increased to 570.000m2. The first produced cars were the 1 and 1,3-litered Swifts. In 2007, Suzuki invested 50 million EUR and in 2008, the factory produced 280.000 cars. Currently the Swift, SX4 S-cross, and Vitara are produced in the Hungarian plant. (Suzuki, 2015)

3) Audi

In 1992 Audi Ag has made the decision to build its new engine site in Győr, Hungary out of 180 potential venues. Their choice was based on the good infrastructure, developed industrial culture, the qualified and cost-effective labour force and the tax benefits given by the government. Audi established the company with 2 million DM, and the production

of the 4-cylinder, 5 valves engines was started in 1994. In 2006, they choose to produce their 6-cylinder and 8-cylinder engines, besides moving the production of the TT coupe and TT roadster to Győr as well. In 2001, the Engine Development center was created. Audi A3's started to be produced also in 2001. The 10 millionth engine was produced in 2005. In 2009 they had 7.500 employees, which increased by 2.100 due to a 900 million EUR investment in 2010. The goal of the investment was to produce four different model fully in Győr, from the bodywork through the paintwork till the assembly. In 2013 the plant reached its maximum capacity while giving job for almost 15.000 people, with all the suppliers and service providers counted into. 125.000 cars are made annually in Győr, such as TTs, A3s, Q3s, and from 2017 the Q4s and all the engines provided by Audi are made in Győr. (Audi Hungaria, 2017)

> "We decided to establish a production unit in Hungary 23 years ago. Since then AUDI HUNGARIA MOTOR Ltd. has become the biggest engine factory and one of the most modern car production plants of the world. It employs 11,411 people. The central location of Hungary, the advanced infrastructure, the stable political and economic conditions of Hungary as an industrial site and skilled workforce all contribute to the success of our company. We are at home in Hungary."
> Peter Kössler, Chairman of the Board of Management, Audi Hungaria motor Ltd., 2015

4) Daimler

Daimler AG decided to establish a new factory in Kecskemét, in 2008. The goal of the investment was the production of the new series of model A and B. In Hungary's history this is among the largest greenfield investment with 800 million EUR value. In 2016 Daimler released that they are going to build another plant in Hungary from 1 billion EUR, by 2020 and create 2.500 jobs in addition to the initial 2.500. It is estimated that calculating with the indirect jobs, it will reach 10.000 jobs provided by Daimler. Nowadays, 180.000 cars are made per year. Model-wise, the B, CLA, and CLA shooting brake are made in Kecskemét. (Mercedes-Benz Manufacturing Hungaria, 2016)

3.5.2.2. Suppliers in Hungary

In the 2000s, subsidiaries of multinational supplier companies have employed nearly 50% of the people working in the Hungarian automotive industry. The Hungarian supplier market can be split into two. Firstly the foreign-owned suppliers, secondly the local ones (Humphrey & Memedovic, 2003). The bigger, foreign-owned supplier companies usually Tier 1 or 2 companies, while the local companies often belong to lower Tier. Multinational companies have multi-plant organizational structure with plants across Europe, while local suppliers have a low number of plants in the given country (Sass & Szalavetz,

2013; Szalavetz, 2012). Global suppliers became major actors in Hungary after it became an important production hub in Europe. 14 out of the top 20 global suppliers set their foot in Hungary (Szalavetz, 2012). (See figure 10.).
In the following section, two global suppliers will be presented that operate in Hungary. They are the most active automotive suppliers in the country.

1) Robert Bosch

Bosch started its operation in Hungary in 1899, then in 1991 it reorganized the initial commercial company and started its production. Bosch quickly became the second largest industrial firm in Hungary. In 1998 a factory was built in Hatvan which is still the largest factory within the group's automotive division. Several products are constructed here, such as ABS, ESP, control units for automatic transmission, airbags, body electronics, complete dashboards and servo steering. In 2016 Bosch had 10 subsidiaries in Hungary, with a total turnover of 3,7 billion EUR, which does not include the trading within the group. In 2017 they employed 14.200 people. Bosch established its Engineering Center Budapest, where more than 1.600 engineers are working in the field of R&D. According to Javier Gonzales Pareja, the representative of the Bosch Group in Hungary "…every ninth Bosch employee in Hungary is a graduate engineer working in the R&D field…". (Bosch Magyarország, 2017).

2) Knorr-Bremse

Knorr-Bremse established its Hungarian subsidiary in 1989 in Kecskemét with the vision of producing breaking systems for commercial vehicles and trains. They opened an R&D Institute in Budapest in 1995. From the parent company's eight Centres of Competence (CoCs), the Hungarian subsidiary is cooperating with four of them as a production plant. In Hungary, they produce valves, actuators, electronic systems, and air treatments. Due to the size of the product portfolio, the Kecskemét factory is the second largest in Europe. In 2012 they employed 919 people. From the total 2,8 billion EUR total sales, 6,91% was directed to R&D activities. In 2012 they made a new greenfield investment, also in Kecskemét, from a 16,1 million EUR budget. This factory further increased the production by 10% and created an additional 110 new jobs (Knorr-Bremse Magyarország, 2016).

4. Research Methodology

In this chapter, the empirical part of the paper will be presented. Firstly, describing qualitative research, then introduce the research design, after that, presenting the data gathering method and finally the method of data analysis will be explained.

4.1 Qualitative research

Qualitative research stands for reflecting the complicated nature of our world. This type of research covers a wide range of methodologies and methods, which show the difference between qualitative and quantitative research. The variety of methods can be seen as tools/techniques how to gather and interpret evidences. As for the methodologies, they are showing the general strategy of the research. While quantitative research is more often used in natural sciences and is based on standardized measures, qualitative approach is relying on non-numerical data and mostly used in social sciences. (Staller, 2010)

The general design is more flexible, moreover the research question can change during the process of research. The research design has to be adapted to the researcher's new knowledge about the investigated topic. This is why there is a need for the researcher. In qualitative research, the researcher's role is being a(n) tool/instrument in the process. The data gathered by the researcher is filtered by him/her, based on his/her understanding of the topic and how it is interpreted afterward. The ground of the interpretation is experience, personality, and values.

In the process of data gathering, the researcher can be an insider on the investigated topic, or an outsider, who has no relation to the topic. Moreover, the researcher can carry out the observation without any interference or interfere by being a collaborative member in order to gather an in-depth understanding of the phenomenon. In both cases, the researcher observes the subject in "its natural environment" for the as closest and real insights as possible (Staller, 2010)

While quantitative research requires a high number of samples, the qualitative approach usually works with smaller, but more purposeful samples. Hence, the researcher is looking for participants who can give a better in-depth insight on the given topic. Therefore, in contrast with the randomly selected samples used in the quantitative approach, qualitative research requires purposefully selected samples.

There are several types of sampling, however, in this research maximum variation and snowball sampling were combined. Firstly, maximum variation sampling was applied in order to get to know various perspectives in the given study and be able to analyse the topic from all angles. It gives a diverse group of findings, which allows the researcher to expose contrasts. Secondly, snowball sampling was used to identify cases, from sampling people, who know people that are relevant to the given topic.

The data gathered in qualitative research is, as mentioned before, non-numerical, hence to collect them, observations, interviews, conversations or documents can be used or the mix of them. Rousseau and Tijoriwala (1998) sais that individuals are the most direct sources of data regarding the details of the psychological contract (Rousseau & Tijoriwala, 1998). Interviews are one of the effective tools in order to discover the interviewee's knowledge, experience, interpretation and perception of the topic. Interviews have different forms, depending on the timeframe, purpose, it can be decided by the researcher which one to use. We can distinguish between informal interview, interview guide and standardized interview. It can be applied to all of the listed interview forms, that they are usually recorded to not lose any important data and it allows access to the data after data gathering has happened. (Patton, 2002)

4.2 Research Design

Research design shows the general direction of the study. Patton (2005) sais, there are three groups of samplings, in qualitative research: naturalistic, emergent design flexibility or purposeful. In the first group, the researcher is very flexible regarding the process and allows the real-world situation to be presented without any external manipulation. In the second category, planning is used but, as the researcher gets to know more about the subject, adaptation can still be used. This approach gives the opportunity not being locked

in a predetermined logic and enables responsiveness. The third sampling category gives less flexibility, however in order to get deep insights about a given phenomenon, this approach gives precious information, from rich units like organizations or people. (Patton, 2005)

According to Keller (2010), the basic subject of the research is the unit of analysis, which gives an answer to the research question (Keller, 2010). These units can be projects, programs, individuals, departments, networks, markets, groups or organizations. Moreover, specifying the time, event and geographic context of the unit of analysis helps to give a better focus to the research. This research works with a small sample of individuals as interviewees, who are involved in the given topic.

The goal of the research design is also to find the relevant links between the literature review (Chapter 1,2,3) and the examined phenomenon. For that reason, purpose sampling strategy will be used in the research. When sampling was done, strategic groups were formed around the investigated topic. Eventually, three strategic groups were identified: government, education, and business.

Relevant data, like experience, perception and knowledge can be gathered from these fields for the sake of answering the research question. Therefore, as mentioned above, maximum variation and snowball sampling were used to find the best possible interviewees among the three categories by firstly, asking Martina Almasi, head of automotive division at HIPA (Hungarian Investment Promotion Agency), who can be a reliable source of information regarding the topic and than ask the interviewees the same (Kreutzer, 2016). Altogether, 24 people were contacted, from which seven accepted to make interviews with.

This purpose of this research is to find an answer for the research question, namely *"What environment is needed for an autonomous technology innovation hub, and if Hungary can become one?"*

4.3 Data gathering method

For the qualitative research data collection, methods can be personal experience, qualitative data, dynamic systems, empathic mindfulness, and neutrality. In order to gather qualitative data, observation, case study, interview and/or document can be used. (Patton, 2005). According to Handy & Ross (2005), having a face to face interview, can give more space and other aspects of communication can be observed, such as non-verbal information.

With the help of this technique, emergent challenges can be explored, answers can be clarified and eventually it gives a better understanding of the question. As the researcher has an active role, she/he defines the insights and experiences gathered through the interviews. The way how the interviewing should be done is being mindfulness and neutrally emphatic. This way, the researcher is not judgmental, but emphatical, hence develops a better understanding. This research uses qualitative data fieldwork and gathers primary data from interviews.

The interview itself is a conversation between the interviewer and an interviewee, and its goal is to gather valuable information and data, which can contribute to answering the research question. The interviewer has to ask relevant questions and listen actively, besides demonstrate fascination and engagement towards the interviewee. An interview can be done by face-to-face meetings or via telecommunication solutions, such as telephone or videophone. The discussions can vary from being unstructured to structured. Latter approach gives more space being spontaneous and allows adaptation in the topics, this is why it requires more time to execute an interview like this. In the prior approach, the questions are predetermined both in the wording and sequence. It is useful to use, when the time is the critical factor, besides having fixed questions, helps to compare with other interviews. On the flipside, individual thoughts can be missed due to this technique. These were the extreme sides of an interview and the task of the interviewer is to establish an interview guide between this two approaches.

This paper's interviews were semi-structured and each interview took from 30 to 55 minutes. In total, 285 minutes of interviews were done. All of them were in Hungarian

language and all the participants were secured, that the given information will be handled confidentially. The interviews were recorded and translated into English.

4.4 Data analysis

According to Bogdan and Biklen (2003), qualitative data analysis is "working with the data, organizing them, breaking them into manageable units, coding them, synthesizing them, and searching for patterns". (Bogdan & Biklen, 2003)
The whole process starts with categorizing and organizing the given data, then searching for patterns and critical themes from it. This process is called "open coding" within the qualitative content theory. (Corbin & Strauss, 1990). With the help of this process, the researcher can classify and identify categories into which the observed phenomena would be grouped.

The qualitative content analysis is a method, which classifies oral or written information into identifiable categories of similar meanings (Moretti et al., 2011). According to Hsieh and Shannon (2005), it is a research method, which works with subjective interpretation of the gathered text, through a systematic classification process, which contains coding and theme/pattern identification (Miles & Huberman, 1994; Hsieh & Shannon, 2005). In this type of analysis both deductive and inductive data analysis can be done, depending on the purpose of the study (Elo & Kyngäs, 2008). The inductive approach starts with codes, categories which are drawn from raw data. On the other hand, the deductive approach has preconceived codes derived from previous relevant research, literature or theory (Cavanagh, 1997).

This research is done with the inductive approach. Within this approach, open coding is used (Strauss, 1987). In the first step, the recorded interviews were typed down and then put into an Excel document, where they were analyzed with open coding technique.

On the one hand, this structure could control the rise of categories and codes, plus, it helps to maintain the center of attention on the research question (Ritchie, Spencer, & O'Connor). This approach also requires manual technique from the researcher in order to

get the insights from the researched units, and the researcher has to be capable of identifying the important data. (Suddaby, 2006).

5. Analysis of Interviews

This chapter will present the key findings of the interviews and present them in categories occurred during the coding process. The categories are: Government, Innovation, Investment and Autonomous cars.

The interviewees can be categorized into three categories, government, education, and business.

From the government's side, interview was done with László Palkovics, Minister of State for Education and commissary of "coordinating the Hungarian involvement in the connected, autonomous and electric cars' development and production". Secondly, Martina Almási, head of automotive division at HIPA (Hungarian Investment Promotions Agency) was interviewed. It is an agency under the coordination of the Ministry for Foreign Affairs, which aims to attract foreign companies to invest in Hungary or support companies operating in Hungary to expand their operations. Thirdly, interview via Skype, was done with Zoltán Rózsás, who is the education and R&D coordinator at ZONE. ZONE is a test track specially designed for testing autonomous cars.

From the education sector, interview was performed with Mátyás Hesz, Technical Expert at Budapest University of Technology specialized in autonomous driving solutions and with Dr. Viktor Tihanyi, adjunct at RECAR (Research Centre for Autonomous Road Vehicles).

From the business side, the interviwees were Peter Frank, Research & Development Director at Knorr-Bremse Commercial Vehicle Systems and Árpád Takács, Outreach Scientist at AImotive, which is an originally Hungarian, leading global provider of AI-powered self-driving technologies.

5.1. Government

Government plays a key role in the success of an innovation hub. They can encourage companies by giving indirect and direct supports. Indirect support can be a strategy towards a given mission, legislation help and dedicated institutions. Latter can be an investment and financial support.

5.1.1. Indirect support

As for the strategy from the government's side, they underlined the role of Hungary as an innovation hub in the field of autonomous technology. Mihály Varga, National Economy Minister of Hungary said that the government wants to play an active role in the new trends in the automotive industry. Interviewees from the business side said, that a clear vision and a systematic strategy is needed in order to achieve such goals and it can be done just with governmental support, which elements' presence is visible for them. There is also a so-called Industry 4.0 National Technology Platform, which's aim is to activate education institutions, research institutions, and businesses to make R&D in Hungary. This gives a platform for businesses to encourage high value-added R&D. The government wants to motivate Hungarian and foreign companies to use digital manufacturing processes and IoT, too.

This commitment can be seen also in the legislation. The legislation is normally very bureaucrat in Hungary, however with surprising pace, the government passed a law in March 2016, which sais that autonomous cars can be tested on Hungarian roads without any spatial or temporal restriction if the aim of the test is development. According to László Palkovics, this is the most liberal legislation for autonomous car testing in the world and the interviewees from the business side strengthened this statement and they are very happy with this legislation.

The government has established the National Research, Development and Innovation Institution and strategy in 2013. The main aim of this institution is to support Hungarian innovative activates, such as autonomous technology. Interviewed companies received support from this institution. It also aims to increase RDI expenditures in the country, and eventually become a more competitive economy. The target numbers of this strategy are first to reach a total R&D expenditure of 1,8% of the GDP, secondly, the business firm's R&D expenditures should be 1,2% of the GDP by 2020 (Nemzetgazdasági

Minisztérium, 2013).

5.1.2. Direct support

Other support from the government can be investments. The biggest project of the country now is ZONE, which is a multi-level testing environment for both normal and autonomous cars. According to Zoltán Rózsás, the key automotive players in Hungary, approached them that they would need a test track like this, however separately, for them it is not worth building such a track. This is why the government decided to invest 500 million Euros into this idea, and started to build the track in May 2017. Two working groups were created who helped the government what requirements should the project have. The first one was the automotive working group, consisted companies (BOSCH, Commsignia, Knorr-Bremse, Continental, EVOPRO, ThyssenKrupp Presta, TÜV Rheinland, ZF, AVL, NI and AImotive), one university (BME GJT) and governmental institutions (NKH and SZTAKI). Their job was to make a precise "technical specification of the elements of vehicle dynamics and physical structure of the automated vehicle tests". They also drafted the needed specifications of the autonomous environment and the related IT infrastructure. Lastly they made a "proposal for autonomous vehicle public road testing." The second working group, called ICT working group, was included IT companies (Ericsson, HUAWEI, Magyar Telekom, Nokia, Oracle, Siemens, T-Systems, Vodafone, Kapsch, RWE and Swarco), universities (BME HIT, BME KJIT) and governmental institutions (NFM, NMHH and Magyar Közút). Their role was to make a "detailed specification of the autonomous vehicle environment and related communication infrastructure" It was deigned by a leading supplier of measurement technology and systems for automotive testing, process, metrology, scientific R&D and QC measurements, called Horiba Mira. (ZONE Project, 2017).

The originally rival companies could cooperate with each other, in order to create this testing environment, which shows how important this topic is for them, and it is worth cooperating with each other, rather being hostile.

It is going to be a multi-level testing environment because, it offers real public road environment, controlled public road tests, controlled system-test, component and integration test, conceptual and feasibility test possibilities.

From these testing environments, the controlled system-test is the one which requires the greatest investment since a new proving ground will be built. The layout of this proving ground can be seen in the figure 11. It will contain offices, workshops, development centers, a research center and service providers on 265 hectares. On the test track itself there is going to be a high speed oval, dynamic platform, breaking surfaces, high speed handling course, low speed handling course, motorway, highway, rural road, service road, high speed oval, slopes and bad roads. Overall on this track platooning and cooperative vehicle control can be tested in different environmental situations. The necessary communication network will also be established, like 5G and V2X environment. Pre-installed data collection devices will offer the required data from the test, besides special data collection systems will be offered, such as drone and other robot based solutions.

The proving ground will be integrated into three real environment loops. Firstly, to the city the proving ground is built next to, Zalaegerszeg, which will be a smart city environment with full V2X communication, 5G, environmental impact measurement opportunity, database about the environment and external measurement infrastructure (drones, DGPS). A parking house will also be built with the ability of wallet parking. Secondly, the proving ground will be integrated into Hungarian motorways and highways, while new public roads will be built with intelligent road features like:

- Full coverage with ETSI ITS G5 station
- Full coverage with cameras
- 5th generation mobile (cellular) networks
- Meteorology stations
- High speed (>200 km/h) test section
- Variable Message Sign, road signs
- Complex – full services – rest areas
- Wrong way warning system
- Heavy truck park system
- Traffic management systems
- High precision GPS (DGPS, RTK)
- High-speed data connection (internet) at services points, WLAN
- 3D digital map

• C-ITS Day-1 Services

Besides the Hungarian roads, international roads will be connected to the real environment test, reaching Slovakia and Austria with a loop of Zalaegerszeg-Maribor-Graz-Zalaegerszeg. This solution requires several cooperations within the three countries and their universities, public road authorities, government, and association. The status of these cooperations can be seen in figure 12.

An interviewee from the business side highlighted one disadvantage regarding ZONE, namely that for Budapest-based companies, it takes 3,5 hours to go to Zalaegerszeg. And considering that they usually do morning and afternoon tests, with different software packages, it is very inconvenient to travel that much. If a regular 8 hour/day job is considered, only one test can be performed, because just the travel time is 7 hours. Hence they would need to establish an office at ZONE.

Zoltán Rózsás, who is working at ZONE, said that the greatest challenge for them is data protection regarding the tested prototypes and to win the trust of the future users of ZONE.

The construction has been started on May 19th, and it will be done in two phases and completely finished in 2020. Compared with other test track in the world, the government says, Zone is the most featured test track of all. (See Figure 13.)

Financial support is also direct support, which can help companies to establish new operations or expand current operations in the country. The government gives different kind of incentives, which can be refundable and/or non-refundable. The following incentives can be used for supporting automotive manufacturing operations: subsidy, based on government's decision; EU co-financed tenders; development tax allowance; training subsidy or job-creation subsidy.

Firstly, the subsidy based on government's decision is an incentive given for projects above 10 million EUR if no EU funds are available or above 25 million EUR. It is a non-refundable post-financed incentive.

Secondly, the EU co-financed incentives, are mostly tender based financing forms. The value of the project should be under 25 million EUR. The application of these tenders could be asset acquisition, new construction, renovation, job creation, infrastruc-

tural development, service development or financing human resources costs. These tenders can be both non-refundable or refundable.

Thirdly, development tax allowance is also available for the post-investment period. It can go up to an 80% corporate tax exemption for 10 years. The condition to be able to live with this opportunity is that the investment has to exceed 10 million EUR and should create minimum 150 new jobs. The second option in terms of the conditions is to have 3,3 million EUR investment and create 75 new jobs in preferred regions of the country.

The next type of incentive the government can provide is training subsidy. It can be 25-90% of the eligible training costs, depending on the number of new jobs created. Maximum 1 million EUR can be given for 50-500 new job creation and maximum 2 million EUR if new job creation exceeds 500. This is a non-refundable incentive.

Lastly, the job-creation subsidies are coming, which has two kinds of options. Both options are non-refundable incentives based on a governmental decision. In the first option, the amount of incentive is 1,1 million EUR/project and the project has to create minimum 500 new jobs. For the second option, only SMEs can apply, where the amount of subsidy is 4.000-7.300 EUR/ new employee. The condition of this option is to create at least 2 new jobs.

Péter Szijjártó, Minister of Foreign Affairs and Trade, said that from "Made in Hungary" we need to reach the label of "Invented in Hungary". This is why the government supports high value-added operations.

5.2. Education

The research showed, that for autonomous technology innovation hub, the most important to have is proper education and well-prepared students.

Education is strongly connected to the government since in the Hungarian education sector, most of the high-schools and universities are backed by the government, there are very few private institutions. All of the interviewees agreed that it is a marginal question that the universities can provide sufficient human input to the companies.

As the interviewees said, the Hungarian engineering education was and still is, a very high-quality education and this is what is needed when it comes to new technologies

like autonomous driving. The teachers are well-experienced and have industry knowledge. For instance, in the faculty of where Mátyás Hesz is working, 50% of the teachers are part-time employees at Knorr-Bremse and part-time employees at the university.

A program called RECAR (Research Center for Autonomous Road Vehicles) was made with cooperation of different players in order to examine autonomous technology and combine their knowledge and competencies and reach a higher level of research results.

The founders of this program are BME KJK (Budapest University of Technology and Economics, Faculty of Transportation Engineering and Vehicle engineering), BME VIK (Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics), MTA SZTAKI (Hungarian Academy of Sciences, Institute for Computer Science and Contol) and ELTE IK (Eötvös Lóránd University, Faculty of Informatics) with industrial partners, such as Bosch, Continental and Knorr-Bremse. They will execute basic and advanced research regarding AI, make co-operative control applications to vehicles, redundant technologies (sensors, actuators, energy and communication networks, software). They will investigate how can reliability be tested and improved, besides make research on data acquisition and property rights. Cybersecurity, driverless technologies, and accidents will be investigated, too.

Under the wing of this program, three new higher education programs will be started, two Msc. and one Bsc. Autonomous Vehicle Control Engineer is the first and Computer Science for Autonomous Driving is the second Msc., both taught in English. Prior, starts in September 2018, latter in February 2018 in Budapest. The Bsc program is called Vehicle Test Engineer and it starts in September 2018 in Zalaegerszeg. According to the interviewees from the education sector, these programs will provide competitiveness for the students who are taking these programs. Mátyás Hesz said that the aim is to ensure a quality supply of students, ready to be employed, this is ensured with the involvement of every interested participant.

Aside from these future programs, dual programs are already used by the major automotive players and Universities:

1) Kecskemét College, Mercedes-Benz, and Knorr-Bremse established a dual training, which aims to raise highly qualified mechanical engineers. Students have trainings in the companies and courses in the college.
2) Daimler and Kecskemét College made an agreement in 2010, and introduced a new specialization in Vehicle Manufacturing under the Faculty of Mechanical Engineering. A department called a Motor Vehicles was also established by Daimler, besides they have created an other dual-education program, too.
3) Robert Bosch Department of Mechatronics was created in the University of Miskolc from the collaboration between this university and Bosch. The main goal of theirs is to encourage practice-oriented education and research, in engineering sciences, mostly in mechatronics.
4) The Audi production plant in Győr has grew as big, that they are constantly seeking for qualified and skilled labour work. This is why they invested significant amounts into higher education and cooperation with Universities in Győr and Budapest. They have created dual programs and trainings. Every year 100 students finish this special education. Audi also offers internship possibilities for Hungarian students where, according to Audi, they receive competitive salary, career development opportunities even during the internship period. Under a cooperation agreement with the local Széchenyi István University, Audi has established it's Internal Combustion Engines Department (Audi Hungaria, 2017).

According to Mátyás Hesz, dual education is useful, because students can get used to the "atmosphere", while they continue their studies. In this case, time management could cause difficulties. The involved company would like to extend the work hours despite the fact, that the university has its own obligations, this might be cumbersome for a 19-22-year-old student, but after the initial difficulties, it could be bearable for the individual. So, they put young students under pressure or into the grinder, and it is not sure if it's for the good. They continuously suffer from lack of time, they must perform in multiple fields, their ambitions are elevated (although this can be positive sometimes). Mátyás always tells his students, to apply for summer internships, trainee programs and if it is possible they should write their masters' thesis at a company.

According to Viktor Tihany with the help of dual programs, students can get involved with projects without getting overwhelmed by their studies. He thinks the best

way to improve is to create their own developments, reading books is not enough, it only gives the basics. He gladly highlighted that their students give them a very positive feedback about their dual education system.

We can see that there is a contradiction between the two statements, which can be the effect of that they are working in two different faculties, with different business partners and the requirements of the partners could vary.

Apart from the dual degree programs, other cooperation between universities and business can be found, too. With BME, Knorr-Bremse has strategic cooperation, they give lectures in the university for example. Bosch, also give lectures in the faculty of vehicle control of BME.

AImotive has no cooperation with universities, due to the fact, that they are working at a different pace than the universities, besides, things change quickly in the company. If they had a task, which they could eliminate and they do not have the capacity for it, then they would outsource that task to universities, however currently, there is no such task.

Most of the interviewees mentioned the need for having a widen or fresher education structure. They already teach engineers not just the core courses for the given profession, but other courses like patenting, research methods, business development methods etc. However, it is not enough for the future of education. More radical change has to be done.

In László Palkovics's opinion, regarding the automotive engineer education, the deterministic control is outdated and the future is AI-based control, hence the education has to reflect this new wave. He also said that teaching how to handle and analyze big data is one of the key topics the education should focus. Besides, cybersecurity education is also very important in his opinion. This is why they created the RECAR program. However other interviewee mentioned that after they create a new curriculum and the first intake finishes the program, the initially formulated criterions will change five times, especially in the autonomous technology knowledge. Árpád Takács strengthened this statement, saying that the pace of this field is incredibly fast, and in 2 years every curriculum becomes outdated, hence it is very hard for the education system to catch up or follow the changes. Conventional vehicle-engineering, vehicle-designing, vehicle-oper-

ating and the related knowledgebase is degrading, basic level knowledge will be sufficient, to participate in the development of new technologies students must acquire a completely different education. Mátyás Hesz sees that those departments can succeed (electrical engineering dept., their traffic-management department), which can be specialized. It's inevitable to choose a specific topic to attract Msc. students, otherwise they will choose from other trending programs. At their department, they don't have specializations, although they could have environment-evaluation, localization, actuator related specializations and other courses related to these topics. He sais they have a bit of a lag, but they are not late. In his idea, the best solution to be extraordinary in a field, is to make the universities to find a specialization which they can focus on and push that. Like tyres in Karlsruhe or engines in München. So this is the challenge, education system and structure will face in the future.

The government can help universities with tenders, for which the universities have to apply, and present what programs, researches they want to start. For instance, just for autonomous technology research, the government gave almost nine million Euros to three universities. According to Mátyás Hesz when a program gets accreditation, it will be shown at "felvi.hu" (Hungarian online platform to apply for Bsc/Msc.), the students can choose this program. It always depends on the leadership of the institution, how can they secure their resources, how can they utilize these resources.

Another perspective was highlighted by Péter Frank, the supply of high-school teachers. He thinks that the teachers of science subjects should earn more than other teachers. Aside of this, he thinks that the career plan, the government has built for teachers, is working well.

5.3. Innovation

Péter Frank's opinion is that innovation is a clearly definable process, which aims to create new products and it is a strategic question to have. They have a systematic method how do they innovate. Approximately every ten engineers get a patent in their company. His point of view is that there are very few companies which bring substantive R&D to Hungary, they are one of them. It is because the foreign companies do not want to risk

their core business. The reason why Knorr-Bremse brought its R&D to Hungary, is that back in the '90s they outsourced some uncertain ideas to Hungary, and the results surprised the HQ. The Hungarian engineers invented ESP in Hungary, Knorr-Bremse decided to move here. Currently, the complete Advanced Engineering department is in Hungary. In his opinion, the success of innovation is the team and they are the most productive when being in "flow". The company develops breaking systems for commercial vehicles, in which they are market leaders. They do the complete R&D and services for the related products. They always have ongoing researches with research institutions and universities because they do not have the capacity to do basic research, therefore they outsource it to them. For example, now, they have a joint project with a university to develop nanocomposites. Knorr-Bremse does not know how to do it, the university is able to that, but they do not know what to develop, Knorr-Bremse knows it. In the past 20 years, they had 4-5 research projects, which turned out to be very useful for autonomous driving, which was not the initial aim of the projects and now they can use it for further developing this technology.

In his belief, innovation has an industry stabilization effect, because to relocate a production plant is manageable, however, to relocate R&D is way harder, due to the human capital.

Martina Almási thinks that the benchmark of innovation in Hungary is Bosch, because of the fact that there are the most engineers hired there. Currently, at the Budapest Engineer Center, 2500 engineers are working in different divisions, from which, one is autonomous technology research.

The automotive industry is a good indicator of innovation and since not just traditional automotive players are involved, but new technology and IT companies, it is one of the most innovative industry.

László Palkovics concluded, that it is important to attract multinational companies to bring their R&D here, but also Hungarian companies should have more innovative ideas, which then become their IP. Currently, Hungary is a labour-based economy, and the goal is to become an innovation-based economy. As he said, innovation in Hungary is not a goal, it is necessary to have.

Árpád Takács's opinion regarding being creative, is that more complex a language is, the more creative it makes the one who speaks it. This is why the Nobel prize/population index of Hungary is so high. They are creating full-stack software and hardware for autonomous cars. The aim is to process the bigger amount of pictorial data for small processors. When they were showing their innovation for investors, AImotive attached one single camera to a Mercedes-Benz vehicle, which was controlled with the help of one single processor, and it drove around Hungaroring (Hungarian F1 race track) successfully. These algorithms are based on AI.

They are a spin-off start-up company, from a former firm and they are relatively small in the automotive industry, hence they would need to cooperate with larger automotive suppliers to be able to sell their solution(s) for OEMs. The market entry of their full-stack autonomous driving software is in 5-10 years, however, in order to produce income, they are developing level 3-4 solutions for OEMs.

Regarding the future of automotive innovation in Hungary, the interviewees were convinced that large German OEMs would not bring their entire R&D activity to Hungary, and partial R&D relocation is also questionable. Therefore, Hungary should focus on smaller OEMs and attract those ones.

5.3.1. Innovation hub

Creating an innovation hub is a difficult project. It requires every element to be developed, such as infrastructure and education. It is very important to have a cause, around which the whole innovation hub can be organized. Innovation hubs become when somebody has an idea and forces innovation there. On the other hand, there has to be needed for the results of the innovation hub.

Education is indispensable to innovation hubs to be created. It "creates" the sufficient engineers, and creates a concentration of a given knowledge, which will attract companies to this hub. Both interviewed companies are considering to move there and establish an office there.

The government's role can vary in the creation of such a hub. It can support an already established hub or can be the visionary, who sets up the vision of it and later give support for the players. Secon

One interviewee mentioned, that it is also important to make the community interested in a given innovation hub. Under community, he means the given city where the innovation hub is established and the economic environment there.

László Palkovics's persuasion is that if the manager of Bosch has been asked to choose where would he start an autonomous car project in Paolo Alto, Stuttgart or Budapest, he would most likely answer, Budapest.

In Hungary, Zalegerszeg has the highest chance of becoming an innovation hub for autonomous technology, due to the presence of the test track and the fact that Zalaegerszeg will become a smart city, where urban autonomous mobility can be tested. Besides, sufficient students will be educated in the country, who will gain the necessary knowledge to work in a hub like this. The interviewees said, that Hungary is going in the right direction to become an innovation hub for autonomous technology. Most of the start-up hubs in Europe, like Helsinki or Berlin, were become a hub, because it was pushed to do so and there was no market pull or demand. Whereas, in case of ZONE, the key automotive players expressed their needs towards such a testing environment. Hence, the chance that ZONE and its environment can become an innovation hub is high.

5.4. Investment

Apart from the above mentioned governmental support, these could be the reasons why to invest in Hungary, and establish R&D operations there.

As mentioned before, the reason why Knorr-Bremse moved its R&D to Hungary, is that in the middle of the 80's, they have found the idea of ESP in Hungary. ThyssenKrupp for instance, went to Hungary because the first electric steering wheel was developed for them at BME. But usually, more general factors influence and investment decision.

Generally speaking, Hungary is facing a serious emigration, especially within highly qualified individuals, however, it does not affect the engineers that much, because their salary's real value considered high in Hungary. Hence, companies investing in Hungary, do not have to fear the lack of qualified engineers. It used to be said, that Hungary is the "cheapest price" country in terms of engineer manpower, by now it turned to "best price". Meaning that, for the provided quality, Hungarian labor force is the cheapest. In 2015 the

5th lowest average wage in Europe was in Hungary, while based on the labor cost/ productivity index, the country is one of the top alternatives for manufacturing plans. The official minimum wage is around 360 EUR, which is also one of the lowest in Europe. However, the low wage is not enough to establish an R&D center, the sufficient human power is needed. As mentioned previously, the Bsc and Msc. engineer education is very competitive compared to the western country's education system. Interestingly, most of the research institutes are in the district 11. in Budapest, where two important universities (ELTE and BME) can be found.

The other reason why foreign companies internationalize their R&D is that they do not have the capacity and manpower to operate in their home country. Regarding German companies, similar way of thinking and the attitude towards work are similar, these are also reasons why some German companies have invested in Hungary.

5.5. Autonomous car

This field is getting more and more attention in the automotive industry, hence in Hungary too.

It can answer the "driver shortage" question in Europe, with relieve the drivers and operate the trucks with higher efficiency. Knorr-Bremse in Hungary has developed a truck, which could do maneuvers in onsite locations, on its own. The driver can have a lunch or have a rest, while the truck is loaded, for instance.

The government has calculated how many engineers in Hungary are currently working on autonomous technology solution, resulted that it is more than 10 thousand people. Besides, the connected service providers and integrators, also employ around this amount of employees. As for the government, Hungary is in the frontline of autonomous technology and the conditions are suitable for staying in this position and strengthen it.

Knorr-Bremse's skills in autonomous technology are environment sensing, behavior planning, and motion control. They spend 10 times more money on testing these softwares than for example mobile phone software developers because the final product has to guarantee continuous and reliable operation. They think these functions and smaller driver assistant functions have huge potential in the future.

Advantages autonomous technology could bring:

- Eliminate the driver
- Lower emission
- Lower the number of accidents
- Optimal trip planning
- Mobility of elder, disabled and youngsters
- Jobs could be created

Open questions:

- Consequences of the autonomous car's decisions
- Challenges from the complexity of road conditions and environment sensing
- Jobs could disappear
- Cost of the technology

The necessity of autonomous cars is foreseeable; however, the time of market entry differs.

It is more effective to develop the technology to its fullest and enter the market, than forcing to enter the market as soon as possible. What is clearly visible, is what people thought about mobility in the last 150-200 years, will change dramatically with the use of autonomous technology.

6. Key findings

Regarding innovation, it can be stated that it is a process where something new is created, which process can be systematic. The usefulness of the given innovation can be questioned, though. In terms of the life of a country, innovation has to be a strategic question. Within the automotive industry in Hungary, there are few, but very strong automotive players, who are doing real innovation and R&D. From the idea creation to implementation, they cover all aspects of innovation. Innovation related activates are harder to relocate, hence it has an industry stabilization effect. This is why the Hungarian government has strong intentions to attract high value-added activities like innovation and R&D.

The research showed, that the most important environmental condition is education when it comes to establishing an innovation hub in the field of automotive technology. The Hungarian engineer education is competitive in Europe, however the need for modernization and restructuring of the system is visible. Modernization has already started with the creation of new Bsc. and Msc. programs, dedicated to better understand autonomous technology and give useful knowledge for students. However, some might say, that this technology changes so fast, that a rigid education system like the one in Hungary can not follow it up, so this is what the education system has to prepare for.

There are also dual programs, which gives students an industrial insight and practical knowledge, which makes their value higher. These programs are the result of cooperation between companies and universities. The advantage of these programs is that students could be faster integrated to a company with a smaller learning curve. These dual programs are successfully operating, mostly in universities, which are close to automotive firms. On the flipside, there could be drawbacks in such programs. Serving both parties' (university and company) needs might be stressful and could be hardly manageable for students. This depends on the agreement between the parties. The study revealed that there are differences in given dual programs in this regard.

Second most important factor when establishing an innovation hub for autonomous technology is the role of the government. They have to create a vision, around which an innovation hub can be established. The government has to create or support the development of the necessary environment. This environment could attract companies and labor

force. The research showed, that the Hungarian government is strategically committed to this topic, besides trying to help the affected parties with direct and indirect support in order to create a pleasant innovation hub environment. From which, ZONE as a direct support might be the most interesting. This project was created because automotive players in Hungary have notified the government about their intentions regarding this topic, hence ZONE was created based on the needs of these players, who were highly involved to what features a project like this should have. By now, several other automotive players showed their interests in the project, which gives a good feeling towards Hungary becoming an autonomous technology innovation hub.

Hungary chose this sector to focus on, because of the fact that automotive industry in Hungary, is responsible for more than 30% of the manufacturing sector's outcome. Hence, this is a strategic industry for the country and the future of this industry is autonomous driving and electrification. If the companies operating in the automotive industry can leverage these trends, the country will benefit from it, hence the intention of the country is these companies' success.

7. Discussion

7.1. Theoretical implications

Nowadays autonomous driving is a hyped and highly researched field. However, most of the studies and reports are investigating the economic, social and manufacturing aspect of it. In order to close the gap, this research's purpose was to find out the environmental needs for such a technology to be researched and developed, besides analyzed if Hungary has a chance to compete for being one innovation/ R&D hub in this field.

In the literature review, innovation was introduced and deeply presented its forms, typologies, and characteristics in the first place. It was followed by R&D theory, R&D internationalization and structures of it, then emphasize on the phenomenon called innovation hub and finally, the aspect of collaboration in an R&D activity was shown. Afterwards, autonomous driving was presented, started with its history, followed by the levels of automation and at the end of this section, benefits and challenges were displayed with future market potentials. The final section of the literature review was to understand the Hungarian business environment, therefore its history, place in the global value chain, education, labor market, innovation and place in the automotive industry was presented.
The empirical part of this paper further investigated, what opportunities Hungary has, to earn a strong position in the autonomous driving technology scene. In order to do that, business professionals, governmental workers, and teaching staff were approached to state their standpoints on this topic.

Regarding innovation, theory basically sais that the best indicators are the number of researchers and number of patents (Porter & Stern 2000; Bilbao-Osorio & Rodriguez-Pose 2004; Bottazzi & Peri 2007). It correlates with the research findings, interviewees always highlighted the importance of these two qualities.

As for the support from the government towards innovation and R&D, literature sais that companies received governmental aid are better performing than the ones have not received any aid (Lerner, 1999). This statement is in line, with what the interviewed business parties mentioned during the interviews, namely that all of them got governmental

support, which helped their operations in the country. What is more, they consider ZONE as a very useful investment from the government, which they would have never built on their own.

Speaking about innovation hubs, the literature highlights the importance of a centralized knowledge around which the hub can be established, like IT in San Francisco or software in Bangalore (Gassman, 1999). This is the standpoint of the interviewees, besides other features, were mentioned by them, such as having a clear vision with strategic alignment and a well-built ecosystem. However, it is clear that the most important factor is the human capital.

Literature review highlights different factors, which are influencing the success of an innovation hub. Factors such as human capital or people, physical assets or infrastructure, economic assets, government, policy and enabling environment are the main influencers. This research was specially designed to understand the need for an autonomous technology innovation hub. It has found that the most important factors are education and governmental support. The other aspects are also important, however, the level of importance of the above mentioned two factors are very high compared to the others. (Bell, 2014; Crowley, 2011; Katz & Wagner, 2014; Schaffers et al 2011, Winden et al, 2017)

Collaboration between firms, government and universities gives a higher efficiency rate for companies, according to the literature. Which was strengthened by examples the interviewees gave. All of them agreed that cooperation has a positive effect on their operations and results.

7.2. Practical implications

The research showed what can Hungary offer for companies who are involved in autonomous driving technology. Because the paper consists empirical research, which is based on interviews with industry experts, the findings of the paper would be relevant for players in this market and the involved institutions.

On the one hand, governmental players can derive valuable information from the research, like what are the current problems the business players are facing with, so the government can help in that given area. Generally, the interviewed companies appreciate the effort of the country and that the government listens to them and their needs.

The paper would also be helpful for the education sector to see, what changes are needed in the education system to satisfy the future market needs in terms of students' knowledge.

For business players, who are not aware of the Hungarian capabilities, this paper would provide a solid base for evaluating the opportunities in the country in the context of autonomous technology R&D.

7.3. Key limitations and further research

This study contributes to academic literature and managerial practices, too. Prior, gives a theoretical basis about the researched topic in order to find the answer to the research question, which afterwards was expended by an empirical research. This research was conducted with the help of qualitative research method and in-depth interviews with governmental, educational and business players. But, there are limitations of the given study, which could have influenced the results and findings.

Firstly, a limitation can occur from the weakness of qualitative research method. The data collected by the qualitative research is based only on the experience and personal perception of the interviewees, which limits the research.

Secondly, due to the purposeful sampling strategy, the total 7 interviewees can limit the findings gathered due to this small sample size.

Thirdly, because of the chosen data analysis method, the researcher is an instrument during the process of analysis. He or she interprets the collected data and recognize patterns/themes. Hence, the results and findings were influenced by this instrument, namely the researcher.

There were no OEMs interviewed when the qualitative research was done, which limits the research. If OEMs have been interviewed, symmetries or asymmetries could have occurred between the perception of the OEMs and the interviewed automotive suppliers. Besides, OEMs perception would have given a broader picture to the study.

The research was focused if autonomous technology can be researched and developed in an innovation hub structure and the necessary environmental conditions it requires. It did not examine which innovation or R&D structure would be the most efficient one to use for this given technology. Hence, it would also be useful to cover, in which structure autonomous technology can be researched and developed the most efficient way.

This research investigated Hungary's potential to become an innovation hub in the field of autonomous technology. However, the presence of the automotive industry is generally strong in the CEE countries and Western-Europe, hence it would be interesting to examine these countries' ambitions and potentials in this field and comparing them with each other, in order to find which country has the highest potential to become such a hub. On the other hand, it would also be interesting to compare different regions in Europe how the cooperation of some countries could end in case of an autonomous technology regional hub.

8. Conclusion

The intention of this research was to find out what environmental conditions are needed for an autonomous technology R&D hub and if Hungary has the chance to become one. This paper gave theoretical findings, which contribute to a solid theoretical basis regarding this topic. Empirical research has found correspondence between literature and the empirical research findings. What is more, it gave further insights into the ongoing, Hungary specific activities regarding autonomous technology innovation and the environment it can provide for a potential innovation hub.

The main finding of the research is that Hungary has a strong chance to have an innovation hub in this field, most likely in Zalaegerszeg. That city will be the first smart city in Hungary, besides an autonomous testing environment will be attached to the city, where autonomous technology R&D can be performed. Human capital, governmental support, legislation and the technology are available there.

In order to become and keep the position of such hub, most importantly, the education has to be modernized, its structure has to be reconsidered and eventually a more flexible and adaptive for new technologies educations has to be created.

This research has answered the research question: *"What environment is needed for an autonomous technology innovation hub, and if Hungary can become one?"*
It also gave theoretical, practical implications, besides possible limitations of the research and opportunities for further research were proposed.

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Appendixes

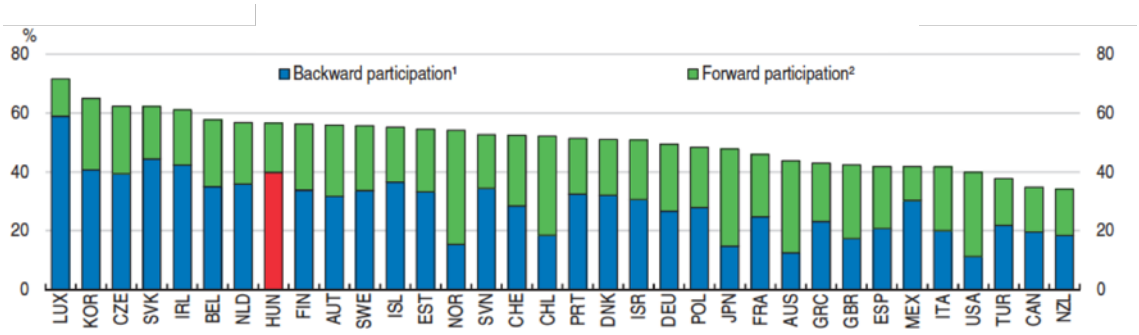
Appendix A: Figures

Figure 1.: Level of automation

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

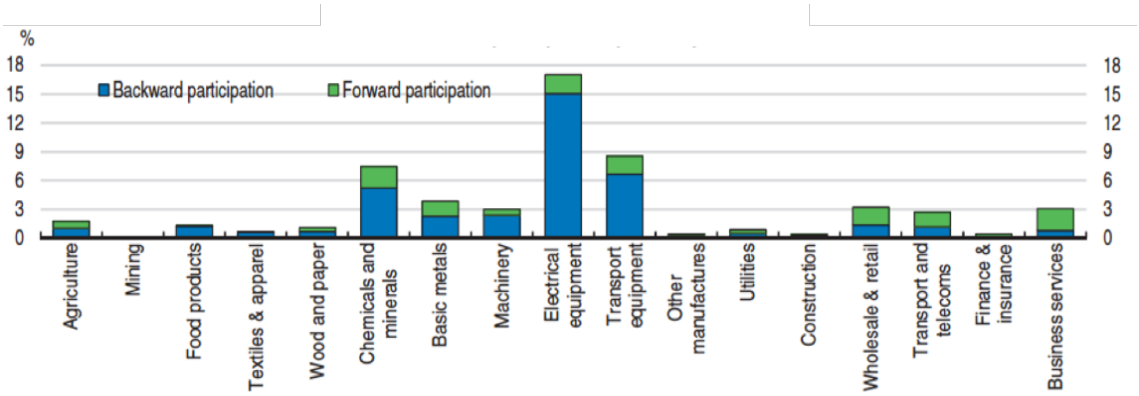
From SAE international (https://www.sae.org/news/3544/)

Figure 2.: Global Value Chain participation by countries



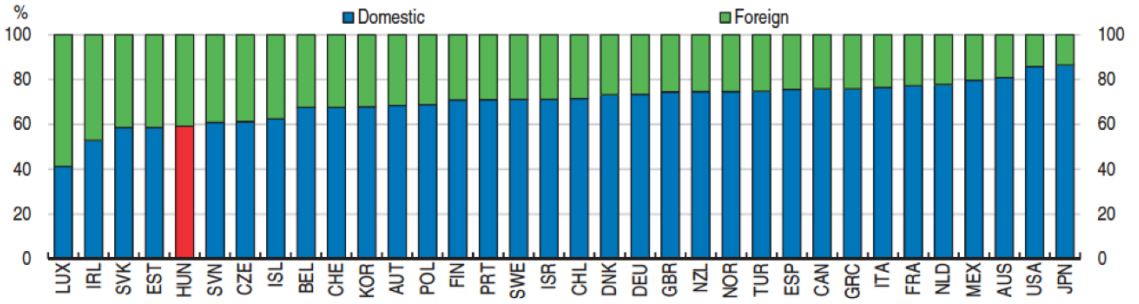
From: OECD Economic Surveys, Hungary, 2016

Figure 3. Global Value Chain participation by industries



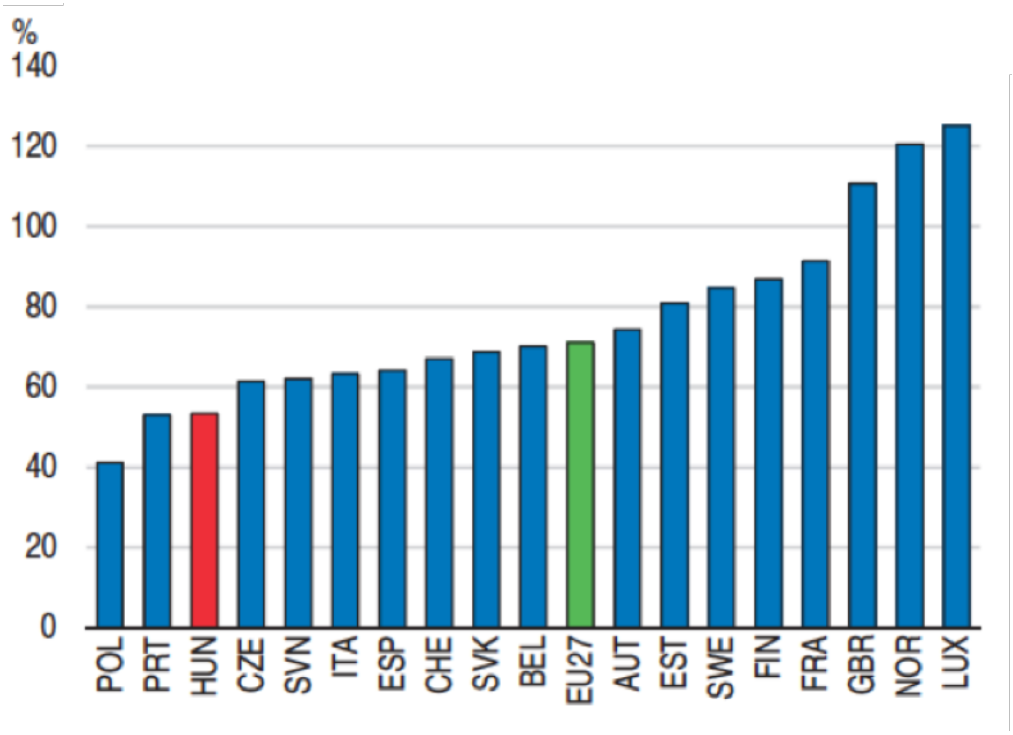
From: OECD Economic Surveys, Hungary, 2016

Figure 4.: Domestic and foreign value-added by countries



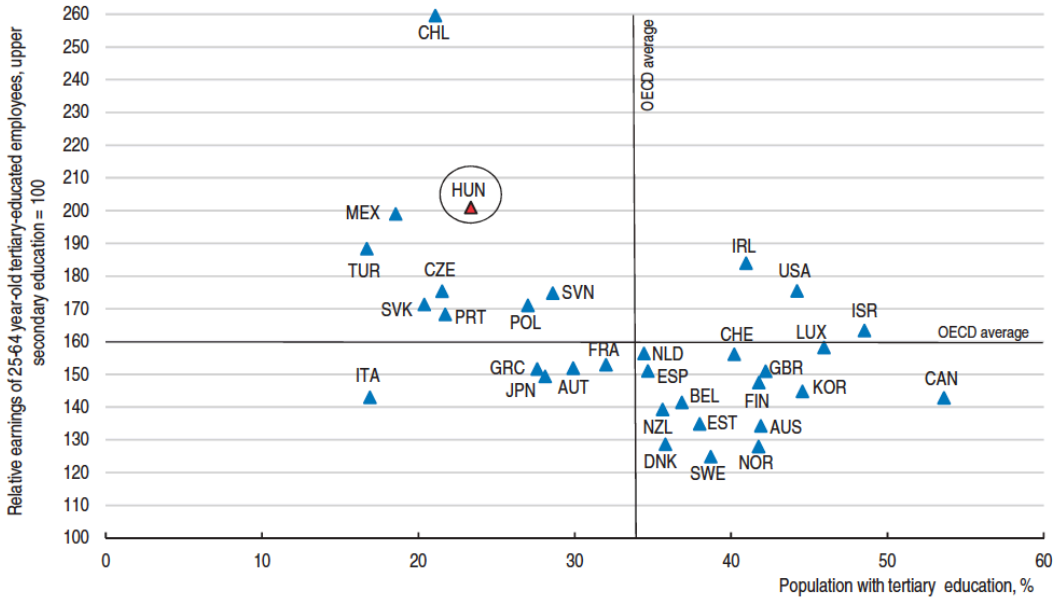
From: OECD Economic Surveys, Hungary, 2016

Figure 5.: Micro firms productivity compared to productivity of all firms



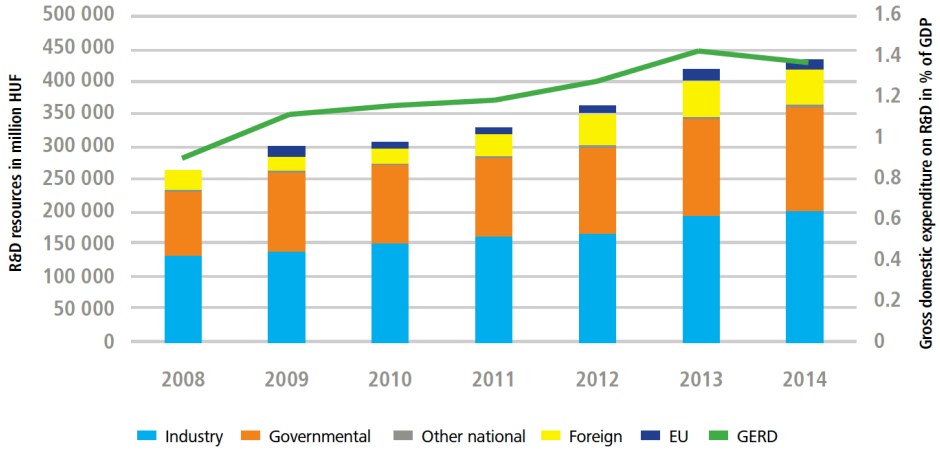
From: OECD Economic Surveys, Hungary, 2016

Figure 6.: Relative earnings of tertiary-educated workers and their share in population



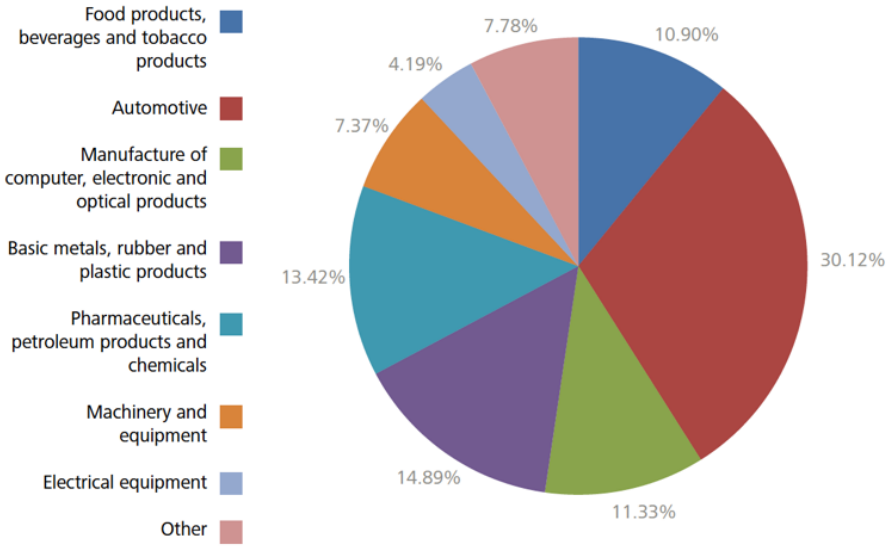
From: OECD Economic Surveys, Hungary, 2016

Figure 7.: Gross Domestic Expenditure on R&D



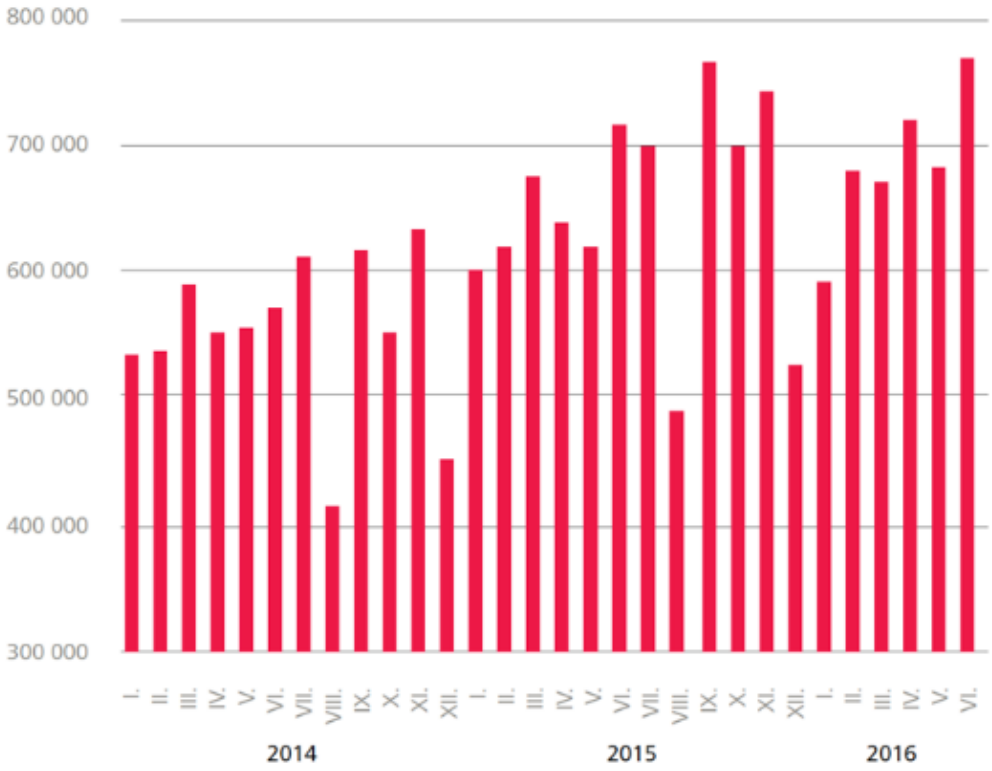
From: KSH (https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_ohk001.html)

Figure 8.: Segments of the Hungarian manufacturing sector (2015)



From: HIPA (https://hipa.hu/images/HIP/Manufacturing%20sector%20overview.pdf)

Figure 9.: Production of the automotive sector 2014-2016 (million HUF)



From: HIPA (https://hipa.hu/images/HIP/Manufacturing%20sector%20overview.pdf)

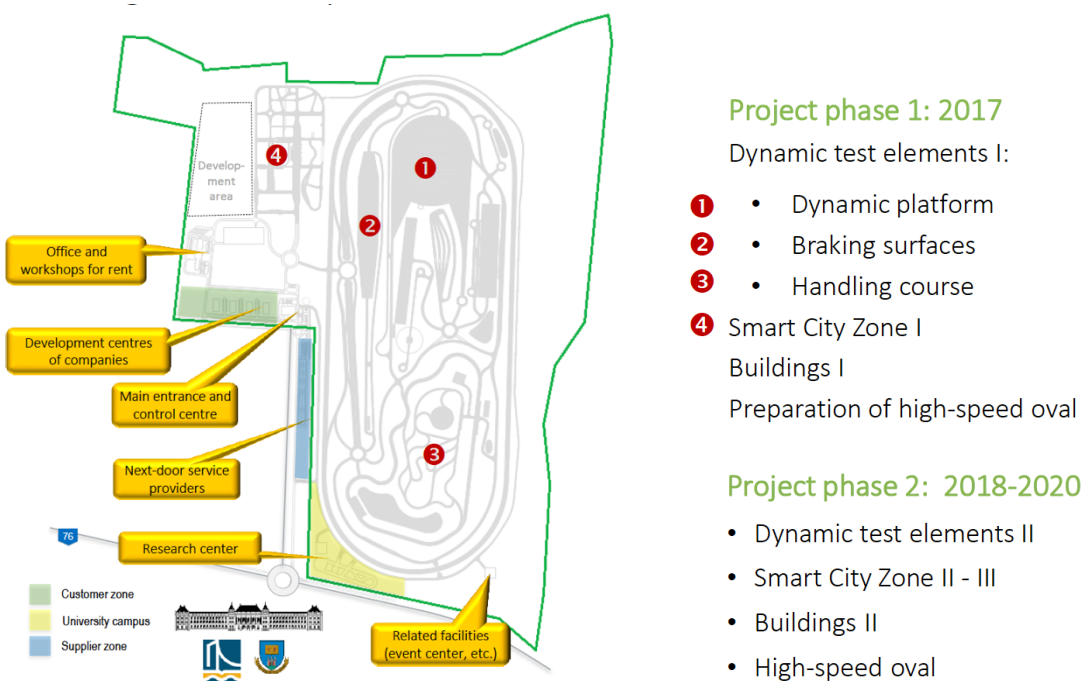
Figure 10.: Key automotive suppliers in Hungary

Supplier		Opening date	Location	Distance from Budapest (km)	Employees	Total annual turnover 2010 (million HUF)	Company profile
Alpine		1999	Biatorbágy	21	1,600	64,697	Top-quality car audio and navigation systems
BorgWarner		2000	Oroszlány	76	700	91,330	Turbochargers
Conti-nental	Continental Automotive Hungary Kft.	1990 1993	Budapest, Veszprém	121	2,718	66,148	**Budapest:** Production of electronic control units, inertial & oil sensors; **Veszprém:** Production of sensors for the automotive industry. Development Centre (sensor & software)
	ContiTech Fluid Automotive Hungária Kft.	1995 1999	Makó, Vác	201 40	1,609	34,855	Production of heating and cooling hoses and fuel hoses for the automotive industry
	ContiTech Rubber Industrial Kft.	2004	Szeged	173	454	28,058	Production of rubber conveyor belt systems and hoses
	Phoenix Airspring Technology Kft.	2004	Nyíregyháza	236	198	NO DATA GIVEN	Production of air spring systems for the automotive industry
Delphi	Delphi Hungary Kft.	1991	Szombathely	228	1,207	61,320	Manufacturing of electronic valves and tubes and other electronic components
	Delphi Thermál Hungary Kft.	1999	Balassagyarmat	87	850	37,680	Machining and assembling air conditioning compressors
Denso		1997	Székesfehérvár	66	3,488	119,068	**Production of:** diesel common rail components; system control components (variable cam shaft timing, electronic throttle control units and various valves); spark plugs; and fuel injectors for gasoline engines
Lear		1997	Gödöllő, Gyöngyös, Győr, Mór	30 78 122 85	5,000	129,186	**Gödöllő & Gyöngyös:** Production of electrical distribution systems; **Győr & Mór:** Production of seating systems and seat covers

Supplier		Opening date	Location	Distance from Budapest (km)	Employees	Total annual turnover 2010 (million HUF)	Company profile
Michelin		1996	Budapest, Nyíregyháza	236	1,800	135,751	Tyres for classic cars, trucks and agricultural machines
Robert Bosch	Robert Bosch Elektronika Kft.	1998	Hatvan	58	3,400	212,876	Automotive electronics components
	Robert Bosch Energy and Body Systems Kft.	2003	Miskolc	183	2,000	68,662	Electrical drives and starters
Sapa Profiles		2009	Székesfehérvár	66	1,100	73,517	Aluminium extrusions; structural parts, crush alloys, engine mounts, lugage covers for the automotive industry
Schaeffler	LuK Savaria Kft.	1996	Szombathely	228	1,700	117,132	Clutch discs, clutch systems
	FAG Kft.	1999	Debrecen	231	1,200	24,591	Production and distribution of rolling bearings and rolling bearing components
Visteon		1991	Székesfehérvár	66	1,450	75,282	Manufacturing of ignition coils, starter motors, turbine fuel pumps, fuel delivery modules/senders, air fuel charging assemblies, washer reservoirs and fuel pressure regulators
Zollner		1988 2002	Vác, Szügy	40 91	2,685	68,218	Production and service of electronical, electromechanical and mechanical products and systems

From: Szalavetz, 2012(https://link.springer.com/chapter/10.1007/978-3-642-25816-9_7)

Figure 11.: Layout of the proving ground



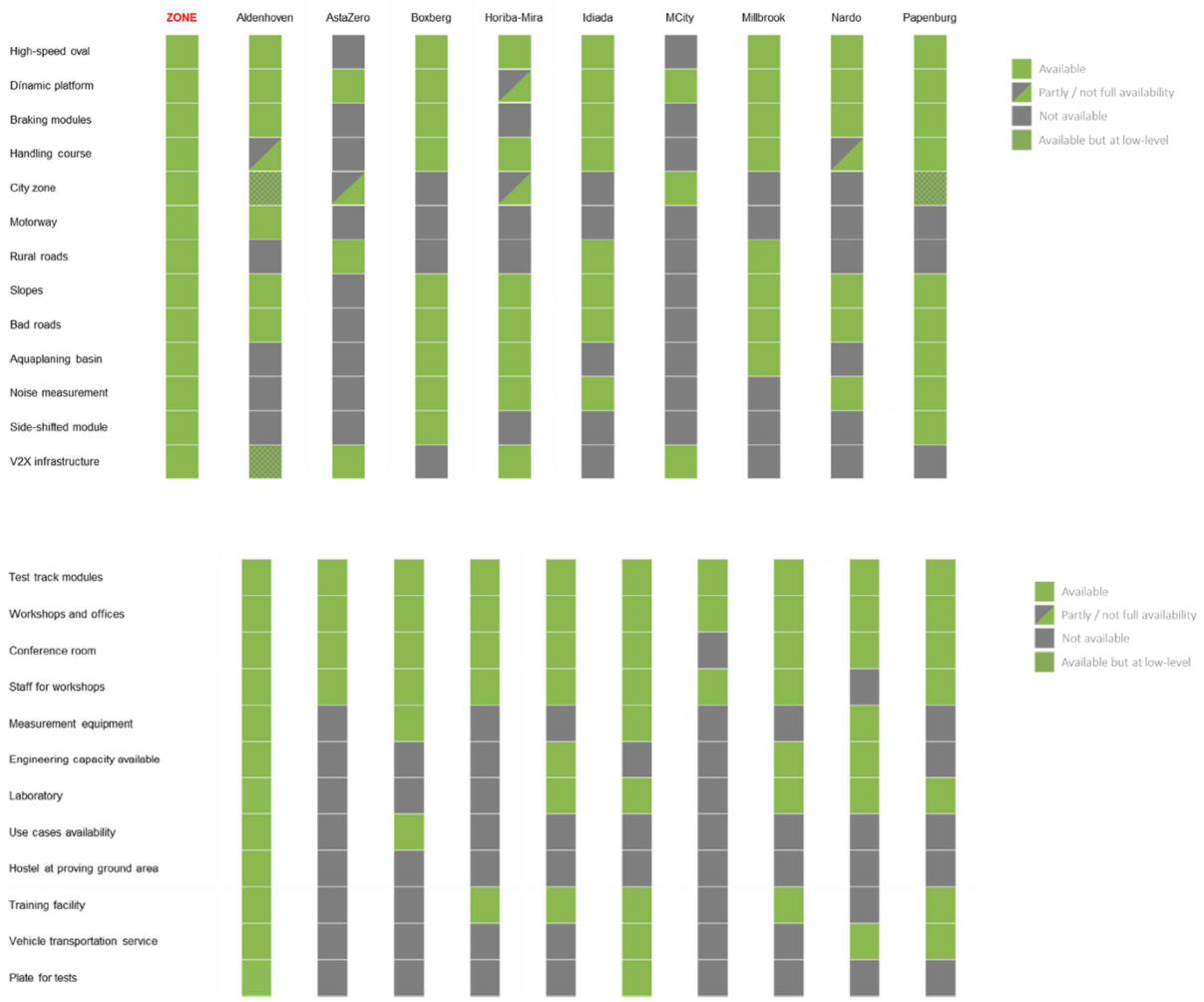
From: ZONE project presentation, 2017 (from László Palkovics)

Figure 12.: Status of cooperations

Level	Purpose	Party HUNGARY	Party AUSTRIA	Party SLOVENIA	Status of preparation
Government/ State	Set-up governmental and diplomacy support to the cross-boarder initiative	Hungarian Government Ministry: NGM/KKM	Austrian Government	Slovenian Government	LoI is being agreed via diplomatic channels
University	Establish education and R&D co-operation in fields of autonomus and electric vehicles	Budapest University of Technology & Economics	Teschnische Universitat Graz	University of Maribor	Signed
Association	Connect professional networks to enhance opportunities in the tri-lateral co-operation	„MAGE"	Autocluster Styria	Slovenian Automotive Cluster	Being prepared
Business	Utilize synergies of business programs in testing of autonomous and electric vehicles	Automotive Proving Ground Ltd.	Alp.Lab Gmbh	„Living.Lab"	Signed
Public road authorities	Align legal environment making optimal public road test environment	Magyar Közút Zrt.	ASFINAG	DARS	Being prepared

From: ZONE project presentation, 2017 (from László Palkovics)

Figure 13.: Test track comparisons



from: ZONE project presentation, 2017 (from László Palkovics)

Appendix B: Interview guides

Interview guide
Business

I am Marton Erdosi, a Double Degree student from Nova SBE and EBS Business School. My research investigates, what environment is needed for autonomous technology R&D hubs, and how can Hungary become such hub.
The interview will be approximately 1-hour long. All the information will be handled confidential. The gathered date will be used only in my thesis.

Part I. Introduction
This part will warm-up the discussion.

1. What is Your position and in which department are you working?

Part II. Innovation and R&D hubs
This part will explore the interviewee's perception regarding innovation and R&D. Besides show the expectations regarding this field.

2. What is the term innovation/ R&D means to You? What does it mean to a company/country in your opinion?
3. Why foreign companies internationalize their R&D activities?
4. Why did Your company choose Hungary?
5. What are critical factors in a successful innovation/R&D project?
6. Why do You think they are important?
7. What kind of R&D activities Your company have?
8. What is Your opinion on cities becoming innovation hubs? And why?
9. Is Your company cooperating with other companies or universities in the field of R&D and innovation?
10. If yes, how are these cooperations affect this activity of Yours?
11. What is the future of innovation/R&D activities within Your company?

Part III. Autonomous driving
This part will present the interviewee's knowledge about autonomous technology and show his/her expectation from his/her point of view.

12. What advantages/disadvantages autonomous technology can have in Hungary?
13. Which is Your company's main focus regarding autonomous technology?
14. Why did Your company choose that given focus?
15. What is Your expectation/forecast about the use of Your technology?
16. What is Your expectation regarding the potential application of autonomous cars in Hungary?

Part IV. Hungary's role
This part shows what does the interviewee think about the government's role in innovation and how can it support autonomous technology activities.

17. How do You see Hungary's ambition regarding innovation and R&D?
18. How can Hungary attract companies like Yours, who are working in this field?
19. How could Hungary better help these companies like Yours?
20. Does Your company cooperate with the government? If yes how?

Part V. Closing
This part will give the opportunity for covering uncovered, but important topics and potentially give potentially relevant interviewees.

21. Is there anything we did not talk about but seems important to you?
22. Do you have any questions?
23. Can you please recommend me someone who You think is interesting to make an interview with about this topic?

Interview guide
Government

I am Marton Erdosi, a Double Degree student from Nova SBE and EBS Business School. My research investigates, what environment is needed for autonomous technology R&D hubs, and how can Hungary become such hub.
The interview will be approximately 1-hour long. All the information will be handled confidential. The gathered date will be used only in my thesis.

Part I. Introduction
This part will warm-up the discussion.

24. What is Your position and in which department are you working?

Part II. Innovation and R&D hubs
This part will explore the interviewee's perception regarding innovation and R&D. Besides show the expectations regarding this field.

25. What is the term innovation/ R&D means to You?
26. According to your experience which R&D activity stands out?
27. Why do you find those two companies outstanding
28. Why foreign companies internationalize their R&D activities?
29. What do You think are the main motives for a successful innovation/ R&D activity?
30. What is Your opinion on cities becoming innovation hubs?
31. How can cooperation (with universities, companies, government, NGOs etc.) effect innovation/R&D?
32. What is the future of innovation/R&D in Your opinion?

Part III. Autonomous driving
This part will present the interviewee's knowledge about autonomous technology and show his/her expectation from his/her point of view.

1. What is Your opinion about the status of autonomous car technology in Hungary?
2. What benefits can autonomous technology bring?

3. What disadvantages autonomous technology have?
4. What are the challenges for this technology?
5. What is Your expectation regarding the potential market of autonomous cars?

Part IV. Hungary's role

This part shows what does the interviewee think about the government's role in innovation and how can it support autonomous technology activities.

6. How do You see Hungary's ambition regarding innovation and R&D?
7. What is the government's role in innovation/ R&D?
8. How can Hungary support foreign and domestic companies to innovate?
9. Why does the government want Hungary to become the European hub for autonomous car technology?
10. How does the government want to execute this plan?
11. How does the Hungarian government imagine its role in this field?
12. How can Hungary attract those companies who are working on this technology?

Part V. Closing

This part will give the opportunity for covering uncovered, but important topics and potentially give potentially relevant interviewees.

13. Is there anything we did not talk about but seems important to you?
14. Do you have any questions?
15. Can you please recommend me someone who You think is interesting to make an interview with about this topic?

Interview guide

Education

I am Marton Erdosi, a Double Degree student from Nova SBE and EBS Business School. My research investigates, what environment is needed for autonomous technology R&D hubs, and how can Hungary become such hub.
The interview will be approximately 1-hour long. All the information will be handled confidential. The gathered date will be used only in my thesis.

Part I. Introduction

This part will warm-up the discussion.

1. What is Your position and in which department are you working?

Part II. Innovation and R&D hubs

This part will explore the interviewee's perception regarding innovation and R&D. Besides show the expectations regarding this field.

2. What is the term innovation/ R&D means to You? What does it mean to a country in your opinion?
3. Why do you think that foreign companies internationalize their R&D activities?
4. What are critical factors in a successful innovation/R&D project?
5. Why do You think they are important?
6. What is the role of education in innovation and R&D?
7. From Your experience, which cooperation between Education and companies is the most exemplary and why?
8. What is Your opinion on cities becoming innovation hubs? And why?
9. What could be the role of education in such a hub?
10. What is the future of innovation/R&D in Hungary?

Part III. Autonomous driving

This part will present the interviewee's knowledge about autonomous technology and show his/her expectation from his/her point of view.

11. What is Your opinion about the status of autonomous car technology in Hungary?
12. What advantages and disadvantages can autonomous technology have for Hungary?
13. What is Your expectation regarding the potential application of autonomous cars in Hungary?
14. What it the role of education in autonomous technology?
15. How can universities support this technology?
16. Are/will be there any specific major (Bsc, Msc or highschool) in this field?
17. How can universities support companies in this field?

Part IV. Hungary's role

This part shows what does the interviewee think about the government's role in innovation and how can it support autonomous technology activities.

18. How do You see Hungary's ambition regarding innovation and R&D?
19. How can the government support universities to innovate and cooperate?
20. How can the government support activities in autonomous technology?
21. Are there any plans to do so?

Part V. Closing

This part will give the opportunity for covering uncovered, but important topics and potentially give potentially relevant interviewees.

22. Is there anything we did not talk about but seems important to you?
23. Do you have any questions?
24. Can you please recommend me someone who You think is interesting to make an interview with about this topic?

Appendix C: Interviews

1)Interview transcript (Péter Frank)

What is your current position and in which department are you working now?

I am a Research and Development Director at Technical Center Hungary. Knorr-Bremse has two main business branches, the rail and road utility vehicle lines of business. I manage developmental institution of the road utility vehicle business branch.

What does the term innovation mean to you? Respectively, what does it mean to the country?

It is a very general question. Innovation as a term is a very clear and easily determinable process in our institution. The aim of innovation is our duty to find out new products and create them. To create an innovative product based on a systematic process what has been developed during the last ten years and we apply it successfully. This systematic process based on a very creative and innovative method. We take innovative workshops in different regions and collect the ideas that are not criticized yet. The collected ideas are prioritized based on particular criteria. After the prioritization process, we create a shortlist of the potential eliminated ideas. This shortlist contains the most useful products. As a next step, we start new product conception projects to decide whether to develop the given product or idea or not. So, frankly to say, fifteen years before I did not believe in innovation and incubation, but today I see, innovation is a clear and systematic process. This system is more than sustainable with the new products and ideas that are continuously collected based on collective demand. As an example, approximately every ten engineers get a patent. These patents are as valuable as these worth to pay high patent fees after them. We have an infinite number of ideas, but the decisive majority of studies are not viable. Viability is decided by the profit and loss division of the institute. Financing of one project means to pay the patent fee of it for the following twenty years. This fact indicates very well to the success of innovation. The second part of the question refers to the meaning of innovation on the country level.

What is your opinion about, why foreign companies do their R&D activities on an international level?

This is determined by a certain company. As I see, our company is in a very special situation. Obviously, we have multinational competitors, but few of the competitors are able to bring substantial research and development to Hungary.

Do you speak German?

No, I do not speak German.

There is a German expression "verlängerte Werkbank", means extended worktable. Those foreign companies who have no domestic capacity to develop the certain products and/or ideas, they bring these projects and activities to Hungary. Mainly these activities/products are not innovative. Only a few foreign companies are able to bring substantial and innovative projects to Hungary. Is this phenomenon really happening, and if it is, what is the cause of these activities? All the companies and decision-making mechanisms are different in each case. Our company is a family-owned enterprise. The decision-making processes are relatively simple. The organizational structure of the company is relatively flat. The company size cannot consider as big. Our company employs twenty-five thousands employee, so there are bigger companies in the industry, especially in the automobile industry. Our focus is on a narrower segment of vehicles, the trucks; we do not operate pith personal vehicles. The other line of business with what we operate is the rail vehicles. To this flat organization, a smaller management team is more than enough to lead. Due to the organization structure, the decision-making processes are quite short. This company was established right after the regime change, we operate for 22 years. In those times research and development activities were not found relevant according to the majority. Meanwhile, the technological tertiary education was flourished due to the non-political nature of the field. So for the intellectuals of these times, technology field was the only possibility to evolve. Technology field was the more neutral one, against for instance studying business and economics, literature or history. Due to the high demand for studying technology, a lot of technical pieces of literature were translated to Hungarian from German, English or Russian. So, more literature was translated than it was necessary to a ten million population country. So this situation was very interesting. So, technology higher education was not suffering damages in the accursed times, especially it

was high-quality education and it is nowadays. The owner of the company realized this opportunity. What was nice at that times from the owner is the preference of innovative projects rather than repetitive and project with lack of capacity. Maybe, the reason of this hierarchy was the defense of "core business" and to keep risk level of activities low, the focus was on continuous innovative production. The uncertain ideas are for creative Hungarians, money is not important to play with here. Vehicle-dynamical measurements and controls were performed while these fittings were not frequent in automobiles at all. In case of automobiles, people think that sharp wimples are so cool and trucks are only shambling on the roads. However, we have realized that these fittings and measurements have a significant role at trucks to avoid upset on the roads what could block the whole highway for half a day and causes huge damages. So these fittings have a significant role in the production and these are serial products already. It is a specialty that the so-called Advanced Engineering division is in Hungary not in other countries. In this division, the focuses are on those products that will not be serially produced in the following five years and have no concrete buyer for them. Not even sure that we know to whom to sell these products, maybe a truck manufacturing company or a TIER1 supplier, or even to know how to fit these products into a which business model. So, these ideas have no guarantee that these are whether realistic or not. These kind of advanced engineering divisions usually do not come to Hungary; typically these stay in Germany. Germans consider it as a strategic step, in Hungary, it is not characteristic at all. So now, I do not know, did I answer your question or not.

Why did your company choose Hungary?

Yes. Obviously, this decision has a cost factor. Here the wages of engineers are lower, but not as low to have existential problems, as in case of doctors, who are rather going abroad because of higher wages. For engineers, the situation is different. There is a significant cost gap between Western Europe and Hungary, which should be maintained, otherwise, jobs will go away from our country. However, this gap is not as big to threaten the wellbeing of engineers in Hungary. It is well known, engineers' wages are high, so we are not suffering from labor migration to Western Europe. I even motivate them to go abroad, at least to our mother company or to other. They will come back soon because

homesick or family will bring them back home. However, they will have excellent living standards and they are going to have an adventure.

What are the critical factors of a successful R&D project?

There are a lot of factor of success, suddenly I cannot collect all of them. So I tell spontaneously what is come to my mind, I am not so prepared. I consider the composition and the abilities of the stuff as a key element. I put a huge effort into elect the best people to work with. Recently I have read, I do not know where maybe on Linkedin an article about whether to put higher effort on recruitment or training. The conclusion of the article said, the better strategy is to put higher effort to recruitment and selection, to higher to most educated and smart candidates, because it is easier to train them, their capability to learn is higher. Actually, from a bad material you can never get marvels, right? This is a management principle about the pulling force and those who have to be pull. To whom you have to focus? The dilemma is about to support those who are smart and effective or support the weaker ones, who have to reach a certain minimum level? To the strong, smart and tension employees. So, we have to focus on recruitment and selection process. Moreover, the external culture of the organization is very important as well. Simply, the aim is to create an environment where people like working.
So now I'm pretty much saying that the engineers are the most productive if we keep them in a flow. Practically, all internal processes and competition systems are available to apply for something internally, to understand the affinities of employees, in which field they feel comfortable themselves, and when they are the most productive. I try to find a leading direction, that employees always could be in a flow, to be satisfied, effective and productive. I have a focus on myself to continue being in a flow as well. I suggest it to everyone. There are available books on the topic even in Hungarian. Moreover, lot kinds of literature analyze the Hungarian case according to the flow theory. So, the human factor is critically important.

What research and development activities do your company do?

The core business activity is to produce utility vehicle braking systems. We are global market leaders. We are doing R&D activities related to all product groups. Moreover, we

are doing engineering services in case of the previously mentioned product groups. About the product groups, these are mainly brake control systems, basically electronic, pneumatic brake controls, including software, what is worth to highlight because these products present the highest complexity. We have projects from concept, development, and innovation through architecture, specification and implementation of simulation, labor and vehicle testing and approval processes relating to the mentioned product groups. Moreover, we have maintenance processes, like software facelifts. The other product group is the so-called air-preparation, the compressed air braking systems on trucks against automobiles what have hydraulic braking systems, it has technical reasons. The air-preparation is a compressor, air-dryer, and similar fittings. There is a quite big team, who work with vehicle dynamics and driver assistant systems, so with self-driving vehicles. Advanced engineering is a big division. Another division is the application group. These people doing the settings of finished products to different newer and newer vehicles. These people continuously traveling around the word to different vehicle producers to set the certain fittings like the braking system, blocking retarder or automatic emergency brake.

What do you think that cities become innovation centers, respectively why cities turn to be innovation centers?

It is a very important thing and it has signs, those government interactions to create innovation center in rural areas not only in Budapest. Unfortunately, it is a bad legacy from before the change of regime, that all Hungary is Budapest-centric. This phenomenon should be offset. To create hubs is necessary but very difficult and it is not establishing itself. This project requires the development of every element, the infrastructure and the road network to be able to reach one point from another. It is a key activity, right? To be able to go from one city to another, for instance, it is impossible to go to Kecskemét by train. It is a very complicate possible journey by bus or by car. At least we have highways. The next one is the education for all. So there are the innovation hubs, and these factors are extremely important. However, it is a huge work to make it real. This is a systematic and strategic work process. It must be done with absolute governmental support. But only in areas where are enough people. Obviously. Only in big cities are capable to maintain universities and high schools. What have enough periphery, those areas are attractive to

people. However, it is not sustainable without the industry which finances the whole concept. This is a very complex thing, but only sustainable if the country stops the Budapest-centric attitude. This concentration tendency is very bad, and I am sure, that rural big cities, like Zalaegerszeg, Kecskemét, Szeged or Debrecen are focus points. Talented children are everywhere. The ratio of talented children is the same in the capital and rural cities, so there is a huge potential to draw the children's attention to the importance of learning. To promote them the benefits of learning as higher living standards, good job, extended opportunities and future perspectives. However, it is a very hard job. I consider this mission very important. If a city reaches a critical mass than this process will operate well. To present it within an example, a new automotive test track will be built in Zalaegerszeg by a government investment, it was realized that it has a high potential to start vehicle test engineer training in the local college in an association with the Technical University. They started to organize yearly conferences together. There are happenings where we and the future user companies of the track are invited as well. This project will reach the maturity stage, but it cannot be predicted how many years are required. After a certain point, this project will exploit and employ engineers from the university by using the test track and relevant companies will set locations next to the track. For us, it is a possible perspective to employ test engineer from here. Our strategy follows this way because it has high potential to focus on talents from a complex project as the previously mentioned.

Does your company cooperate with other companies in R&D field?

Of course, we do. We were the first who have applied dual education in association with GAMF and Mercedes. As far as I know, today the third generation studying in this dual framework. Dual education framework has an upstream tendency nowadays. We just implemented two new dual master programs in association with Budapest University of Technology and Economics as an absolute strategic step. Twenty years before, our company was established between the walls of the university in rented rooms. We also work a lot with public research sites, as MTA (Hungarian Academy of Sciences), SZTAKI (Hungarian Academy of Sciences Institute for Computer Science and Control) and different professorships of the university. We are participating in different research projects. We have a very serious and important, so-called student program. Within this program,

bachelor and master students are able to choose thesis and dissertation topics from topics published by our company. Master students are more frequently apply to our topics. It is a win-win situation, students are extremely happy that they can deal with meaningful tasks. University is happy because they do not have to stress to find out new tasks to students because we are continuously exploiting new problems and tasks to solve. Meanwhile, our engineers are happy because students solve those problems for what they do not have time. Engineers are full of ideas, but they do not have for them, so I advised them to do a list about ideas for what they do not have capacity because of the deadlines' of mandatory projects. Engineers are creating a one page summary of the required tasks regarding their idea and students apply to do the task based on a senior engineers' ordinances. Students are so enthusiastic and engineers are satisfied. This relationship results from a mutual satisfaction, students learn from seniors, and seniors' ideas have come true. This is a win-win-win situation for the company, students, and university. We have a doctoral program as well. Basically, I prefer to employ students with master degree. During interviews, I always suggest to students with a bachelor degree to apply to a master program and then to our company. So I can only recommend it to everyone, respectively our doctoral scholarship program. Suddenly I do not know how many Ph.D. students do we have, but we have a lot. We have different Ph.D. topics and we also teach in the university.

Do these education associations have any kind of effect on R&D activities?

We experience a very positive effect on R&D activities. We continuously have research projects that involve research institutes. There are some topics or research field what we cannot do. For those researchers what require basic analysis, we do not have the capacity. We started a common project in association with John von Neumann University in Kecskemét, they are professional in polymers (plastics). The kick-off meeting of the project was before yesterday, we will develop new nanocomposites together, but have no capacity to these developments, but the university has. However, the university does not know what they have to develop exactly. This is a very cooperation between us with common interests. We have a lot of cooperation projects with other parties, but this came into my mind suddenly. Nowadays, everybody hypes these autonomous vehicles. During the last

four or five years, we had more research projects like this, partly in association with Hungarian partners and partly with foreign partners. For instance, we had a common project with Mercedes. We developed some kind of vehicle architectures that we did not know yet these could be used for autonomous vehicles. We started to rehash these architectures what are perfectly fit to current projects.

What is the future of innovation/R&D in Hungary according to your opinion?

It is only up to us. This is a strategic concept; the majority supports this perspective to have a high-level R&D research in Hungary and our company is the focus point. Basically, it is in public mind and it is a very good direction. Everyone can be anything, just have to work for it. My duty is to gather more high-quality projects to our company. As I am the company leader, my aim is the company development, to enlarge more valuable projects. Moreover, I have a sublimely kind of thinking about the value promotion of tertiary engineer education, because only the minority of the ten million people knows what engineers are doing. So this is a small elite society where we are now in this institution. But the majority even do not know what an incredible pleasure to be an engineer, and what a profitable profession. So the promotion of the profession is essential. The other thing that is frequently suggested by me is ksh.hu, the Central Statistical Office of Hungary and the interactive .population pyramid. This pyramid shows the current composition of the Hungarian population by distinguishing men and women in its two sides. This pyramid shows how many men and woman like in Hungary according to age. It can look like as a pine tree or a leafy tree. If the pyramid has pine tree form, that means the majority of the society is young, this is the healthy society where the continuous resupply is provided. Young people are keeping (finance) old men. So, the optimal is the pine tree form. The leafy tree means the majority of the society is about old/ older people. Western-Europe societies and Hungary are aging society. That means, when my generation will be the pensioner, our society will be about older generations and the number of active younger generations will be lower. This will be very embarrassing. The productive layer keeps the others, including older generations and children. Unfortunately, this is a pretty dramatic picture of our society. The current number of university and high school students is quite low and we can realize a decreasing tendency. The number of children is lower

and lower, but I do not know the reason why. However, intervention is necessary and here I do not want to refer to increase fertility rates, it is not my table. From my aspect, those productive professions, like engineering is must be promoted among the declining number of children. The aim of this concept is the increase the number of future engineers, they are able to produce added value to reach a point where our country is rich and young generations are able to finance children and old generations. The future of innovation and R&D activities in Hungary based on my vision, our profession must be a core business. The last thing it has to be added, a factory or a production line can be relocated from Germany to Hungary or from Hungary to Ukraine or China is a huge job but possible to complete. To relocate R&D is much more difficult. Where the human know-how and intellectual added value is high. The intellectual added value is provided by the humans. The production line robots are must be serviced with as few as a possible human resource. Obviously, it is not easy to relocate. However, to relocate the know-how is very difficult. Therefore, research and development activities have an industry stabilization effect. We have R&D and production. R&D has an effect on the production. Based on the given criteria, we are only able to bring a certain product to Hungary from Germany if we possess the required engineer know-how according to the given technology. Production is stabilized by a strong R&D. This is a strategic thing again.

What advantages and disadvantages have the self-driving automobile technology?

Well, I guess, it comes mainly with advantages. Those products that are developed by our company are not especially produced to domestic market. Hungary is a relevant market to our self-developed trucks as any other country. Basically, we supply to the word market what appear in Hungary also. However, the motivation factors are different in utility vehicles in the light of self-driving functions such as at automobiles. We do not drive utility vehicles because of driving fun, but in order to transport goods, the vehicles should be profitable. One of the biggest issues in this field is the driver shortage. I had a conversation with György Wáberer who said, 8000 drivers, are missing from the long-distance transportation. This is too much. It is impossible to recruit 8000 drivers while the demand for them in Western-Europe is higher. It is clear, that we have a shortage because of the migration of drivers to Western-Europe. Our drivers are coming from Eastern- Europe, Ukraine, and Romania. We can increase the efficiency if we build self-driving functions

into the trucks to relieve the driver. I have an example; see on YouTube, we have developed a truck which is capable of on-site maneuvering at low speed by itself. So the driver get out and go to lunch or have a rest and the truck goes to the docking station where they are packed in and out, then come back and does not crush with the trundle and keep the right-hand rule. When the truck is packed than it notes to the driver when can they meet. Then the driver sits in and drives the truck to the complex public traffic area where the self-driving function is difficult to use. With this functionality, what is workable at low speed, the architecture is moderately easy to use. This function saves one hour from the maximum nine driving hours of a driver. So we can extend the operating hours of a truck from nine to ten and the driver can have a rest and this plus one hour can be consumed on the road able to reach further than without this system. It can be the reason why the driver is able to reach for example the Hegyeshalmi border and do not have to stop in Austria because of the truck stop and able to drive five more hours. I consider the ten hours instead of nine hours, we increased the efficiency by 10%, what is very good. It is also important that the machine could operate 24 hours, but only 9 are allowed because of the driver. This is a very strange thing. We are working on relieving functions in certain operational conditions. For instance, you can go on the boring highway, so it is not really big deal, there is not a complex traffic situation. There are no traffic lights, crossroads, only one-way traffic, so this is a relatively moderate situation. You can find menacing lines and the contraflow is physically bounded. Then we can significantly increase the efficiency of transportation, what has a huge effect on the whole economy; product transportation is a very high volume activity in many kinds of business lines, so it is essential. Since that time, I just presented the efficiency relations of this function and did not mention the safety factor. Therefore, there is very few drivers, a lot of drivers are selected who has low or even does not have any experience at all. They have a huge responsibility, the weight of one truck is 40 tons and we experience lot accidents. An accident of a truck has more significant financial consequences than in case of an automobile accident. I do not speak about the number of deaths. If a truck upsets, then it blocks the half of the highway for minimum half a day what have serious consequences. It is possible that an oil tanker flows out what causes serious natural damages and so on. So the whole safety concept is very important. These effects and consequences and effects are not Hungary-specific, but general.

On which field does your company focuses on self-driving technology?

Basically, our specialty is safety. We use these words (security and safety) in English because all of the synonyms are well-chiseled. Our specialty is safety as we consider our profession we are successful in brake system production. The software of a brake system is not more complex as cell phones, but we spend ten times more on these developmental processes. The quality of the two systems' is different. Out projects are about R&D and product development. Both parts of our activities are connected to security. At self-driving, we are highly focused on environment detection and behavior planning. We have a motion control system what is about the vehicle dynamics control in a classical sense. The system still contains the actuation layer what control the actuators, steering-wheel, drive train, motors and brakes in order to get the wished moving of the vehicle. That is a strategy if the driver goes to Kiskunfélegyháza than the system plans the navigation the path then the driver goes along the way to get to know the free spaces, object, and obstacles based on the sensors. As a result, we create a corridor where the truck is able to go along then we create a trajectory which is a concrete track where we want to drive the vehicle. A trajectory which is planned for an optimal truck's sluggishness and dynamic has to avoid zigzags and the vehicle dynamics has to be able to follow. Motion control drives the vehicle along the path accurately or as it happens. Motion control determines the technique of taking a turn, whether to take it by a steering wheel or an asymmetric braking. Obviously, not the convenient overtaking is the critical point, but the evasive maneuver when the vehicle is still not able to stop and must have to sidestep the other vehicle. These are the critical situations. This requires very strong vehicle dynamics skills and knowledge. This is the part what we consider ourselves.

Why point this field was chosen by your company?

You can ask Georg Knorr who has established the company in 1905 about why point this field has been chosen. At that time he has realized the advantages and opportunities what was described in the previous questions. Our core business is what can support the progression or the complete happiness of the word is that to increase the safety of utility vehicles. We state these self-driving functions and simpler driver assistant functions have a huge potential for vehicular safety and efficiency increase. This is my persuasion.

What are your expectations and predictions about the usage of your company's technology?

The situation is, this is an evolution thing. I do not consider this progression as a revolution but as an evolution. The intelligence vehicle driving is already on the roads, the driver has only one brake pedal while we control all the wheels separately. So we have developed our abilities. The driver makes elemental decisions, but the machine makes a lot of decisions and sometimes the machine is the one decision maker as the automatic braking or keeping the vehicle in one line. These products are already in serial production. We already have the products what we will produce in the future. I do not want to give prophecies, what if we will have a well-defined roadmap, but we have plans the date is not sure when could these ideas come to reality.

What is your opinion about the usage of self-driving vehicles in Hungary?

I do not see any differences in usage between Hungary and other countries. This progression requires big infrastructural reforms, as well-recognizable lines, clear roads, and so on. Of course, a developed and richer country will be able to fit these requirements than Hungary. However, my opinion is, these changes will penetrate in Hungary just in other countries. So there are no differences from this aspect.

How could you describe the ambitions of Hungary in the field of R&D?

There is a very strong governmental interest in this direction. There is a separate institution, the National Research, Development, and Innovation Office (NKFIH) what was established especially with this aim. This foundation does a very good job with the financing and support of innovation projects. They have a hard job, it is very difficult to judge the tenders winsomely, objectively in the interest of the big aim. So I feel, there are a lot of tasks to do. Moreover, the strongly judged education strategy is strengthening in rural areas. I am optimistic about the question. The financial opportunities are narrow. Maybe this is the reason why this progression is not as dynamic as it expected.

How could the government attract companies like yours to Hungary?

Like the government doing it now. With financial support, education development, test tracks and by investors who are attracted to these elements. The collaboration of the government and industry companies is the key, this is working now.

By how, and with what could the government provides more support to these companies?

They have to create an environment which supports to solve acute and trivial problems, as the shortage of skilled workforce (young engineers). This is a very serious problem which requires government intervention and support. In my opinion, the wage of university teachers' and the high school real subject teachers' should be increased significantly. It is not shocking if I say, physics and mathematics teachers should earn more than for instance, a literature teacher. Maybe it is impolite to say something like the previously stated opinion, but the necessity is obvious. So this replacement problem is true in the cases of students who are good in mathematics and physics and do not know where to go to study after the high school. They have the possibility to apply to teachers' training college or to engineering faculties. These faculties require nearly the same skills and knowledge. The right sense says to rather go to engineer faculty because this career is well paid. However, real teachers should be paid more well, because if there will be a shortage of teachers than we will not have any engineers after ten years. So mathematics teachers have a key role in this process. We need charismatic teachers who motivate students and hold study groups, doing physical attempts and teach programming and so on. In case of chemistry teaching, my opinion is the same. Our company is full of with enthusiastic and motivated employees but it would be very good if mathematics teachers would be as motivated and enthusiastic as we are. However, they are unmotivated because of their low wages. So this is a key problem. We have a lot of teachers so an intervention is necessary. However, there is an intervention by the government side. They are doing a serious they made a serious pedagogical and career path for teachers and a two stairs wage increase to university teachers, but it still not enough. This is the problem.

Do your company cooperate with the government, if yes, by how and in what degree?

I already described this. There is more governmental research center with we have a strong relationship. For instance, SZTAKI, different institutes of the Polytechnic, as University of Szeged, GAMF. These universities are all state-owned.
The government supported us many times. We received significant financial support to build up both of our factories. Now we have two R&D projects that are financed by the NKFIH, the European Union and the Hungarian government. I consider very positively this test track investment what was done only by the government. The government realized this beneficial strategic direction. We do not participate in the previously mentioned project, but we are in the mentioned two other projects.

Is there any topic what was not mentioned but you consider important to do?

We have mentioned the education, infrastructure, innovation and financial allocations. The freshly graduated entrants, the young engineers should have to understand that they are adults. However, in the universities, they are not treated as an adult. I also needed time to realize, up to fifty years, that now I am in the generation which is doing the key decision-making, and I am the creator something. I really respect my parents, but they are not as active they were. Now they cannot give advice, I have to support them and children are listening to me and keep my advice. The next generation should realize that they have to grow up the challenges and people will ask advice from them, not vica versa. There will not be anybody they could turn to and give advice. So they have to grow up and I really miss these ambitions from the next generations, everybody is so childish. Everybody waits for someone who will support their career. Everyone should build their own career! These generations should help to attract jobs and projects from Western-Europe. So I have this message to the younger generations.
Thank You!

2) Interview transcript (Martina Almási)

What is Your position and in which department are you working?

I'm Martina Almási, currently head of the automotive development at the National Investment Agency

What is the term innovation/ R&D means to You?

It means continuous reformation, embracing new technologies, reacting to these novelties, furthermore implementing these changes. I would like to highlight that the automotive industry has a great emphasis (globally) on this aspect, and we are committed to achieve this in Hungary as well, to create an innovative background for these companies.

According to your experience which R&D activity stands out?

We are talking about the automotive industry, although other industries (e.g. pharmaceuticals, electrical industry) also perform this activity, in case of the above-mentioned industry the two most important disciplines are electromobility and autonomous cars; the government aspires to create a supportive environment, furthermore big companies dispose over significant R&D and innovation capabilities. I think Bosch ltd. and Thyssen Krupp ltd. leads the way in these disciplines, although I don't want to belittle other smaller companies, e.g. Continental and Valeo also has significant R&D potential, not to mention smaller companies such as Almotive and Comsignia, they've grown out of their start-up phase. But to clarify I think in these disciplines Bosch has the advantage, due to the fact, that they employ the highest numbers of R&D engineers.

Why do you find those two companies outstanding?

Because they have massive R&D departments, backed with great resources, they can dedicate engineers to their researches, Bosch employs 2500, Thyssen employs 600 engineers for this purpose, although both companies pursue goals beyond the above highlighted two disciplines, but as you can see, the Bosch Budapest site stands out from this aspect as well.

Why foreign companies internationalize their R&D activities?

This is one of the most important activity at a production organized company (innovation and product development) understandably it is one of their most protected assets e.g. their German or US HQ, but there is an increasing trend, where they tend to outsource, mainly to the regions where they already have other facilities, for instance if they have a Hungarian subsidiary and as a result they are familiar with the Hungarian economic situation they are inclined to outsource some type of activity or service. This doesn't have to be R&D, it can be an internal service centre, accounting or other type of financial service, R&D is always the most sensitive topic, but if they receive good feedback about the employees, they see the potential, that they can achieve something innovative for the company furthermore human resources are available, the R&D outsourcing is possible. First, they outsource lower level R&D activities, such as product development or process development, after that higher value-added R&D activities might be outsourced.

What is Your opinion on cities becoming innovation hubs?

Yes, it's a trend, if some innovative companies create facilities near a certain location they create an innovative environment, they don't have to be big companies, they can be start-up companies, a vivid, innovation organised atmosphere will be created, this can attract other investors with similar mindsets, furthermore it will be a desirable place for the employees as well. Besides these mechanisms the government can also create incentives, a properly built funding structure can attract innovation, it might become a self-sustaining process.

What is the future of innovation/R&D in Your opinion?

It's hard to say, but about the automotive field I've mentioned electromobility and autonomous vehicles, but there are reasons behind these trends; big automotive companies are going through changes, different kind of industries appeared in the field, such as Google, or we can mention telecommunication companies, who are willing to extend their portfolios. The reason behind this expansion is obvious, autonomous vehicles communicate with each other, as a result innovation in this field is inevitable. This sort of expansion will result in the appearance of several new services: vehicles will communicate with each other, with the roadside infrastructure, this might lead to smart cities. Smart cities will require global thinking and much higher level of complexity.

What is Your opinion about the status of autonomous car technology in Hungary?

It's hard to give an answer as a person who is responsible to create incentives for this industry, I'm not familiar with the technological and engineering aspects, but I can see how this sector becoming more and more important, Hungary also tries to give more and more attention to this field; e.g. creating a test track in Zalaegerszeg, creating new specializations at BUTE (BME) and ELTE. We can observe cooperation between companies, government and educational institutions, these synergies can catalyse innovation.

What advantages and disadvantages can autonomous technology have for Hungary?

This topic also oriented towards legislation and technical details, our organisation's task is to promote investments, as a result we are not deeply involved on these topics, but we must keep up with the changes of technical legislation. We monitor the changes, it's obvious that these companies have a wide choice of opportunities; nowadays testing – even on public roads – is permitted by the law. As you can see we try to keep up with the international trends, to encourage autonomous testing, on test tracks (like Zalaegerszeg) or on public roads, but we have to create a solid legal background for them.

What is Your expectation regarding the potential application of autonomous cars in Hungary?

I think it has a great potential, it can give a great relief for the users, they can utilize the time, which they would spend driving, sitting in traffic jams, not to mention economic advantages. Number of parking cars will be reduced, cars will be used as a service not as a personal vehicle, to transport citizens. If I'm correct right now we use our cars 20-30% of the time, in the rest of the time they take up parking spaces.

How do You see Hungary's ambition regarding innovation and R&D?

This has the upmost importance, the new trends and possible synergies require continuous innovation, one thing the government can help with is creating the educational background. You will hear about these actions at RECAR and from Mr. Palkovics, that BUTE (BME) and ELTE will start two new specializations in the next semester, these will be three years long English courses about autonomous vehicles, those students will

have great competencies for their future career. Our government can give support by designing a useful educational structure, creating specializations and departments which can host innovative technologies, but this kind of support shouldn't be limited to universities, it should be achieved at high school level, where we can grab the interest of young individuals, even girls might find this career path delightful – obviously this is also related to the lack of workforce. The other critical step is to create proper infrastructure, to support investors, companies creating their own infrastructure. Here, at HIPA and NBÜ we try to facilitate the translocation of highest value-added activities into Hungary. We try to attract R&D, high technology demand activities, they demand less workforce, but our main goal is to attract frontier technologies, not second-line used technologies, this way we can stay productive and innovative.

What is the government's role in innovation/ R&D?

One part of it is to support education, R&D but I'm sure Mr. Palkovics will describe you this in detail. Our role at HIPA is to help interested and already existing (Hungarian) companies with their R&D and innovation goals by the means of finances, e.g. with non-repayable funds and creating appropriate environment. We get involved with local parties, help them to create relations with multinational companies, we listen to their proposals about the necessary changes of the current legislation, we can even help them to push through bills.

Currently, how can Hungary support foreign and domestic companies to innovate?

Since 2017 there are two sorts of incentives, available from NBÜ. One supports technology-intense activities, which supports companies located in Hungary with at least 250 employees, in this case it's not necessary to create new jobs, but they have to commit to keep the existing jobs. Also, this means a 30 million € investment, in most cases this is the relevant volume of investment for a big automotive company. By the way, we plan to change the scoring system, with the purpose to attract even more technological investments into Hungary. In this case our main priority is to make enterprises more productive – consequently Hungary; we do not aim to create as many jobs as possible. This incentive is given according to the regional map, the tender considers the location of the investment – unavailable in Budapest – the percentage of subsidy depends on this

factor. Our other incentive is for R&D goals – this is project-based. It's not distributed according to the (development) regional map, it's available in the whole country, and for Budapest as well. It's not equipment-based, our goal is not to finance the infrastructure, machines, buildings, but to help with the R&D wage costs, amortization fees or costs. This is carried out in synergy with the National Intellectual Property Bureau (Szellemi Tulajdon Nemzeti Hivatala; SZTNH), we judge together which project is in the R&D field, they classify our projects. There are some additional criteria: they have to create at least 25 new development-engineer jobs or employ the same number of development-engineers. The amount of financial support is based on the work hours of R&D engineers.

Does the government have future plans regarding supporting companies' innovation?

The above-mentioned programs will be continued, minor adjustments will take place, they are under negotiation, but the general direction will remain unchanged. We are committed to support implementation of high value-added processes in Hungary. Mr. Szijjártó, minister of foreign affairs, has also emphasized several times, that our goal is to advance from our "Made In Hungary" status to "Invented In Hungary", besides that there are EU-funded R&D subsidies. Maybe Mr. Palkovics will inform you about the details of other available funds for consortiums, our jurisdiction is limited to those two programs.

How does the Hungarian Government perceive its role in the autonomous technology?

The test track in Zalaegerszeg is an infrastructural investment, the Hungarian government tries to attract this kind of activities. This can be a great asset, this track won't belong to a certain company, it will be available for anyone, this is a market-based activity, I'm sure you will hear some details about that.

What further incentives are available for autonomous car development?

Basically, the government creates a solid background through legislation, this enables companies to prosper, to make their investments in Hungary. One tool for this is our test track, this required a huge investment from the government. Despite that I would like to

emphasize our main task is to ensure the legislation background, e.g. Jedlik Ányos plan's goal is to create and promote electromobility.

Why Hungary has this ambition? Why the government chose this sector?

I see initiatives in other industries as well, maybe our test-track gets most of the attention in the automotive sector, which appears related to autonomous technology. Automotive industry is a good indicator of innovation, due to the fact that not only conventional technologies are involved, there are numerous involved industries, like the previously mentioned Smart city. This trend effects our way of life, also this trend is rapidly changing year by year. Enormous resources are allocated to this industry, from a global view this is might be the most innovative. This generates the rapid changes.

How can Hungary attract the companies who are working on this technology?

The most sought-after capabilities are solid legislation and educational background. We all know we have the brains for this industry, but we need to extend and update high school and university education to involve more students, to ensure the necessary workforce. This is the bottleneck of every investment, the available workforce, in the necessary numbers and with the necessary qualifications. Besides this, well-built infrastructure is also a must, but this comes after workforce. In conclusion, the most important task is to reinforce the education system, last, but not least we have to create a welcoming legal environment for the investors.

From Your experience, what is the best example for cooperation in the Hungarian R&D sector, between firms and the government?

The test track was designed by two workgroups, they created the concept with the involvement of automotive companies, it was an exemplary project, we managed to make competitors work together, they found the common ground. The other workgroup was working on the involvement of telecommunication companies, it was a similar project. These examples perfectly display, that in the automotive and telecommunication industry cooperation is inevitable, but I can't tell you an exact precedent.

Is there anything we did not talk about but seems important to you?

-Your focus was on autonomous cars, but there are major developments in the field of electromobility in Hungary. Samsung SDI has a battery factory built in Hungary, BYD

a Chinese manufacturer assembles electric buses in Hungary for Komárom city. More and more companies get involved, some of them start R&D activities, some of them outsource production to Hungary, e.g. Audi starts its electric engine assembly line, as we can see the number of suppliers shows an increase. I'm glad that the number of such companies in Hungary is constantly growing. Yes, several company came outsourced to Hungary, but lots of them already have facilities here, but they see the changing trends and they're trying to adjust, to follow the trends. They try to switch from old to new technologies, according to the decisions made in their HQs. Let me describe you our situation in this case: there is a German company with a Hungarian and a Polish subsidiary, both equipped with older technology. We have to compete with the other regional subsidiary, to get the upgrade to the new technology, otherwise we've lost the competition. The winner not only gets the upgraded technology – which can lead to further improvements – but after a time the outdated technology will be decommissioned.

Do you have any questions?

No

Can you please recommend me someone who You think is interesting to make an interview with about this topic?

Yes, sure, as I told You when we first met. I would recommend László Palkovics, who is responsible for this topic in governmental levels. As for the business side, You should approach Bosch, Continental, AImotive, Knorr-Bremse and Thyssenkrupp. I can give You contacts for these companies. If You want to speak with anybody from the universities, I can recommend to look for the leaders of RECAR program.

Thank You very much for Your help!

3) Interview transcript (László Palkovics)

What is your current position and what department do you work for?

I am currently secretary of education, at EMMI (Ministry of Human Capacities) and government commissioner responsible for the coordination of Hungarian participation in the development and production of autonomous and electric propulsion vehicles; and the establishment of the ELI Science Park project for research and economic development.

What does the word "innovation" mean to you, and what does it mean for Hungary?

Well, innovation means many things, the question is, what we understand under it. Innovation means change. But what usually mean in this context, is the creation of something new, which manifests itself in a certain product, which can be sold, or could be sold by someone. For the country, especially Hungary in this regard, is in a relatively unfortunate position, due to our lack of oil, metals, and some other resources. We have water, which won't provide a strategy, since rain exist in itself. What is important for the country, is that the companies are in a relatively good position today, and brought a significant amount of production here. Those companies cannot stop – the production report did not end here – with production, the field of autonomous vehicles is where the most serious research is conducted, so that products can be produced which are developed in Hungary, that are later released. So the Hungarian industry is very particular. It is mostly dominated by multinational companies. They are already seriously researching and developing in Hungary. So, if you ask the researcher or the manager of Bosch, that if they would launch an autonomous vehicle project in Palo Alto, Stuttgart, or Budapest, then the chances of Budapest are more likely, than the rest. They have the knowledge, and the flexibility, and it is cheaper, if that matters. So it is very important, that multinational companies relocate here with research and development, that happens, as well as Hungarian companies to incorporate own ideas into their products, which is their IP, their intellectual property. Since they can present their unique products, in one way or the other on the domestic, or foreign market. So, the problem with Hungarian SMEs, is that they receive the plans from their partners, and they produce and send the ordered piece back. But they don't have any say in the plan, they don't have an engineer, so can't really have from the start. So, from their perspective, it would be important to present their own product. There are several reasons for this, which I might explain later.

Why do you think that foreign companies internalise their R&D activities?

They do this, because for one, the capacities, that are available in a country, are sooner or later become finite. In the middle of the 90's, the German industry began to move abroad with research and development, because there were no engineers in the country. So, in 95, they couldn't find any engineers in the vicinity of Munich, so they came to Budapest.

And this process happens everywhere. They try to find the most qualified people in a specific field, and then they hire them. That's what I think.

What are the critical factors during an R&D project?

Well, first of all, where does innovation itself begin? Innovation begins, by me having an idea. So the idea, an idea in itself, if I tell it to someone, is just hot air, because they can't do anything with it. So an idea must be followed by a second step, which is the creation of something tangible. This is called a patent, so when I write down my idea, and if it is a good idea, is it sufficient enough to be patented, or am I required to surround it with other patents, so that I am capable of upholding my idea in its form. After that, comes the research – or happens simultaneously – the research and predevelopment phase, which processes the idea, so they check if the idea, which might be bad, by the way, but can still be patented, and they check if they can produce some decent solution, some decent product from this idea. So, this is the phase of predevelopment. Even though the idea does not cost too much, (I can just come up with that myself), predevelopment is a very serious thing. The costs of patenting, and maintaining a patent are, very serious. So it requires resources and support in some form. So in Hungary, these ideas usually fail at this phase, because writing up a patent is not an easy thing. So you need someone, who's an expert in it. And then someone needs to pay for the fee, as well as the fee to maintain it. So you already need resources. The predevelopment phase, so when it is bordering research, I only just checked that in what kind of environment can I use it. So we calculate that, and it has a cost. And when that is over, and I say that the whole thing is feasible, then comes the actual product development. Well, now it is important for it to be in some kind of corporate environment, and have a process. And then, there are serious market analyses, so the product which was produced is suitable to be sold, since it has to generate profit somehow. This is where there are serious risks involved, like not assessing something correctly, or not assessing something at all. And then, there won't be any product at all.

What could be the purpose of education in the field of Research and Development?

It needs to be said, why this is important. So in our education system, we successfully introduced in the last few years, just to explain what patent means. What does "research"

mean. What does "research methodology" mean. When we are training an engineer, it is not enough just to educate them in a specific profession, but to show them what other processes belong to it. This where patenting belongs, and this is where research methodology belongs, for example. This is where corporate research methods belong. So this is a complex environment. Hungary isn't doing well right now, unlike Israel for instance, where newly graduated or young students might have an idea and they have the capacity to establish a company based on it. It is of importance to explain, why it is important, that they have some sort of start-up company. Or research and education has to explain, why the whole innovation process is important.

From you experience, what is the most exemplary cooperation between the education system and the corporations?

Well, there are several. Like how the university of technology cooperates with car manufacturers, in my opinion is quite exemplary. From my personal experience, the cooperation of Knorr-Bremse and the university of technology is excellent. The cooperation of ThyssenKrupp and the university of technology is excellent. Not long ago, a car manufacturing initiative was established, called Rekard, related to the project, where several universities work with several corporations, and produce things at the university. In the education system, starting next January, a new masters program will launch in English for autonomous vehicles. So these are very good co-ops. Audi and the University of Győr perpetuates an excellent cooperation, for example. More specifically, Audi maintains a department at the University of Győr, where they provide their share, so industrial experience is presented, partly in finances. And the university teaches it to the students, this is also an excellent cooperation. We standardized this just now, by the way. There was a tender designed, which many universities won already, called FIEK, (Centre for University-Industry Cooperation). This means, that the university receives funds, to create a business incubator, a process, and tools, providing product development support, for companies for example. And there are so many already, it could be listed. In Debrecen, and Szeged. Since we are talking about the vehicle industry, these are very good examples.

What is your opinion on cities becoming innovation centres, and why do they become innovation centres?

Well, because someone starts them. So things like these have several prerequisites, so that this sort of technological environment, technological park, knowledge park, research park, any science park can be established. So, there are several essential prerequisites. On one hand, there has to be a university, a strong university. Without that, there can rarely be such thing. So there are universities everywhere. Since the resources, like research results, research resources, and qualified people all come from them. It is important to have a cause; around which they can organise. This can be something physically realised, like a research institute. The ELI Science Park in Szeged represents the core there for example. And the whole thing will be built around it. It is not? important for it to be important for the community, and by community I mean the specific city, the economic environment, which moves there, or will utilise its results. The intentions of the government are very important, especially at its inception, when these processes begin. And also, a very serious community engagement is required. If the corporations already finance part of it, several things can be done. The government has to take a serious part in it as well. So typically, the business incubators are, where we give opportunities to 1-man companies as well as 5-man companies. But the support costs money, so the role of the government is important. And it is very important for it to have some sort of pull, so for someone to want these results. So there needs to be a good economic industrial environment, that requires it. And already seems like this more or less, by the way. There are prerequisites inside the university as well, but those belong to the university.

What could be the role of education in the creation of a similar hub?

Well, to research and educate. So the objective of universities is to produce the next line of professionals, who will work and complete tasks for the companies, which are present in this hub, which is basically fundamental research, and applied research, but could be something else as well, which does not exist at that moment.

What is the future of R&D in Hungary?

Well, it is difficult to answer what it's future is. That is the goal, so that the Hungarian economy is a work based economy, so that we produce something. It has innovative elements, of course, and we would like for it to become and innovation based economy. So a little similar to, e.g.: Israel, or the Netherlands or Canada. Or we could go in the direction, where a young professional graduates a university, it's not strictly necessary that they apply to a multinational corporation, but instead, if they have an idea, they found a company. But this requires us to understand this more. So I believe, that innovation in Hungary should not be a goal, but a necessity.

What is your opinion about the state of autonomous car technology in Hungary?

Well, which part of it do you mean? So if we talk about the research part of it, then like I said, Hungary is in the lead worldwide. So they don't know much more about this field in the Silicon Valley, than the Hungarian institutions. I'll tell you, that we calculated recently, how many engineers work with autonomous vehicle propulsion with the vehicle part, and we counted above 10 thousand. Then we looked at the other side, like communication, and the companies dealing with integration, service providers, and there are also approximately 10 thousand there as well. So I think we're doing well here. As far as development capacity, well, we have the production capacity, because what kind of control module Bosch produces, they can produce any kind. Or if ThyssenKrupp develops wheels for autonomous cars, or makes wheel servos, it is the same, there is no difference. I believe, that every condition is given in Hungary, for us to fare well. This is where the Hungarian government comes in, but that might be the next question? So let's say the initial conditions are good, on the corporate and university side as well, since we are experts in it. We started this research in vehicle handling at the beginning and the middle of the 80's, which technically lead to this today, so Knorr-Bosch came here, because they invented the idea of ESP here. ThyssenKrupp came here, because they created their first wheel for their electric car at the at the university of technology, from which a company was born, that employs 1000 engineers today, and owns two factories in Hungary. So I think, that the conditions in Hungary are exceptionally good.

What kind of advantages and disadvantages do you see in the use of these technologies in Hungary?

Well, the advantages are very relevant, and this is true everywhere by the way. We could eliminate the driver. So it's not the driver who drives the car, which has several consequences, one of which is that the driver won't get exhausted. They don't need to know how to drive. They can be intoxicated, when they sit in this type of car. Another advantage, is that a driver drives a car in accordance to their abilities, so if we examine the attributes of the car from an external point of view, it will be much easier to perform, like fuel consumption, or energy consumption. So let's say it will be more useful, since the number of transient modes are less, so we don't consume battery power as much, or we don't exhaust harmful fumes. And about the driver, of course, if we look at 93-94% of accidents, they are caused due to the driver's abilities. A significant amount of these accident could be eliminated with autonomous technology. Well, if there are disadvantages of autonomous vehicle systems, then I wouldn't even call them disadvantages, more like open questions. It is an open question, whether the decisions that we human drivers make, that mostly belong in an ethical category, can we expect an artificial intelligence to make as well? I don't think so. So they have to make a decision based on some sort of data. A typical example: should I hit the child on the crosswalk, or the ambulance? So this is an ethical question, we decide, and then we face the consequences for the rest of our lives, but the decision was ours. Now, in this case, someone else makes the decision for us: a machine. Whether I die, or someone else dies. So this question is not right on an ethical level, because it is not able to make this decision. So there are more open questions, I would say. But basically, there are almost exclusively advantages in this sort this technology.

What is your opinion on the application of autonomous cars in Hungary?

Well, in this case, this doesn't mean one country in itself. The right question would be: how can we or how we will be able to apply autonomous cars in certain environments. If we do it in Hungary then we do it in Germany as well, vice versa. I think, that the need for autonomous cars is clearly apparent. How do we put these into practice, first on a closed track, without a driver. Then we move to the city centre, the airport, then on the

highway. Trucks are driving behind one another in the outer lane, and only the one in the front drives or not? So in city traffic, the driver is still in control, but all ADAS are like, don't hit the pedestrian, so we break instead. So these will follow each other one by one, and they aren't specific to one particular country, so all the conditions are met in Hungary for it to work. There is one other issue of course. Since we are talking about autonomous vehicles, but we should be talking about autonomous and interconnected vehicles, which is a different level. Autonomous means that, it is required to be able to drive, like we would. On the other hand, it is much more than that. Because even if it doesn't have any connection with its surroundings, it still needs to go from A to B without killing anyone. But if it is connected to the environment, so it can communicate, cooperate with other vehicles, traffic system, traffic signs, with children or pedestrians, bicyclists on or beside the road, now that is how we can really take advantage of most of it.

What is the role of education in autonomous vehicle technology?

Well, it has several roles. Certain technologies come into practice, that are still subject of research. We are not talking about deterministic control, or not only deterministic control, so we are not talking about model based control, but non-model specific artificial intelligence based control. So this should strongly appear in it. The handling of data, so the entire data analysis, big data history is a new field of science, it has to be taught in some form. But other issues belong here as well, like their security, so cyber security means an entirely different field. Up to a point, that it has to be taught. What happens if a car like this causes an accident? How can we analyse it, if we don't see the car's data? So there are many things in education that are different compared, to what preceded it. But these fields are not entirely new. I've just checked, that the first article we wrote about the application of neural webs in vehicles, we wrote in '93. And then there was a pause, since we did not have the percentage improvement, but we have it now. So there are several fields, that need to be taught.

How can education support the field of autonomous vehicles?

Education? Well, engineers are trained by it, who do research, but you will see the details in the material related to this.

Is there or will there be a specific program in this field?

There will be, two actually. Two English master's program. One, starting in February 2018, the other in September 2018. The former, at the university of technology, called "Autonomous Vehicle Control Systems", the other will be at ELTE from February, and at ELTE? from September, which will be "Computer Science for Autonomous Vehicles", but this basically means artificial intelligence. The two majors are interconnected in a way, and what the other teaches is basically computer science. The other is more engineering natured, so it is related to both is a way. In addition, there will be a third major, the vehicle testing engineer type BSc., about how type of vehicles are tested. That will be in Zalaegerszeg. Yes. We are planning it for the University of Technology of Zalaegerszeg, or Pannon University, we'll see.

How can the education support the companies that work with this technology?

Well, by training professionals, and carrying out research for them, which is already happening…

How do you see Hungary's ambition in the field of R&D?

Well, ambition is strong here, because we think that companies in Hungary develop something like this, based on the knowledge that we already achieved before, then that is serious ambition. This is where we can seriously position ourselves. One of the results of this, is the entire testing environment, like the testing track in Zalaegerszeg, or that autonomous vehicles are allowed to be used or tested on highways and main roads. Even today, this is one of the most liberal regulations in the world.

What is the role of the government in this field?

Well, the role of the government is to finance the solutions that the universities and partly the corporations produce. So there is a financial angle. To create an investment, that is otherwise risky or isn't worth it for a private investor or a corporation, but it is for the

government. The third, is to shape the legal environment in such a way, that vehicles like this can be examined. Or if there are infrastructural elements, 5G network, these are important requirements for them as well. Then the government promotes and supports them.

How can the government support the companies here that deal with research and development, and innovation?

Well, for example, by building a test track, that otherwise did not exist. So they cannot be tested elsewhere, which is a form of support. But also, by granting a lot of support programs, by receiving support after applied engineers, if they apply them in this field. So there are a lot of such things.

How can the government promote the education to innovate and cooperate?

By giving them money to do it. We establish tenders, and will continue to do so, that are fundamentally based on cooperation. The cooperation between universities, cooperation between universities and research plants, and cooperation between universities and corporations. This is partly an indicator for the use of universities, and their benefit. But we already give money for it, just for the research of autonomous vehicles, universities were granted 2.5 billion HUF, three universities in total. €8 million is a lot of money.

How do you see the role of the government in the technology of autonomous vehicles?

Well, the government does many things, but usually the government is a particularity, the community is much more interesting. You can pull a certain technology through legislations, so we can say that the law is progressive, and a car has to be made, because from 2025 on this type will be allowed. So that defines something, which the industry has to abide. But legislation can be different, we can look at what already exists, then legislate it so that it doesn't get side-tracked. So the government has an important role in this with legislations. The government serves an important role through financing as well, so level 4 or 5 autonomous car do not exist, but level 3 does, by the way. But for example, there was a legislative amendment in Europe for level 3 cars, so these cars could be allowed in

traffic. But the point is, that if anything happens, the driver takes back control. Then the government can support such causes, by building highways and a traffic system which are capable of accommodating autonomous cars on a larger scale. The government can provide support to accelerate the development of 5G networks, which are capable of strengthening the communication between vehicles. So we can have a certain ability of control from the outside. And then the government can provide support to the development of this technology, let's say, someone buys a car like this, and shows a return with less fuel consumption and accidents, then a subsidy is provided with it, like not having to pay VAT after the car. Or they can deduct a couple of million HUF from the price of the car, like we do it now with electric cars right now. So there are many ways the government can support a technology like this, so that that the technology itself is allowed to develop. Partly with infrastructural matters, proper legislative actions, or direct financial contributions.

What is the reason of this ambition for the government, why did it choose this specific industry/sector?

Well, there was a state when the Hungarian industry dealt with this on a research level and on a testing level as well. And they sought out the government, saying that there is a fault, or a problem, that the government can remedy in some way. And that's why this concept emerged, and we started to build this experimental environment. At this moment, this is the one and only, with such complexity. Whoever we tell about this project, they go like "wow!". This is really serious. So Hungary tries to position itself in this field, not only to develop more of them, but to test them as well, so Hungary could be this quasi autonomous vehicle examining hub, which we extended in the direction of Austria and Slovenia as well. But this could mean an interesting European, Central European environment, where we determine the technology, and not just getting something that someone else made.

How can the government attract companies to Hungary that work in this field?

Well, most of them are already here. So there is no need for that. Those that develop these, are Bosch, Continental, ThyssenKrupp, Knorr-Bremse, AiMotive, or Commisignia, if

you will. So they are already in Hungary. Audi appeared, BMW will inspect the test course next week. So the important, thing is to be good at what we do. So for the test course, and for the research that the universities perform to be good. So there could be, what do you call it, an ecosystem. So it could mean a positive thing afterwards. And we support this sort of thing as well, that the incentives for Hungarian investment are quite liberal and quite good actually.

Thank You!

4) Interview transcript (Mátyás Hesz)

What's your current department and position?

Currently I'm employed at Budapest University of Technology and Economics (BUTE), department of automotive engineering. It's worth mentioning, that we have a special or unique network built around the test track project with László Palkovics (currently a government commissioner for the test track project), he was the head of this department for a long time, furthermore he was our lead developer for the automotive Knorr Bremse project. Since he was assigned to this position, to be the government commissioner for creating the test track, he became deeply involved into this task, it can be said that he is an essential member of this department. So, from our point of view we are experienced in special disciplines and we are trying to improve in these fields (hopefully we can operate these developments as well). My workstation is here, in the government commissioners' bureau, most of the time we receive our tasks from my current boss, Mr. Palkovics.

What does the term innovation means to you? What does it mean to the country?

Innovation? Well, something undiscovered, creating a product by the means of mechanical engineering. Creating something from nothing.

What do you think, why companies internationalize their R&D activities?

Long ago they said about Hungarian engineering costs: cheapest price, now it has changed, they rather say: best price. We are not the cheapest, but we are still affordable. In my opinion these companies won't expand further into eastern Europe, but nowadays everything is possible. From my point of view German tech companies see Hungary as a middle-priced outsourcing place. We can solve most of the problems, using the German standards.

What are the critical factors for a successful innovation/R&D project?

It depends on the mindset. We have a certain product to develop, it has a development cycle, it has a life cycle, it might be achievable with the existing human resources. We have a fluctuation of employees, that can be handled throughout the years. If we are talking about building up a research centre, it is a completely different approach, if we or they want to operate it here for a long period. In this case, chances of succeeding greatly depends on the engineer-resources, number of available engineers, furthermore HR policies are greatly dependent on the period of operation. We can see great examples, bad examples from big companies. The average fluctuation always appears, but we can see brain-drain effects, that on the long term can be harmful. When a research centre attracts such a high number of employees there is a risk, that the parent company may not be able to obtain the necessary funds to pay their employees. If this case occurs, only strong parent company-backed facilities can survive (the parent company has almost endless funds, to compensate the losses even for several years). To sum up the bottleneck can be the number of graduating engineers. We can do anything, multinational companies might outsource here, they can create 5-600, 800, 1000, 1500 or even 1800 jobs, e.g. a company (red letters on white background) wants to hire 2000 people (they will double the number of their employees). These are outstanding news, good to hear about, although the numbers can vary how many (5000, 6000, 8000 or even 10000) hardcore engineers are needed, but the limit is 10000. There are no more engineers, we can create all the departments, but they will be empty. In a nutshell secure human resources will be critical. Tasks and trends may come and go, but it is crucial to have the desired number of employees.

What's the role of education in R&D/innovation?

This is also a marginal question, can we give the right input for the industry? Can we educate engineers worth hiring? Engineers who can pick up the pace, because it is obvious that a fresh graduate can't keep up with the high standards after two weeks of training.

So, after 2,3,4,6,9 months of training ... You don't have to type everything…At first, I wanted to emphasize that it can take a long time to properly introduce a graduate into the company policies (with proper mindset).

According to your experience which kind cooperation (education and private sector) is the best example? Please elaborate why?

I wouldn't like to highlight any, but Bosch, Knorr and Continental have superb initiatives, their dual education is quite useful, students can get used to the "atmosphere", while he or she continues his or her studies. In this case time management causes difficulties, the company would like to extend the work hours despite the fact, that the university has its own obligations, this might be cumbersome for a 19-22-year-old student, but after the initial difficulties it is bearable for the individual. So, they put young students under pressure or into the grinder, and I'm not sure if it's for the good. They continuously suffer from lack of time, they must perform in multiple fields, their ambitions are elevated (although this can be positive sometimes). The concept of dual education is good, you must look for opportunities. I always tell my students, to apply for summer internships, trainee programs besides their thesis work, and if it's possible they should write their masters' thesis at a company. When the student applies for 3 different locations, at least he/she will have a perspective (e.g. the first location is terrible, the second okay, the third is great) and a choice for the future. Maybe the "OK" company has a great job opening. But when a student realises after 3 months, that it is not a place for him/her it's wasted time/opportunity. In case someone wants to build a career, it's not advised to switch between companies every semester, this might look malicious. You must stand your ground, despite the harsh conditions, for a good career path you must pay the "price". Sorry sometimes I go off topic.

What's your opinion on cities becoming innovation centres, what's the mechanism behind this phenomenon?

If I'm correct in San Francisco has an air pollution problem, this attracts certain experts to resolve the issue. In Singapore I have no idea what's the cause, maybe the economical and geological circumstances played an important role. In Hungary Zalaegerszeg has a huge potential for the automotive industry, if we look at other tech-related industries…If we look at the automotive aspect, this test track and its' surrounding area, the suburbs of Zalaegerszeg might grow up to the task, as a city that offers smart mobilisation solutions, or it can be a "living lab" or a great test environment. E.g. the mayor might know if he

has enough milk in his fridge, but this might not be the priority for mobility experts. So Zalaegerszeg has a defined opportunity, to attract R&D capacities, to become an innovative city or even an innovative region.

How could education facilitate the creation of such hub?

We should separate this topic into two pieces: if we look at it on a national level (in Hungary) the Hungarian graduates are attracted to these opportunities. On the other side we can educate locally, e.g. test engineers, but they can be R&D personnel as well. Probably multinational companies will outsource their offices, subsidiaries, R&D department to that location. But after all, in both cases human resources means the key. We've discussed before, that the purpose of education is to supply this chain for optimal operation.

In your opinion what's the future of R&D in Hungary?

We have great outlooks! I would estimate, that German companies dominate with their 80% R&D share in Hungarian automotive industry. 15-20 years before it was impossible or at least was hard to bring a prototype vehicle to Hungary, now we have the trust and respect, that we can do this, and this type of research is on the rise. I think we can grow up to the task, although we will never have the same approval as our German colleagues.

What's your opinion on the current situation of autonomous car technology in Hungary?

Understood. I assume you are aware, that on 2017.apr.12. an NFM legislation came to force, which modifies 5/1990 and 6/1990 KÖHÉM legislations, this legislation allows autonomous vehicle tests on public roads for research purposes, without any time or areal restrictions. That means we could have a trip here, in Stoczek street, after proper registration, test appointment (and with proper test driver license), I bet some of this you've heard it in the previous interviews. From this aspect we've adopted the German, Finnish and English legislation. This legislation worth mentioning, we can catch up to the forefront (e.g. Norway), because it allows to carry out autonomous tests on public roads. From this aspect Hungary is following the trend, we might be still part of the forefront, which is obviously a significant achievement.

About development? As you know we have projects here, and there are projects at big companies (I could name 3 of them). From my professional view several initiatives can be seen, also we already know that Bosch will have a dedicated department for this, inside CCDA design you can find chassis control. It can be seen, certain directions can be seen, there are at least three domestic players with advanced function developments.

What sort of benefit or drawback may concern Hungary because of this technology?
This cannot be specified for a certain country, if we look at autonomous vehicles as a complex field I will say the same issues as the other interviewees. A significant drop of traffic accidents can be expected, furthermore we might be able to lower road accident related deaths. Fuel and route efficiency can be also a big advantage, this will instantly decrease traffic-related emissions. These are the most important ones, but we can increase the mobility of elderly, disabled people, you could even get a car to transport your dog. For instance, you can send your dog to the vet and it will return vaccinated if you would wish. Most of all I would like to point out the possible decrease in traffic accidents, this is the greatest advantage. Although it's full of challenges. Really difficult challenges. Even the evaluation of the complex surroundings and traffic conditions raises extreme challenges. Several years of work will be needed to rectify this problem to an acceptable level. I'm a big fan of this discipline. I'm not all in for this technology, I believe that on the mid-term extensively supported driving experience is the way to go, which means the refinement of driver aid systems, integrating them on a complex level, and if these systems can perform their tasks and they can help the driver, then we have a solution for up to 50, 60, 80 years. This means that my vehicle would not behave as and individual instrument, but as part of a temporary, cooperative system. Information coming from this system might alarm me to a highspeed cross-traffic threat, the system might reduce the speed, or it can alarm me that there is a possibility of collision. This can become a superb technology, but my intuition says we are far from perfect, if perfection is even possible. My approach is the following: we shouldn't dump this technology, some say that 50 years is too far from now, it's not interesting, but throughout the development cycle (by the time we achieve our goal) great products can be derived from this development process, we can integrate these into our current vehicles, while the human driver can remain in charge, the driver will have control over the steering wheel, but will be supported by a solid technology. I think this is more reasonable in short and middle term, opposite to the urge to create autonomous vehicles, e.g. Continental said their aim is 2025, some companies even announced 2019 as a goal. Currently we should be a bit more careful, we shouldn't rush. The driving force behind that is mainly marketing, everybody wants to lead the market. After all we will see who was right.

13. What's your opinion about introducing autonomous cars in Hungary?

They will be introduced. Soon they will appear in special conditions. I'm looking forward to this step, I hope that these cars will fit into the current "ecosystem", won't disturb the current traffic system (and vice versa). I'm in favour of this step, but there are tons of questions we need to address, if we want to execute this step seamlessly.

14. What's the role of education in this field?

Understood. So, we see, or at least we know, in case someone wants to get familiar with the basics of this special vehicle-managing discipline, currently he/she must visit 4-5 different institutes, complete 4-5 courses. It is a great responsibility to collect the necessary courses, skills and abilities into one program, which can give an insight to the individuals, furthermore we must create a program that ensures that the graduates can carry out meaningful work for their employers, there is no such thing, that someone understands 6-7 subjects, disciplines. We fully understand, that at a company, employing 600-800 or even up to 1000 engineers, the tasks are portioned into the smallest possible pieces, as a result if we want to introduce someone into a new project/task he/she must take a course, most of the employees are far from seeing the whole picture. This is our ambition, to show the whole picture, we (me definitely) accept that we can't create "super students" who will be experts in every field and can be a useful workforce in every department. You still have to coach them, they will also be assigned to a smaller portion of a big task. Our goal is to give an advantage, the individual shouldn't reach the goal from 150 m, we help him to cut it down to 50 m.

What kind of support can you give in this field?

We can connect this one to the previous question. How could we support? Obviously, we pass over the basic knowledge, here we can point back to the collaboration with companies, at his level they must be involved. The extension of RECAR happened after Bosch and Knorr (and recently Continental) decided to support it as a party concerned in the education, in return they can formulate their claims about the education amongst other interested parties. From another approach: the aim is to ensure there is a quality supply of students, ready to be employed, this is ensured with the involvement of every interested participant. There's nothing new under the sun.

Is there, or will be a specification about this field, at university or high school level?

There will be a university level specialization, it is currently forming, this specialization at high school level is unnecessary. It's crucial to graduate from high school or from

vocational school, to master the basics, there is no need for philistines. Just for one moment I would like to jump back to the dual education: it's great when a student remains open-minded, if we create a "tenant" who is unable to move from "A" company to "B" company we hardly solve any problems. He/she won't understand the company structure, only understands how "vector" instruments work, where to put certain probes and how can information be obtained from a certain ECU. When he/she goes to another company, and "racelogic", "NI" or any sort of "despace" toolset will be completely unfamiliar, the employee won't have a clue, what to do. If we give so practice oriented knowledge, the guys are pre-educated for a certain brand, when something different occurs he/she cannot resolve the issue, he/she will be helpless because of our philistine education. In case of dual education it can be a real threat, if it's ignored (in my opinion), but there are great programs, it can be done properly. We always have our reservations, if we are too practice-oriented we can spoil the student. Therefore, the student can take a great step forward, he/she won't have to start with the 6 months long coaching period, by the time he/she earns full salary a project can be assigned to the individual from the second month. The guys are pre-educated, they know where's the WC, canteen, they know what sort of instruments are used, how the measured values should be evaluated, what is the filtered data, what sort of reports should be compiled, how to handle suppliers, they are aware of the hierarchy and the SL levels within the hierarchy. All in all, they are socialized in this environment, but as I've mentioned there are some risks.

How can education support this industrial sector?

First, I would mention writing a thesis at a company. It's a great for opportunity this purpose. Maybe I should elaborate this more sophisticatedly, but as a teacher we can see when the student is interested, we can handle him/her over on a silver platter for the company (we can search and offer him/her a mutually interesting topic), in addition this is the most direct way of support. This system can be turned inside out, sometimes the company comes to us, e.g. Bosch has a semester long course at the university's vehicle guidance department, I think this can give a great insight. The semester is 14 weeks long, we deduce 2 weeks, so usually they have a 12 x 2-hour timeframe to show themselves. You can see this support is mutual, it goes vice versa. From the company's point it is essential to attract the right amount of properly educated students, who are willing to work for them. This is the reason we have laboratory practices in the early semesters, informative seminars, field

trips, to contact the students. After their bachelor's degree most of our students come back from their summer break with a trainee position, to do their masters.

How do you see the Hungarian ambitions in the R&D field?

Well, I can see a strong commitment. We might say the usual clichés that they usually say about the high added value, etc. I'm sure the interviewees before me has already told them. We must step up from our assembly-line role. If you ask anyone who has spent time in this business you will hear that the more we innovate the better our position get; because opposite to production innovation is harder to relocate. If there is an existing competency in a research centre, which provides useful products it will always have a solid place in the company's structure. Assembly lines can be moved anytime, anywhere, the tasks are so detailed and so small that nearly anyone can do them in the required quantities and qualities. Back to my first thought, it is necessary to use the clichés about high value-added processes.

How can the government support the education to be innovative or to be cooperative?

Honestly, there are direct and indirect ways. The direct methods are the following: creating research centres, financing or co-financing research programs. Educational plans, accreditation processes pointing to this direction can be supported indirectly. So, you can support an initiative with a handful of money (directly) or you can create incentives to help these disciplines appear in the educational system. The government has a substantial role, they control the resources. All of this might depend on the policymakers in the government, to start a course, to specify the headcount for the class. We start with 450 students, we hope that by the and of their studies we will have 25-30 pioneers, as you can see the government has a great influence on this.

How can the government support autonomous technologies?

In my opinion the support process is straightforward. When a program gets accreditation, it will be shown at felvi.hu, the students can choose this program and financial support is calculated based on the number of students. If some individual creates a proper, working education model it will be treated just as I've mentioned before, furthermore one can get funds from a tender or can be granted direct support. It always depends on the leadership of the institution, how can they secure their resources, how can they utilize these resources. The output has a great importance in this case.

Is there any topic we've missed, but you would like to discuss it?

I would like to discuss the education. You can decide if you would like to keep this section, but this is an integral part of this topic, it's worth elaborating. Changing the structure of education has its critical steps. Currently I'm witnessing changes, or signs of changes from the inside. What do I mean under changes? Conventional vehicle-engineering, vehicle-designing, vehicle-operating and the related knowledgebase is degrading, basic level knowledge will be sufficient, to participate in the development of new technologies you must acquire a completely different education. I see that those departments can succeed (electrical engineering dept., our traffic-management dept., this was formerly led by Prof. Bokor, currently Péter Gáspár is the head of dept., who has great relations with SZTAKI) who are willing to keep up with the changes and give useful knowledge. It's inevitable to choose a specific topic to attract Msc. students, otherwise they will choose from other trending programs. This is a self-criticism, I emphasize it doesn't closely related to the topic, but I would like to give you a hint how to understand this topic, to show it from another perspective. At our department we don't have specializations, although we could have environment-evaluation, localization, actuator related specializations and other courses related to them. We're not late, but we have a bit of lag.

Who do you mean under "others", are they foreign institutes?

Not only, we can mention Hungarian departments, e.g. the electrical-engineering department. If we want to be part of the forefront, now we can close the gap, but we must admit that we're a step behind. We have our autonomous Smart, with a basic platform, which can execute 2-3 tasks.

I'm glad that you've mentioned this!

This is a Knorr-implementation combined with a Smart vehicle. We have great relations with Knorr, it originates back to many years. Mr. Palkovics opened Knorr Bremse's research centre with 6-8 people, it started from these offices. After that Thyssen Krupp came here, then they moved to Daróczi street. In '98 the glass-centre was built by Knorr for their commercial vehicles. As you can see we have a long-lasting relationship with Knorr Bremse, not to mention that half of our colleagues work for Knorr (part-time Knorr and part-time university employees), this gives a great interoperability, our Smart vehicle is a great example for this synergy. We can say, that at Knorr they assembled an almost identical autonomous vehicle for us, to use it for educational purposes. In case I don't want to be the leader of the education program, I must assign a topic for myself and I must master that discipline, you need 6-8 or even 10 PhD students, you must allocate

colleagues to your research who share the same interests and ask them to study the topic. It should work like the tyre-modelling and tyre-ground connection in Karlsruhe, or the engine-topic in Munich, we should also create some sort of special research portfolio, for instance we could be the best in radar technology. It's important to note, we can't be expert in every field, it's impossible. We can understand these technologies on a general level, one of my colleagues explained the situation perfectly: in case of new technologies we understand the headlines of the chapters, despite the fact, that we are quite good at "hardcore, old-school" mechanical engineering. We need those "old-school" knowledge, but we have a framework for our education system. We have a time limit; how should we divide this period? Should we educate 80% classic and 20% modern disciplines? They won't be interested if it's only 20%, furthermore suspension is just a piece of metal for them, by the end of 80's and 90's suspension design has reached its limits, from that point there is nothing new under the sun. Today the car is controlled by ESP and other electronic devices, it doesn't matter if it's oversteering or understeering, we will use electronics to solve the issue, physical parts doesn't really concern this process. So how should we educate our students? Should we teach them the momentane axle, the momentane centre, make them draw tons of diagrams? Should we give them an insight, as much we can? For this we have capabilities, but we won't be sitting in the classroom at 8 pm, no one stays until that. This is the big question, how to form the structure of education, thoughts from the MSC program might come from this question, to show something interesting for the bachelors. During the MSC education we encourage them to consider these novel topics, and I would like to emphasize that we can only give insights in such a short period, they won't be experts. To sum up my thoughts on this last topic we should define a topic, which we should cultivate it on the highest levels, we should be able to publish our results – maybe in "Vehicle Dynamics" journal or similar – to generate impact, others may read our achievements, they might be interested in our achievements. It's crucial to figure out our possibilities, where we can stand out from the crowd, in case we fail to do so we will remain a general automotive education institute.

Thank You!

5) Interview transcript (Árpád Takács)

What's your current position (and your department)?

I'm Árpád Takács my field is business development, to be precise I'm an outreach scientist, this means professional communications specialist. I've been working here for two years, back then we were a small company called ADASworks. I was the 30th employee, my first position used to be an AI (artificial intelligence) researcher, I've been moved to the communication and business development field 1,5 year ago, currently I'm responsible for the all professional communications inside the company, but I'm not working with our PR department. Business development means if a partner comes to us I'll present them the automotive demos, I represent the engineering department; to keep track of the latest projects I'm seated with the engineers, not with the business development colleagues, furthermore I'm responsible for all external (domestic) communications, related to this field, e.g. presentations, trainees, guest speakers etc. As you can see my responsibilities are quite versatile, it's a bit start-up-like, but my main task is business development from the professional side.

What does the term innovation means to you? What does it mean for the country?

As an engineer I've been always taught to seek solutions for the problems that life throws at me, if you create something using any novelties, or you use something that hasn't been applied it's called innovation. Let me explain: if one publishes an image recognition algorithm, then someone uses this algorithm in a vehicle, and it turn's out to be useless. Innovation means to make this algorithm work, create something useful from it. Innovation is not restricted to engineering, any sort of advancement can be called innovative if the process creates something useful, some sort of product. For the country? My honourable professor, Mr. Gábor Stefán (from BME) said, that Hungarian is a beautiful language, but it's hard to learn, but if we learn this sophisticated language it will make our logic sophisticated as well. We, Hungarian people are creative-minded, the Nobel prize/population ratio clearly displays that. If you reverse the order of words in a sentence you will get a different meaning in Hungarian, while in English your sentence will become senseless. On a national level innovation means that people have innovative mindsets, you will be innovative by instinct. With this example I wanted to point out that innovation can be adapted, but cannot be forced in a country, you can't

force innovation onto the recipients if they lack the necessary mindset – this is a global issue.

What's your opinion about companies internationalizing their R&D activates?

There is an enormous lack of professionals, the lack of workforce is a global issue, not our domestic problem. There are governments who believe total employment is the holy grail, they try to educate everybody, meanwhile they reduce the number of freelancers who can be flexible, it's not an accident that a global 7-8% unemployment is considered normal. It's not beneficial to force everyone into employment, freelancers will find their way of life, others will have the opportunity to choose their specification e.g. in our company we have an economist and a microbiologist, they also work as AI researchers. Companies outsource because they run out of workforce, luckily Hungary has great research centres – you can observe, most of these centres are in 11th district – ELTE and BME (BUTE) provides well educated workforce, who would like to go beyond assembly lines, they want to create something. These research centres are always located near these young, ambitious people, this is a great trend.

What are the critical factors for a successful R&D project?

You need to employ competent people, they can create completely new, unknown disciplines, therefore you need a continuous source of workforce. You need to create the atmosphere, where the guys say no matter what, we can do it. So, it's crucial to have employees with this mindset, they can work in unknown fields, in our case it's called autonomous vehicles, this is what innovation is about. I think for success you need to have this start-up mentality: no matter what we can do it, although we know that soon it won't become a product.

What kind of R&D activities do you cultivate at your company?

We are creating solutions for autonomous vehicles, mainly 3 things are needed to achieve this. You need AI based algorithms (created by physicians, mathematicians, informaticians), it must be able to locate, identify, localize, control and create decisions,

this R&D activity requires great efforts, although it's rather research, you can see new articles being published daily on this topic, we must process these articles, extend them and we add our own ideas. Second, you need development tools, to create an autonomous vehicle you need more than a store-bought software. There are no platforms for this kind of development, you must create your own, which can provide data, perform testing, verify and able to teach AI. Third: you need hardware development. The currently applied automotive hardware is not suitable for serial production, automotive companies can't afford to use a 1 kW computer in the boot, purpose-built equipment will be created for AI algorithms – currently they don't exist, we have developments to solve this problem as well, furthermore we have algorithms developed for automotive applications, to sum up we have these 3 types of researches. It's worth mentioning it's classified as different R&D fields… not by HIPA but maybe the patent office does that? Maybe the patent office, I think they give R&D classifications. We needed them for the public road tests of autonomous vehicles, we must conform with the Hungarian road test regulations. To carry out this test the company must be qualified as an R&D company by the government (patent office), we've received our permissions for these 3 researches, so we have a certification that says: we're making innovation.

What's your opinion on cities becoming innovation centres? What is the reason behind this trend?

Well, San Francisco became a centre due to historical reasons, it's located near Silicon-valley, the concept was created by the USA to locate all the important tech companies. This became a self-perpetuating progress, it started before modern innovation start-up era. Singapore is a different case, it used to be a fisher village 50-60-70 year before, suddenly Malaysia said they will abandon this territory, a local (born in that fisher's village) came back and said he will create a country from that land. He erased the fisher huts, and launched an R&D campaign, because southeast Asia didn't have any sort of those activities. He established one of the world's richest countries. In Singapore it was easy, because of the size of the country, in the Silicon-valley they had the infrastructure. Maybe Berlin and Helsinki became significant hubs, but their progress is a bit forced, they are unstable. You can create tons of events, conferences, dozens of start-up companies at these places, but they will look like each other's clones. If I want to outsource to

any European science hub I will see the same schemes in Berlin, Helsinki, Madrid etc.; these cities used the proven methods to create hubs; I doubt that they will be able to keep their appeal in the next 5-10 years. Why are they created? Somebody had an idea, they forced it into an innovation scheme. The necessary funds and workhours were provided by some businessman, but in our globalized world it's almost negligible who created that start-up company. If you do it the start-up way your main policy will be tax relief, useful consultation system, maybe you can support this process with a bureau to create the opportunities, which can be presented in a conference.

Do you have cooperation with universities or other companies in the R&D field?

Unfortunately, no there are two reasons behind this. First universities work at a different speed then ours, we are in a rapidly changing environment, roles and task must be up to date. If we cooperate with a university we must employ people from there, by the time they can start working we can solve the problem with our internal workforce and we can move on to the next task. If we had a completely separated task, that could be outsourced to them cooperation would be plausible, but this is a very unstable field. If you are an industrial company with a certain goal you should hire experts, tempt them to your company instead of outsourcing, waiting and burning money, this way you can redefine the task. Big companies can do this because they have numerous divisions, they can afford to create another one. Our workforce is around 150 people, if we involve 10-15 people from other companies this will make a great difference for us, they will earn money from that project and probably they will be eager to complete the task.

What's the future of Hungarian innovation / R&D according to your perception?

It depends on our control of higher education, if we can guarantee that the university graduates (thousands, tens of thousands) will be useful employees, we have to enhance dual education, they need to have 6 months internships instead of 6 weeks. You must encourage students to participate in a project, you must encourage companies to hire them with proper salaries (not with a 50.000 HUF/month wage) this way we can integrate project into their studies; furthermore, after graduation they will have a solid job,

they will have the necessary experience. Until this innovation will have its difficulties, companies must make huge efforts to coach the graduates, because skilled workers will be needed. Of course, you will need workers to carry out the less skill-intensive tasks, but it can kill the creativity. Dual. practice oriented education should be supported with every possible means.

What sort of benefits/drawbacks can Hungary expect from autonomous technology?

First, I would discuss the global issues. Fact: each year 1.3 million people die in traffic accidents, equal to losing 10 full Boeing 747 airplanes every day, why do we allow this to happen on our roads? It's simple, people think they drive better than a robot, their self-importance tells them to take control (you can see this egoism on Hungarian roads). To be honest Hungarian roads are safer than average, we only have 400–500 deadly incidents / year. The fact scares me, that everybody has a friend, relative who seriously injured or died in a traffic accident, we see this threat as a distant, unlikely event, until it happens to us. Autonomous vehicles will clearly lower the number of traffic incidents, maybe to zero. We can live in a world without accidents. You can have a beer, the car will take you home, you can play games, study on the way; yet we don't see exactly how it is going to work, if every vehicle becomes autonomous mobility – as we knew it in the last 150–200 years – will completely transform. Think about how global mobility has changed when the tyre, steam-engine, airplane was invented. Autonomous vehicles will induce a reform just like the other mentioned inventions – just like steam-powered vehicles meant a huge step. We can't see the exact effects, but mobility will become safer.

What autonomous technology is in the focus at your company?

We focus on software, we are not interested in building cars. Our goal is to create an AI based software (full stack system), which can solve every kind of autonomous task. It sees the environment, locates the position of the vehicle, based on that it makes decisions after that it can be controlled. To sum up we are creating a software that can make a vehicle autonomous after it is fitted with the necessary sensors and this software. We buy our sensors, only some of the necessary sensors are developed here.

Why did you choose this field?

I can tell you, but it goes back a long time. We're a spinoff company, we used to be part of Kishonti Ltd., this was a market leader company in GPU chip testing and benchmarking, e.g. we were testing smartphones and their performance, which hardware was sufficient for the given task. If the device couldn't handle the workload the codes were optimized. This required serious competencies, 2.5 years before Adasworks was created, a 5-10-person group left Kishonti Ltd., they were specialized in image processing. Their task was to process the most images with the given hardware with/without AI technology. When Adasworks was created we presented Mercedes a demo: with the help of one camera the vehicle was able to make a full lap on Hungaroring, using a mobile phone processor, it was to process the tasks with even weaker processors, back then it was a huge achievement, we specialized in image processing, and we've succeeded, because there was no AI-based image processing for autonomous vehicles, furthermore nobody was able to run these algorithms in real time due to their high processing demands. Then we've contacted car manufacturers and their suppliers with our advanced algorithm for their autonomous vehicle. They were interested but requested specifications. I answered what do you need? We will make it to meet your specifications, unfortunately they didn't have specifications, they are just integrating devices into their products, this happens in 80% of the cases. They assemble the engine and the chassis, this is their product, end of story. We had a product, nobody knew if it was good or not, there was no feedback. We decided to build an autonomous car on our own, if I want to create my own prototype I'll know what's necessary for the perception process. So why are we focusing on software? We started from a complete software-firmware to create efficient image processing, after a while it turned out that we have the competencies to build the whole autonomous vehicle, this applies to our hardware development as well. When we tried to get hardware for our program they said it will take a while, nobody really knows what kind of hardware is needed for this purpose, they have hardware that can process data from community sites. We said that we want to process full HD pictures, we are not interested to choose from dozens of kittens which one is brown. To sum up the driving force behind this is time: we can't afford to wait for other suppliers, we are a start-up company, we want to integrate the technology in our vehicle ASAP.

What's the forecast/expectation about utilizing your technology?

Our priority would be to create and license a software, to generate revenue after every car that uses our software. The drawback is the automotive industry is not flexible, their regulations can't be changed, we must wait for a long time until the first fully autonomous vehicles will be manufactured. I'm sure that you're aware of the 6 levels of autonomy. Level zero lacks any control, at level one and two you can find driver-aid systems, they are in commercial applications. Level three is capable of decision making, four and five implies a high level of control, currently we are developing level 4 and 5 systems – the 4 technological scales are changing, on top of the car we have cameras instead of "lidar" devices. Google car has a lidar device on the top, besides that is costs 30 million HUF, it has drawbacks. It is a laser scanner, after scanning the environment it compares the results with a previously scanned 3D world, based on that it can locate itself. If I have hundreds of employees, they can draw the traffic signs into the map by hand and the car can travel based on that data. What's the problem with this? You must create a map and keep this map up-to-date, besides Google only a few companies are capable of that. Basically, we're software developers, we have internal prototype, we have several partners as well; e.g. we have a level 4 software for Peugeot group, PSA, this is not product development, these are prototypes, we study that the concept is capable of driving, but it takes years. We have an automotive partner who doesn't wait years, we are developing them an intelligent back view camera system. The camera on the back recognises cyclist, pedestrians, estimates their distance, it alarms you in case you would hit them while driving backwards – this is a driver aid system, it can turn into a product in 1-2 years. This is our profile, we create enormous collections of algorithms and functions. They can be integrated into level 4-5 systems, but certain blocks can be excluded, if I want to create a level 3 driver aid system in the short term; to deliver for my customer. Obviously, these products can't be directly built into a vehicle, we don't have the capabilities to compete with an automotive supplier, we have common projects with those suppliers, if we succeed we reach out automotive companies with the product.

What's your opinion on the application of autonomous vehicles in Hungary?

Please let me elaborate this from my personal view, I'm from Szabadka and I've travelled a lot on highway M5, I hate every mile of that road, the Romanian truck drivers the Serbian workers, not to mention the BMW drivers with Slovakian number plates made me hate that stretch of road; I hate to use the highways in Hungary. If the policy makers have a sense they will vote for the change, a huge transit traffic goes through us, they can correct the lack of railway transit with obligatory autonomous policies (if the commercial vehicle has such capabilities), after that this regulation can be extended to every vehicle travelling on highways; this will take 10-15 years. Prediction says about 5% of the vehicles will be autonomous by 2035, but most of the personal vehicles will be able to change lanes and commute on highways; most traffic accidents happen on highways, after that comes minor accidents in cities, but emergency breaking, and forward collision warning technology can eliminate those kinds of incidents. Probably the first area of application will be highways and fixed-track vehicles. Under fixed-track I mean e.g. buses, it has a permanent track, with lidar technology you can scan the bus line. These will be the first global and domestic applications. Mixing autonomous and conventional vehicles might lead to peculiar situations, legislation, insurance and developers should be aware the gravity of the situation. Some thoughts about Hungary: we have busy transit roads, thus our road network is advanced, so cities will probably decide to invest in the technology; on the other side I'm sure autonomous taxis will have a small share in Hungary, compared to the USA, because USA has a vehicle-oriented culture.

How do you see Hungarian R&D ambitions?

You can see the ambitions, this is unarguable. I think these efforts are sufficient, and I'm not saying that because your next interviewee will be Mr. Palkovics, by the way we send our best regards, he helped us and the autonomous industry several times, despite our concerns about Hungarian bureaucracy they've created the legislation background for testing on public roads, even liberal European countries failed to enable that. We have a good basis for innovation – our students, universities have high standards, although they are a bit too centralized – under this I mean the leading role of Budapest. There are good universities outside Budapest, but e.g. University of Szeged lacks a

strong engineering department, despite their solid achievements in scientific and medical fields, the university in Győr is Audi-oriented, Audi has its own department in the university, like the University of Miskolc, Bosch has a department there. Our economy is focused on the automotive industry, 30% of our GDP comes from this sector, although 90% of this sector consists of assembly lines, innovation is a small piece of the pie. It's obvious, that under the term innovation mainly we think about innovation in the automotive industry, even if it sounds unpleasant. We can talk about IoT and dozens of other topics, but automotive industry is the driving force behind Hungarian innovation. The general direction looks good, but we should extend dual education – while programmers know they will have a job if they can use C++ language – a mechanical or an electrical engineer should keep up with the industry and understand the structure of multinational companies. We can't expect them to be creative and innovative if they learn process control from the Béla Lantos book (it was the bible of process control in the 80's), creativity comes from looking behind the scenes of development process. They can see our daily challenges, e.g. we have 12 sensors and we are trying to integrate 3 sensors to create useful data – currently this is a global issue, to integrate sensors, e.g. cameras and radar devices – how do you know that the camera and the radar sees the same vehicle? It's not so obvious, the whole industry is working on this problem, but you won't meet this challenge at the university, by thinking about that you create an environment of… So, looking from the HR side you can also support innovation, not only from the government side.

How can the government attract companies with activities like yours?

It's difficult, our geological location is not the best, Silicon Valley is the leader in autonomous technology, every important competitor has at least one office there. Michigan and MCT also became a significant place, due to the presence of MIT in the area; last there is Detroit used to be the flagship of car manufacturing, currently known for their criminal statistics, but you can see initiatives in Detroit. China is one of the winners, they sell the highest numbers of cars by far; the other Asian company is Toyota in japan, they are the biggest car manufacturer in the world. In Europe we have the traditional German automotive companies with their suppliers, BMW or Mercedes will never decide to outsource its complete R&D department, they have their R&D facilities

in Germany (BMW, Mercedes, Audi, each centre has ~ 2000 employees), Audi launched a new research facility, but surprisingly it's in Germany as well; Bosch executes most of its autonomous development in Hungary, but their HQ is also located in Germany, they give the instructions to their Hungarian colleges. How could we attract more R&D to Hungary? I don't know, the situation is a bit peculiar, we can't really control this trend, it's influenced by the centralized German mentality, of course there are companies aside from Germany: Jaguar, Land Rover, PSA, Seat etc. but they are not as big as their German competitor. We can grab the attention of smaller companies, e.g. with the recently launched Autonomous Vehicle Developing master's program in cooperation with ELTE and BME. If they can make it work it will be an outstanding English course, so foreign students will also apply; workforce can attract companies and their R&D facilities, besides German companies. About the test track in Zalaegerszeg I would say this is a great initiative, first this is an automotive test track and it functions as an autonomous test track as well. The main aim of the track is to host the testing of brake systems, truck brake systems etc. There are fast curves and open areas to let Knorr push truck brakes to their limits, I'm sure you've discussed it with them. There is an urban facility, to test autonomous vehicles – our company helped a lot to create the specifications. Bosch, Continental, Thyssen-Krupp, Knorr-Bremse, AiMotive, representatives from the government and universities were also involved. We've discussed the design of the test track, we've made an agreement, that for autonomous vehicle development tests on public roads are inevitable. Roads can crack, traffic markings can erode, the vehicle is surrounded by real people, the walls are not made from cardboard, our everyday environment is much more versatile then a 5-10-acre test field. Testing on a track is great, but we must carry out tests in the real world, this is the reason why Hungarian government allowed public road tests (tests on public roads and in closed environment are equally important). Furthermore Zalaegerszeg-Budapest is a 3.5-hour long journey, I can't afford to commute during my 8-hour shift to test my lane-keep assistant, yes you can stay in a hotel for the night, but your company wouldn't be happy about the bills, furthermore do companies, start-up companies want to devote this amount of time to go to Zalaegerszeg? In the event of a large-scale testing the whole team goes to a track for 1-2 weeks to make well-aimed tests a certain function, which has been developed for years. Autonomous vehicles are different, you use the test track twice a day, the software package might change within one day, to test the software you most go out

to the testing facility, you can't move the whole company to that facility, so this test track in Zalaegerszeg is a great relief for some companies, but it's not the best solution for agile testing, we can involve companies into the testing process if they move to Zalaegerszeg. For example, we can decide to hire 10-15 people, move them to Zalaegerszeg, they can run the tests on our software and give us feedback. My other concern is the timeline: the track will be ready in 2018-2019, by then a lot can change, although we are looking forward to using the facility, but I would like to emphasize that testing in real environment is also crucial, I wouldn't criticize nor promote this project until its ready.

Is there any way to give better support for these companies?

I think we've got all the necessary support, period. I would recommend keeping up the good work.

Is your company in cooperation with the government? Could you describe the level of cooperation?

We are consultants at the strategic meetings, we have meaningful relations with NFM and NGM. Obviously NGM decides about investments, but the NFM releases the test-permit. Maybe NGM is led by Mihály Varga..? And the leader of NGM is Mr. Lepsényi? Never mind, we attend a lot of events, presentations, conferences. We can elaborate our professional opinion, we can present the feedbacks about testing, it's a great advantage that on the ministerial level we can consult with experts instead of bureaucrats, and they listen to us! Usually bureaucrats like to talk a lot, unlike experts, they can see the core of the problem and try to solve it. This is how we communicate, our legal department consults with the ministry daily, furthermore our auto-testing team must report the place and time of public tests to the ministry. We try our best to promote autonomous development, we help other companies to communicate with the government, our aim is to create a positive atmosphere for these developments, and I think we're doing a great job.

Outstanding, is there any topic that we've forgot to discuss any important topics?

Don't know, we've discussed our activities, innovation in general – I was a bit long-winded good luck to organise my thoughts, you can simplify it. I'd like to state again: innovation can't be forced, but if we provide the necessary resources, visions it will emerge on its own, no worries. We can declare the government provides legislation background, we are happy to work in such an atmosphere – although we are the only company in the region with such a development. You can find start-up companies in the USA, Singapore, in Europe you can find automotive companies and their suppliers, so we have a bit of competition, but competition is necessary to keep up the good work. I would like to emphasize one thing: we're looking forward to this new master's program, it's interesting, but we must wait 3-4-5 years until graduates can come to us, who knows if we will be still on the market? I'm sure the automotive industry will keep its momentum in Hungary, with hard work and determination we can achieve great things. **Thank You!**

6) Interview transcript (Viktor Tihanyi)

What's your current position and department?

I have several positions, currently I'm working at the university as an assistant professor, and as an R&D leader. Besides that, I work for Knorr Bremse as a project engineer in the autonomous field.

What does the term innovation means to you? What does it mean for the country?

Maybe development, I'm not sure, I'm not good at describing general concepts, maybe we should go to the factual questions.

What do you think, why companies internationalize their R&D activities?

Every multinational company has a dedicated strategy, the reasons behind their decision might be financial or originate from lack of workforce. If the company can't find sufficient workforce in its home country, they have to outsource, the other reason can be the

high domestic salaries – especially in developed countries – they can get the same resources at significantly lower cost, this is the financial aspect.

What are the critical factors for a successful R&D project?

Obviously, you need to have satisfactory human resources with the highest possible qualifications. I'm a bit confused, because R&D is such a big field, that…I think from a project management view we must adapt the tasks and resources to the project, it's hard to determine these factors for such a general question. I would say that good implementation is a critical factor. You have to assign the right people for the right tasks, you have to declare univocal goals. In general, I can't give you a more detailed description, these factors can be very project-specific, the R&D sector includes basic research, applied technology research, we can classify product pre-development and product developement can be also classified as R&D activities, every process and phase have its own success factors.

What is the role of education in R&D and innovation?

The role of education is to give our students proper education, skills, to participate in long-term researches, for big companies or at academic levels. The task of the university is to create the foundations for them, if we look at the autonomous technology it's a rapidly changing discipline, the syllabus should be reformed in every two years. In this case the students need a solid basic knowledge, we can't keep up with the rapid changes of the technology, it would be quite difficult for our institution to always change the syllabus, although we try our best to keep up with the technology. We will start a masters program, which will focus on autonomous vehicles. This program contains syllabus focused on this discipline, to give the basics, we would like to be flexible, so the exact starting date is still unknown, maybe we can start in February or in September. To keep up with the changes, we've created a vehicle automatization specialization for the currently existing vehicle-engineering department, this masters program is in progress. In this program we've kept the basic courses about vehicle engineering, although we've introduced 6 new subjects, completely based on autonomous technology, our intention

is to keep those courses up-to-date. We consult with industrial experts, we invite experts to give lectures, they can give the necessary knowledge to our students.

According to your experience which kind of cooperation (between private and educational sector) is the most exemplary? Please elaborate why.

We might look at our cooperation with Knorr Bremse as a benchmark, we are closely linked to them – I don't know if Péter Frank has mentioned this – the Hungarian R&D centre started from this department as a small company, which is now located at Major street. We have teachers from their R&D centre and vice versa, this means our colleagues have the necessary industrial experience, this gives us an enormous advantage. They can pass on the latest technological advances and best practises. This synergy is quite useful for the company as well, students can be introduced to the company, they can work there during their MSc, BSc or PhD studies, with the financial support of several scholarships. Furthermore, we consider the students workload, to protect them from overwork. This way we can avoid the current situation (here and the electrical engineering dept.), when students need to perform in both fields (workplace and studies). With this concept we can avoid this situation, students can get involved with projects without getting overwhelmed by their studies. I think the best way to improve is to create your own developments, reading books is not enough, it only gives the basics. Gladly, our students give us a very positive feedback about our dual education system and our scholarships are also popular.

What's your opinion about cities becoming innovation centres, what is the reason behind this trend?

If knowledge cumulates at a certain location it will attract companies and human resources. Due to this effect the mentioned locations become centres. I hope Hungary will become such a centre, some of the high-end companies has already built autonomous technology related facilities here. It's crucial to create the proper educational background for this progression.

What is the role of education in creating such a hub?

The basic role is to support, the answer to this question is like my previous answer, about the role of universities. If we look at it from the educational aspect basic research should be done by the universities, these activities should stay there. As a result, big companies can spend less on basic research, they have a comparative advantage in applied researches, they can allocate funds in higher volumes then universities.

In your opinion what is the future of R&D in Hungary?

We should support and strengthen R&D as much as we can, with goals or with funds, but as I can see there is no lack of such support; R&D is on the rise in Hungary. This is not our sole intention, multinational companies also create their centres here, e.g. Bosch and other automotive companies; the Hungarian higher education has high standards, furthermore we have sufficient number of experts, so multinational companies realised it's a good investment to outsource and create centres here. I wouldn't like to mention other countries, but low salaries will not induce the creation of research centres, the necessary amount of workforce is critical. Throughout the years Hungary might become a "best cost" company, we have lower salaries compared to the western salaries, but we have the necessary knowledge to increase our share.

What's your opinion on Hungarian autonomous vehicles technology?

As I've mentioned Hungary allocates great resources for both industrial and educational fields, not to mention the support of the government, e.g. the autonomous test track being built in Zalaegerszeg, that is a strategic investment. If we look at the whole picture it becomes evident that our position is promising. Not only multinational, but start-up companies also choose Hungary, their performance is also outstanding; to conclude I can give positive outlooks for the future.

How can Hungary benefit from this technology? What are the drawbacks?

There are two main driving forces behind this phenomenon. One is economic efficiency and environment protection (e.g. minimizing emissions and fuel consumption). The other one is to minimize traffic accidents, improve statistics, both can be achieved by

applying autonomous technology. If we get to this milestone, when we will be able to create and use fully autonomous vehicles, but this won't happen in the close future. Until then we will have a period when autonomous and conventional vehicles will be mixed. Autonomous technology will have its own progress: first special conditions will be needed for autonomous operation, as the development proceeds they will be able to handle complex situations, until it will be able to replace the chauffeur, but conventional vehicles won't disappear. This will cause a lot of headache: to solve compatibility problems between a conventional and a fully autonomous vehicle. If all the vehicles would be autonomous, they could communicate with each other, even a global control would be possible. Until this happens individuals will participate in traffic, this will make things complicated. I think one unquestionable benefit of fully autonomous vehicles is safety, emission and fuel consumption will be optimized, through global control we can optimize traffic, there won't be traffic jams, this is a promising future. I can't say any drawback about this technology, I have concerns about mixing conventional and autonomous technology. Professional drivers will be concerned, their jobs will cease to exist, but experts say other kind of jobs will be created, briefly these are the issues worth mentioning.

What's your opinion on the application of autonomous vehicles in Hungary?

I don't see the difference between Hungary or any other countries, although there are differences, e.g. in India you won't see road signs, most likely you will see a cow on the road. As you can see there are country specific challenges, but in Europe the roads are unified, there are no significant differences.

What's the role of education in this field?

I would like to mention the following example: the university has a tender to promote this technology amongst high schoolers, so we make efforts into this direction as well. We organise an open day every year where we show them the technological advancements, these events are quite popular. The previously mentioned tender is a proactive

measure to make this discipline interesting for students, this way we can make them understand how exciting, how important is this field, we can assure them that they will have great jobs. There, we suffer from a huge lack of professionals in this field.

How can education support companies interested in this field?

Obviously, we can help by providing proper education and cooperation e.g. dual education.

How do you see Hungarian innovation/R&D ambitions?

I see positive tendencies, the government makes efforts to develop this field, their goal is to improve innovation, R&D as much as possible and they are providing the necessary funds for this goal.

How can the government facilitate innovation and cooperation in the education sector?

The government provides incentives for innovation, furthermore there are tenders to promote cooperation between academical institutes and industrial companies, the necessary assets are available.

How can the government support autonomous technology?

We have several tenders aimed for autonomous technologies. As I've mentioned the Zalaegerszeg test track is also a government-funded project, this approximately meant a 40 billion HUF investment, there are tenders related to this test track, they were created for academic researches, to study autonomous technologies related to the test track. For instance, not only autonomous researchers face difficulties, testing also has its hardships. There are no international standards, how should be an autonomous vehicle tested, what do they have to perform on the test track; we have standards for certain driver aid systems, but validation processes for highly autonomous vehicles are still under research.

I don't know if you are involved, but the university operates a RECAR program, could you describe this program?

We have a tender about this, ELTE, BME, MTA and SZTAKI is involved (there might be more participants, I'm not sure). This program has three main objectives: one is the research itself, to perform, coordinate researches about autonomous technology, the second goal is the education, to support education. We are talking about educating engineering students with appropriate background knowledge, our masters program is part of this effort. The third goal is testing and validation, in this matter we have direct connection with the test track in Zalaegerszeg. The specification progress was organized in the framework of RECAR program, the headquarters was deeply involved in creating the specifications, they had a big role in launching as well. Under these tasks I mean organizing meetings with industrial partners, collecting requests from them, what is needed for such a test track.

Is there any topic we've missed, but you think it's worth mentioning?

I think we've discussed every topic, related to universities and education. If you have any further questions, please contact me.
Thank You!

7) Interview transcript (Zoltán Rózsás)

What's your current position and department?
I'm working for Próbapálya Zala Kft. as the leader of knowledge-stream.

What does the term innovation means to you? What does it mean for the country?
Innovation is creating, developing a product or application that hasn't been available before for wide audiences; thus, improving general health, general quality of life and safety.

What's your opinion, why companies internationalize their R&D activities?

Maybe a German company can relate to the Hungarian mindset, we have similar work ethics, especially in engineering field. In general, multinational companies can see us as R&D partners for several reasons. First, yet we are cheaper than our western competitors, while our bachelors, masters and PhD graduates can bring the same level of knowledge like their eastern peers. This comparison shows our strongpoints: they can get the same level of knowledge they could get in eastern Europe, but at a lower price. Furthermore, if a problem is inspected by experts from different cultural backgrounds the solution might be more detailed and versatile.

What are the critical factors for a successful R&D project?

To propose solutions for acute problems. The demographic charts show, that the population of EU is getting older, this will generate a higher demand for driver aid systems and autonomous vehicles, with innovative solutions we can give elderly people the chance of mobility – which they used the have throughout their whole lives. If we want to define criteria for a project, customer expectations and deadlines are the most important factors.

According to your experience which kind of cooperation is exemplary between a company and an educational institute?

We've worked with our partners on an industrial R&D project; to enhance the vehicle with visual capabilities, this solution is still in application at the Szentgotthárd Opel factory. As a result of this cooperation industrial parties, university researchers and academicians developed relations with each other. The automotive Próbapálya Zala Kft. is currently in cooperation with BME and Pannon university. In the framework of dual education and through other scholarships 30 students are employed at our company, who participate in R&D activities.

What is the role of education in R&D?

The role of education is to maintain a network, to fill up the mentioned "pool" with talents who will graduate as masters, to see, guide and take care of these young man.

What's your opinion on Hungarian cities becoming innovation centres? What is the mechanism behind this trend?

The reason behind this trend, well how should I say this – I'm a mechanical engineer, others can use more expressive phrases for that – these cities can attract and keep talents, while smaller villages might lack this attractiveness.

How could education help to create such hubs?

Education is a dual-purpose field (at least). One purpose is to follow the technical advances, to be reactive – if you want to launch a program it takes at least 2 years, the first student will graduate 3 years after the launch, in case of vehicle engineering or autonomous vehicle programs you must wait 5 years for the first graduate. By the time the first class graduates the syllabus will be outdated. Under reactivity I mean the continuous reform of conventional education system in such rapidly changing fields – maybe reactivity is a good expression for that, or maybe proactive? The essential part is to design a system that can keep up with rapid development of technology. The other aspect is to give useful knowledge, to provide fundamentals for their future career in R&D or industrial applications.

What's the future of R&D and innovation in Hungary?

I would say this is a great time to increase our momentum in R&D and innovation – which is significant since the 90's – with investments like the Autóipari Próbapálya, Zala. This gives automotive companies a chance to increase their existing R&D capabilities. Currently the closest track, where they can carry out such tests is in Obstberg (1000 km from here). With this track automotive companies can cut down the cost and time of testing, validating new products, prototypes. This can give a huge advantage for domestic automotive companies and vehicle R&D activities.

What's your opinion on the application of autonomous technology in Hungary?

Most of the technology is available, our partners (Bosch, Continental, Thyssenkrupp and Tesla) are working on full steam. The technology has almost reach the level of applicability, although legal background is equally important for the application.

What benefits/drawbacks can you see related to the domestic utilization of this technology?

The benefit is the wide applicability of the technology. People without driver's license could buy mobility, e.g. citizens under the age of 18, elderly people, or disabled personnel, who could not drive a car, furthermore number of traffic accidents should dramatically decrease due to autonomous technology. My first concern: this technology will probably appear in high-end vehicles, this will have a negative impact. To mention another benefit, vehicles will become greener, without drivers vehicles can maintain a constant speed with better fuel economy, their program could avoid unnecessary accelerations end decelerations.

What's your opinion about the application of autonomous vehicles in Hungary?

I think it will rapidly spread in our globalized word, you can already see S-class Mercedes and Audi A8 vehicles on the road, automotive technology will have similar impact, because they will be used in this high-end, expensive category. I would estimate this technology will spread slowly; but look at the car radio: in the 90's it was an extra, in 2000 it was a standard, during the decades drastic changes can occur, e.g. legislation can be changed, in case the government realizes the benefits of this technology they can make autonomous technology an obligatory feature; I bet they will do that.

What's the role of education in autonomous technology?

It depends on the level of education, high-school should only prepare students to get familiar with this technology. Higher education is more complex, in that case your graduates must be able to apply their knowledge in industrial environment.

How can education support this field (autonomous vehicles)?

By creating education programs, specializations, providing the necessary knowledge-base to ensure their professional background in the beginning of their career.

Is there any sort of specialization in this field? Can we expect new specializations?

Yes, there are two of them. We have two or three in progress, there is an autonomous vehicle control specialization, this will be available in Budapest, this is a full time, English program, to my best knowledge it will be launched in February. A test engineer program will be available soon, it should start in late September of 2019. This program will be available in Zalaegerszeg, Budapest and Veszprém (at Pannon university); the autonomous vehicle control MSc program's practical courses will take place in Zalaegerszeg.

1How can education support companies who are interested in this technology?

Mainly by building partnership, we take into consideration their professional expectations towards graduates, and they should reform education to meet these expectations.

How do you see Hungarian ambitions in the R&D field?

We have interests in this field, and we should pursue these interests. My statement lays on experience, we consult with a lot of companies about the test track, Bosch employs more than 4000 Hungarian engineers in this field, who are creating their latest automotive developments. This clearly represents the potential of innovative Hungarian workforce. Our ambitions and expectations are correct, we can reach our goals

.

What's the role of government in this field?

The government should create an atmosphere where companies and educational institutes can work in cooperation to solve the problems of our future with the help of academicians, university and industrial personnel.

How can the government support companies interested in research, R&D?

By providing investment opportunities and support system which promotes these companies to increase the volume of their high value-added processes.

Do you know if the government has an intention to create other kind of supportive systems in this field?

Well, our project falls into that category, through this investment, with this test track Hungarian government invests in automotive R&D. Its intention is to create thousands of R&D positions at companies who will use this track.

What kind of support could Hungarian government give the education system to be innovative and cooperative?

They can help with targeted resources. This is the mechanism behind the current tenders and this was applied in recent tenders, the framework was based on industrial cooperation and achievements, this determined the amount of available funds. This is a great incentive to create cooperation between universities and companies.

How do you see the role of government in the world of autonomous vehicles?

The rule of government is mainly enactment of the law, besides creating incentives like the test track, where these vehicles can be tested and validated, besides that dynamic legislation is also crucial.

What's the reason behind the Hungarian government's ambition? Why was this sector/industry chosen?

I have a logical answer for that. If we have a look at the Hungarian industrial sector, we can see that automotive companies take a great share in our GDP. If the government invests in this industry, high return on the investment is almost certain.

How can the Hungarian government attract companies interested in this sector?

It's not working this way, we can't attract these companies, Hungarian companies (with R&D departments since 1991) formulated their needs almost 10 years ago for a test track, they described what sort of test track would be beneficial for them; due to the complexity of their needs – e.g. a company developing a truck brake system has different needs than a company focused on steering wheel actuators. It was clear that they would have built several small, separated units, for themselves; it couldn't be a profitable investment. In a nutshell we've built this track based on the requirements of the automotive companies, it was designed by a company named Horiba Mira, which has connections to the automotive industry. I can proudly say more than 20 dominant automotive companies participated to create the specification of this track. They've decided, to use this facility. How can we attract further companies? We must gain their trust. These are sensitive issues, we must demonstrate we can handle confidently the information about prototypes, we are able to keep up with the deadlines, we can satisfy the requirements of our customers.

Is there any topic we've missed but you would like to discuss here?

I think we've discussed it thoroughly, so not really.

Thank You!

Appendix D: Coding the interviews

Raw data(quotes)	Open coding	Concept	Category
"Only a few foreign companies are able to bring substantial and innovative projects to Hungary. "	low number of substantial innovation	substantial innovation	Innovation
"So, technology higher education was not suffering damages in the accursed times, especially it was high-quality education and it is nowadays."	engineer tertiary education	tertiary education	Education
"defense of core business and to keep risk level of activities low.....the uncertain ideas are for creative Hungarians..."	uncertain ideas, creative hungarians	creativity	Innovation
"It is a specialty that the complete so-called Advanced Engineering division is in Hungary not in other countries."	complete development	development	Innovation
"..Obviously, this decision has a cost factor...wages of engineers are lower"	cost	foctors of investing	Investment
"...so we are not suffering from labor migration to Western Europe..."	no migaration	foctors of investing	Investment
"... composition and the abilities of the stuff as a key element..."	team	critical factors	Innovation
"...from a bad material you can never get marvels, right?"	productivity and flow	critical factors	Innovation
"So now I'm pretty much saying that the engineers are the most productive if we keep them in "flow"."			
"The core business activity is to produce utility vehicle braking systems...we are global market leaders...."	competition	importance of competition	Innovation
"We are doing "engineering services" in case of the previously mentioned product groups."	complete research and development	research and development	Innovation
"...complete research and development process.."	development process	development	Innovation
"... doing the settings of finished products to different newer and newer vehicles..."	attachment	specialization	Innovation
"To create hubs is necessary but very difficult and it is not establishing itself."	question of will	factors of hub	Innovation hub
"This project requires the development of every element, the infrastructure...and education"	everything has to be developed	factors of hub	Innovation hub
"....This is a systematic and strategic work process. It must be done with absolute governmental support."	strategic governmental support	governmental strategy	Government
" If a city reaches a critical mass than this process will operate well."	training	tertiary education	Education
"...it was realized that it has a high potential to start vehicle test engineer training in the local college in an association with the Technical University..."	cooperation	factors of hub	Innovation hub
"After a certain point, this project will exploit and employ engineers from the university by using the test track and relevant companies will set locations next to the track...for us, it is a possible perspective to employ test engineer from here"	pull	factors of hub	innovációs hub
"We were the first who have applied dual education in association with GAMF and Mercedes at Kecskemét..."	dual training	tertiary education	Education
"with Budapest University of Technology and Economics we have an absolute strategic cooperation."	educational cooperation	tertiary education	Education
"....with public research sites, as MTA (Hungarian Academy of Sciences), SZTAKI (Hungarian Academy of Sciences Institute for Computer Science and Control) and different professorships of the universities...and participating in different reearch projects..."	governmental cooperation	tertiary education	Education
" We have a very serious and important, so-called student program...where thesises can be written.."	scholarship program	tertiary education	Education
"...have a doctoral program, too..."	tertiary education and cooperation		
"...and we also teach at the university"			
"So, we always have ongoing reseach and development projects, into which we involve research institutions."	continous researching	factors of r and d	Innovation
"....we do not have the capacity to do the basic research...."	outsource	developing efficiency	Innovation
" ...we can not develope nano composits, the unversity does, but they do not know what to develop..."	competency	factors of r and d	Innovation
"...in the last 20 years, i think we had 4 or 5 research projects....which we did not know back than, that it would be useful for autonomous vehicles. And now, we start to find these projects and damn it, these architectures are just perfect for ..."	technological maturity	technology	Innovation
"...i think it is a strategic thing."	strategic question	factors of innovation	Innovation
"...we should have high level research and development in Hungary and we should be a melting point."	high level of research and development in Hungary	Hungarian r and d	Innovation
"...the engineering tertiary education should be better promoted.."	propagate the engineering education	engineering education	Education
"....so basically, currently the number of students in high-schools and universities is decreasing."	decreasing number of students	problem of tertiary education	Education
"The future of it is what we do (research and development)."	future is research and development	r and d	Innovation
"...a plant is managable to be relocated from Germany to Hungary....research and development unit to be relocated is way harder."	hard to relocate human force	factors of innovation	Innovation
"... basically research and development has an industry stabilization effect, too."	r and d industry stabilizationeffect	effects of innovation	Innovation
"... driver shortage,so tha lack of drivers."	driver shortage	advantage of autonomous cars	Autonomous technology
"....which relieves the driver, so we can be more efficient..."	increase efficiency	advantage of autonomous cars	Autonomous technology
"....we developed a fully hungarian project, a truck which could do manouvers in a site by its own.."	hungarian development	development	Innovation
"And when a truck has an accident, it has greater financial consequences than a normal vehicle..."	cost consequence	advantage of autonomous cars	Autonomous technology
"...what we know the best is safety...."	knowledge in safety systems	autonomous vehicle technology	Autonomous technology
"....we just spend 10 times more for testing.....we have to produce a software which is immaculate and guaranteed."	reliable technology	autonomous vehicle technology	Autonomous technology
"....environment-sensing, behaviour planning and motion controll...."	autonomous safety systems	autonomous vehicle technology	Autonomous technology

"...and we think, these autonomous functions and smaller driver assitance functions have huge potentials, due to the safety and efficiency they bring..."	high potential field safety efficiency	factors of investing advantages of autonomous technology advantages of autonomous technology	Investment Autonomous technology Autonomous technology
"... I dont look at this as a revolution, but as evolution.."	technologiacal evolution	autonomous technology	Autonomous technology
"...what i see from the government's side, is that there is a very stong will towards this direction..." "...there are dedicated institutions like the National Research, Development and Innovation Fund...which was established directl because of this aim..." "....it really thrives to reach these goals and to promote, support and finance innovation."	strong governmental will dedicated institutions support of innovation	governmental will governmental investment governmental support	Government Government Government
"With support, development of education, building test track and eventually increasing the mood for investing."	increase the investor environment b support developing education infrastructure	governmental goals governmental support role of government role of government	Government Government Government Government
"...the lack of trained labour force...." "For example, I think the wage of high-school teachers should be raised, especially the ones who teach science subjects.." "...the government built up a solid pedagogic career plan..."	lack of trained human capital increase wage of teacehers educational career plan	labour force shortage high school education education strategy	Education Education Education
"...we received significant financial support for both of our plants." "...we currently have two research and development projects, which were partially financed by the government." "....the government realized that this is a strategic way, so it is worth investing here."	financial support for plants support research and development governmental strategic path	governmental support governmental innovation governmental strategy	Government Government Government
"We have to grow up and I really miss this from the current generation..."	become adult late	youngsters situation	Generation problems
"...continous reformation"	revival	idea of innovation	Innovation
"...in the filed of automotive industry, the two most important trends are electromobility and autonomous vehicles" "Bosch is the one which is leading, because they have the greatest number of research and development engineers."	automotive trend highest number of research and development engineers	autonomous trend development	Autonomous technology Innovation
"...so dedicated development engineers are there in this two topics."	dedicated developers	development	Innovation
"...innovation, product development and process development....these are the ones which the HQs are mostly protecting....in Germany or in the US..." "...when they already know the market environment here, it is easier for them to relocate other operations or services here." "The basis of this is the well trained enginneers, labour force. And that generally, it is cheaper to employ a Hungarian engineer than for example a German."	secured innovation trust well trained labour force	innovation internatianlization innovation internatianlization factors of investing	Innovation Innovation Investment
"The competency and the wage I would say."	competency wage	factors of investing factors of investing	Investment Investment
"...where you can find a twirling, focused culture..." "...the government can urge this, with supporting structures, which attracts the companies, hence attracts the labour force and it generates itself like this.."	culture governmental urge inducing process	factors of innovation hub governmental strategy birth of innovation hub	Innovation hub Government Innovation hub
"..electromobility and autonomous driving..." " there is a little shift, due to new market entrants to the automotive industry..." "So it requires a more complex and global environment from the side of the cities."	new trends new entrants complex competition	autonomous technology trend competition competition	Autonomous technology Innovation Innovation
"... it gets more important in the automotive industry, hence in Hungary, too." "...and the government with establishing the test track in Zalaegerszeg and with creating new Msc and Bsc programs, it tries to support this direction..." "So it is visible, that various players have cooperated here."	importance of autonomous technology governmental test track cooperation of players	autnonomous technology governmental support cooperation	Autonomous technology Government Innovation
"...there will be less parking places in the cities, because the vehicles will provide services instead of being parked in one place..." "....we will better utilize the vehicles..."	less parking lots higher utility	advantages of autonomous technology advantages of autonomous technology	Autonomous technology Autonomous technology
"...government can contribute by creating the educational backgound." "....at BME and ELTE there will be new master and bachelor programs in the field of autonomous technology, I do not even know, I think it is gonna be 3 years, and in english for sure." " it will provide competitivness for the students." "...the government can, creating programs and majors which are related to these new innovative technologies..." "....the other thing is to create the right infrastructure." " ...supporting the firms, investors and their plans regarding these technologies..."	educational background new programs competitiveness innovative technologies developing infrastructure támogatás	role of government tertiary education tertiary education tertiary education infrastructure governnmental support	Government Education Education Education Infrastructure Government
"Firstly supporting education and research and development..." "....we sfinancially support research and development activities or making the circumstences better for them.." "We also want to lighten the regulation environment..."	support financing legistlational background	governmental support governmental finance legal regulation	Government Government Government

"One of them is supporting the technology intense industries....they have to sign that they keep the current one and invest at least 30 million euros..."	support types	governmental support	Government
"...to make them to bring the most modern technologies here to Hungary."	aim of support	governmental support	Government
" The other one is the supporting of research and development projects....here, the wages and amortization costs can be supported."	support types	governmental support	Government
"... most likely next year there will be facilitation in the supports."	ease of supports	governmental support	Government
"So we still try to help the most value-added activites to come to Hungary."	high value-added activity	governmental support	Government
"Minister, Szijjártó, told several times, and really this is our goal, that instead of "made in hungary", "invented in Hungary" should be in the labels.."	aim of support	governmental support	Government
"...it is a great advantage, because it is not the project of a specific company, it will be available for everybody."	available test track	governmental investment	Government
"I think the regulation backround is very important, that these companies can grow easier and move on in this trend. And do this in Hungary."	legistlational background	legislation	Government
"Automotive industry is a good indicator for innovation, especially in these days, when new entrants are in the mareket from IT and technology fields..."	automotive industry indicator of innovation	innovation indicator	Innovation
"...there is a need for an expanded or fresher educational structure..."	new education structure	education system	Education
"....that the well trained labor force should be available in the right number in the given place."	availability of labour force	human capital	Education
"Besided, the creation of infrastructure is also an important question, but nowadays this is not the most important, but the labour force."	infrastructure	governmental investment	Government
"To keep the position of the education and further reinforcing it is the most important. The other one is the creation of good supporting and investment friendly environment."	creating a good investor environment	investor environment	Government
"What I think is exemplary, that these companies who are competitors initially, they sat to a table and were able to cooperate with each other."	cooperation	importance of cooperation in innovation	Innovation
"Hence, in the field of autonomous vehicles, this is an important cooperation." í	example of cooperation	cooperation	Innovation
"... in the field of electromobility, there are important developments in Hungary."	electromobility	automotive trend	Automotive industry
"....more and more suppliers join."	role of suppliers	automotive players	Automotive industry
"...who win in these races can further develop, whereas the others who lose, can not develop so the initial production capacity will decrease too.."	evolving posibility	automotive competition	Automotive industry
"...what we usually undertand is the creation of something new, which than would be found in a product, which can be sold in the end..."	new product	idea of innovation	Innovation
"...who brought significant production, do not stop producing..."	continous development	progression	Innovation
"Very much multinational companies dominate..."	dominance of MNCs	competition	Innovation
"So if You ask the leader of Bosch that where would he/she start an autonomous vehicle project, in Palo Alto, Stuttgart or Budapest, Budapest would have better chances in my opinion."	competitiveness of Budapest	factors of innovation	Innovation
"We have the knowledge, it is more flexible and it is cheaper too."	advantages to Hungary	r and d	Innovation
"So it is very important that multinational companies come here to Hungary with more research and development. This is already happening, but we also need Hungarian companies to create their own IP."	importance of Hungarian research and development		
"The german industry in the middle of the 90's started to internationalize their research and development, because they had no enough engineers back home.."	engineer shortage	reason of r and d internationalization	Investment
"This is what we call a patent..."	patent	IP	Innovation
"...research or paralelly the predevelopment phase, which processes the idea"	process of innovation	innovation system	Innovation
"...when we educate engineers, it not enough to teach them to the given profession, we have to show them what processes are related to this thing, like patenting, research methods, business development methods etc.."	training of engineers	tertiary education	Education
"In Hungary we are not in a good position in this field in contrast with Izrael. After graduating university very few hungarians start a company...."	bad start-up culture	state of start-ups	entrepreneurship
"...there was a program started called recar, where several universities and companies are cooperating with each other, and creating things together..."	RECAR cooperation	RECAR	Government
"...from nex January, at BME, an Msc will be started in english, regarding autonomous vehicle solutions..."	new dedicated master program	tertiary education	Education
"There is an outstanding cooperation between Audi and the University of Győr, they are operating a faculty there so the industrial experience will be presented there."	example for cooperation	cooperation	Education
"There is a tendering contruction, which lots of universities have won already, that promotes to creating an incubation environment where product development can be performed.."	support od product development	support of education	Education
"... most importantly there has to be a strong university."	strong university	tertiary education	Education
"...very important to have a cause around which something can be organized."	vision, cause	factors of innovation	Innovation hub
"It is also important that the community should feel it is an important question. Under community i mean city or economical environment..."	role of community	factors of innovation	Innovation hub
" The aim of the government is also very important, especially in the begenning, when these processes are started..."	will of the government	factors of innovation	Innovation hub
"And it is also important to have a demand for it, so somebody should have a claim towards this..."	need	factors of innovation	Innovation hub
"....to do research and educate..."	research, education	tertiary education's task	Education
"Teritary education's goal is to produce the professionals who can work after graduation, and to do tasks for these companies in the hub..."	role of tertiary education in the innovation hubs	factors of innovation hub	Innovation hub
"...now tha Hungarian economy is a work-based economy....and we want it to become an innovation-based economy..."	role of innovation in Hungary	types of economies	Innovation
" ...innovation in Hungary is not a goal, it is neccessary to have."	need of innovation	wills of innovation	Innovation

"...we calculated last time, that more than 10 thousand engineers are working in the field of autonomous technology in Hungary."	employment of autonomous technology Hungary	autonomous technology	Autonomous technology
".....from the service, communication and integrator side, an other 10 thousand people work..."	employment of service providers	support autonomous technology	Autonomous technology
"...as i said, Hungary in this field is in the frontline in the world..."	competitive technology	state of autonomous technology	Autonomous technology
"Lets say the starting conditions are good."	available conditions	conditions of autonomous driving	Autonomous technology
" ....In the beginning of the 80's, we started the researches regarding vehicle control technologies, because of which Knorr Bremse came here to Hungary. The idea of ESP was found here."	research and development experience	r and d	Innovation
"The Thyssenkrupp came here because with BME university, we made them the first electric steering wheel. Now it is an individual company with more than 1000 engineers and two production plants."	sikeres magyar kutatások	hungarian innovation	Innovation
"eliminate the driver."	reliefe of driver	advantage of autonomous vehicles	Autonomous technology
"...we wont pollute as much gases...”"	consumption	advantage of autonomous vehicles	Autonomous technology
"...if we look at the numbers, 93-4% of the accidents are caused by the abilities of the human driver..."	accident prevention	advantage of autonomous vehicles	Autonomous technology
"It is an open question that the decision we should take, these cars will take so it brings up some ethical questions.."	ethical question	question of autonomous vehicles	Autonomous technology
"I think, that the need of autonomous vehicles is visible..."	need of autonomous vehicles	autonomous technology	Autonomous technology
"How they would be implemented, maybe firstly in closed tracks, without a driver, or in case of a lane of trucks, one driver will be in the first truck and the other trucks will follow is autonomously is a question..."	use of autonomous vehicles	autonomous technology	Autonomous technology
"here it is not about the eterministic control, or not just about the deterministric control. It is more about a AI based control..."	AI education	tertiary education	Education
"The handling of data, the whole data analysis, big data are new territories in the science, all of which have to be educated..."	Big data education	tertiary education	Education
"....the safety of these, so cybersecurity is also a separated subject..."	cyber security education	tertiary education	Education
"To train engineers and do research...”"	teach, do research	task of education	Education
"...BME will do it, the " autonomous vehicle contorl systems" program"	new masters	tertiary education	Education
"That one is the „Computer Science for Autonomous Vehicles", but it mostly means AI. "	new masters	tertiary education	Education
" the vehicle test engineer Bsc, so how to test these vehicles."	nem bachelors	tertiary education	Education
"So one of the requirements is the whole testing environment, partially the test track in Zalaegerszeg..."	creating a test environment	governmental investment	Government
"...and partially, that the vehicles can be tested on highways and motorways in all Hungary..."	legal regulations	governmental legislation	Government
"...to finance those solutions, which are done by the universities and by the companies."	financing	governmental tasks	Government
"To do investments, which for private investors would not worth to invest due to high risk, but it is worth for the government to do so."	governmental investment	governmental tasks	Government
"Thirdly creating legal background, which supports autonomous vehicles' tests."	legal environment	governmental tasks	Government
"....if there are infrastructural elements like 5g....than the government should promote and support this..."	development of infrastructure	governmental tasks	Government
"Like building a testing environment which has not existed before.."	investment	stimulation of investing	Government
"....with supporting programs, they receive support after the new engineers if they are employed in these fields..."	support	stimulation of investing	Government
"so we are creating tenders, which are based on cooperations..."	tender supports	tertiary education	Education
"...for the research of autonomous vehicles almost 10 million euros were given for 3 universites..."	cooperation	tertiary education	Education
	tender	tertiary education	Education
"...through the regulation, the government has a serious role..."	reulation	governmental tasks	Government
"The government also plays a significant role through finacning, too..."	financing	governmental tasks	Government
"The government can also give support, which enhance the appearance of 5G network...."	infrastructure	governmental tasks	Government
" They approached the government that there is a problem, which the government could solve somehow..."	external need	governmental ambition	Government
"This is why this concept have been created and started to build this testing environment. Right now, this is the most complex test track in the world."	complex testing environment	governmental investment	Government
"...so basically hungary will be an autonomous vehicle examinition hub."	autonomous hub	birth of innovation hubs	Innovation hub
"So there should be a good test trac, good research done by universites and the correct ecosystem."	ZONE factors	stimulation of investing	ZONE
"creating something from nothing"	from nothing to something	idea of innnovation	Innovation
"..cheapest price, like Hungarian labour force, but now it is more used "best price"...."	cheap labour force	factor of investing	Investment
"..the supply of engineers, and the agregate number of available engineers are strongly affecting the success of a company..."	supply of engineers	factor of investing	Investment
"dbut around 10 thousand engineers can be produced, there is no more, we can not do more..."	limit of engineer education	limit of tertiary education	Education
"..it is a marginal question,yes, we have to provide sufficient imput for these companies..."	educate sufficient input	tertiary education	Education
„because nobody has illusion, after 2 weeks a fresh graduate can not be used...."	quality of education	tertiary education	Education
"...these dual programs are very good, because the kid experience a little business environment while studying..."	advantage of dual programs	tertiary education	Education
"But I am not sure that it is good for everybody, that in a young age like that students are suffering from the lack of time..."	disadvantagae of dual programs	tertiary education	Education
"...they should go there for thesis , internships, tranee programs and write master thesis there..."	importance of gaining experience	industrial experience	Education
" In Hungary, Zalaegerszeg has the chance to become such a hub in the field of autonomous technology..."	Hungarian hub location	Hungarian innovation hub	Innovation hub
"...because of the environment of the test track, the smart city environment..."	smartcity	Hungarian innovation hub	Innovation hub
"...this system has to be fed to be able to work..."	support the system	tertiary education	Education
"....the prospects are very good."	good prospects	future of innovation	Innovation
"...now we have the trust, and the respect, that it would be succesful and the research and development in this filed is competitive..."	earn trust	factors of investing	Investment

"... government made a law, that autonomous car testing is allowed on Hungarian roads if the goal of the test is research and development..."	existence of legal regulation	governmental legislation	Government
"There are projects here, comapneies here in this field, I could say 3 of them. Bosch already has a division directly doing autonomous driving research and development..."	ongoing research and development	continous developing	Innovation
"...the less number of accident and fatal accidents..."	less accidents	advantage of autonomous driving	Autonomous technology
"The other one is the optimization of fuel, hence less pollution...."	less consumption	advantage of autonomous driving	Autonomous technology
"...the elders, disabled, kids woudl be able to mobilize themselves..."	wide range of mobility	advantage of autonomous driving	Autonomous technology
"...environment-sensing, and the challanges due to environmental conditions are the drawbacks...."	environment-sensing	autonomous technology	Autonomous technology
"...the highly supporting driving, which means that these functions should be further developed and make them more complex...."	market entry of technology	autonomous technology	Autonomous technology
"...optimally the human driver can be served in the long terms for 50,60,80 years with these systems..."	market entry of autonomous technology	autonomous technology	Autonomous technology
"I think it makes sense in the midle-long run, and do not want to enter the market with a not complete technology...."	timing	intruduction of autonomous technology	Autonomous technology
"In special conditions, it is sure that we will see autonomous vehicles.."	user conditions	use of autonomous technology	Autonomous technology
"...there are mllions of questions, for which we have to find the answer, till it is gonna be smooth..."	questions		
"... if somebody wants to learn this special vehicle control tecnhnology, now he/she should go to 4-5 different places to study, in order to gain the neccessary knowledge base..."	difficulty of autnomous technology learning	educate autonomous technology	Education
"...the tasks are so sliced down, that the employee will work with the slice of the slice...."	specialization	industrial experience	Education
"The expand of the RECAR program was like that Bosch, Knorr and Continental have appeared as partners..."	RECAR cooperation	RECAR	Government
"The goal is the same....that the student has to be prepared for them to use them."	requirements of companies	new education system	Education
"In high-school level, i do not see the neccesity of it"	opportunites of dual programs	tertiary education	Education
"...regarding the dual education, it could be very useful and good if the student do not narrows his/her views.."			
"...if it trains the student in a given direction, it might ruin the student, but it makes good for itself, for the company, because the student is going to be a very good input..."	disadvatage of dual programs	tertiary education	Education
"...those are the discertations written in companies..."	indstrial experience	task of education	Education
"...Bosch has a course in the faculty of vehicle control..."	business cooperation with university	education cooperation	Education
"... that throughout the education process, where can the company grab the student and what quality human capital is willing to go there and work there...."	selecting the labour force	labour force competition	Investment
"...we have to step out from the dump screwing circle..."	situation of hungarian economy	need of innovation	Innovation
"..the more the innovation here....the harder to bring it away...."	effect of research and development	effect of innovation	Innovation
"... directly fot establishing research institutions, research programs and financing them...."	financing	role of government	Government
"...Indirectly to support curriculums regarding these subjects...."	investment	role of government	Government
"So it all depends on the governmental decision makers, if a program can be started or not...."	indirect support	role of government	Government
	governmental decision	role of government	Government
"...earn to be accreditated and to be started...."	program accreditation	tertiary education	Education
"It just depends on the leader of that university, if he is able to levarage and live with those opportunities...."	responsibility	tertiary education	Education
"...training and restructuring the training, and to keep up with this technology....this has critical points."	restructure education	restructure of tertiary education	Education
"...the neccessary knowledge in vehicle engineering and vehicle design will be lower down for a basic knowledge and new knowledge will be needed..."	need of new knowledge	new tertiary education system	Education
"... there has to be a specific topic, and has to be dig down in it...lets say our topic is going to be environment-sensing or acuratos or localization or anything else..."	need of specialization	new tertiary education system	Education
"if we really want to be in the frontline, we can keep up, but we are one step lag from them..."	close up	lag between faculties	Education
"we have a very good relation with Knorr...."	good relationship with companies	state og tertiary education	Education
"for example 50% of our teachers are working part-time at Knorr and part-time at the university..."	business experience	experience of techers	Education
"Like tires and connection between furface and tires in Kalrsruhe, or engines in Münich, we should also have a specific topic like, radars or cameras, we are the best..."	need of specialization	specialization	Education
" Everything is innovation if there is a newness in it, or something which works on paper but nobody has tried it in practise..."	newness	idea of innovation	Education
"...which is a tangible thing and not something with just numbers...."	tangible result	idea of innovation	Education
"...if a language is hard, it is creative, hence it makes the speaker creative....this is why our nobel prize/ population ratio is so high..."	Hungarian creativity	factors of innovation	Innovation
"...innovation can not be forced to a country..."	push innovation	disadvantage of innovation	Innovation
"...the lack of prefessionals is huge there..."	shortage of qualified people	factors of investing	Investment
"...the optimal unemployement is around 7-8%..."	optimal unemployement	factors of investing	Investment
"They bring it here, because at home they do not have human capital."	shortage of trained people	factors of investing	Investment
"...interestingly most of the research and development centers are in the 11th district of Budapest, because ELTE and BME pour out the very well educated students..."	r and d around educatin	r and d	Innovation
"...supply most importantly..."	supply	tertiary education	Education
"...there has to be somebody with a vision, who tells them that this is gonna work..."	succees of innovation	strategy	Innovation
"So algorithm, tools and hardware..."	development of autonomous technology	autonomous technology innovation	Innovation
"These 3 types od innovation we have here and the government determined these 3 separated research and development fields..."	types of innovation	innovation	Innovation

"...they are too close to each other, and they are too similar to be able to make a difference, so there is no demand..."	disadvantage of start up hubs	disadvantages of innovation hubs	Innovation hub
"I doubt that these are gonna be in a leader role in 5-10 years, than the innovation hubs establsihed to a real demand..."	lack of demand	factors of innovation hubs	Innovation hub
"Why they came to exist? Because somebody had an idea, that we gonna have innovation here by forcing it."	pushing an idea	factors of innovation hubs	Innovation hub
"....if you have for example good tax allowances, or good consultancy system, it is not neccessarily has to be a hub, it could also be a government who helps You to establish those opportunites, which results you can show in a conference for instance."	create opportunities	investing environment	Investment
"...the universities have a different pace than we have..."	pace difference between universities and companies	disadvantage of university cooperation	Education
"...things like roles and tasks are changing way faster here..."	speed of change	disadvantage of university cooperation	Education
"If we had a part-task, which we do not have the required knowledge about and we could completly outsource it, tahn we would cooperate with universities..."	outsource	cooperation opportunities with universities	Education
"...it depensd how can we control the university programs..."	tertiary training	tertiary education	Education
"He/she should not be a lost bird, we should force the dual programs, change the internship time from 6 weeks to 6 months...."	role of dual programs	tertiary education	Education
"...it is obviously the task of the board of education. But the dual programs and practise oriented programs should be very very supported..."	experiencing board of educationú	industrial experience tertiary education	Education Education
"....there wont be accidents..."	decrease nb of accidents	advantage of autonomous technology	Autonomous technology
"....it will change everything we thougght about mobility in the last 150-200 years..."	change of mobility	advantage of autonomous technology	Autonomous technology
"....complete, full-stack systems, meaning from the beginning to to the end, it solves all autnomous tasks."	developing autonomous technology	autonomous technology	Autonomous technology
"...who worket with picture processing... "	image processing	autonomous technology	Autonomous technology
"...small processors like this should process greater amount of pictural data with or without AI."	developing	r and d	Innovation
"...one Mercedes with one camera did the Formula 1 circuit alone, this was the first autonomous car, which had only one processor contoling the vehicle."	show	r and d	Innovation
"...AI based algorythms..."	requirements	reason of innovation	Innovation
"They do not know what is their requirement....they are integrators, they "just" put together parts..."	competency	reason of innovation	Innovation
"...we have the competency to build an autonomous software and from that time, we are working ot this..."	role of timing	reason of innovation	Innovation
"....this is the result of the fact, that we can not wait for anybody, we are a start-up, and we want this technology to be used in the cars quickly."			
"...we create a software which we gonna licence."	software licencing	source of income	Income
"For a long time it wont be in mass production,a car which knows everything..."	indroducing autonomous technology	limits of autonomous technology	Autonomous technology
"...vwe have a level 4 software developement, this is a product development for a prototype development."	developmetn	r and d	Innovation
"....what we basically do is a huge collection of algorythms."	autonomous technology	autonomous technology	Autonomous tehnology
"...we have to cooperate with an automotive supplier, with which we can create a project and approach OEMs..."	cooperation	supplier cooperation	Income
"....at least those trucks, that are coming to the highway, they should use autonomous driving mode."	use of highways	legal regulation	Government
"....later, implement it on the highways ass soon as possible, and make it mandatory to use there."	mandatory technology	legal regulation	Government
"....Specially in Hungary, because we are a transit country..."	transit country	Hungarian specifics	Government
"I am really satisfied..."	presence of ambition	role of government	Government
"... the government really helped us in the whole research and development process."	support	role of government	Government
"Hungary is a bureaucratic country, however it gave the lie to itself by making the test of autonomous cars on roads legal.....big liberal countries could not do it..."	legal support	governmental legislation	Government
"The thing is that Hungary has the good ingredients for innovation, the students...the education is really good."	good tertiary education	teritary education	Education
"We are a very automotive industry centric country...our GDP's 30% is coming from this industry..."	automotive endustry centralized	importance of automotive industry	Automotive industry
"Obviously if we say innovation, the first thing is automotive innovation."	automotive innovation	Hungarian relation to automotive industry	Automotive industry
"The problem is that we are not in the right place geographically."	geographical playe	Hungarian specifics	Hungary
" A German BMW or Mercedes wold never say that the whole research and development division is relocated outside of Germany..."	depending on Germany	limits od development	Innovation
"...there is gonna be a program in ELTE and BME, called " Autonomus Vehicle Developing Engineer" an Msc..."	new masters	tertiary education	Education
"If there is labour force, not the German companies, but others, smallers, might bring a development center here..."	establishment developing center	r and d	Innovation
"...it would be neccessary to do test on roads..."	testing on public ways	legal regulations	Government
"Anyway we look at it, Budapest-Zalaegerszeg is 3,5 hours one way..."	disadvantage of ZONE	ZONE	Government
"Autonomous driving is an effective research, where daily 2 tests are done, with different software packages..."	disadvantage of ZONE	ZONE	Government
"We can attract companies to the test track if they move there and establish an office there...."	ZONE companies	ZONE	Government
"So what they do now is good, keep it up..."	good path	strategy	Government

"We are there in strategic meeting as consultants."	consultants	strategy	Government
" ...the point is that we are in a lot of events, round-table-meetings, and presenations..."I	presence of events	strategy	Government
"...the ones who wee the problems and really do aginst it and try to help..."	every mean of help	governmental help	Government
"...and make Hungary an ecosystem which is a good place for autonomous vehicle development. And the direction we are going now I think is good..."	Hungarian autonomous development ecosystem	autonomous innovation hub	Innovation hub
"...lets say progression..."	progression	idea of innovation	Innovation
"...financial and capacity reasons."	cost	factor of investing	Investment
	capacity need	factor of investing	Investment
"Correct people with correct tasks and well built goals do their job."	factors of succes	factor of innovation	Innovation
"...to educate proper students with proper skills and knowledge..."	educate students	tertiary education	Education
"...this is a very changing environment, that in 2 years every curriculum will be outdated....hence it would be hard to follow it up in the education."	dynamic change in curriculum	tertiary education structure	Education
	new masters	tertiary education	Education
"Here in the unversity a new program wil be started as an Msc. specially focused on autonomous vehicles..."			
"...I would say the cooperation with Knorr-Bremse can be called a benchmark."	kooperation benchmark	cooperation	Innovation
"... the teachers here....they have the neccessary industrial backgound, which I think is a very competitive thing in the education."	teachers' industry experience	tertiary education	Education
"...students can work while doing Msc, Bsc or a Phd "	dual training	tertiary education	Education
"TWe can provide several types of scholarships..."	scholarship support	support of tertiary education	Education
"...our new dual master program also aims to take under consideration the students' workload in the university and in the company, too."	load of students	dual programs	Education
"....the feedbacks are really positive regarding our dual program, but the other possibilites are also popular..."	satisfaction of students	quality tertiary education	Education
"...somewhere the knowledge starts to concentrate, that attracts the other companies and companies the human capital...."	attraction	factors of innovation hub	Innovation hub
"Hopefully Hungary will become such a hub..."	Hungary as a center	Hungarian innovation hub	Innovation hub
"And aside from the importance of the companies, education is really important..."	sufficient education	tertiary education	Education
"...the university should do basic research....the big companies can not put so much effort into the basic research...."	basic research	role of tertiary education	Education
"...it has to be forced and supported..."	support	support of innovation	Innovation
"I do not see if there is a lack of it..the Hungarian research and development is strongly evolving."	strong development in r and d	Hungarian innovation	Innovation
"The education is very good in Hungary, hence serious companies should come here..."	good quality education	quality of tertiary education	Education
"but low wage is not enough for a research center....the sufficient human capital is needed to have."	sufficient human capital	factors of investing	Investment
"...we are the „best-cost" country..."	cost	factors of investing	Investment
"...from the education side, serious resources are allocated here, and also from the government's side..."	good governmental resources	governmental ambitions	Education
"so there are serious start-p companies in Hungary, who are operating in this field."	serious autonomous technology start-ups	start-up ecosystem	Entrepreneurship
"....less accidents..."	less accidents	advantage of autonomous technolog	Autonomous technology
"...economically efficient..."	efficinecy	advantage of autonomous technolog	Autonomous technology
"..firstly they can perform autonomous driving in special circumstances."	limited usage	disadvantage of autonomous technolog	Autonomous technology
"Consumption and traffic-organization would be minimizable."	less comsumption	advantage of autonomous technolog	Autonomous technology
"....the drivers would loose their jobs...."	jobs dissapear	disadvantage of autonomous technolog	Autonomous technology
"...so new kind of jobs will be created, but in other forms..."	jobs creating	advantage of autonomous technolog	Autonomous technology
"...the university has a specific tender regarding this, to propagate this technology in high-schools..."	tenders	support of education	Education
"...with right education."	good quality education	tertiary education	Education
" ...with university-business copperation."	cooperation	strong cooperation	Cooperation
"...in the current position, i see it positively, I think the government put a lot of effort into this field."	positive ambition	role of government	Government
"...that we have the neccessary tools."	existing tools	role of government	Government
"...we currently have some tenders regarding autonomous cars and autonomous technology..."	autonomous vehicle tenders	governmental support	Government
"...it is not just the development of the autonomous car what causes problems, testing it is also a challange, because there are no international norms...."	challanges of testing	realize the need	Government
"One of them is research itself, and the research of autnomous technology, coordination of it etc....Secondly, education. The support of education."	birth of RECAR	RECAR	Government
"...thirdly, the test, so validation."	testing environment	governmental investment	Government
"...organizing meeting with industrial partners, collecting their needs etc..."	assess the need to the testing environment	governmental investment	Government
"....the use of new products, or developing new applications, creating something never existed before for widely use for the society."	new uses	idea of innovation	Innovation
"...in case of a German company, maybe that we have similar way of thinking, and attitude towards tasks..."	similarities	factors of investing	Investment
"...till now, we are way cheaper than the western locations..."	cost	factors of investing	Investment
"...the knowledge of gradates from Bsc., Msc. or Doctoral programs, is competitive compared to the western countries' graduates..."	competitive knowledge	factors of investing	Investment
"...give an answer fo an acute problem."	answer for problems	factors of innovation	Innovation
"...the specific customer needs and deadlines are the critical factors."	consumer demand	factors of innovation	Innovation
"...to fill up that "pool" non-stop with talents, who can do a master degree...."	talent education	tertiary education	Education

"...thanks to this cooperation, industry placers have met each other, the academic people and educational people, too."	test track cooperation	cooperation	Innovation
"...education should be reactive..."	changes in education	tertiary education	Education
"Till we create a curriculum and the first student graduates, the originally composed criterions change 5 times...."	changes in education	tertiary education	Education
"....it gives a qualification...based on which, they can move to industrial applications or reserch and development."	personal development	tertiary education	Education
"...it is very good, the way it goes now, and the pace how research and development and innovation goes ..."	it is lively	state of innovation	Innovation
"where only normal tests can be performed is Obstberg, 1000 kms away from here...."	lack of testing place	limits of testing	ZONE
"...so mobility would be able to be bough by people who do not have the chance now...."	wider users of mobility	advantages of autonomous technology	Autonomous technology
"...drastically less accidents..."	less accidents	disadvantages of autonomous technology	Autonomous technology
"...when this technology will be available, it is gonna be very expensive..."	expensive technology	disadvantages of autonomous technology	Autonomous technology
"...we would be use these vehicles with more efficeincy..."	econonomic use	advantages of autonomous technology	Autonomous technology
"So my pont of view, is that it is going to spread ery slowly...."	slow expansion	expansion of autonomous technology	Autonomous technology
"...who can use their related knowledge in industrial environment, too."	use of knowledge	tertiary education	Education
"...create programs,majors which can be a solid base of...."	creation of programs	tertiary education	Education
"...one of them is autonomous vehicle control engineer, this is in Budapest as an Msc, totally in english...."	new masters	tertiary education	Education
"...test engineer program is also gonna be available...."	new bachelor	tertiary education	Education
			Education
"...it is contact with them, and sensoring their needs regarding human capital, and modify the structure of education accordingly."	sensing the neeeds	tertiary education	Education
"... They can rely on the Hungarian labour force when it comes to innovation."	reliable labour force	factors if investing	Investment
"....these expectations and goals are totally fine."	well described goals	strategy	Innovation
"...create the right atmosphere for companies and for education..."	creation of good atmosphere	stimulate investments	Investment
"...somehow support them, with investments..."	with support	governmental support	Government
"Within the framework of tenders...."	tenders	governmental tender	Government
"....the regulations should be dinamic..."	dynamic legal regulations	governmental legislation	Government
"....with investment, like this track, where these vehicles can be tested and validated..."			
"....they pay a lot into the hungarian GDP..."	pulling industry	Hungarian automotive industry	Automotive industry
"...around 10 years ago, these companies told their need towards a test track like this..."	industrial need	governmental help	Government
"...one player's test track investment would not return..."	cost effective	governmental investment	Government
"....this is created based on the key automotive players' needs, by Horiba Mira."	industrial need	governmental help	Government
"....more than 20, really big automotive player who were involved to the specification of the track..."	strong cooperation	cooperation	Innovation
"And they stated that they are going to use this track."	real nemand	use of ZONE	ZONE
"...we can keep the information regarding the prototypes."	earn trust	use of ZONE	ZONE
"...we have to earn their trust."			