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Managing Transition to Electrical and Autonomous Vehicles

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Abstract

Constant innovation within automotive industry created more safe, ecological and affordable vehicles. This industry is now facing significant changes created by the introduction of electrical powertrains and autonomous vehicle technologies, as well. These technologies reached a level of development which makes feasible their widespread deployment. This may provide significant social benefits by improving safety and saving lives, reducing fuel consumption, congestion and pollution, improving mobility and land use. The transition from traditional vehicles to autonomous and electrical vehicles is driven by convergence of connectivity, electrification and changing customer needs. The main objective of the investigation, presented in this paper, was to explore various aspects of this paradigm shift, highlight potential benefits, technological changes and policy recommendations.

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Keywords: electrical and autonomous vehicles; regulations; innovation; dominant design; policy

1. Introduction

Technological advancements are enabling the transition from conventional, fully human-driven vehicle toward autonomous, mostly electrical, autonomous vehicle which will not require driver at all. Drivers and passengers will benefit from the change. They have vast prospects for more prolific use of passengers' time in a vehicle, for reducing crashes, traffic congestion, energy usage and pollution. New technology may also change the forms of

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vehicle ownership and ways how land is used. In the near future is expected the creation of new markets and economic opportunities.

Massive changes caused by the advent of autonomous vehicles are still puzzling legislators and lagging policymakers, whose propositions will influence their future impact and adoption. Together with the automotive industry, they are responsible for the transformations process.

There are several reasons why autonomous electrical vehicles getting their enormous actuality right now. Technology maturity provides opportunities for commercial introduction. All major automotive incumbents are involved in market research and development of new businesses enabled by new technology innovations. There are also new entrants, who leverage their complementary capabilities into newly promised lucrative market. Associated figures show enormity of stakes, representing hundreds of thousands killed in traffic accidents, millions of injured and billions in other liabilities. For example, the latest Australian road fatality data show that during 2016 were 1,295 road deaths[1]. In United States (US), according the National Safety Council, fatalities rose 6 percent in 2016, reaching an estimated 40,200 deaths compared to 37,757 deaths the previous year[2]. In 2010 alone, there were 5,419,000 crashes, killing 32,999 and injuring 2,239,000 [3].

More efficient use of roads reduces the costs of traffic jams especially because travel time can be used productively. Improved safety on the road allows new designs with light materials, making savings in road maintenance and fuel consumption. A different pattern of vehicles usage will be created. They are currently much underused assets. On average, they are unused 96% of time and even this 4% is characterized with very low occupancy. Autonomous vehicles should deliver similar degree of benefits in view of comfort, availability and point-to-point traveling to counteract such inefficiencies. A research from Organization for Economic Cooperation and Development (OECD)[4] found that 80% of current parking spaces will be unnecessary in the future, implying that this land can have different use.

We have identified stakeholders of this change and they are: Science and technology institutions, automotive industry worldwide, customers as drivers and passengers, local and global communities, local and global governing bodies, environmental, health and other institutions.

Policymakers are some of the key stakeholders of change management processes. They define, or influence adoptions and final destinations of some value propositions, offered by electrical and autonomous vehicles and their advocates. They should decide at what level electrical and autonomous vehicles will be regulated, what kind will be permitted to the road and who will operate them. Safety procedure for testing, approval and operation should be defined. The safe adoption of new technology will be accomplished through smart road infrastructure, separate highway lines, by having a choice among manufacturers that create autonomous vehicles, or consumer incentives to purchase these vehicles. Regulators should make compromise between safe adoption and potential liabilities.

Our investigation aims to explore some features of electrical and autonomous vehicles, and estimate their potential effects on future transportation. It should identify the remaining barriers to pervasive penetration and sweeping adoption of autonomous vehicles on a large scale and consequently, to propose policies for well-planned and managed transition considering the increasing proportion of autonomous vehicles in a future.

Concurrent with the change to autonomous vehicles, there is the transition in powertrain technology, from combustion engines to electrical vehicles (EV). We are investigating both changes since they are now happening at the same time, affecting the same industry, environment and the community [5,6]. Since we are already in the transition, there is a large number of hybrid vehicles on the road, and vehicles with driver assistance applications.

2. Background

There were three phases in autonomous vehicles developments research so far. In last two decades of previous century, the research was mostly conducted at universities which cooperated with automotive companies and transportation departments. Two main ideas resulted from this research. One vision was focused on highways with automated infrastructure and low intelligent vehicles which relied on this infrastructure. The other research stream was focused on vehicles themselves, which could be used on the roads without sophisticated automation. At the beginning of this century, the most important research was conducted by the US Defense Advanced Research Projects Agency (DARPA) and presented by Buehler et al.[7], which initiated three different studies, two in rural and one in urban environment. These studies were subsequently continued at universities, aiming to further develop autonomous vehicles technology. In the third phase, large private companies, not necessarily automotive (for e.g. Google and Apple), intensified their own research and announced plans to commercialize this technology.

For example, in last few years, at the Royal Melbourne Institute of Technology (RMIT) University, as in other universities across Australia, research is conducted in electrical vehicles, as well as in Autonomous Systems (AS). An electrical golf cart, whose control system is designed by School of Engineering students, is shown in the Fig. 1(a). Australian community is aware of the need for change. For example, this AS is designed originally for the first Defense Science and Technology (DST) Annual Autonomous Ground Vehicle Competition (AGVC) run in 2013. There are other AS, or mobile robotics, competitions on national and on international level, like National Instruments (NI) Autonomous Robotics Competition (ARC) running each year internationally. An autonomous vehicle, or passenger car, is actually a mobile robot.

a

b

Fig. 1. (a) AV with the control system designed by RMIT students; (b) EV designed by RMIT University students

In order to support technology change to electrical vehicles, community and large institutions, or associations, are organizing various events and also competitions. An electrical vehicle (EV) designed by RMIT students is shown in the Fig. 1(b). It was designed for Formula SAE or Formula Student. It is a worldwide challenge for the university students. Each year they have to design a new open-wheeled racing car. There is also World Solar Challenge where students build solar electrical vehicles and compete on international level. Solar, electrical vehicle designed by Western Sydney University students is shown in Fig. 2(a). Electrical vehicle of the future will most likely use integration of all electrical power generation sources. New, comprehensive EV power system conceptual design is show in Fig 2 (b). As a device that can use and generate electrical energy, this vehicle will become an important addition to the smart power grid[8].

Having all of this in mind, and much more, communities around the world are well aware of the need for change and support it in variety of ways. In parallel with technological developments, many activities were initiated to create new policies and to define the appropriate legislation framework.

3. Changes and transition management process

Transition management is aiming to influence, redirect and select the choice of emerging changes, to anticipate and mitigate their uncertainties. This can be accomplished if it is based on principles of embracing key societal values and beliefs with a long-term vision's horizon allowing derivation of short-term objectives. The strategic goals are radical changes on different hierarchical levels and system transformation through creative destructions of unsustainable systems.

On the macro level, these changes are influenced by societal and political values, beliefs and global functions, and institutions of the marketplace. In this context, the middle level represents established system practices encompassing dominant rules and technologies, engineering community, policymakers, investors, suppliers, infrastructure that shape technological innovations and embody a socio-technical system which filters out unsuccessful innovations and incorporates worthy ones. Radical changes are not appropriate at this level because different groups invested heavily and they strongly protect their own interests. The micro level is an environment where radical changes and innovations can occur using the window of opportunity enabled by processes on higher levels. By accumulating small innovations across different applications until critical mass is reached and having transition management activities conducted at all levels may lead to the breakthrough solutions.

These transition activities can be strategic, comprising the vision development and establishing long term goals at macro level. Developing institutions, regulations, practices and technology are tactical activities. At micro level, operational activities are dealing with radical innovations, transforming technological, institutional and societal practices which, in final instance, can change structure and culture at macro level.

Changes and the transition from traditional, combustion engine powered vehicles, to autonomous and electric vehicles involve above described activities conducted at all levels. The transition management cannot be done centrally and hierarchically because of uneven power distribution among all participants with vested, sometimes opposing interests and who may resist the changes. In the focus of this paper are some aspects of technological innovations and some policies that have impacts on their propulsion. These innovations have the potential to contribute to the welfare of society as a whole and therefore, it is important that policies do not become a limiting factor which prevents future developments. Table 1 presents illustrated, anticipated pathways for automated private and shared vehicles and heavy duty trucks. Industry and academia, as key stakeholders in the initial stages of the transition, are conducting intensive research and development in all areas. Initially, driver assistance applications were investigated [9-11,12]. Later, the autodriver algorithm[13,14] set up the scene for the research into autonomous path planning[15-18].

Revolutionary changes in auto industry are part of the larger 'fourth industrial revolution' aiming to deliver safer, cleaner, more intelligent and energy efficient vehicles for consumers around the world. The pace of technological changes, including developments in emerging markets, disruptive innovations, increased automation, digitization and creation of new business models are dramatically changing automotive industry and global economy.

3.1 Technological changes and dominant design

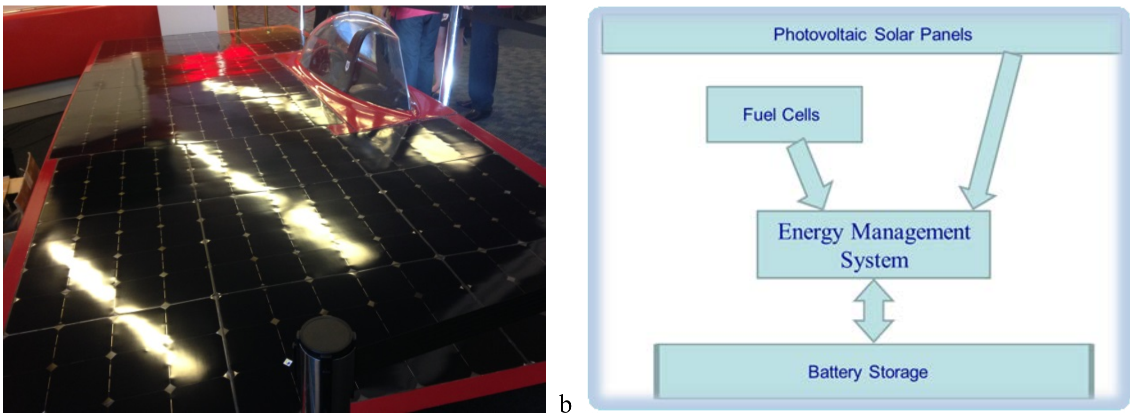
The main stage of the change management process, and transition towards electrical and autonomous vehicles, are technological changes. The issues such as product innovation, process innovation, the transilience map, technological guideposts and creative symbiosis, technology s-curves and evolutionary models were researched in the works of Abernathy and Utterback[19], Sahal[20], Foster[21], Nelson and Winter[22] and Dosi[23].

Table 1. Deployment Pathways - Source: Based on CityMobil2 project (CityMobil2, 2015)[24]

<table>
<tr><th colspan="2"></th><th>Shared
Vehicle Automation</th><th>Private Vehicle Automation</th><th>Truck Automation</th></tr>
<tr><td rowspan="2">Established technologies</td><td>L0
No automation</td><td colspan="3">Park distance control
Emergency braking
Anti-lock braking
Electronic stability control</td></tr>
<tr><td>L1
Driver Assistance</td><td colspan="3">Lane departure warning, Lane change assist, Adaptive Cruise Control (ACC)
Front collision warning, ACC including stop-and-go function
Driver steering recommendation, Lane Keeping Assist
Park Assist</td></tr>
</table>

				Cooperative ACC control, platooning
Future technologies	**L2 Partial automation**		Partial automated parking Traffic jam assistance	Traffic jam assistance
	L3 Conditional automation		Highway chauffeur Traffic jam chauffeur	Highway chauffeur Truck platooning Traffic jam chauffeur
	L4 High automation	Cybercars/ delivery vehicles. Last mile use, low speed context Automated bus: dedicated lane (established tech) and segregated lane (future tech) Automated bus in mixed traffic	Highway autopilot including highway convoy Parking garage pilot	Highway autopilot with ad-hoc platooning Truck terminal parking
	L5 Full Autonomy	Cybercars Self-driving “taxi” or delivery van in mixed traffic	Self-driving vehicle	Self-driving trucks

A theoretical explanation of these changes is given by Anderson in his cyclical model of technological changes based on the concept of dominant design. The concept of cyclical technological changes is based on the principle of technological discontinuity which can be competence-enhancing or competence destroying (Tushman and Anderson)[25]. The first form advances the state of existing knowledge and know-how while the second significantly advances the technological frontier, but with new knowledge, skills and competence base, that are inconsistent with preceding know-how. A discontinuous technological innovation, as a part of Anderson’s model of technological changes, is characterized by irregular patterns of cyclical changes. A series of cycles consisting of long periods of incremental changes is interrupted by major breakthroughs of technological discontinuities. In this phase, the current technology typically gets replaced by new innovative products, or services, and immediately starts a competition in offering new designs. The phase is finishing when one design, among competing technological opportunities, prevails as an industry standard and as a result of social, political and organizational change management dynamics. This design is characterized as dominant.



a b

Fig. 2. (a) Solar electrical vehicle designed by Western Sydney University students; (b) Comprehensive power system for electrical vehicles

The concept of ‘dominant design’ was introduced by Utterback and Abernathy[26]. They stated that a dominant design is a strong impetus in industry progressions and identified key technological features of its transformation into de facto industry standard by which all organizations must abide if they intend to succeed and prevail. The process of achieving the dominance passes through several change management phases. We may observe that autonomous and electric vehicles currently follow the similar pattern:

- One pioneering firm has been conducting R&D activities with intention to apply new technology and create new commercial product. Incumbent organizations were primarily focused to incrementally or drastically improve existing designs by integrating various technological innovations from their previous products.
- The first working prototype of the new product and technology is publically presented, forcing competing organizations to reassess their research programs.
- In this phase, the first commercial products are launched and for the first time a small group of early adopters is introduced to new design architecture. This fact should be another warning sign to competitors to reassess and accelerate their research endeavors.
- From this early market emerges a prime candidate to become a front-runner in the competition.
- As a final outcome at some point in time, one particular technology direction prevails and becomes a dominant design in this process.

This is all graphically represented in the new products’ and technology state transition diagram shown in Fig. 3.

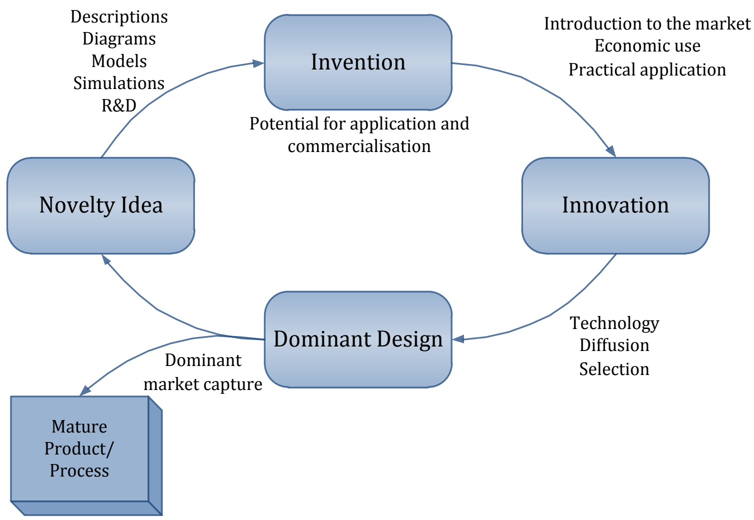


Fig. 3. Emerging new products’ and technology state transition diagram (inspired by Utterback and Abernathy[26])

The previous phases were identified in many earlier change management processes when certain products or technologies achieved a dominant design status: videotape format war between Betamax and VHS, war of currents between Nikola Tesla’s AC power and Edison’s DC electricity[27], Windows operating system, etc. Dominant designs in the past usually emerged at points when numbers of competing firms reached their maximum. From that moment, other companies were virtually forced to incorporate these new features. Thanks to Nikola Tesla’s contribution to introduction of more efficient electrical power generation and distribution system, one of the currently leading companies in electrical and autonomous automotive engineering is named “TESLA”. TESLA already offers full electrical and full autonomous vehicles worldwide. Currently, there is already core infrastructure in Europe that supports electrical vehicles driving across the continent. As new technology, electrical vehicles are more expensive, but some of the governments subsidize customer to make transition to electrical vehicles.

According to Utterback and Suarez[28], dominant designs strongly influence directions of future technological development, their diffusion and adoptions create utterly new competitive industry dynamics. Up to this moment, companies were heavily investing and experimenting with various designs but they have not been able to achieve the economy of scale.

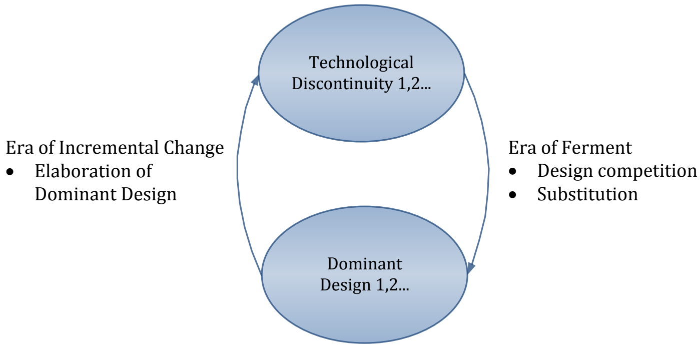


Fig. 4. The technology cycle (inspired by Anderson and Tushman[29])

Having accomplished that their design becomes dominant, they are usually awarded with a time window advantage to develop economy of scale what can raise the barriers for entry in the industry. Anderson and Tushman[17] studied the cyclical effect of a technological disruption on mature industries. They found that in the early periods of each cycle, the number of competing firms has been increasing until a dominant design emerged and starts decreasing afterwards until a small number firms begin to dominate the industry. The cycle restarts again when a new disruption creates the circumstances for a new upsurge of innovation and influences the repeating of the industry life cycle (Fig. 4).

3.2 Policies and regulations

Legislative activities are a key part of change management process which oversees the emergence and development of electrical and autonomous vehicles. Activities are conducted by government and industry bodies and directed to various public concerns - health, safety and environment. Public policies are incorporated into jurisdiction as regulations and imposed by the government. Industry standards are based on engineering benchmarks that stipulate product specifications and performances and often reflect the dominant design stemming from technological innovative changes. However, there are also examples that government mandated use of particular technology and dominant designs such as in US, where RCA established its design as dominant for the television industry or in European Union (EU), where Global System for Mobile communication (GSM) was chosen as the 2nd generation wireless instead of Code Division Multiple Access (CDMA) although the latter had better use of spectrum.

There are increasing pressures on all levels of government to provide environment where potential of new autonomous and electrical vehicles technology can be fully released, consumption of fuel and emissions to be reduced, while safety and infrastructural integration should be preserved. Government exerts its influence through new cars licensing monopoly. Although vehicle operations, owners' actions regarding vehicle modifications, repairs, maintenance and standards that facilitate compatibilities and human-computer interaction are not under government's authority, they still have a crucial part in safety standardization. Considering that autonomous vehicles will influence many aspects of human activity, there is a need to make comprehensive assessment and develop new policies.

It is also required to make evaluations and quantify future profits from new technologies to establish which social group would benefit the most, and who might lose. It is needed to leverage previous experience in regard to introductions of earlier automotive technologies, such as: air bag, seat belt and other. Policymakers should determine how public interest can be the best served, and which incentives are needed for technology to be developed, what would be the impact of new automotive technology on future transportation modes and how this can influence planning at all levels.

There is also a need to identify and assess which kind of data are required for current and future transportation modes, the sharing, access and security of data related to vehicle manufacturers, regulators, policy enforcement, insurance, vehicle owners, users and other stakeholders. In summary, future researches of new policies should result in a definition of best practices which would become guiding principles and inspirations for new regulations covering electrical and autonomous vehicles.

3.3 Risks and benefits

In this paper were underlined various regulatory, technological and public value matters related to the transition to electrical and autonomous vehicles. It is clear that autonomous technology offers a value proposition to improve a range of aspects of societal wellbeing. Although, there are still many drawbacks and threats, it seems that potential advantages will exceed these risks. However, the pathway to reaching this stage and to materialize technology promises is not predetermined. There are not guarantees that this technology will be widely adopted if we just refer to autonomous driving. Probably, there will be always some customers that would enjoy self-driving. At the same time, benefits of the electrical vehicles introduction are clearer. That transition is in line with the propositions to reduce carbon dioxide (CO_2) and other greenhouse gases emissions. Air quality improvements are a global initiative and the systems approach is essential[30].

The first step in the transition to new, electrical drive train technology is to introduce various hybrid vehicles[31]. Major players in automotive industry already have large variety of hybrid vehicles on the market. Electrical vehicles are one more power grid element that could use or generate energy. Since there is a large flexibility in the time scheduling of the EV interaction with the grid, there are no serious grid disruptions anticipated. This issue is already comprehensively investigated and results published. A good overview on accessing flexibility of electric vehicles for smart grid integration is presented here[32]. In addition to that, an electrical vehicle, when connected to grid, may act as Uninterruptible Power Supply (UPS) and be used to resynchronize and stabilize the utility grid[8].

Some forms of government subsidies to make technology introductions viable are justified until market forces prevail and the prices go down. Tax break in Denmark, for example, caused a surge of electrical cars sale when their government relinquished usual 180% tax rate[33]. In Germany, the government approved one billion euros incentive scheme to promote and sell 400,000 electric cars. As of February 2016, their proposal for the auto industry is to cover 40% of the cost of the purchase subsidy. Currently, there are only 50,000 electric cars out of 45 million on German roads and the aim is to reach one million electric cars by 2020[34]. Industry players also contribute to new technology affordability by delivering new technology solutions. Google, for example, promised new LIDAR (Light Detection and Ranging - a remote sensing method used to examine the surface of the Earth) for the small portion of its current price, while in Tesla company even do not use this sensor in their design[34].

There are currently several concepts of autonomous vehicles in terms of their levels of automation, ranging from human drivers in complete control of all driving functions of the vehicle, up to the point that vehicle can drive itself without a human driver (Table 1). Some concepts require that human driver and vehicle share driving tasks. Regulators should consider all these cases and propose legislations which would improve safety and deliver promised benefits without having negative influence on technology development. Otherwise, premature or excessive regulations could limit innovations and alternative concepts in early stages of technology development.

3.4 Other issues

There are other important change management issues that are identified in the field of automotive industry: automated commercial vehicle operations, cyber security and resiliency, data ownership, access, protection and discovery; energy and environment; human factors and human-machine interaction; infrastructure and operations;

liabilities, risk and insurance; shared mobility and transit; roadworthiness testing, certification and licensing; V2X (vehicle-to-everything) communication, architecture and deployment pathways. These deployments may follow incremental progressions of conventional vehicles leading to higher levels of automation, or a radical technology-shift approach that would lead to rapid dispositions of highly automated urban mobility vehicles.

In addition, there is a range of general change management topics that go beyond the scope of this article: implementation of changes, vision and strategy, monitoring, communications, resistance, organizational changes and reengineering, reinforcing and sustaining changes. The scope of this article is limited to describing the necessity of changes on a global level based on benefits they are promising, caused by the maturity of automotive industry and technological innovation push and on overseeing the role of policies in this development.

Electrical vehicles have no carbon dioxide emissions problem, but if the electricity used for charging was produced by fossil fuel power stations the problem still exists. We have to look at environmental questions, related to EV transition, more comprehensively. Of course we can charge our vehicles by green energy produced by hydro or solar power plants. In addition to that electrical vehicles can use fuels cells to generate electricity and the only byproduct in that case is the water. Electrical vehicle of the future will use battery system for energy storage in addition to fuel cells and Photovoltaics (PV) panels as generators of energy. The technology also includes regenerative braking, Thermoelectric TEG Generators and might be more.

4. Conclusion

The aim of this paper was to present some key issues related to the process of transition from traditional to autonomous and electric vehicles, to make assessment of potential advantages and disadvantages of autonomous and electrical vehicles technology and to investigate some concerns that are relevant to policymakers. The main focus is on innovative technological changes, accompanied policies and regulations and some of associated risks in this transition. There is a widespread consensus that improvements in social welfare, reductions in cost of congestion and environmental pollution, outweigh negative impacts. The most of benefits will remain in a public domain is a stimulus for regulators and policymakers to get involved and balance public and private costs and benefits.

There are many environment complexities in which technological innovations are taking place. Also, the transition management is encompassing all levels, from individual technology applications and their aggregations, which have a potential to reach the levels of dominant designs, across varieties of institutions, policies, engineering communities and supply chains, up to the highest level which represents the culture, social values, beliefs and global marketplace.

One of the findings is that technology innovations are the most important factor which influences a transition from conventional to autonomous and electrical vehicles. In the paper is presented a concept of cyclical nature of technological development and the evolution of technological dominant design. It is expected that this process will also take place in a contemporary development of autonomous vehicles. Rapidity of future technological developments is dependent on technology adoption and various risks that are related to this change management process. Risks are primarily bound to potential manufacturers' liabilities, viabilities of business models and premature, inadequate or excessive regulations. There are also some specific technological risks related to spectrum allocation and communications, data privacy and security and uncertainties related to the prediction accuracy of anticipated changes.

References

1. *Road Deaths Australia: Monthly Bulletin, April 2017.* Bureau of Infrastructure, Transport and Regional Economics (BITRE), Department of Infrastructure and Regional Development, Australia
2. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812384
3. *Fatality Analysis Reporting System 2010*. fars.NHTSA.dot.gov Retrieved July 3, 2014
4. *Urban Mobility System Upgrade*, OECD/ITF; 2015
5. M. Elbanhawi, M. Simic, and R. Jazar, "In the Passenger Seat: Investigating Ride Comfort Measures in Autonomous Cars," *Intelligent Transportation Systems Magazine, IEEE*, 2015; vol. 7, no. 3, pp. 4-17.
6. H. H. H. Achim Kampker, Ordung M, Jan-Philip Ganser, "Enabling Integrated Production of Electric Vehicles in Automotive Final Assembly: Realization of an Expert Study," *International Journal of Industrial and Manufacturing Engineering*, 2017; vol.4, no. 2.
7. Buehler, Martin, Karl Iagnemma, and Sanjiv Singh, eds., The DARPA Urban Challenge: Autonomous Vehicles in City Traffic,

Springer Tracts in Advanced Robotics series, 2010, Vol. 56.
8. Cvetkovic, I., et al. *Future home uninterruptible renewable energy system with vehicle-to-grid technology. in 2009 IEEE Energy Conversion Congress and Exposition*. 2009.
9. Simic, M., *Vehicle and Public Safety through Driver Assistance Applications*, in *Sustainable Automotive Technologies 2010*. 2010, © Springer-Verlag Berlin Heidelberg
10. Simic, M. and M. Dekic. *Active Safety with Dedicated Short Range Communications*. in *22nd JUMV International Automotive Conference*. 2009. Belgrade, Serbia.
11. Simic, M. *Blind Spot Warning Systems Solutions*. in *22nd JUMV International Automotive Conference*. 2009. Belgrade, Serbia.
12. Elbanhawai, M. and M. Simic, *Examining the use of b-splines in parking assist systems* Applied Mechanics and Materials, 2014. 490-491: p. 5.
13. Bourmistrova, A., et al., *Autodriver algorithm.* Journal of Systemics, Cybernetics and Informatics, 2011. 9(1): p. 8.
14. Jazar, R.N., M. Simic, and A. Khazaei. *Autodriver Algorithm for Autonomous Vehicle*. in *2010 ASME International Mechanical Engineering Congress and R&D Expo*. 2010. Vancouver, British Columbia, Canada
15. Elbanhawi, M., M. Simic and R. Jazar, *The Role of Path Continuity in Lateral Vehicle Control.* Procedia Computer Science, 2015. 60: p. 1289-1298.
16. Elbanhawai, M., M. Simic and R.N. Jazar, *Improved Manoeuvring of Autonomous Passenger Vehicles: Simulations and Field Results.* Journal of Vibration and Control, 2015: p. 35.
17. Elbanhawai, M., M. Simic and R.N. Jazar, *Continuous Path Smoothing for Car-Like Robots Using B-Spline Curves.* Journal of Intelligent & Robotic Systems, 2015. **77**(242).
18. Elbanhawai, M. and M. Simic, *Continuous-Curvature Bounded Trajectory Planning Using Parametric Splines*, in *Frontiers in Artificial Intelligence and Applications*, R.N.-S.e. al., Editor. 2014, IOS Press BV: Chania, Greece.
19. Abernathy W, Utterback J. Patterns of industrial innovation. *Technology Review* 1978; 7:40–47
20. Sahal D. *Patterns of technological innovations*. New York: Addison-Wesley; 1981.
21. Foster R. *Innovation: the attacker's advantage*. New York, Summit Books; 1986.
22. Nelson RR, Winter SG. *An evolutionary theory of economic change*. Cambridge, The Belknap of Harvard University Press; 1982
23. Dosi G. Technological paradigms and technological trajectories. *Research Policy* 1982; 11:147–162
24. CityMobil2, 2015. CityMobil2: *Cities demonstrating automated road passenger transport*. Available at: http://www.citymobil2.eu/
25. Tushman LM, Anderson P. Technological discontinuities and organizational environments. *Administrative Science Quarterly*, 1986; Vol 31:439–465
26. Utterback J, Abernathy W. A dynamic model of process and product innovation. *Omega* 1975; 33:639–656
27. Nigel Cawthorne, Tesla Vs Edison: *The Life-Long Feud that Electrified the World*, ISBN-13: 978-0785833789
28. Suarez, F., Utterback, J. Dominant designs and the survival of firms. *Strategic Management Journal* 1995; 16, 415–430.
29. Anderson P, Tushman LM. Technological discontinuities and dominant designs: a cyclical model of technological change. *Administrative Science Quarterly*, 1990; Vol 35, No. 4, pp. 604–633
30. Bonnema, G.M., G. Muller, and L. Schuddeboom. *Electric mobility and charging: Systems of systems and infrastructure systems*. in *2015 10th System of Systems Engineering Conference (SoSE)*. 2015.
31. Rusu, F.A. and G. Livint. *Study of hybrid power sources for electrical vehicles*. in *2016 International Conference on Development and Application Systems (DAS)*. 2016.
32. Einwächter, F. and C. Sourkounis. *Accessing flexibility of electric vehicles for smart grid integration*. in *2014 Ninth International Conference on Ecological Vehicles and Renewable Energies (EVER)*. 2014.
33. Hanley S. *Electric Car Sales in Denmark Plummet After Change in Tax Policy*, 2016; Important Media Network
34. Cremer, A. *Germany to launch 1 billion-euro discount scheme for electric car buyers*. Berlin: Reuters - Technology News. Retrieved 2016-05-14.