



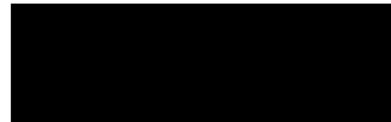
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*A critical evaluation of [REDACTED] [REDACTED]
innovation space and identification of
innovation opportunities to secure the
company's future in the changing business
environment for automotive industry*

MSc IIM

2021

DECLARATION

This work has not previously been accepted in substance for any other degree and is not being concurrently submitted in candidature for any other degree.

Signed (candidate)

Date

STATEMENT 1

This work is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed (Candidate)

Date.....

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And special dedication to my mum, [REDACTED] [REDACTED] (MHSRIP)

TABLE OF CONTENTS

CHAPTER		TITLE	PAGE
		SECTION I: PROJECT INTRO & SCOPING	
Chapter	1	Project Introduction	1
	1.1	Abstract	1
	1.2	Research Hypotheses	2
	1.3	Research Rationale/ Purpose of the Study	2
Chapter	2	Project Scope	3
	2.1	Context of the Study	3
	2.2	Significance of the study	3
	2.3	Project Research Objectives	4
	2.4	Proposed Paradigm and Methodology	4
	2.5	Survey Techniques and Data Collection Methods	5
	2.6	Sampling Framework and Selection Criteria	5
	2.7	Difficulties Envisaged and Research Limitations	6
	2.8	Planning the Resources required for research	6
	2.9	Research Ethics	6
	2.10	Planning the Analysis	7
		SECTION II: INSIGHT INTO THE COMPANY & LITERATURE REVIEW	
Chapter	3	Insight into [REDACTED] Business	8
	3.1	Introduction and background to the organisation	8
	3.1.1	Vision	8
	3.1.2	Statement of Purpose	9
	3.1.3	Key global challenges in the Automotive Sector	9

	3.2	■■■■ Innovation Strategy	10
	3.2.1	Mobility and Connectivity	12
	3.2.2	Commercial Vehicle and Services	13
	3.2.3	Leading the Electric Vehicle Revolution	15
	3.2.4	Innovation into Battery Power Pack	16
	3.2.5	Partnering to Serve Customers Better	16
	3.2.6	Engineering Flexible Vehicle Architectures	17
	3.2.7	Pioneering the Autonomous Vehicles Innovation	18
	3.2.8	■■■■ Financial Innovation	20
Chapter	4	Literature Review	23
	4.1	Introduction	23
	4.2	What is innovation in ■■■■ context and why does it matter?	24
	4.3	The Industry 4.0 Technologies	27
	4.4	Employment of Industry 4.0 Technologies at ■■■■	28
	4.5	Case Studies of 4.0 Technologies at ■■■■	30
		SECTION III: PROJECT EXECUTION PHASE	
Chapter	5	Brief Introduction of the Project Execution Phase	31
Chapter	6	An analysis of factors affecting future product offering by ■■■■ ■■■■ ■■■■	32
	6.1	PESTLE Analysis of factors influencing the future product offering	32
	6.2	Analysis of Global Competition in Automotive Innovation Space	37

	6.3	Analysis of [REDACTED] using 4P's Innovation Space	38
	6.4	An Analysis of [REDACTED] against the ISO 56002 Innovation Management Principles	39
	6.5	Analysis [REDACTED] using Henderson and Clark matrix of architectural knowledge	41
Chapter	7	An analysis of [REDACTED] strategic partnerships in the innovation space	42
	7.1	An Insight into Argo AI innovation partnership	42
	7.2	SWOT Analysis of Smart Partnership	43
		SECTION IV: RECOMMENDATIONS FOR IMPROVEMENT	
Chapter	8	An analysis of opportunities of improvement and Mapping an improvement journey	44
	8.1	What opportunities of vehicle electrification can the company leverage on?	44
	8.2	What opportunities in vehicle digital space can the company take advantage of?	45
Chapter	9	Project Conclusion	47
	9.1	Conclusion	47
	9.2	Contribution of this Study	49
		REFERENCES	50
		APPENDIX	55

- Appendix 1 : Research Time Chart to Fulfil the MSC IIM Dissertation**
- Appendix 2 : Summary of previous studies quantifying the economic potential of CAVs**
- Appendix 3 : ISO56002:2019 Innovation Management System**
- Appendix 4 : Super capacitors array**

SECTION I

PROJECT INTRO & SCOPING

Chapter 1: Project Introduction

1.1. Abstract

The overall aim of this dissertation is to offer a critical evaluation of the future product offering of [REDACTED] and the strategic partnerships that the company has formed in the innovation space. The research also aims to identify opportunities of innovation that will enhance the company's sustainability and competitiveness in the future business environment.

The author's motivation to carry out research for this dissertation comes from awareness of how quick the automotive landscape is changing, being fueled by introduction of new technology, new entrants into the market, pressure from the governments and scientists against greenhouse gases, and changes in consumer taste in general. The author is well aware that availability of big data, development of artificial intelligence, machine learning, as a typical example, and calls for firms like car manufacturers to develop smarter approach to doing business. The above has driven necessity to develop innovative products and services, and to develop smart partnerships with competitors and to form alliances with other firms that are not in car industry.

1.2 Research Hypotheses

The author will be interested to investigate the following few questions:

- *Are future product offerings adequately aligned with changes in the automotive industry?*
- *Is the company making effective strategic partnerships in the innovation space?*
- *What opportunities of improvement can the company leverage?*
- *How can the company improve?*

1.3 Research Rationale/ Purpose of the Study

The question in the research hypothesis above prompts the researcher to focus on the company's innovation process, products & services that have been born through innovation, and allows the researcher to evaluate that process against the auto industry standards in general. The researcher will offer critique on strengths and weaknesses that of [REDACTED] and will evaluate threats and opportunities that are available to the company.

Chapter 2: Project Scope

2.1 *Context of the Study*

This research pays particular focus on major innovations in mobility industry that includes vehicle electrification and vehicle connectivity. The research looks at how [REDACTED] fits in, and in some instances, how the company is leading the game changing technology. In doing so, the researcher will evaluate strategic partnerships and alliances that [REDACTED] is marking with major tech players like Apple, Google, Baidu and many others to bring tech tools that customers are already using as part of their lifestyle into a seamless in-vehicle integration experience. The research will review and evaluate open partnership with other vehicle manufacturers like [REDACTED], as well as other technology pioneers like Argo AI.

The research will also look at how [REDACTED] is aspiring to lead commercial vehicle segment through offering innovation solutions that provide right tools for the job; offer low cost of commercial vehicle ownership; provide high reliability; maximum productivity; enhances commercial personnel safety; and generally convert commercial vehicles into a mobile office space for the drivers and work personnel.

The research will closely evaluate the innovation cost and return on investment, in order to demonstrate benefits *or lack of benefits* of pathways taken by the company. The project will then seek to identify strategic options that the company can follow in order to enhance chances of sustainability and competitiveness.

2.2 *Significance of the study*

The study aims to fill a gap between [REDACTED] innovation strategy and the new challenges faced by the automotive sector. The researcher will conduct appraisal of [REDACTED] innovation strategy and assess its suitability in the micro and macro business environment. The ultimate aim is to make recommendations that will improve the company's chances of sustainability, to enhance its competitiveness.

2.3 Project Research Objectives

The project aims to achieve the following four objectives for [REDACTED]

1. Conduct an analysis of [REDACTED] in the digital and electrification innovation space and explore partnerships that the company is involved with, and an analysis of how the company is meeting, and in some case influencing change in consumer taste.
2. Evaluate the costs and benefits of innovation for [REDACTED] including a focus on opportunities as well risks and de-risking activities
3. Review what is happening industrywide in the mobility industry innovation space
4. Recommend pathways and de-risking activities that may further help [REDACTED] to secure a leading position in the future of mobility industry

2.4 Proposed Paradigm and Methodology

The researcher acknowledges a fact that there are two basic approaches to research, viz., **quantitative approach** and **qualitative approach** (Kothari, 2009).

Quantitative approach allows mining of relevant data. This allows the carrying out of rigorous quantitative analysis, in order to attain quantifiable objective facts.

In contrast, qualitative approach will give subjective assessment of attitudes, opinions, preferences, and judgements, that may not make provable claims, that is, may not be proved true or false. They may be outside the realms of what is verifiable.

The researcher will use a **methodological triangulation approach** to gather valuable information for the project. *Taylor et. al., (2006)*, describe **Triangulation** as the use of more than one method in studying the same phenomenon, to allow validation of that phenomenon. In this context, the project will draw on both **quantitative approach** and **qualitative approach** to overcome the assumptions and limitations inherent within one particular approach. Having said that, the researcher will have to weigh credibility of sources of both qualitative and quantitative information.

2.5 Survey Techniques and Data Collection Methods

Internally sourced data:

As stated by *Saunders et al (2007)*, that a survey is 'the collection of a large amount of data from a sizable population in a highly economical way', the author believes the use of interviews and primary quantitative data that is already available within the company will be the most economical way of gathering data.

Analysis of primary statistical data available within the company will support the quantitative side of this research, since the company has abundant sources of statistical data within its business functions.

The researcher plans to use interviews to fulfill the qualitative side of primary data collection. Interviews will allow the researcher to establish rapport with key persons in the company, and giving the researcher more advantage to probe for extra, deeper responses from the interviewees. The researcher strongly believes that interviews will highlight hidden opportunities for innovation. Another advantage of interviews is that they will enable the author to use intuition to evaluate the relevance and authenticity of the collected data.

Externally sourced data:

Secondary statistical data will be collected from sources like the Automotive News, ACEA, Oliver Wynman, Ofgem, to name a few.

2.6 Sampling Framework and Selection Criteria

The following respondents will constitute the sampling framework for qualitative data as they represent complementary sources of primary qualitative data:

- *Product Development Teams*
- *Training courses*
- *Electrification Vehicle Teams*
- *Connected Vehicle Teams*
- *Product Quality Teams*
-  *Smart Mobility*

The following sets of statistical data will constitute sampling framework for the quantitative side of research:

- *Automotive industry statistical data from sources like Automotive News, ACEA, Oliver Wynman, Ofgem, ACEA, and many more for external data.*
- *Various sources within   intranet for internal statistical data*

2.7 Difficulties Envisaged and Research Limitations

The following challenges or limitations anticipated during the research:

- Due to confidentiality issues, some information or data that is crucial to this research may not be readily available.
- There will be requirement to generalise some information in the dissertation in order to protect confidential information
- Data sets from different sources may show different granularity or use different scales of measuring common items
- Respondents may not be timely available or cooperative to supply information or data for the project
- Qualitative data or information is prone to bias and may be heavily based on opinions of the respondents
- It may be a challenge to the researcher to extract data that is relevant and sizeable to the project from tonnes of scattered data

2.8 Planning the Resources required for research

The researcher recognises human resources, time and technology availability as fundamental resources that will be required.

- I. Human Resources – the researcher will request access to personnel that are key to providing information about the company's business. Where necessary, the author will request meetings with several key people in the organisation during the research.
- II. Time – the researcher will allocate approximately 10hrs per week on research and dissertation write-up. Research progress will be monitored using project milestones technique.
- III. Technology – the researcher will require access to several IT systems in the company for data mining purposes.

2.9 Research Ethics

In order to offer a completely credible information to the company and the research body, the researcher will use very high integrity to undertake the research. The author will remain professional in all circumstances, and will ensure that all procedures that are expected by the company, the legislation, the society and the university are followed.

The researcher will fully inform participants regarding the purpose of research, its limits, and outcomes. The researcher will not use any personal data or any other information that falls outside the GDPR boundaries.

No assumptions will be made to fill a gap where there researcher is unclear with policies or procedures, and further clarifications will be sought before proceeding. Finally, there is not intended harm from this research.

2.10 Planning the Analysis

In broader terms, the researcher will utilise PESTLE analysis to cover all areas that may have influence in shaping [REDACTED] innovation journey. *Cadle et al (2010)*, highlight PESTLE analysis as a useful technique for examining a business environment in general, taking into account external factors that affect the business. A PESTLE model is as illustrated on the figure below.

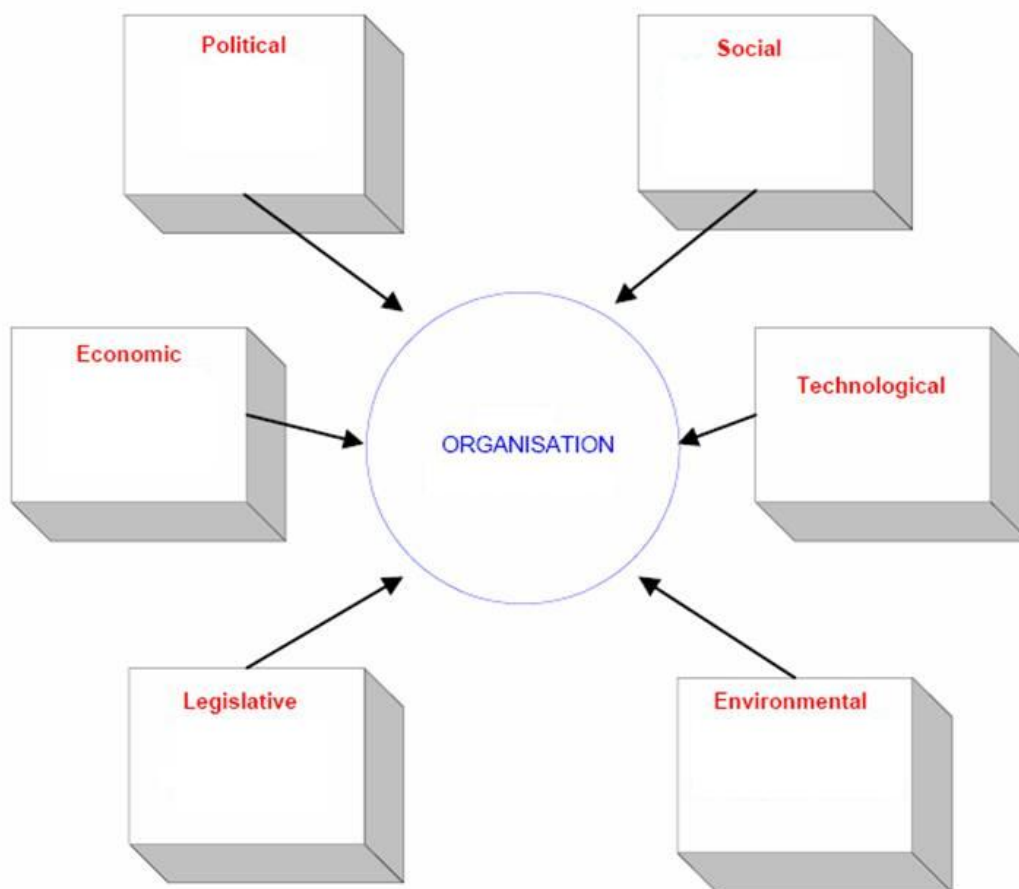


Figure 1: A PESTLE Model

This report therefore adopts the **PESTLE** model to evaluate impact the external factors like **Political**, **Economic**, **Social**, **Technological**, **Legislative** and **Environmental** on [REDACTED] innovation.

SECTION II

Insight into Company Business & Literature Review

Chapter 3: Insight into [REDACTED] Business

3.1 Introduction and background to the organisation

[REDACTED] is a family company that was started by Henry [REDACTED] in Detroit in 1903. His invention and innovation of automobiles, beginning with the Model-A car in 1904, changed how the world moved. Today, the company is a global success, with operations that span across all continents. Henry [REDACTED] is a genius, who transformed not only the automobile but working life and the role of transportation. He invented the assembly production line that is used world over across different industries.

3.1.1 Vision

The company shares the following vision:

“We are here for one purpose, to help build a better world, where every person is free to move and pursue their dreams.”

Source: [https://corporate.\[REDACTED\].com/about/purpose](https://corporate.[REDACTED].com/about/purpose)

3.1.2 Statement of Purpose

The company's statement of purpose mentions that it is rooted in the effort to enable **better lives** through removing obstacles that limit people's progress, thereby allowing people to pursue their dreams and live the best life possible. The company aims to **build strong community bonds**. It has a strong conviction towards promoting a **healthier planet** and creating a sustainable future.

3.1.3 Key global challenges in the Automotive Sector

The automotive industry has faced unparalleled economic and industry disruption in recent years. In 2019, the Covid-19 pandemic significantly suppressed the economic activity. The pandemic created societal shifts regarding the way we live and work. This had impact to all areas including the automotive industry.

While the long-term impact of these changes may not be yet clear, for example in vehicle ownership and usage, it is worth noting that there will be a significant shift in these areas. The pandemic caused disruption to supply chains and as lockdown restrictions slowed down many manufacturers, including in the automotive industry, started facing supply constraints particularly around semiconductors. The automotive industry is therefore undergoing a period of profound change as result of the pandemic.

The [REDACTED] (and other automotive manufacturers) has been facing the challenge of moving away from diesel-powered vehicles for some time. The changing legislative framework and consumer preferences in the light of climate change have contributed to the pace of change.

The growth of electric vehicles and the move away from internal combustion engines has gathered pace, with many new entrants to the industry who do not have the legacy costs of traditional manufacturers.

As such, the [REDACTED] is rebalancing between passenger vehicle and commercial vehicle activities to build the optimal product portfolio leveraging our global strengths to align to customer demand. The company is also working towards offering differentiating digital experiences from the consumer perspective and offering best in class customer experiences that stretch beyond vehicle ownership. It aims to win a significant market share in an increasingly connected world.

The implications are wide ranging, and the company needs to become sensitive market signals in order to remain viable in the near term and build a long-term platform for continued success.

The semiconductor shortage problem may not fully resolve in the for a number years, so the company needs to innovate by rethinking its product design, to eliminate features that are less important or redundant to the customer in order to optimize the limited semiconductors resources.

3.2 Innovation Strategy

has a key innovation strategy to turn around its business despite the key global challenges mentioned above. The company is rebranding from to . This essentially means the company is transforming from a traditional 'Build and Sell OEM' to an 'Always On' business model. To elaborate further, is changing from '*making cars to sell to the customer*' into a company that is 'always on' in providing customers with mobility solutions and beyond. Societal changes in mobility requirements has influenced such a change in business strategy.

Belk(2007); Belk(2014); Eckhardt & Bardhi (2012) point out that business models and revenue streams in automotive industry are drastically impacted by societal change in mobility, shifting from a possession-based mobility pattern to a service-based usage of shared-mobility.

is essentially working on major innovations that offer fully connected and software defined vehicles; transforming from ICE (internal Combustion Engines) into BEV (Battery Electric Vehicles); pioneering AV's (Autonomous Vehicles); and pioneering game changing innovations in the Commercial Vehicle sector.

Pütz et al., 2019 define connected automated vehicles (CAV) as vehicles that can communicate with each other and with infrastructure to provide information on location, speed and other types of information, and generally have the potential to profoundly impact current business models and revenue streams in the automotive and transportation sectors.

Hussain et al., 2018, further describe CAV from an economic perspective as a "*sensed servgood*". *Tien (2017)* coined the term, "*servgood*", to refer to '*physical tangible goods that are supported by services that make them more useful, smarter, adaptive, and customizable*'. There is a view that CAV's are "*servgood*", since they are service-rich with the '*addition of more computation and communication power*', (*Hussain et al., 2018*).

Raposo, (2021), note that Connected and Automated Mobility will disrupt the road transport sector, which has remained substantially unchanged since the vehicle became mass-produced in the first half of the twentieth century. An analysis done by *Clements and Kockelman (2017)*, over 13 thirteen industries shows that economic gains brought by CAV can reach \$1.2 trillion in the US, of which \$418 billion are the industry-specific effects and \$936 billion correspond to the economy-wide effects due to savings from reduced collisions and increased productivity. However, the research does not show the length of period to realise such benefits.

It is interesting to note from the *Clements and Kockelman (2017); Albright et al., 2015*, analysis that even though CAV will bring positive impact to the economy, there are certain industries like the insurance industry and the vehicle maintenance industry that will suffer from loss of business.

Another study by *Strategy Analytics and Intel in 2017* points out to a global \$7 trillion opportunity in revenues that will come from services linked to fully automated vehicles in 2050, of which \$1.7 trillion will correspond to Europe (24% of the total revenues) (*Lanctot, 2017*). *Appendix 2 shows further study data related to economic potential of CAVs.*

██████████ is exiting loss making business functions and refocusing its product portfolio to enhance competitiveness in an environment that is characterized by rapid change of technology and product offering. *Habeck et al, (2014)*, highlight that significant value shifts are expected in future mobility ecosystem, which will require business model changes and new partnerships.

Dickson (1992) asserts that first and central to developing a sustainable competitive advantage in rapidly and often unpredictably changing circumstances, is the ability to learn fast and adapt quickly. The author totally agrees with Dickinson's statement and would like to refine the statement by adding that the learning rate and rate of adaptation should align to the rate of change.

According to *Bratton and Gold (1999)*, the ability to respond to and deal with rapid change is essential in today's environment of uncertainty and even chaos. Again, the author strongly feels this statement should be a generally acceptable theoretical assumption even though it does not elaborate how such ability can be acquired.

██████████ unveils new key functions like Blue Oval Intelligence; ██████████ Smart Mobility, which are standalone functions under the ██████████ umbrella in a drive to respond to and deal with rapid change in the mobility landscape. These business functions will be discussed further in the report. The ██████████ flagship also unveils several partnerships to support business transformation and innovation journey. The opportunity to create digital business ecosystem platforms around the physical core product of the automobile vehicle arises from the interconnectedness of modern vehicles, *Krueger et. al (2016)*; *Fagnant & Kockelman (2015)*.

According to *Raposo, (2021)*, *Corwin et al., (2015)*, there is evidence that shows that the deployment of Connected and Automated Vehicles could provide profitable opportunities for sectors like automotive, electronics and software, telecommunication, data services, digital media and freight transport. They point out that other sectors including insurance and vehicle maintenance and repair businesses might suffer revenue decreases in the future. Vehicle connectivity and automation is generating a new ecosystem for transport and mobility.

3.2.1 Mobility and Connectivity

The creation of data-driven services generates new value streams, leading to the emergence of new actors and ultimately to new market configurations. In the automotive industry, the data generated by vehicles during use paves the way for new types of data-driven services, *Kaiser et. al (2021)*.

█ has set a strategy to lead the creation of safer, more efficient and sustainable transportation networks and supported by a large selection of mobility options. They are coordinating a variety of transportation options offer improved solutions to traffic flow problems; parking problems, and many other problems associated with mobility.

The **Blue Oval Intelligence** was unveiled at the beginning of 2021 by █ █ as its next generation of technology. Blue Oval Intelligence is a centrepiece that covers introduction of vehicle sensing hardware; introduction of powerful memory in the connected vehicle ecosystem; introduction of state of the art On-Board Computers; flexible vehicle electrical architectures that can be adapted across different electric vehicle platforms; Cloud and Edge Networks; and █ bespoke software architectures.

Illustration below shows a simplified presentation of next generation electrical architecture with unified powerful hardware and connected to several sensors to make an ecosystem.

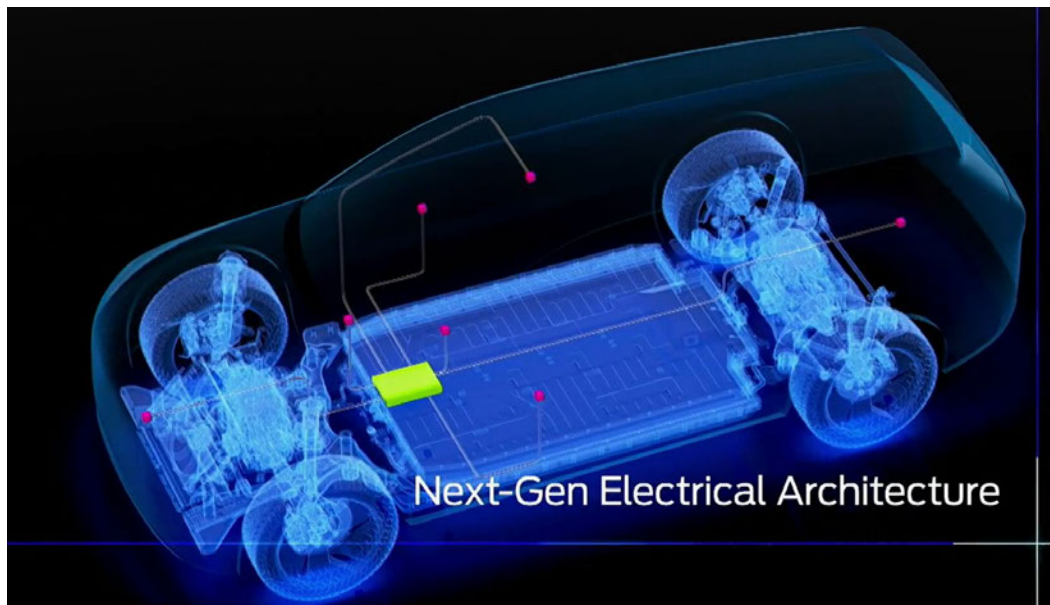


Figure 2: Next generation electrical architecture with sensors ecosystem

The In-Vehicle electrical architecture has been redesigned to allow a software-first approach. A software-first approach implies everything else in the vehicle is driven via software decisions. The new electrical architecture includes migrating In-vehicle computing from standalone processors to a centralised processing centre with significantly more computing power and memory to allow sensors to operate fast; and permits the OTA (over the air) software updates without changing the hardware.

Such connectivity is an innovation that re-invents customer experience with modern digitally enables tools of In-vehicle connected services like ordering online; pick up and drop; mobile repairs and easy refinancing and repurchase. For example, in the past a customer needed to book time off to get their vehicle serviced, but this time the scheduling of service automatic and comes to you in some instances.

The Blue Oval Intelligence will push [REDACTED] fully connected software defined vehicles to be more and more capable with time. It will allow constant vehicle updates. This means that vehicles can listen, learn and rapidly improve. This is a typical example of practical application of Machine Learning and Artificial Intelligence.

[REDACTED] claims by end of 2022 it will have over 1million connected vehicles in the field receiving wireless updates at a scale greater than Tesla. [REDACTED] vehicles will constantly get updated OTA, offering a constant source of support to the customers through a connected ecosystem of vehicles and servers. This is a practical application of cloud computing by [REDACTED] [REDACTED]. Such connectivity will allow customers to take their digital life into the vehicle seamlessly. The company aims to integrate into its vehicles the best in class technology like Apple car play, whole Google automotive services, use of Alexa voice, to allow people to take their digital life into [REDACTED] vehicles. Commercial customers will be able to perform delivery journey planning in-vehicle.

3.2.2 Commercial Vehicle and Services

[REDACTED] is a standalone commercial vehicle services and distribution business within [REDACTED] that is fully dedicated to commercial customers around the world. The company describes [REDACTED] Pro as the world's 1st to market comprehensive set of solutions for commercial services.

[REDACTED] manages the widest and most flexible range of ICE (Internal Combustion Engine) and BEV (Battery Electric Vehicle) vans and trucks, serving virtually every vocation, and utilising a fully connected digital platform to help businesses thrive. It is meant to be a one-stop shop to improve productivity; lower costs of ownership; increase uptime.



Figure 3: [REDACTED] emblem for standalone commercial vehicle services and distribution business

■■■ understands commercial customers command the right tool for the job; want low cost of ownership; prefer high reliability; want maximum productivity; employee safety; sustainable solutions and support.

The company has realised the fact that their commercial vehicle need to takes different shapes and customization to get the job done in different work environments. As a result, ■■■ has built a network of nearly 300 upfitters in North America alone strategically located near manufacturing plant and dealers, to customise vehicles for different use cases.

It also understands that companies that use ■■■ commercial trucks want to work and generate profit margins, rather than to waste time managing fleet complexities, which may cut into their margins. Having said that, ■■■ thrives to help solve fleet management problems through connectivity, providing an ‘Always-On’ relationship with its commercial customers. Hence, the company launched ■■■ ProLive, a service that is supposed to enhance customer uptime and services. ■■■ estimates that the ■■■ ProLive service will reduce downtime by up to 60% and maximises productivity for its commercial vehicle users.

It ■■■ ProLive service is driven by connectivity with cloud based solutions. The company describes it as 3 core elements with easy and reliable data exchange, *as illustrated on Figure 4*. The service is supposed to connect different teams in a real-time manner to enable live solutions, thereby cutting downtime.

The company targets to connect up to 1 million commercial vehicles by 2022, expanding to 3 million by 2025. The ■■■ innovation is expected to grow commercial vehicle business revenue from \$27bn in 2019 to \$45Bn by 2025.



Figure 4: illustration of the ■■■ ProLive service network

3.2.3 Leading the Electric Vehicle Revolution

■ is certain that innovation towards electrified vehicles (EV) will bring more performance, more capability, more productivity, and zero emissions. As a result, the company will be offering electrified version for its most popular current models as a strategy for the future. The company is planning to lead initiatives that create robust charging networks, so that electric vehicle (EV) ownership is more rewarding. Information shared by the company reveals an increase in planned investment in EV technology and supporting infrastructure to more than US\$22bn between 2021 and 2025.

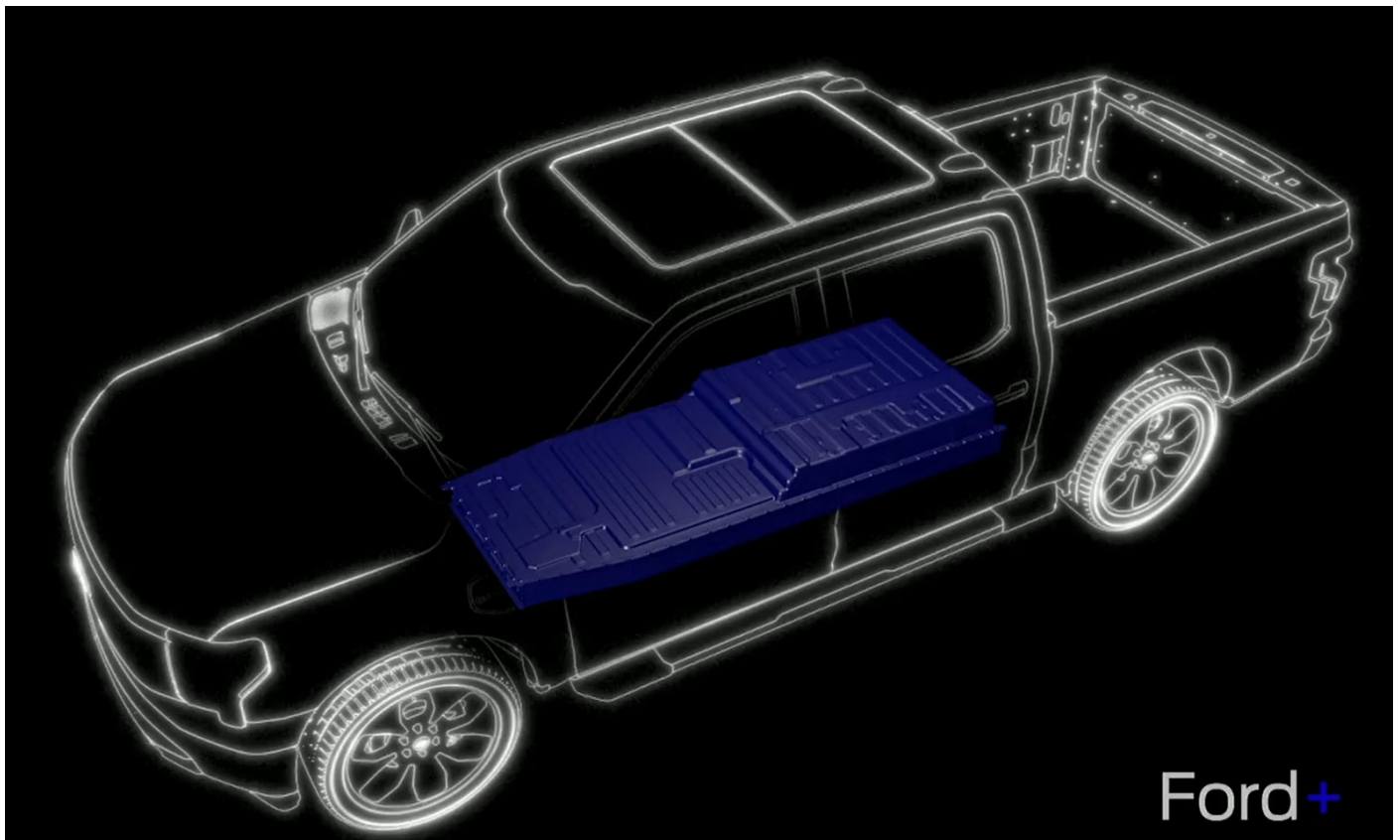


Figure 5: simplified illustration of electrified F150 ■ Truck

The lineup of electrified vehicle portfolio include the following **F150 Lightning** with more horse power than any previous F-150 trucks. The F150 Lightning vehicle spec shows it has a bi-power capability, meaning it can be charged and has exportable power to support a construction site electric tools. ■ claims the vehicle has capability to power a house during power outage.

Mustang Mach-E is the ■ sports electric coupe, which so happened to be the world number 1 seller electric sports car in 2021. The company claims an impressive 0-60 in less than 4sec!

The company reveals that **E-Transit** is the electric version of the world's number 1 ■ Transit Van which has 40% reduction in requirements for scheduled maintenance. The company plans to have 40% vehicle volume fully electric by 2030, a massive shift from a single digit volume of present day.

3.2.4 Innovation into Battery Power Pack

The company has created **Ion Park**, a Battery Centre of Excellence for development of future battery technologies. The center will accelerate innovative solutions across the whole value chain. They have analysed hundreds of current battery chemistries from numerous suppliers, and collaborated with research universities. The following are examples of products developed so far:

- **Ionboost+** which the company claims is the highest energy density of any cell of its type, high accuracy sensing technology, and is delivering high efficiency and range.
- **IonBoostPro** is a Lithium ion phosphate combination that is optimised for commercial vehicle heavy duty cycles
- **Sulfide-based solid electrolyte** is solid state battery technology with increased range and the company has designed it such that it can be manufactured under same facilities as the Lithium Ion Phosphate Battery. This is an innovative way to cut manufacturing investment.

3.2.5 Partnering to Serve Customers Better

The company is forming several innovative partnerships across the globe in order to serve the customer better and profitably. One typical example of such partnership is with Volkswagen in order to utilise the Volkswagen (VW) electric vehicle platform in Europe and develop electric commercial vehicles. This partnership will be discussed in detail later in the report.

Another good example to highlight is the partnership with Argo AI in order to advance autonomous driving vehicles (AV), an innovation that turns around how the society has been travelling in vehicles over the past century. is allocating \$7bn into this partnership through 2025 and they are testing their AV's in 6 US cities in very different and complex environments. They are also expanding tests in Germany.

has also formed joint venture with ALD Automotive, a well-established mobility company in Europe in order to develop an integrated leasing and fleet management solution across the European continent.

The venture is meant to bring connected uptime services together with vehicle leasing and vehicle financing into bespoke solutions for wide range of fleet customers. The company sees the venture as a future proof for the commercial vehicle business, making it an undeniable business of choice.



Figure 6: emblem for smart partnership with ALD automotive

█ has collaborated with Google so that beginning 2023 the Google Automotive Services will power █ and Lincoln. █ customers will be able to access robust third party app ecosystem with Google AI, Maps, and many more. █ views an open approach to collaborating with major tech players as a real differentiator. █ customers get the best in class technology that already used to in an integrated experience. Likewise, █ has collaborated with Baidu in China so that mobile phone becomes a fully in-vehicle asset.

█ has created a joint venture with Blue Oval SK to develop and industrialise battery for █ and Lincoln vehicle lines. The key aim is to scale battery production quickly. █ has transformed its Van dyke Transmission Plant in Michigan into an electric power center since 2010. The joint venture has a cost ambition to deliver 40% reduction in battery cost by 2025. █ is also collaborating on other areas; including insurance companies to create usage based insurance products.

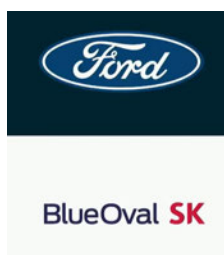


Figure 7: emblem for smart partnership with Blue Oval SK

3.2.6 Engineering Flexible Vehicle Architectures

█ is re-engineering five flexible vehicle architectures to allow adaptations that fit into entire vehicle global portfolio. The architectures take into account that Europe generally prefers smaller vehicles; America prefers large trucks and utility vehicles; and commercial customers want capable heavy duty truck world over.

The company is working on sharable battery cells; battery management systems, motors, motor controller units, gear systems across different sizes of BEV's. This effectively allows 80% cross vehicle value to be shareable across the entire vehicle portfolio, *illustrated in Figure 8*. This presents an unprecedented opportunity for scaling, efficiency, and more profitability.

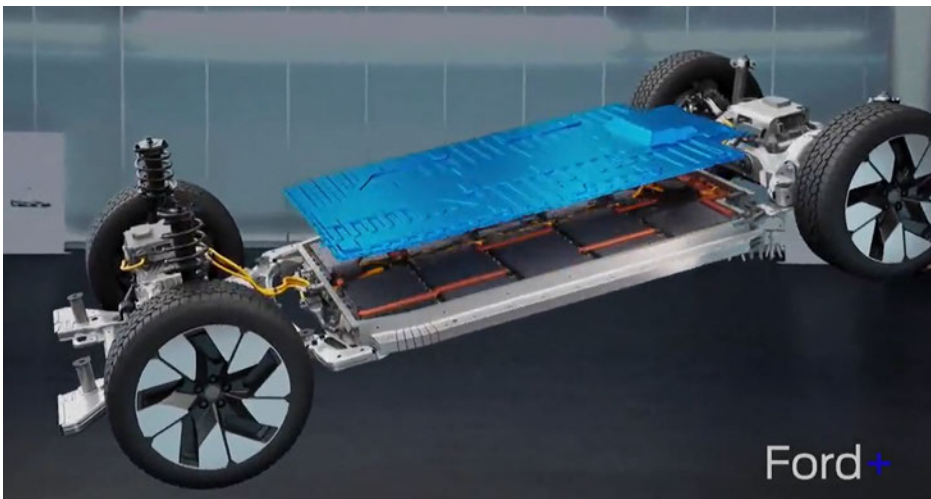


Figure 8: A general model of BEV architecture

3.2.7 Pioneering the Autonomous Vehicles Innovation

Analysis from experts within the company shows that autonomous vehicles will make mobility more accessible to people; will enhance safety for both people inside and outside the vehicle; will have potential to alleviate traffic congestion; will bring convenience and will also offer what they call ‘The Gift of Time’. The gift of time essentially meaning people will have Time to Do Something Else whilst travelling with self-driving vehicles.

Why Autonomous Vehicles – The Gift of Time

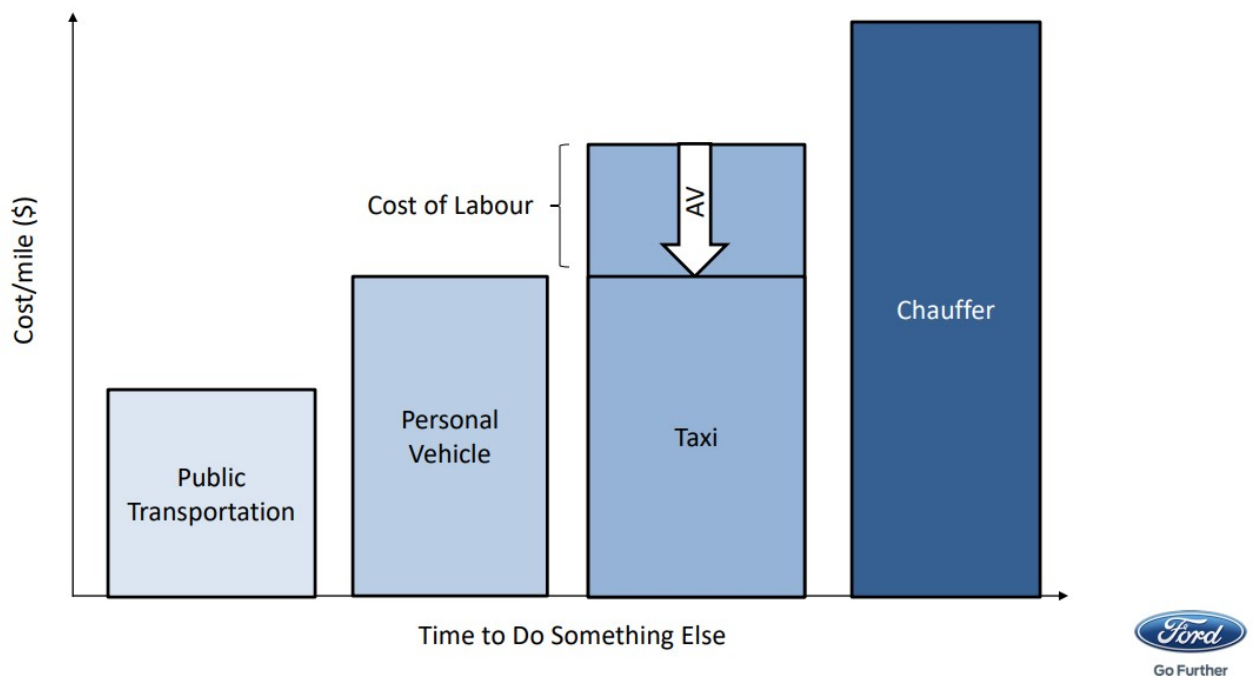


Figure 9: Motivation that drives Autonomous Vehicle Innovation

Ford Level 4 Autonomous Vehicle Configuration

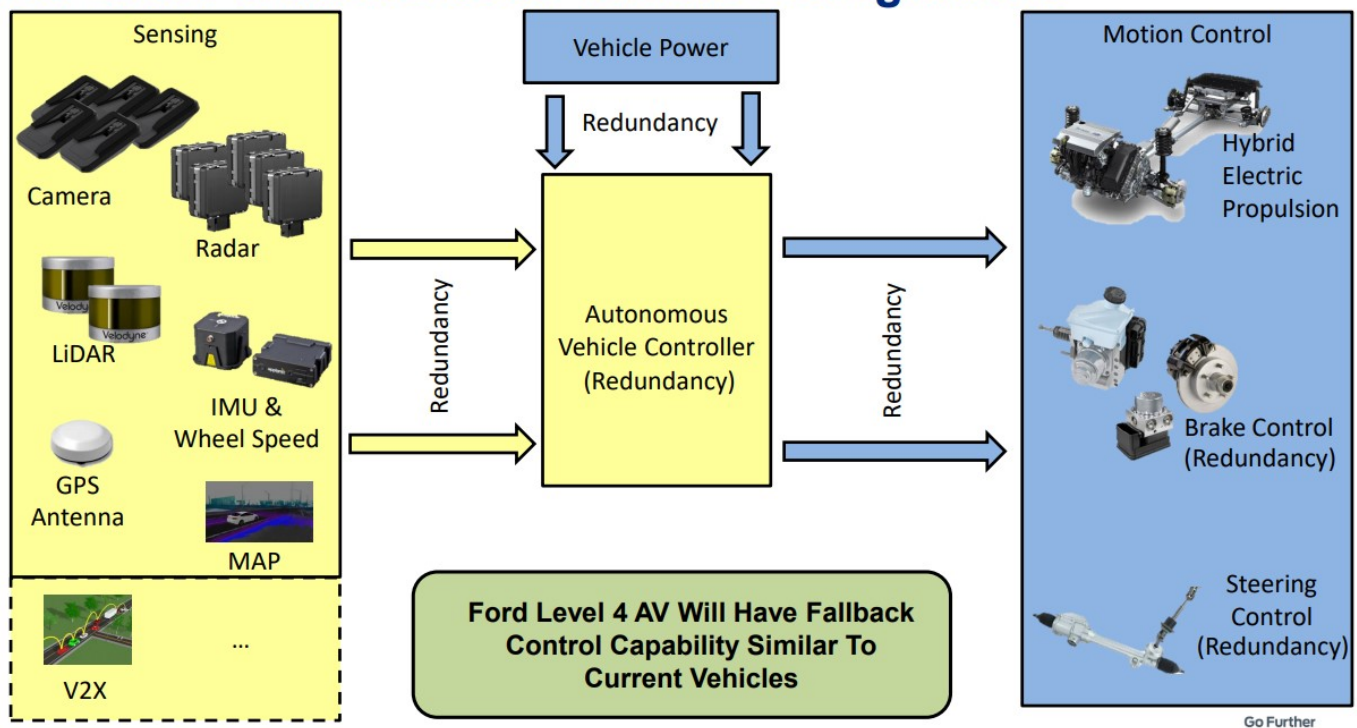


Figure 10: Autonomous Vehicle Design; **Source:** Colm Boran, *Autonomous Vehicle Systems Engineering*, [REDACTED]

The company is forming several innovative partnerships across the globe in order to serve the customer better and profitably. One typical example of such partnership is with Volkswagen in order to utilise the Volkswagen (VW) electric vehicle platform in Europe and develop electric commercial vehicles. This partnership will be discussed in detail later in the report.

3.2.8 Financial Innovation

(a) Operating Efficiency Model

As highlighted earlier, [REDACTED] is exiting loss making business and re-focusing its product portfolio resulting in a de-risked asset-light business model. For example, the company reduced manufacturing plants from 4 to 1 in South America due to loss making (\$3.5Bn over the last 5yrs), and they are exiting manufacturing in Brazil.

(b) Material Cost Reduction Model

The company is innovating towards material cost reduction. As [REDACTED] accelerates towards EV's, they are focussing on three areas of material cost:

- (1) the batteries;
- (2) the non-battery elements of the EV system; and
- (3) the non EV parts of their vehicle.

The company has assessed that non-battery elements constitute approximately 20% of a BEV and aims to use scaling to control material cost through economies of scale. The company write their own software for battery controls, but work with suppliers to develop custom hardware solutions. This further reduces costs. The company is claims it is absolutely committed to designing and manufacturing its own batteries, with the target to manufacture 240GWh of battery cell capacity by the end of the decade. This is about 10 plants worth of capacity dotted as shown in *Figure 11* below:



Figure 11: Manufacturing capacity for the battery technology

The company has set itself a steep target to reduce its battery pack cost by 40% by 2025 compared to 2021. The breakdown in cost reduction targets are as per *Figure 12* below:

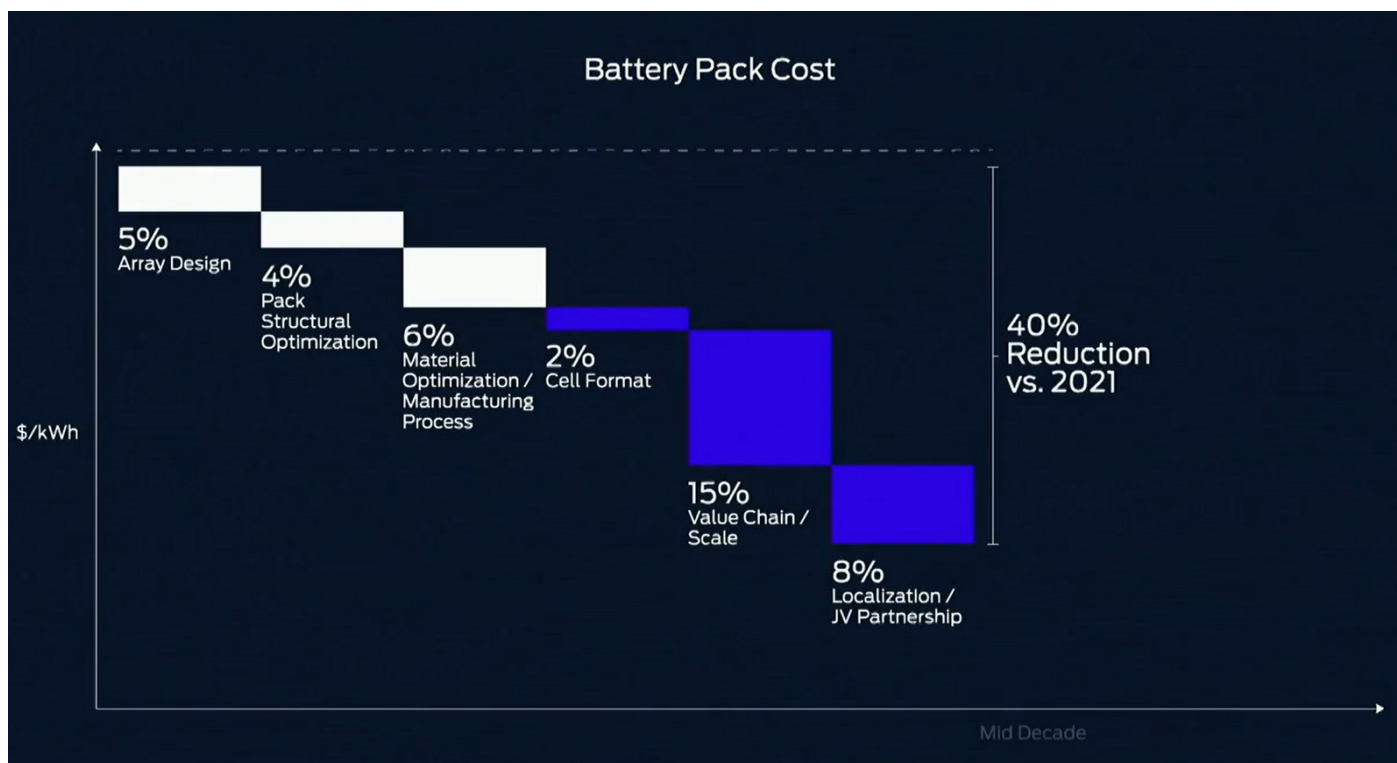


Figure 12: breakdown in cost reduction targets for Battery Pack

(c) Connected vehicle Profit Model

■ sees connected services as a source of tremendous value creation. As already mentioned, the target of connected vehicles rises from 1 million (2021) to 33 million (2028). Assuming 50% Attach Rate at \$20 per month (assuming 50% of customers who own ■ Connected Vehicle choose to use connectivity services at a fee of \$20 per month), the company will generate \$4bn of new revenue, as seen in formula *Figure 13* below

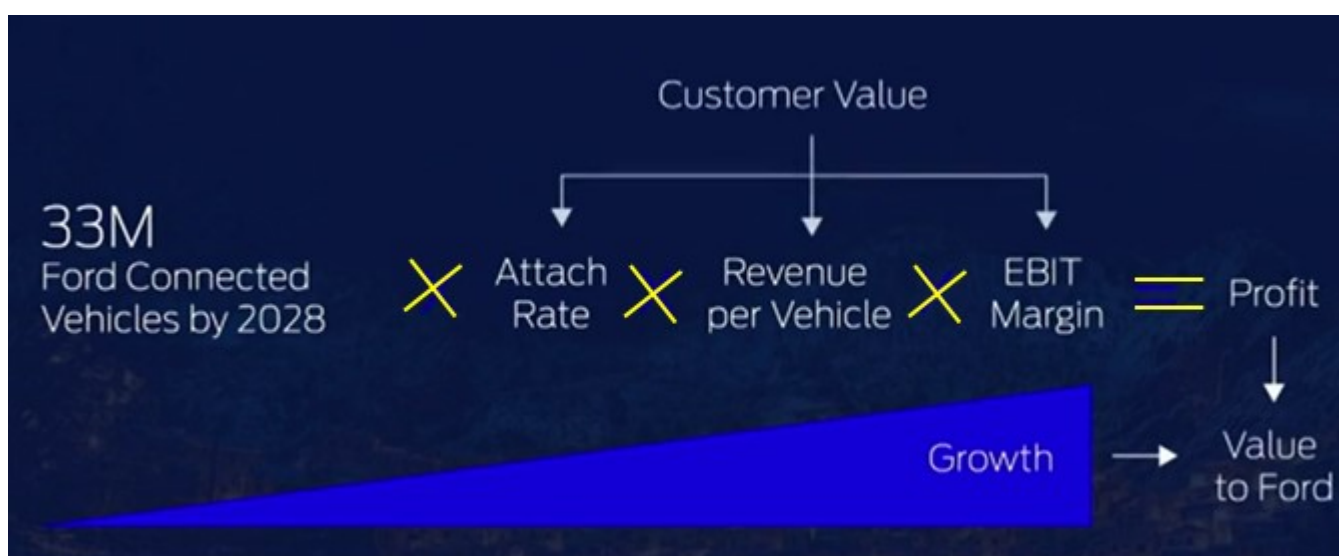


Figure 13: Connected vehicle Profit Model

(d) Competitive product portfolio

The company directors have announced the arranged the product portfolio has yielded strongest results in decades. The lineup to showcase is as follows:

■ ■ ■ ■	F Series	= #1 full size pick up globally
■ ■ ■ ■	Mustang	= #1 sports coupe globally
■ ■ ■ ■	Transit	= #1 Cargo van globally
■ ■ ■ ■	Explorer	= #1 America's all-time best selling SUV
■ ■ ■ ■	Ranger	= #2 medium size pick truck globally
■ ■ ■ ■	Bronco	= a new entry and game changer

Chapter 4: Literature Review

4.1 Introduction

The literature review in this report covers themes of relevance to the study. The key themes include the Industry 4.0 technologies as well as concepts of innovation. The review also looks at relevance of industry 4.0 technologies and concepts of innovation to mobility industry as well as to [REDACTED] in particular.

The **OECD's Oslo Manual, 2018** define innovation as a new or improved product or process that is available to users and differs significantly from previous products or processes.

Different characteristics like the degree of novelty, form, continuity, and many more can be used to classify innovation. *Dosi, (1982); Dewar & Dutton, (1986)* divided innovation into two categories, radical and incremental.

Radical innovation is where there is extreme risk taken with lot of uncertainty, and is much challenging to explore. However, radical innovation is seen as a source of long-term growth. On the other hand, a continual process of making additional improvements characterizes incremental innovation.

Dosi (1982) and Tushman & Anderson (1986) distinguished between innovations according to whether they affect existing ways of doing things (continuous) or develop new products, services or processes, individually or in combination (discontinuous). Continuous innovations happen in stable routines under clear rules, whereas discontinuous innovations are competence-destroying and very ambiguous. A further explanation is that an innovation is said to be competence-enhancing when it builds up on an existing technology using firm's existing competencies. On the contrary, an innovation is said to be competence-destroying when it replaces a technology and therefore render firm's competencies obsolete.

Tidd & Bessant, 2012, point out that the ability to see connections, to spot opportunities and to take advantage of them drives innovation. They note that innovation is not just about opening up new markets – it can also offer new ways of serving established and mature ones. They also emphasise, at the other end of the technological scale there is a scope for improvement on an old product.

Innovation is not just about technology, it is about what people desire, and if it is technically feasible as well as economically viable then value is achieved, *Roger L. Martin, 2009*. The illustration below shows the value of innovation according to Roger L. Martin, 2009

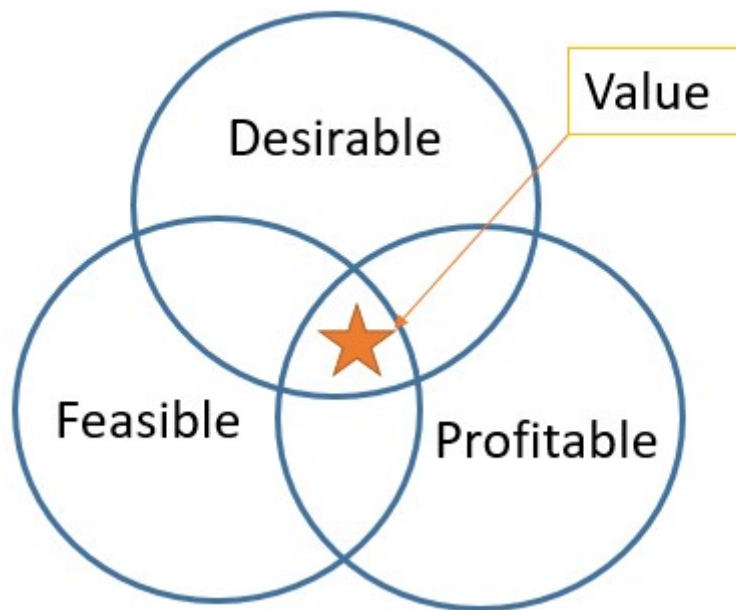


Figure 14: What do we mean by innovation, Roger L. Martin, 2009

Christopher Freeman (1982), in his famous study of economics of innovation, wrote: ‘not to innovate is to die’. **Maital, Seshadri, 2012**, believe that three key reasons to innovate are to energize people, build growth and profit, and to survive. According to **Hannan and Freeman, 1984; Nelson and Winter, 1982**, old routines need to be replaced by new ones if the firm is not to be driven out of business.

4.2 What is innovation in [REDACTED] context and why does it matter?

According to the policy article in [REDACTED] innovation is creating new value or capturing value in a new way. Value is the key word, highlighting the difference between innovation and invention. While invention requires the creation of new ideas, processes or products, innovation moves one-step further and requires implementation of the inventive act. The [REDACTED] definition of innovation is not detached from definitions by writers like **Rogers and Shoemaker (1972); Trott (2017)**.

[REDACTED] believes the first step to innovation is to understand the marketplace that you operate within and having clear visibility of oncoming trends. **Eckert (2019)** supports this belief by asserting that, a company needs a framework to channel innovative energies so that they solve customer pain points to result in a commercial outcome the market will pay for. **Eckert (2019)** highlights that unconstrained innovations lead to inventions that are impressive and creative, but ultimately prove impractical or irrelevant for driving business growth.

Paul Trott (2017) emphasises that, commercialising technology and new products, in particular, is one of the key challenges within innovation. **Trott (2017)** talks of ‘Market Vision’ or the ability to look into the future and picture products and services that will be successful as a basic requirement for firms that wish to engage in innovation.

Paul Trott (2017) discusses time lag between innovation and useable products, and give example of how Alexander Fleming discovered penicillin in 1928 but it 10 years to purify the mould until in 1938 a team of scientists led by the Australian-born Howard Florey and German-born Ernst Chain managed to purify it, and the first useable product appeared in 1945. Such an example is directly applicable to the development of autonomous vehicles within [REDACTED] [REDACTED]. The concept of AV’s is not new. AGV’s (autonomous guided vehicles) have been in use within advanced manufacturing environment since the 80’s, and constantly developed over the years. That concept is now developing further into passenger vehicle market.

Rogers (1962), (1983) first came up with diffusion theory, of which technological diffusion is the process by which innovations spread within the and across economies. A technology adoption model on *Figure 15* demonstrate technology diffusion principle, with bell curve showing the number of new users and S-Curve showing the market share. The diffusion model below can be used to illustrate a fact that the market share of electric vehicles will continue to grow and to demonstrate that being an early entrant is very essential to secure a sizeable market share. Such is a reality that [REDACTED] [REDACTED] should grasp.

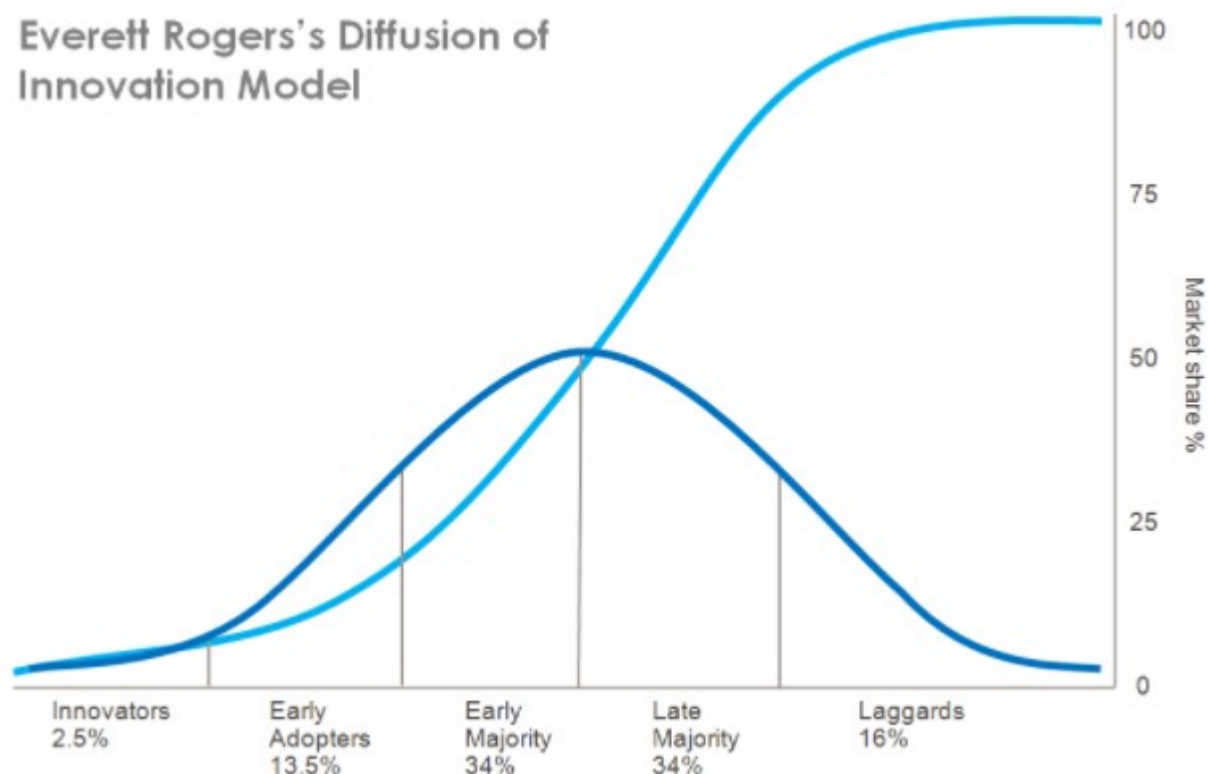


Figure 15: Diffusion of Innovation Model

Henderson and Clark (1990) examined product innovations and demonstrate that product innovations are complex entities embedded in organizational capabilities, which are difficult to create and costly to adjust.

Henderson and Clark (1990) propose a two dimensional model that represents technological knowledge that is behind innovation. The horizontal dimension representing knowledge of components and the vertical dimension representing knowledge of linkage between the components, called architectural knowledge. They model points out that, the most radical innovations come when knowledge of both components and their relation (or architecture) both high.

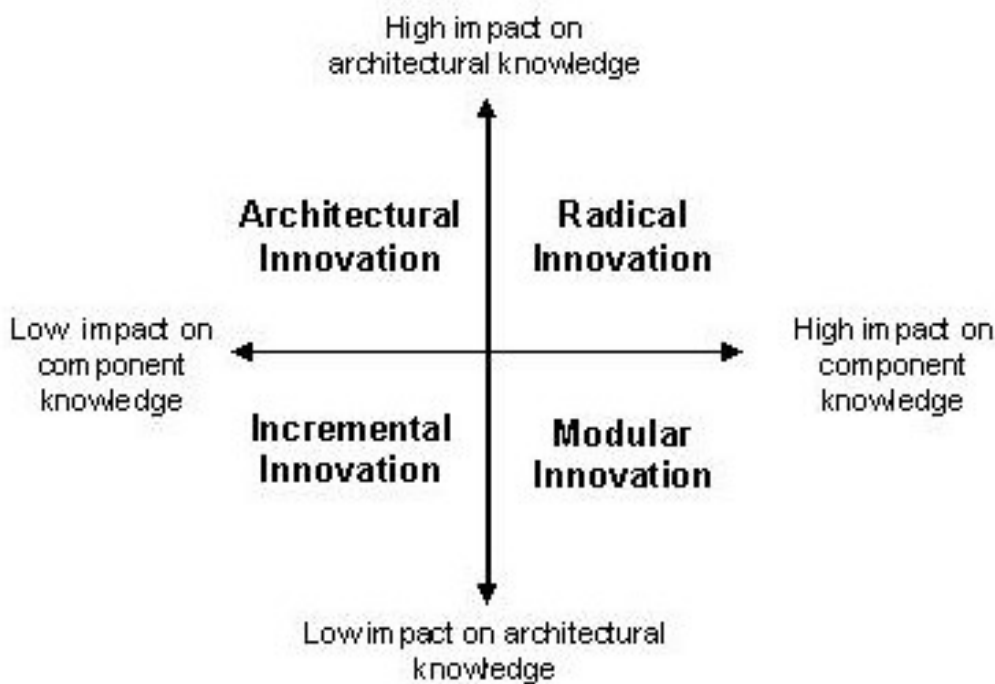


Figure 16: The Architectural Innovation Model, (Henderson and Clark 1990)

Transformation from internal combustion engines into electric vehicles can be seen as a radical innovation because the way the vehicle are powered is totally different, components are totally different and the way the components work with each other is totally different as well.

According to **Greg Satell (2017)** Innovation Matrix, the product innovation done by [REDACTED] falls into Sustaining Innovation because the problem and the domain are well defined. The problem on the table is to address GHG emissions, a carbon footprint that is detrimental to the environment. The technology already exists, that is, internal combustion engines and electric vehicle technology have been around for over a century, but the technology needs to get better.

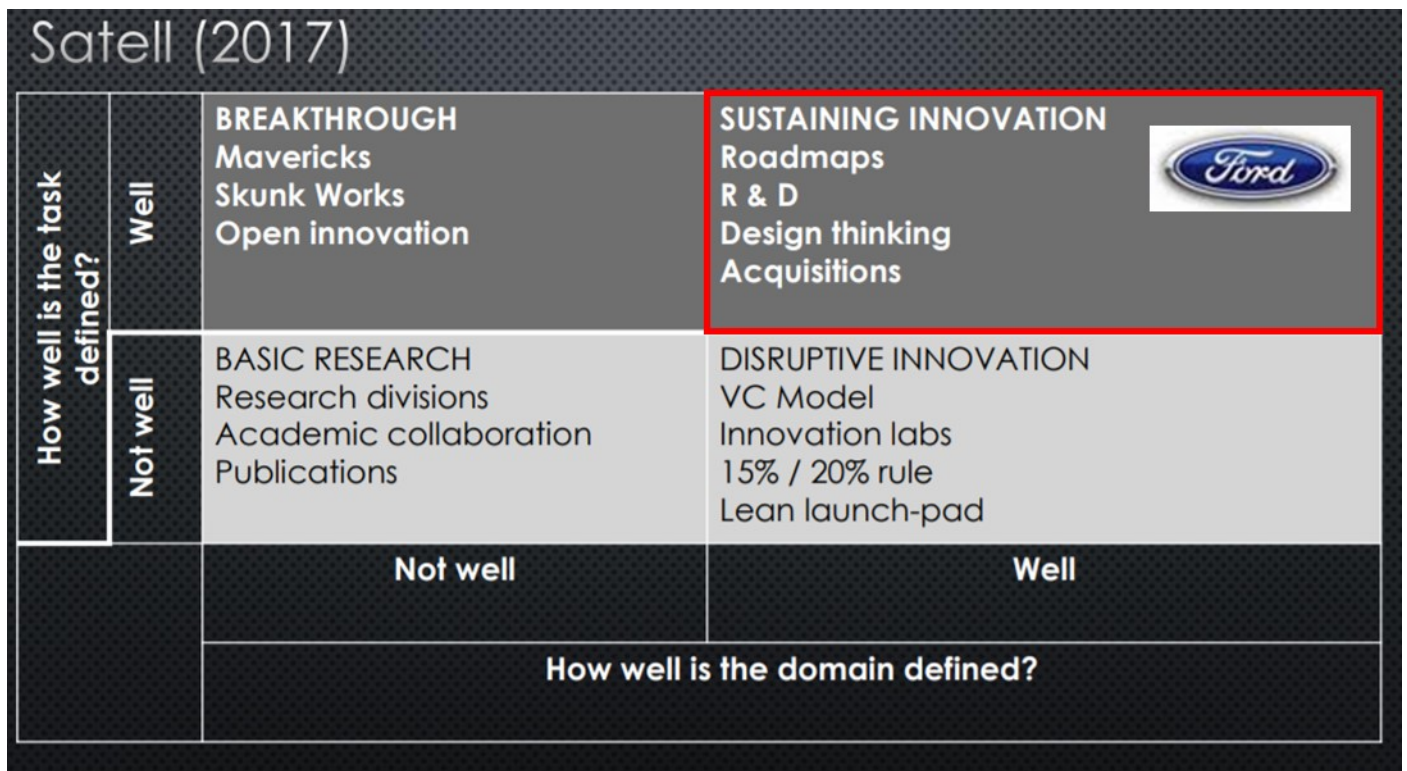


Figure 17: Illustration of innovation position according to Satell Matrix

4.3 The Industry 4.0 Technologies

Industry 4.0 can be defined as a revolution of the fourth generation that applies cyber-physical systems (CPS) principles in manufacturing industry. This brings together the internet and smart industrial technologies with enhanced human-machine interactions, *Lasi et al., 2014; Posada et al., 2015; Valdez et al., 2015*.

Industry 4.0 technologies are broadly classed to cover areas such as Big Data Analytics, cloud technology, autonomous vehicles, artificial intelligence (AI), virtual reality (VR) and augmented reality (AR), industrial use of the Internet of things (IIOT), cybersecurity, additive manufacturing, to name a few.

According to *Blunck & Werthmann (2017)*, Industry 4.0 offers a great opportunity to realize a circular economy through improved identification and tracking of smart products along the entire supply chain and intelligent use of data. Their viewpoint is supported by, *Lopes de Sousa Jabbour et al. (2018)*, as well as *Moktadir et al. (2018)*.

A circular economy is where there is no waste in the supply chain; instead, all materials are re-used following the end-of-life of a product, *Lieder & Rashid (2015)*. According to *Lieder & Rashid (2015)*, a circular economy is a striking balance between ambition for economic growth and achieving harmony with environmentalists since there is less pollution and less depletion of resources.

4.4 Employment of Industry 4.0 Technologies at [REDACTED]

[REDACTED] has a research centre in Aachen that aims to develop Industry 4.0 technologies like Generative Design, 3D/4D printing, VR/AR, PLM, Digital Twin, AGV, Drone, IOT, AI, 5G and Blockchain to modernize, disrupt and turnaround automotive operations. The research centre also aims to understand opportunities and risks related to those technologies.

[REDACTED] [REDACTED] has a long-standing Additive Manufacturing (AM) history spanning almost 30 years. The company has global rapid manufacturing centres in North America (Dearborn, Irvine, Mexico) and Europe (England, Belgium, Spain, Germany, Romania, Turkey).

By 2018, [REDACTED] [REDACTED] was making approximately 100K – 150K parts per year, primarily prototypes. **Baumers (2012)** suggests that material costs for AM are very significant. **Stoneman (2002)** suggests that increasing adoption of AM may lead to a reduction in raw material cost through economies of scale. [REDACTED] [REDACTED] is currently researching on scaling up AM operations in order to achieve the economies of scale across a broad range of components.

The illustration on *Figure 18* below is an extract from [REDACTED] Factory of the Future Seminar

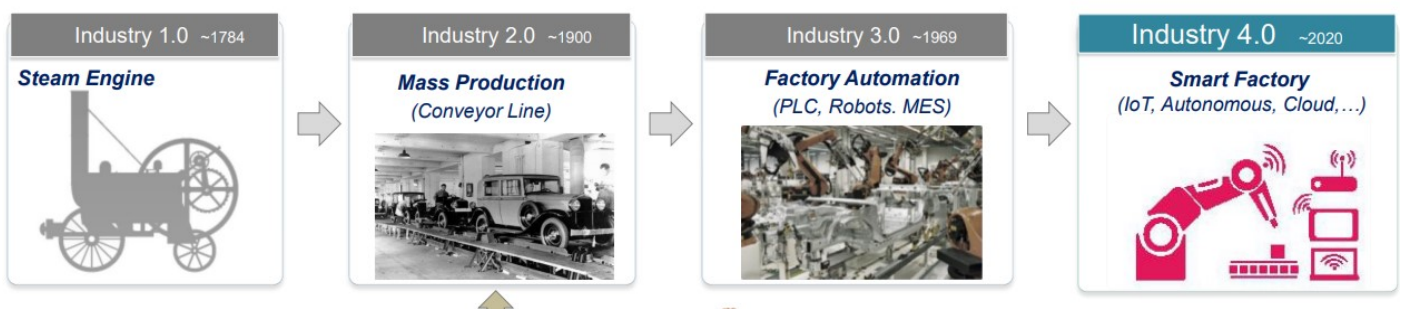


Figure 18: Illustration of development from Industry 1.0 to 4.0 at [REDACTED] [REDACTED]

The company is fast transforming from Manufacturing 3.0 to Manufacturing 4.0 throughout its global operations. This mean the company is transforming from a culture of being “Reactive” to problems to a culture of being “Proactive”, that is, to act in real time before problem events happen, as illustrated in *Figure 19* below. The company is developing and using several powerful tools for data mining, machine learning, and pattern recognition using big data to develop proactive solutions in manufacturing operations.

Mfg. 3.0 Vs Mfg. 4.0

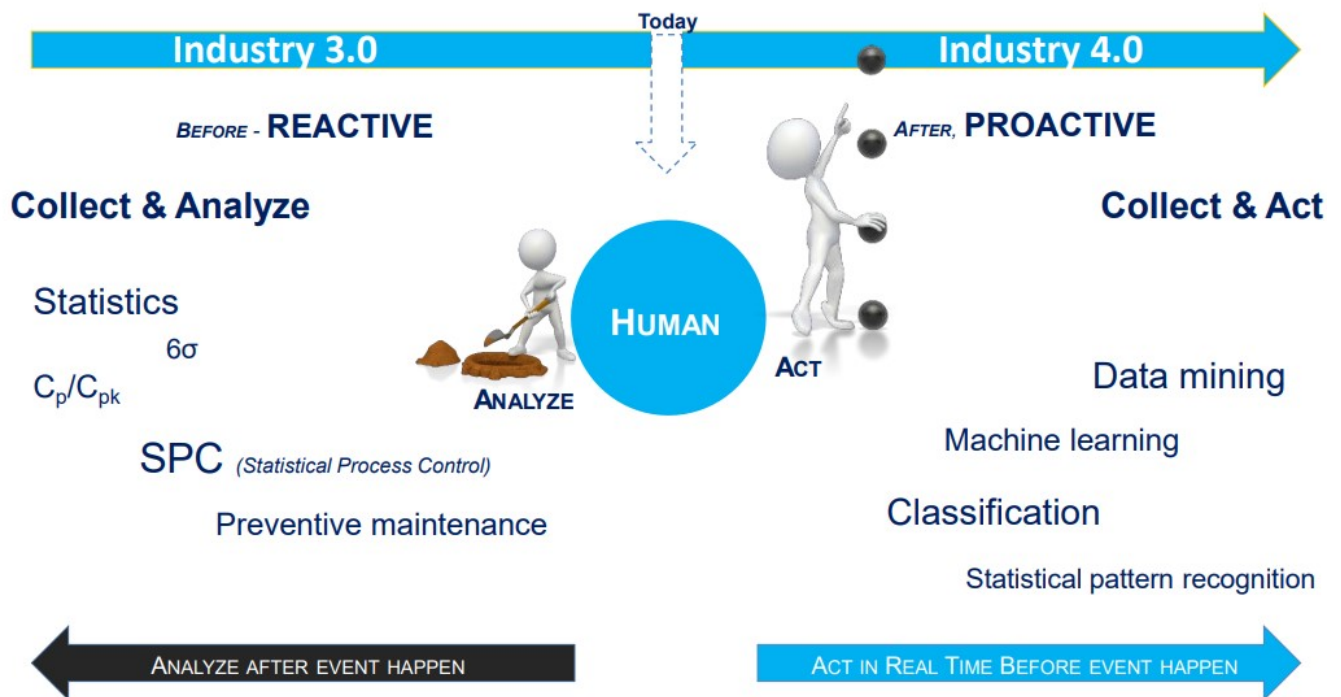


Figure 19: Comparison of Industry 3.0 and 4.0 approaches

An interesting note worth discussing is the transformation of [REDACTED] from traditional factory to digital factory. As illustrated below, the company is slowly employing digital product development approach characterised by 3D Scanning, which inputs into 3D modelling, which then leads to simulation of product function and virtual try-outs and virtual verifications.

Such an approach cuts waste in several ways such as discovery of design and manufacturing errors at a later stage leading the huge amounts of Correction - Rejects, rework, and reruns. Digital approach also cuts out inventory of excess raw materials, work-in-process, waiting times, tooling costs associated with machining of automotive parts, unnecessary non-value add operations.

Automation puts workforce into better utilization. Menial tasks are conducted by technologies like the COBOT (Collaborative Robots - robots with comprehensive safety systems and corresponding sensor technology) that are working in close proximity with humans, thereby allowing human beings to do more challenging tasks safely in the same environment.

4.5 Case Studies of 4.0 Technologies at [REDACTED]

4.5.1 CASE STUDY 1: Innovation in Product Development using Digital Approach

Figure 20 demonstrates how digital manufacturing has improved product development process. 3D scanning followed by 3D modelling, simulation and virtual part try-out has replaced the traditional long process that involved fabricating parts for try-outs and has cut costs and lead-time for new components development.

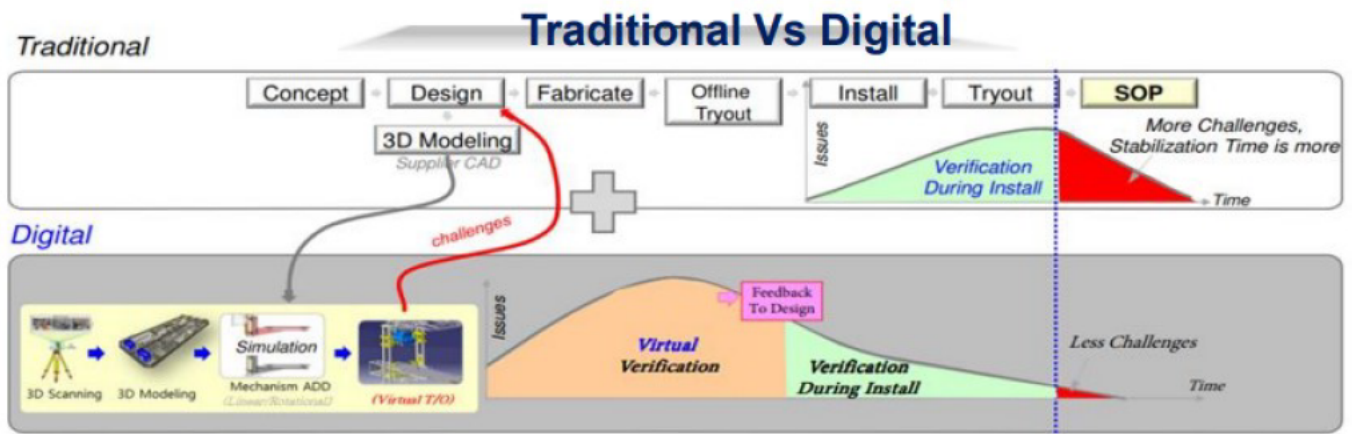


Figure 20: Traditional vs Digital Manufacturing approaches

4.5.2 CASE STUDY 2: Innovation in Product Development using Additive Manufacturing

Figure 21 below shows lead-time benefits of Additive Manufacturing (AM) over conventional manufacturing on automotive components at [REDACTED]



Prototype Intake



Low Volume Production

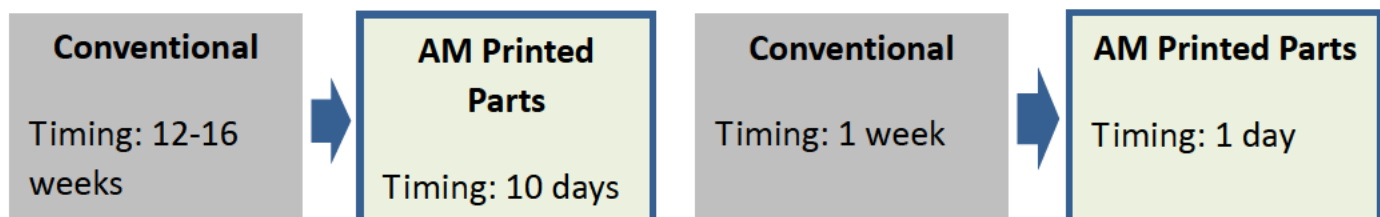


Figure 21: Comparison of product delivery lead-time: Conventional Method vs 3D Printing

SECTION III

Project Execution Phase

Chapter 5: Brief Introduction of the Project Execution Phase

The project aims to achieve the following four objectives for [REDACTED] [REDACTED]

1. Conduct an analysis of [REDACTED] [REDACTED] in the digital and electrification innovation space and explore partnerships that the company is involved with, and an analysis of how the company is meeting, and in some case influencing change in consumer taste.
2. Evaluate the costs and benefits of innovation for [REDACTED] [REDACTED] including a focus on opportunities as well risks and de-risking activities
3. Review what is happening industrywide in the mobility industry innovation space
4. Recommend pathways and de-risking activities that may further help [REDACTED] [REDACTED] [REDACTED] to secure a leading position in the future of mobility industry

Chapter 6: An analysis of factors affecting future product offering by [REDACTED] [REDACTED]

The following are key questions that this research attempts to address:

1. *What are internal external factors affecting the future product offering?*
2. *Are future product offering adequately aligned with changes in in the automotive industry?*

6.1 PESTLE Analysis of factors influencing the future product offering

PESTLE model attempts to evaluate impact the external factors like Political, Economic, Social, Technological, Legislative and Environmental on [REDACTED] [REDACTED] innovation and future product offering. It is worth noting that the list is not exhaustive.

(a) Political:

The political environment plays a huge role on automotive business. Government policies have influence on business risk. [REDACTED] [REDACTED] should be ready to deal with the local and international outcomes of politics. For example, as part of abiding to the Kyoto protocol, governments are taking stances to improve the development of electric vehicles.

The tough measures that governments putting will make business not viable for producing internal combustion engines. On the other hand, incentives that have been put in place such as zero tax on EV's are encouraging the society to shift away from traditional internal combustion engines.

[REDACTED] aims to branch out to other countries with its electric vehicles, but that success is dependent on geo politics as well as on strength of competitors like Tesla, Toyota, Nissan.

Political threats have played a huge influence in the past, for example, President Trump's threat to impose tariffs of 25% on passenger vehicle (*see Figure 22*), similar to the 'chicken tax', led [REDACTED] [REDACTED] to cancel plans for Mexico Plant. [REDACTED] eventually did not open a planned facility for assembling [REDACTED] Focus, which would have brought \$1.6bn and 2,800 jobs to the state of San Luis Potosí. The Chicken Tax is a 25 percent tariff on light trucks (and originally on potato starch, dextrin, and brandy) imposed in 1964 by the United States under President Lyndon B. Johnson in response to tariffs placed by France and West Germany on importation of U.S. chicken, **Dolan, 2009**.

Car Industry Fears Trump Tariffs On Vehicle Imports

Charles
Wallace

Charles Wallace Former Contributor
Business

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 This article is more than 2 years old.



U.S. President Donald Trump Photographer: Al Drago/Bloomberg © 2019 BLOOMBERG FINANCE LP

Figure 22: *Emphasis of tariff threat to import for automotive manufacturers*

Ford cancels plans for Mexico plant as Donald Trump threatens to tax GM

President-elect threatened to tax General Motors for importing cars from Mexico, prompting rival Ford to announce it won't open planned facility



▲ Donald Trump targeted General Motors in a tweet threatening a 'big' tax. Photograph: Evan Vucci/AP

Figure 23: ■■■ reaction to political threat to manufacturing outside US borders, **Source:** *The Guardian*: <https://www.theguardian.com/business/2017/jan/03/donald-trump-general-motors-tax-chevrolet-cruz>

(b) Economical:

Subsidies and incentives given to the society to adopt EV has an effect of boosting economic growth and increasing diffusion of EV technology, as noted by brief literature review below.

An econometric analysis by **Rezvani et al (2015)** revealed that adoption rate of EVs is affected by several factors, such as purchase cost, hands-on experience with EV technology, emotions related to driving a EV, and environmental concerns.

Coffman et al (2016) noted factors that are beyond the direct control of EV manufacturers such as fuel prices, the cost of battery materials, policy incentives, consumer characteristics, availability of charging stations, travel distances, public visibility, and vehicle diversity. Macro-effects of unemployment and fuel prices were also found to drive the adoption of hybrid vehicles in the US (**Jenn et al 2013**), a finding that may also apply to EVs.

Mersky et al (2016) found that the growth of BEV sales was closely linked to regional income levels. **Hess et al (2012)** found that incentives were necessary to promote consumer interest in EVs. Similarly, **Breetz and Salon (2018)** concluded that state and federal subsidies were necessary for BEVs to be cost-competitive in 14 US cities. **Langbroek et al (2016)** evaluated the effect of policy incentives on BEV adoption and showed that policy incentives have a positive influence on adoption.

(c) Social:

The idea of an electric car being associated with green, clean and healthy environment has been well sold to the society. The people now love the idea of owning a Tesla, or a Nissan Leaf. The image that Tesla has portrayed, a combination of power, luxury, and green appeals people who have eco-friendliness in mind. This puts a difficult challenge for traditional automakers like [REDACTED] to gain market share in the EV generation.

The *Financial Times*, (2021) reports, Tesla has become the first carmaker to be valued at \$1tn to become the world's most valuable carmaker by market value. As reported by the *Financial Times* (2021), the Tesla value has increased fivefold with the company now worth more than the next nine most valuable public carmakers combined, shown in figure 24 below. Such report shows the power of societal perception and the value that is put to a product.

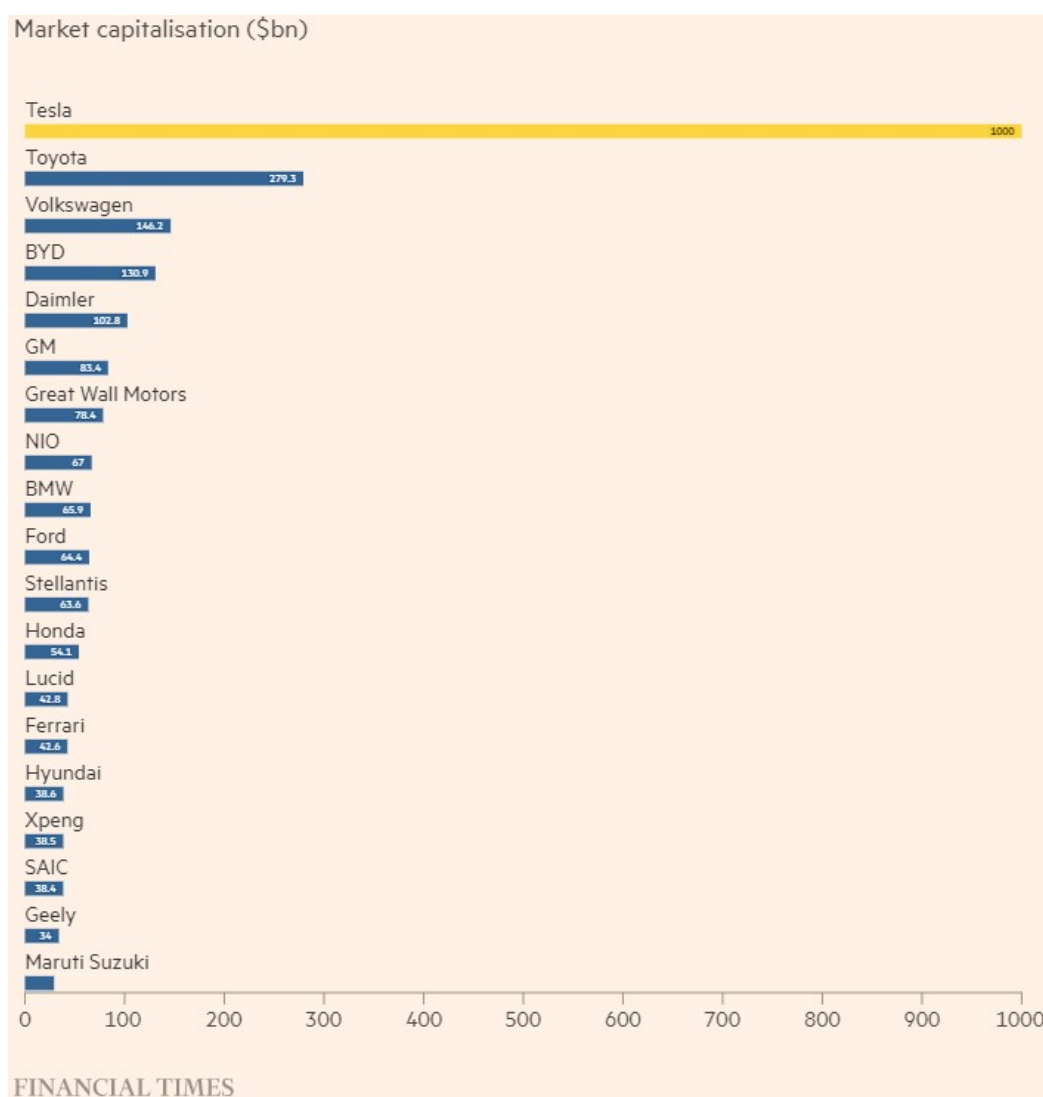


Figure 24: Size comparison of Tesla with other automotive manufacturers

(d) Technological:

Advance in technology can be viewed as a double-edged sword. On the good side, advancement in technology can help a company secure and maintain a competitive advantage. However, there is a risk that the society may not adopt the technology that the company invests in, or another technology may supersede that technology before profits are realized. A good example is the story of Betamax (by SONY) vs VHS (by JVC). Betamax. SONY released Betamax in 1975

In comparison, the VHS had a 2 hour recording time; had recording settings such as SP, LP, and SLP; and its tapes were designed to be interchangeable between machines from different brand manufacturers. Even though the Betamax had a superior recording format over VHS due to better resolution, it could only record for 1 hour, which was too short to record a full football game or a full movie in one tape. The Betamax was also more expensive than VHS.

The market landscape for the video recording changed drastically in the short space of time. Betamax owned 100% of the market in 1975, by 1980 VHS was controlling 60% of the market. By 1986, it was just 7.5%. The market turned away, movie studios and video rental stores turned away from Betamax and in 1988 Sony threw in the towel by discontinuing the Betamax product and started making VHS machines. Sony had ignored what the market wanted and clung to the idea that Betamax was better quality, whereas the market wanted a cheaper product with longer playtime. The VHS/BETA format war is an interesting example of a company trying to dictate the market and not listening to what the public really wants, *Logie, J., 2020*.

(e) Legal:

The legislation against CO₂ has become stricter over the years. The legislation sanctions that, if the average CO₂ emissions of a manufacturer's fleet of vehicles exceeds certain targets in a given year, the manufacturer has an obligation to pay an excess emissions premium for each car registered. For example, as from 2019 onwards, a vehicle manufacturer faces a penalty of €95 per vehicle sold for each g/km of CO₂ that is above stipulated maximum target. This compels vehicle manufacturers to rethink their products and innovate towards smarter technologies such as EVs in order to avoid legislative penalty.

(f) Environmental Ethics:

Climate related reputation risk is very relevant. A good case study is the 2015 VW Emissions Scandal, that carried the damaging headlines such as: *“Volkswagen cheated European emissions rules designed to save lives by installing unlawful defeat devices in diesel cars”*, (*BBC, 2019*).

The auto giant admitted in 2015 that it had utilised software that reduced readings of emissions in tests on 11 million cars worldwide and faced legal action worldwide. It was fined €30bn (£26bn), suffered recall costs and civil settlements on top. Above all, the VW incurred a severely damaged brand.

6.2 Analysis of Global Competition in Automotive Innovation Space

Tesla has some very well known quality problems. This is an opportunity for [REDACTED] [REDACTED] to capitalise on as it has a very good quality record.

[REDACTED] has come up with the F150 Lightning, an all-electric of its bestselling car. If the public embraces F150 Lightning then [REDACTED] is in for a good paycheck.

China has the biggest car market in the world, as seen in *Figure 26*. China is all about EV start-ups. The first waves was all about start-ups like BYD, they started Taxi fleet sold to the government. Then there was the appearance of the likes of Nio, following the Tesla model of business. Now we have the Nio, Xpeng, WN, and Li Auto. Nio is commonly known as the Chinese Tesla, a big disruptor in in a region that is separate from the US.

Nio's key proposition to the market is redefining the use of the car. Instead of selling just a product, Nio promotes the car as part of a lifestyle. This proposition is very similar to [REDACTED] proposition discussed earlier on. Like Tesla, the company does not use dealers but instead has self-owned Nio Houses and has its own apps with high utilization rates. This creates brand loyalty.

Charging still remains an issue for many potential EV customers. Nio has solved the problem in a unique way by creating swappable battery modules and investing heavily in swapping stations.

According to *emag (2021)*, Xpeng is known for redefining the automobile as a giant smart mobile device rather than a means of transportation, which is an appealing proposition to the emerging generation.



Figure 25: Impressive designs from the Far East create future competition in automotive, **Source:** <https://emag.directindustry.com/who-are-the-three-main-chinese-electric-car-companies/>

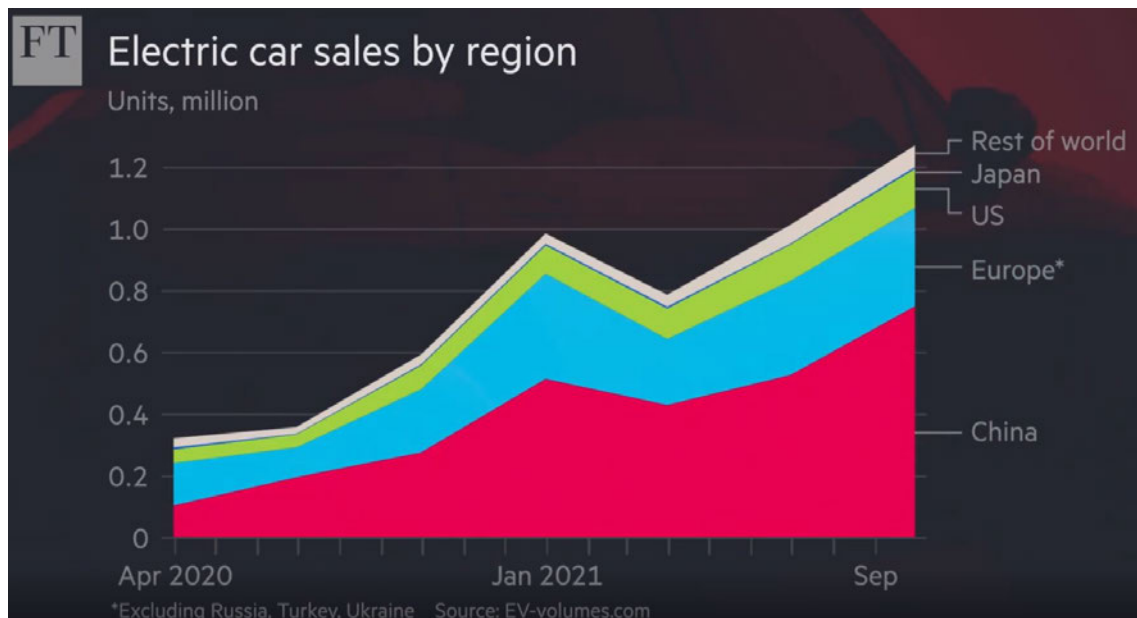


Figure 26: Global EV Volume Sales as of 2021, **Source:** <https://www.ft.com/video/69084b66-3723-4d33-af7b-e593fda81107>

6.3 Analysis of [REDACTED] using 4P's Innovation Space

The 4P's model in Figure 27 is a framework that can be used to organise and focus innovation effort. It is worth noting that innovation in one dimension often bring changes to the other dimensions and that the dividing line between dimensions is often fuzzy.

Innovation Space 4P's

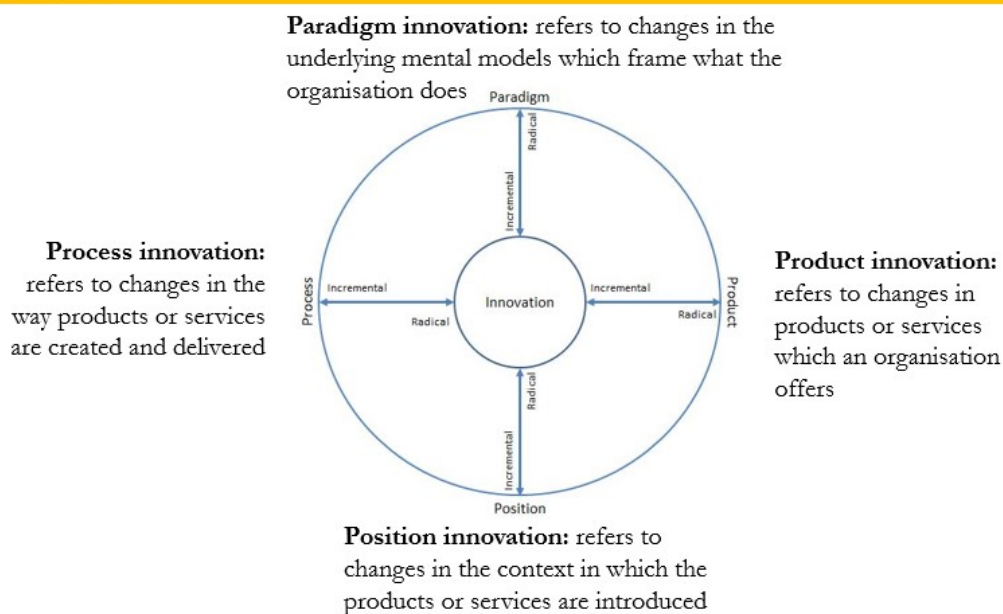


Figure 27: The 4 P of Innovation(Tidd & Bessant 2018)

According to *Tidd & Bessant 2018*, process innovation is a change in the way a product or service is delivered to the customer. This may entail greater automation and rethinking how a process is managed. Position innovation implies a change in the context in which products or services are introduced or positioned in the market place in order to change the perception of consumers.

The authour has applied the 4P innovation model to [REDACTED] scenarios as per *Figure 28* below.

Summary of how 4P's are driving innovation at Ford

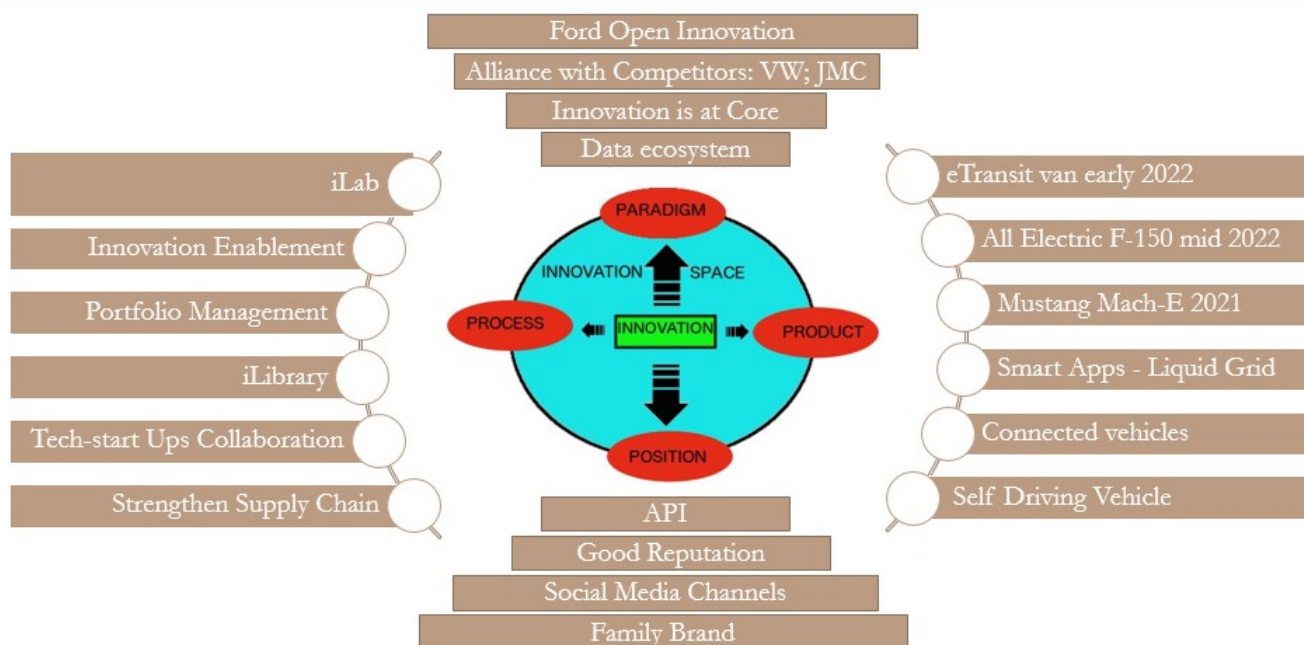


Figure 28: A summary of how 4P's are driving innovation at [REDACTED]

6.4 An Analysis of [REDACTED] against the ISO 56002 Innovation Management Principles

ISO56002:2019 Innovation Management System (IMS) is noted as a collection of processes in business that are formalised to underpin the delivery of sustainable innovation within the organization. The IMS guidance, launched in July 2019, outlines the 7 key principles that an innovative organization should focus on. These include:

Leadership, Planning, Operations & Delivery, Support and Resources, Performance Evaluation, Improvement, Organizational Context & Culture. *Further detail is available in Appendix 3*

The author has analysed the extent to which the ISO56002:2019 standards could influence the management of new product development at [REDACTED] summarised in Figure 29 and using Figure 30 as guideline.

ISO56002:2019 Innovation Management System in Ford Perspective

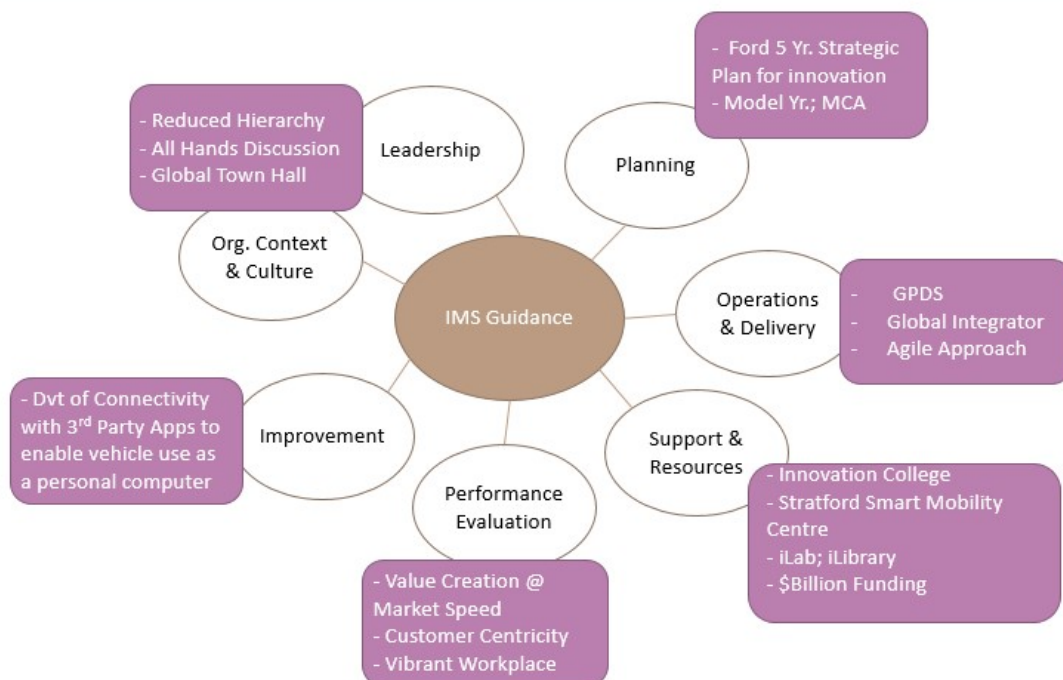


Figure 29: Extent to which the standards could influence the management of new product development at [REDACTED]

ISO 56002 Innovation Management Principles

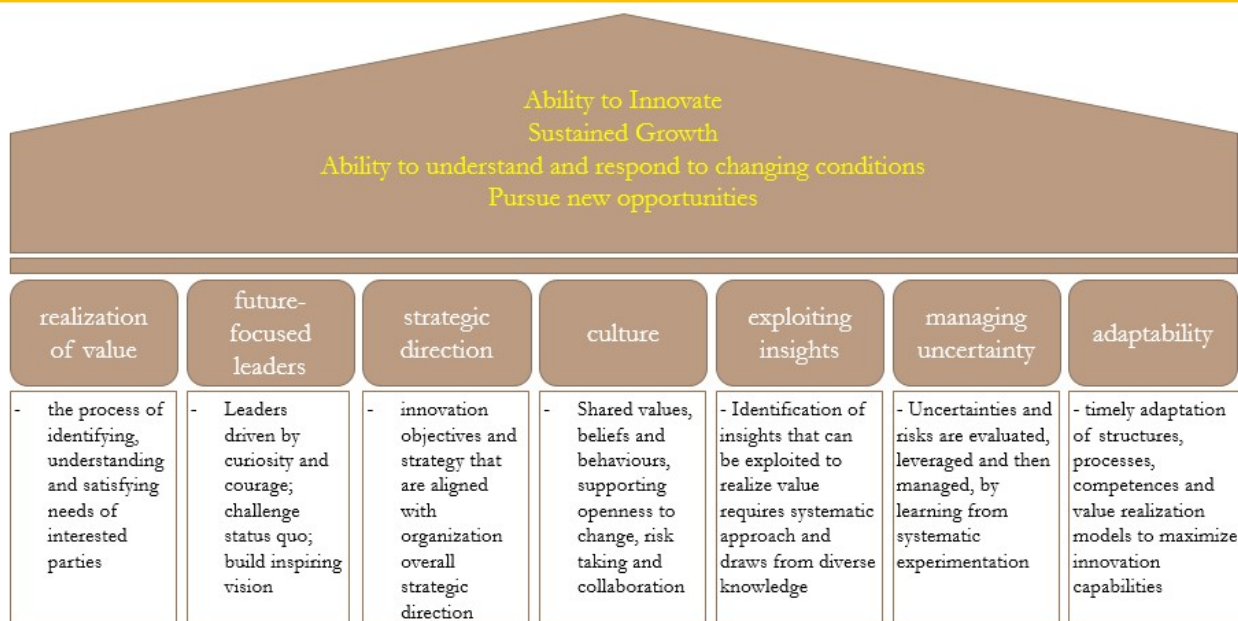


Figure 30: The basis of effective management of innovation activities and foundation of IMS, diagram drawn using extracts from ISO 56000 International Standard for Innovation manual

6.5 Analysis using Henderson and Clark matrix of architectural knowledge

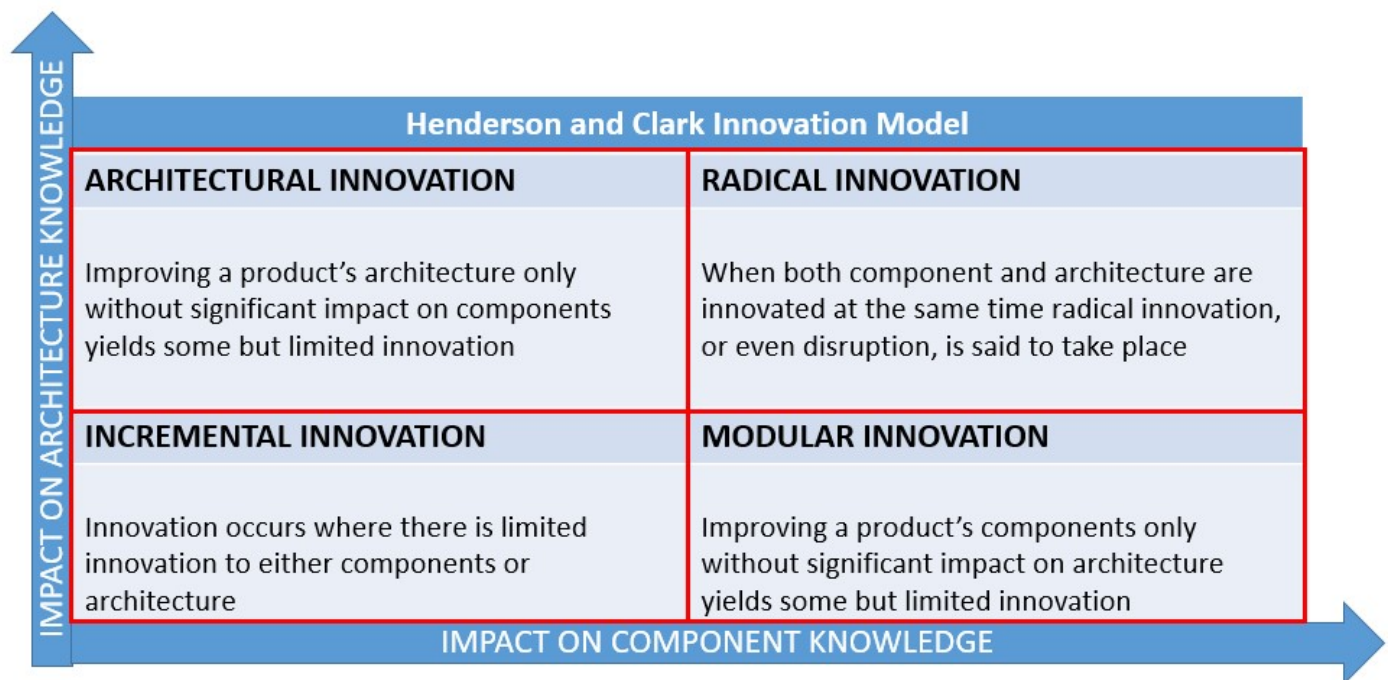


Figure 31: Henderson and Clark innovation model

examples

Architectural Innovation flexible vehicle electrical architectures that can be adapted across different electric vehicle platforms	Radical Innovation - EV development - Self Driving Vehicle developement
Incremental Innovation Improvement of On-Board Computers	Modular Innovation - Development of visual communication between autonomous vehicles and pedestrians - Liquid Grid: All-In-One app that allows travellers to book any type of transport

Chapter 7: An analysis of [REDACTED] strategic partnerships in the innovation space

7.1 An Insight into Argo AI

[REDACTED] has strategically made smart partnership with Argo AI. Argo AI is a self-driving technology platform company that builds the software, hardware, maps, and cloud-support infrastructure that power self-driving vehicles. The Argo AI's aim is to make mobility around cities safe, easy and enjoyable for everyone. It is a good decision for [REDACTED] to make partnership a company with such an attractive statement on purpose of existence.



Figure 32: [REDACTED] self-driving car under road test

Argo AI recognised that movement can be challenging, with some neighbourhoods lacking public transportation options, and some modes of transports not easily accessible to the young, the elderly or the disabled. The company also recognised problems with congestion. It went further to recognise that there are less apparent challenges such as the way cars interact with pedestrians; how cars interact with cyclists, and how they interact with each other. Argo AI's also recognises that traffic fatalities are too high as they are today, for example, according to National Highway Traffic Safety Administration (NHTSA), there were 36,560 traffic fatalities in the United States in 2018 alone.

Another interesting statistic by the NHTSA is that, for example, in 2010 the total economic cost of motor vehicle crashes in the United States was \$242 billion, which is equivalent to approximately \$784 for every person living in the United States and 1.6% of the US gross domestic product, **Blincoe L.J., Miller T.R., Zaloshnja E., et al. (2010)**. Argo AI challenges that such figures should not be accepted as normal. The company is confident that self driving technology has great potential to alleviate these problems.

Argo AI also reveals strong advantages of self driving technology over human beings. For example, the technology has a 360 degree awareness, does not get distracted, and does not get fatigue like human beings, thereby making roads safer. The company believes there will be ability to utilise autonomous technology to move goods in a highly coordinated fashion and to utilize off peak time slots to avoid city congestions.

7.2 SWOT Analysis of Smart Partnership

The researcher conducted a SWOT Analysis of smart partnerships that [REDACTED] Limited forged (or is forging) with other companies. **Proctor (1996)** defines a SWOT Analysis as “a technique specifically designed to help identify suitable business strategies for an organization to follow. It involves specifying and relating strengths & weaknesses that are internal to the organization, and opportunities & threats that relate to the environment that is external to the organization”. As a key take away from SWOT Analysis, it is worth to emphasize how important it is, to leverage strengths, learn from weaknesses, minimize threats, and to take advantage of available opportunities.



Figure 33: SWOT Analysis Source:

<https://corporatefinanceinstitute.com/resources/knowledge/strategy/swot-analysis/>

[REDACTED] examples

Strengths	Weaknesses
Access to shared technologies and blueprints eg [REDACTED] Ranger and VW Amarok sharing a design platform and manufacturing facility	Individual development is limited by binding legal contracts of partnership
Opportunities	Threats
- Joint access to bigger market share to compete with Tesla - Joint capital to fund innovation and competition against Tesla	Behaviour of partner may tarnish both companies, eg VW diesel scandal

SECTION IV

Recommendations for Improvement

Chapter 8: An analysis of opportunities of improvement and Mapping an improvement journey

8.1 What opportunities of vehicle electrification can the company leverage on?

While Tesla has become the most valuable automaker in terms of market capitalisation, the company is well known quality problems. Such a weakness on Tesla should be an opportunity for [REDACTED] to take advantage of. A report by *The New York Times (2021)*, revealed social media survey which shows Tesla struggled with quality issues such as large gaps between body panels, poor paint jobs and chipped glass, as it scaled its production from tens of thousands to half a million vehicles a year in 2020.

The New York Times (2021), also reported a growing number consumer complaints on Tesla battery fires and other quality issues in China, resulting in Chinese regulators summoning Tesla executives to ensure the company strictly abide by Chinese laws and regulations, strengthens internal management, and implements corporate quality and safety regulations. It is recommended that [REDACTED] should take such key incidents on Tesla as lessons learnt, in order to prevent such occurrences to [REDACTED]

However, despite its historic reliability concerns, Tesla took the top spot for overall owner satisfaction among the 27 brands mentioned in survey done by *Consumer Reports (2021)*, showing an intensely loyal following.

A study carried out by *J.D. Power, (2021)*^{*1} showed Battery-electric vehicle owners across industry are less satisfied with after sales service they are getting. Only 54% battery electric vehicle (BEV) owners took their vehicle in for annual service in 2021, and the overall service satisfaction was 69 points lower than the average customer on non-automotive goods, and 76 points lower for service quality.

The study also shows the BEV are currently more difficult to service than traditional internal combustion engine vehicles, due to lack of experience at the dealership. Another interesting point to note is that the lower frequency of service visits means dealers have fewer chances to make a positive impression on these customers. It is recommended that [REDACTED] should take early advantage of the about weakness revealed by *J.D. Power, (2021)*, and invest in more dealer service training to reduce risk of losing return customers.

A research by *Ofgem, (2021)*, has found that almost 24% consumers plan to buy an electric vehicle or plug-in hybrid in the next five years. Electric Vehicle Experience study by *J.D. Power, (2021)* ^{*2} shows that among the early adopters of electric vehicle (EV), 82% will consider purchasing another EV in the future. Nearly two-thirds (64%) of these owners indicate they desire to repurchase the same brand. Such a statistic is very essential in mapping [REDACTED] direction as it strongly shows the market future is in electric vehicles. The ownership index score shows electric vehicle owners' satisfaction is driven by seven factors, which include:

- I. accuracy of stated battery range;
- II. availability of public charging stations;
- III. battery range;
- IV. cost of ownership;
- V. driving enjoyment;
- VI. ease of charging at home;
- VII. vehicle quality and reliability.

It is worth noting that cost of ownership is a key driver in the purchase of an EV's over the traditional Internal Combustion Engines (ICE). EV's have fewer parts to maintain, have less frequent service requirements and results in lower fuel costs than ICE vehicles. Such a factor plays a key role in influencing adoption of EV's.

It is recommended [REDACTED] [REDACTED] should drive disruptive innovation to offer unique electric vehicle experience to customers based on the above factors in order to influence brand loyalty and repeat purchases in future.

Despite the above statistics, it is still well worth noting that 38% of consumers are unlikely to purchase an electric vehicle within the next five years from 2021. This is due to perceived barriers such as the price being too high (59%), a short battery life and/or short range (38%) and worries about having nowhere to charge their electric vehicle close to home (36%), *Ofgem, (2021)*.

8.2 What opportunities in vehicle digital space can the company take advantage of?

Digital initiatives that [REDACTED] [REDACTED] should consider to support future success include, digitally resolving customer pain points; creating lock-in opportunities; creating connected life; and choosing where to play.

Digitally resolving customer pain points may include reducing the time it takes customers to get to places and providing in-car connectivity better than competitors. A good digital business model will carefully consider other dynamics, as well, such as rolling out to the market scale-sensitive elements such as recommendations and reviews; exploiting data to match their users with content; and optimizing value-creation efforts and reach. It is recommended, that while do so, [REDACTED] should adhere to the regulations such as the Europe's General Data Protection Regulation (GDPR) to avoid severe financial penalties and tarnish of image.

Most successful digital business models create ecosystems to capture and lock in customers, orchestrate partners to support brand positioning, and align offers to address customer needs, at the same time featuring a variety of monetization options.

The customer journey, which formerly was a linear path with clear starting and ending points, is transformed in the digital ecosystem into a circle characterized by continuous involvement, going far beyond traditional parameters. [REDACTED] customer lock in include the [REDACTED] ProLive for the 'Always-On' relationship with its commercial customers generating tremendous revenue through continuous service subscription.

However, there is large scope for [REDACTED] [REDACTED] to tap into profitable opportunities like digital automotive insurance services. [REDACTED] can also lock in customers by integrating the best in class technology like Apple car play, whole Google automotive services, Alexa voice, and many more, to allow people to take their digital life into [REDACTED] vehicles.

Oliver Wynman, 2017 suggests, to reach and lock in customers, companies need to scale their digital business rapidly, which will require substantial investments. New markets with continuous shifts in competition, size, and customer segments will exhibit elevated levels of ambiguity. [REDACTED] needs to abandon volume planning due to the nature of market ambiguity as it tries to implement innovative projects, if the company is to excel in new fields.

It is recommended that [REDACTED] should choose carefully where to play. Unlike digital powerhouses such as Apple or Google, who can approach a market from a variety of entry points, [REDACTED] [REDACTED] has better chances of success in mobility-related digital business areas than in spaces more distantly related to the industry, such as home ecosystems. It also is recommended [REDACTED] [REDACTED] should develop successful digital models by making use of unique assets like their pre-existing customer relationships and trusted physical products that it already has in its portfolio.

As part of development of core strength in the innovation space, it is recommended to [REDACTED] senior leadership should be aware that success requires company-wide commitment. Even the best digital business model will fail to gain traction if the necessity of "taking the organization along" is underestimated.

There is need to develop new capabilities and agile work methods to implement digital strategy effectively. The traditional and standard corporate approach that imposes bureaucracy and is usually conducted top-down, will fall short of reaching digital targets quickly. **Oliver Wynman, 2017** suggests that agile development should always begin from the customer's perspective, not from a data or technology standpoint.

Chapter 9: Project Conclusion

9.1 Conclusion

According to research by *Oliver Wynman, (2015)*, around 40 percent of all innovation spending is predetermined by compulsory developments due to legislation and by necessary serial development. *Oliver Wynman, (2015)*, concludes that the fundamental R&D question for automotive companies is to choose the right technologies and to define the right targets for them in the right time frame. The research suggests the first step for R&D optimization is to evaluate the future market potential of all ongoing innovation projects, to define the threats they face from other technologies in the same area and to model price scenarios.

Consideration should also be given on supporting or enabling technologies that are required, and questions should be asked if those enabling technologies will remain available in future. Otherwise there is risk of supportability to innovation if enabling technologies disappear. Another key question to consider is which regional markets will be likely to embrace the technology

The author concludes that the world is a very different place and the automotive industry is at the heart of a converging crisis. Traditional automotive players like [REDACTED] are facing some very difficult challenges, which include pressure from the society to eliminate their carbon footprints, and stiff competition from new entrants into the auto industry (mainly Tesla), who have come in with disruptive innovation. Another great challenge is a question around what to do with data.

In the digital era, vehicles continue generate data about how they are used, where they are, and who is behind the wheel. The volume of data from vehicles is growing exponentially with greater proliferation of shared mobility, progress in powertrain electrification, car autonomy, and vehicle connectivity. There is a key question as how automakers can best turn this data into valuable services and products in the evolving automotive ecosystem. *McKinsey, 2016*, estimated that, by 2030 the global scale of car data will generate an overall revenue pool of USD 450 - 750 billion.

McKinsey, 2021, estimates that by 2030, about 95 percent of new vehicles sold globally will be connected, up from around 50 percent today. The concluding key question is on how [REDACTED] can maximise opportunity to be a key player data monetization. The company will have to create very competitive products and service that utilise the data mentioned above. Competition on data monetization does not only come from other automotive players, but from other industries as well.

The disruptive changes facing the automotive industry today, mainly the connected cars, autonomous driving, and the Internet of Things all demand a digital proficiency that few industry players currently possess. Adding to this challenge is the fact that most automakers still lack comprehensive digital strategies for addressing the “connected life” needs of their customers.

Capturing business opportunities in the digital space requires traditional automakers like [REDACTED] to fundamentally change their approach. It is worth noting that most automakers have already waded into new mobility services value pool, competing against asset-light start-ups and so-called unicorns (privately held start-ups valued at over \$1 billion) such as Uber.

Oliver Wynman, 2017, asserts that companies must develop ecosystems of partners, establish multi-speed capabilities, and completely rewire their product development processes. The conclusion is that those automakers who are slow to adapt will quickly find themselves outmatched by players who are willing to make the substantial investments needed to transform their businesses.

In conclusion, this is the time to put together a coherent digital strategy and make a digital switch in auto industry. According research carried out by **Oliver Wynman, 2017**, car companies can develop digital strategies rapidly from the digital business models that have emerged across different industries. There is a lot to learn regarding how to attract customers and serve them differently from digital business models such as Uber or Airbnb. A Google-like digital model, which uses data aggregation to monopolize the data required for a business is a powerful approach.

Concerning development of electric vehicles, some of the further automotive innovations that are already making an impact include electric vehicles with improved range, which outperform the internal combustion engine vehicles. Research and development in higher density batteries and super capacitors (**Appendix 4**) is still required for further breakthrough improvement in EV range. The **National Geographic, (2013)** comparison of batteries and super capacitors concludes that Super capacitors not only charge faster than batteries, they last longer when it comes to wear and tear from repeat cycles of charging and discharging.

However, super capacitors have a size disadvantage (too large) and cost disadvantage (too expensive) compared to batteries. The author concludes and **recommends** that [REDACTED] should invest in R&D that explores potential of both battery and super capacitor technology.

The author also concludes and **recommends** that [REDACTED] should R&D for quick and wireless charging. Such a breakthrough will be a game-changer as travellers will prefer that charges at the shortest possible time to allow them to proceed with their journey.

Concerning development of self-driving cars, the conclusion is that [REDACTED] is already making numerous advances in that innovation space, but more focus is still required. The author believes the manufacturer that will produce the most consistently reliable autonomous vehicle technology (fully autonomous driving systems) stands a chance to lead the vehicle market in future.

9.2 Contribution of this Study

The author has offered critique of the whole strategy, process and products, evaluated the successes, highlighted potential pitfalls and offered generic recommendations for [REDACTED] [REDACTED] to consider for further development.

The research has demonstrated a well-grounded innovation strategy, process and products by [REDACTED] [REDACTED] and made fair and unbiased comparison with other players in industry. The author concludes that it is clear that [REDACTED] [REDACTED] has been successful in accelerating customer-centred design solutions into its vehicles; there is still a lot of work to be done. The author concludes there are plenty of opportunities that are internal to [REDACTED] [REDACTED]. There is need to spread the innovation culture across the organisation in order to accelerate innovation projects.

The following example supports the author's critique. In 2017, [REDACTED] hired a leading brand expert Musa Tariq as vice president and chief brand officer, responsible for further building and differentiating the company's iconic [REDACTED] brand globally. Tariq was former Apple's Global Marketing and Communication director for Retail and had trail blazing record in digital marketing and social media for premium brands Nike and Burberry. Tariq left [REDACTED] [REDACTED] in less than 2 years with a sentiment "I realized the culture wasn't for me", (*Automotive News, 2018*).

Externally, [REDACTED] [REDACTED] needs to improve its innovation visibility against the likes of Tesla, Volvo, BMW and Nissan and other new entrants like Nio, Xpeng, and Li Auto in the Far East.

The author recommends [REDACTED] [REDACTED] should innovate to provide an experience rather than a product. It should make people's lives better in mature economies and major cities as well as helping solve problems in areas of the world that tend to be under-served by technology advances.

[REDACTED] should re-imagine what mobility will look like and foresee clean, smart vehicles communicating with each other, as well as the road infrastructure and public transit systems, orchestrated by open cloud-based platforms. This will keep [REDACTED] as a world's most trusted company.

REFERENCES

- Albright et al., 2015**, J. Albright, A. Bell, J. Schneider, ■■■ Nyce, *Automobile insurance in the era of autonomous vehicles*, KPMG (2015), <https://home.kpmg/cn/en/home/insights/2015/06/automobile-insurance-in-the-era-of-autonomous-vehicles-o-201506.html>
- Automotive News (2018)**: Execs lured from Silicon Valley now leaving ■■■ Automotive News, 26 March 2018, <https://www.autonews.com/article/20180326/OEM02/180329814/execs-lured-from-silicon-valley-now-leaving-■■■>
- Baumers, Martin, (2012)** “Economic Aspects of Additive Manufacturing: Benefits, Costs, and Energy Consumption.” 2012. Doctoral Thesis. Loughborough University.
- BBC (2019)**: Volkswagen: UK drivers fight for 'dieselgate' compensation, 2 December 2019, <https://www.bbc.co.uk/news/business-50631823>
- Belk, R. (2007)**, *Why not share rather than own?*, Ann. Am. Acad. Pol. Soc. Sci., 611 (2007), pp. 126-140
- Belk, R. (2014)**, *You are what you can access: sharing and collaborative consumption online*, J. Bus. Res., 67 (2014), pp. 1595-1600
- Blincoe L.J., Miller T.R., Zaloshnja E., et al. (2010)**: The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised), National Highway Traffic Safety Administration, Washington, DC2015 (Publication No. DOT HS 812 013. Available at <http://www-nrd.nhtsa.dot.gov/Pubs/812013.pdf>
- Blunck, E., Werthmann, H., (2017)**, Industry 4.0, Dubrovnik International Economic Meeting 3.
- Bratton, J. and Gold, J. (1999)**, *Human Resource Management: Theory and Practice*, 2nd Edition, London: Erlbaum
- Breetz H. L. and Salon D., 2018**: Do electric vehicles need subsidies? Ownership costs for conventional, hybrid, and electric vehicles in 14 US cities Energy Policy 120 238–49
- Cadle et al (2010)**: Cadle, J., Paul, D., and Turner, P. (2010), BUSINESS ANALYSIS TECHNIQUES 72 Essential Tools for Success, British Informatics Society Limited (BISL), Chapter 1, pp. 1-8
- Clements, L.M., Kockelman, K.M. (2017)**, *Economic effects of automated vehicles*, Transportation Research Record, 2606 (1) (2017), pp. 106-114, 10.3141/2606-14
- Coffman M., Bernstein P., Wee S., 2016**: Electric vehicles revisited: a review of factors that affect adoption Transp. Rev. 37 79–93
- Consumer Reports (2021)**, The Most Satisfying Cars on the Market, Insights for shoppers to find the perfect car, February 2021, <https://www.consumerreports.org/car-reliability-owner-satisfaction/most-satisfying-cars-on-the-market-car-owner-satisfaction-a8149304159/>

Corwin et al., 2015, S. Corwin, J. Vitale, E. Kelly, E. Cathles, *The Future of Mobility: How transportation technology and social trends are creating a new business ecosystem*, Deloitte LLP (2015), <https://www2.deloitte.com/cn/en/pages/manufacturing/articles/the-future-of-mobility.html>

Denzin, N.K., (1989): *The Research Act: A Theoretical Introduction to Sociological Methods*, 3rd Edition, Englewood Cliffs, NJ: Prentice Hall

Dewar, R. & Dutton, J. (1986), The Adoption of Radical and Incremental Innovations: An Empirical Analysis. *Management Science*. 32(11): 1422-1433.

Dickson, P.R. (1992), 'Towards a general theory of competitive rationality', *Journal of Marketing*, 56, January, 69-83

Dolan, Matthew, (2009): "To Outfox the Chicken Tax, [REDACTED] Strips Its Own Vans", *Wall Street Journal*, (September 23, 2009)

Dosi, G. (1982), Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change, *Research Policy*, 11(3): 147-162. *Management Science*. 32(11): 1422-1433

Eckert, V. H. (2019): Why your customers should be central to your innovation efforts, *Strategy + Business Journal*, Issue 97/ Winter 2019, <https://www.strategy-business.com/blog/Why-your-customers-should-be-central-to-your-innovation-efforts?gko=9eb19>

Eckhardt, G.M.; Bardhi F. (2012), *Access-based consumption: the case of car sharing*, *J. Consum. Res.*, 39 (2012), pp. 881-898

emag (2021), Who are the Three Main Chinese Electric Car Companies?, September 2021, <https://emag.directindustry.com/who-are-the-three-main-chinese-electric-car-companies/>

Fagnant, D.J.; Kockelman, K.(2015), *Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations*, *Transp. Res. Part A*, 77 (2015), p. 15

Financial Times, (2021), Tesla soars past \$1tn in market value, First carmaker to reach milestone after major order from Hertz for electric vehicles, <https://www.ft.com/content/4eb7504e-94ef-4f99-937d-807aa159b282>

Habeck et al., 2014, A. Habeck, J. Newman, M. Bertoncello, M. Kasser, F. Weig, M. Hehensteiger, Z. Yan, *Connected car, automotive value chain unbound*, McKinsey & Company (2014), pp. 1-50

Hannan, M.T., Freeman, J.(1984): Structural Inertia and Organizational Change, *American Sociological Review*, Vol. 49, No. 2 (Apr., 1984), pp. 149-164 (16 pages), Published By: American Sociological Association

Henderson, R.M., Clark, K.B. (1990): Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms, *Administrative Science Quarterly*

Hess S., Fowler M., Adler T., Bahreinian A., 2012: A joint model for vehicle type and fuel type choice: evidence from a cross-nested logit study *Transportation* 39 593–625

Hussain et al., 2018, R. Hussain, J. Lee, S. Zeadally, *Autonomous cars: Social and economic implications*, *IT Professional*, 20 (6) (2018), pp. 70-77, 10.1109/MITP.2018.2876922

InnovateXL, 2019: ISO56002:2019 Innovation Management System, The InnovateXL Innovation Management System, www.innovatexl.co.uk

J.D. Power, (2021) *¹, Pandemic Challenges: Auto Dealer Service Departments Make Best of Tough Situation, J.D. Power Finds, March 2021, <https://www.jdpower.com/business/press-releases/2021-customer-service-index-csi-study>

J.D. Power, (2021) *², Majority of Electric Vehicle Owners Are Intent on Purchasing Another One in the Future, J.D. Power Finds, January 2021, <https://www.jdpower.com/business/press-releases/2021-us-electric-vehicle-experience-evx-ownership-study>

J.D. Power, (2021) *³, Battleground for Electric Vehicle Purchase Consideration is Wide Open, J.D. Power Finds, February 2021, <https://www.jdpower.com/business/press-releases/2021-us-electric-vehicle-consideration-evc-study>

Jenn A., Azevedo I. L., Ferreira P., 2013: The impact of federal incentives on the adoption of hybrid electric vehicles in the United States Energy Econ. 40 936–42

Kaiser, ■ Stocker, A., Viscusi, G., Fellmann, M., Richter, A., 2021, *Conceptualising value creation in data-driven services: The case of vehicle data*, International Journal of Information Management, Volume 59, 2021, 102335, ISSN 0268-4012, <https://doi.org/10.1016/j.ijinfomgt.2021.102335>, (<https://www.sciencedirect.com/science/article/pii/S0268401221000281>)

Kothari, R. ■ 2009: *Research Methodology: Methods And Techniques*, New Age International Pvt Ltd Publishers, 2nd Edition, Chapter 1, pp.1-6

Krueger, R.; Rashidi, T.; Rose J.M. (2016), *Preferences for shared autonomous vehicles*, Transp. Res. C Emerg. Technol., 69 (2016), p. 13

Laurent, 2017, *Accelerating the future: The economic impact of the emerging passenger economy*, Strategy Analytics, 5 (2017)

Langbroek J. H., Franklin J. P., Susilo Y. O., 2016: The effect of policy incentives on electric vehicle adoption Energy Policy 94 94–103

Lasi, H., Fettke, P., Kemper, H.G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. Business & Information Systems Engineering, 6(4), 239. <http://dx.doi.org/10.1007/s12599-014-0334-4>

Lewin, K. (1958), “Group decision and social change,” in Readings in Social Psychology, eds. E. E. Maccoby, T. M. Newcomb, and E. L. Hartley, Holt, Rinehart and Winston, New York, pp. 197–211.

Lieder, M. & Rashid, A., 2015. Towards Circular Economy Implementation: A Comprehensive Review in Context of Manufacturing Industry. Journal of Cleaner Production, 115, pp.36–51.

Logie, J., 2020: Betamax vs VHS: The Story of the First Format War, How failure to listen to the market led to the demise of Betamax, <https://medium.com/swlh/vhs-vs-beta-the-story-of-the-original-format-war-a5fd84668748>

Lopes de Sousa Jabbour, A.B.; Jabbour, ■ J. ■ Godinho Filho, M.; Roubaud, D., 2018. Industry 4.0 and the circular economy, Ann Oper Res 54 (2018) 2787.

Lucci, J., & Stolz, L, (2010): *Product-related costs – the management perspective: Costs under Control?*, Automotive Manager I/2010, Oliver Wyman Consulting GmbH, www.oliverwyman.com

Maital S., Seshadri, D.V.R., 2012: Innovation Management: Strategies, Concepts and Tools for Growth and Profit, Chapter 10, SAGE Publications India, 11 Sept 2012, ISBN 8132110757, 9788132110750

McKinsey, 2016, Monetizing car data, New service business opportunities to create new customer benefits, September 2016, <https://www.mckinsey.com/~media/mckinsey/industries/automotive%20and%20assembly/our%20insights/monetizing%20car%20data/monetizing-car-data.ashx#:~:text=The%20overall%20revenue%20pool%20from,450%20%2D%20750%20billion%20by%20030.>

McKinsey, 2021, Unlocking the full life-cycle value from connected-car data, February 2021, <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/unlocking-the-full-life-cycle-value-from-connected-car-data>

Mersky A., Sprei F., Samaras Qian Z S., 2016: Effectiveness of incentives on electric vehicle adoption in Norway Transp. Res. D 46 56–68

Moktadir, M.A.; Rahman, T.; Rahman, M.H.; Ali, S.M.; Paul, S.K., 2018. Drivers to sustainable manufacturing practices and circular economy, Journal of Cleaner Production 174 (2018) 1366–1380

National Geographic, (2013), Supercapacitors Amp Up as an Alternative to Batteries, Aug 2013 <https://www.nationalgeographic.com/science/article/130821-supercapacitors>

Ofgem, (2021), One in four consumers plan to buy an electric car in next five years according to Ofgem research, May, 2021, <https://www.ofgem.gov.uk/publications/one-four-consumers-plan-buy-electric-car-next-five-years-according-ofgem-research>

Oliver Wynman, (2015), A comprehensive study on innovation in the automotive industry, Car Innovation 2015, http://www.emic-bg.org/files/CarInnovation2015_engl.pdf

Oliver Wynman, (2017), Digital Business Models for Automakers, Driving Digital Business Models in Automotive 2017, [https://www.oliverwynman.com/content/dam/oliver-wyman/v2/publications/2017/sep/20170921 Oliver Wyman Digital OEM Business Models Web final.pdf](https://www.oliverwynman.com/content/dam/oliver-wyman/v2/publications/2017/sep/20170921%20Oliver%20Wyman%20Digital%20OEM%20Business%20Models%20Web%20final.pdf)

Posada, J., Toro, Barandiaran, I., Oyarzun, D., Stricker, D., De Amicis, R. et al. (2015). Visual computing as a key enabling technology for industrie 4.0 and industrial internet. Computer Graphics and Applications, IEEE, 35(2), 26-40. <http://dx.doi.org/10.1109/MCG.2015.45>

Proctor, T (1996): Marketing Management: Integrating Theory and Practice, London: International Thomson Business Press.

Pütz et al., 2019: F. Pütz, F. Murphy, M. Mullins, L. O'Malley, Connected automated vehicles and insurance: Analysing future market-structure from a business ecosystem perspective, Technology in Society, 59 (2019), Article 101182

Raposo, M.A. (2021), *Economic implications of a connected and automated mobility in Europe*, Research in Transportation Economics, <https://doi.org/10.1016/j.retrec.2021.101072>

Rezvani Z, Jansson J., Bodin J., 2015: Advances in consumer electric vehicle adoption research: a review and research agenda Transp. Res. D 34 122–36

- Roger L. Martin, 2009:** The Design of Business, Harvard Business Press, ISBN 978-1422177808.
- Rogers, E. and Shoemaker, R. (1972):** Communications of Innovations, Free Press, New York
- Rogers, Everett M. (1962).** Diffusion of innovations (1st ed.). New York: Free Press of Glencoe. OCLC 254636.
- Rogers, Everett M. (1983).** Diffusion of innovations (3rd ed.). New York: Free Press of Glencoe. ISBN 9780029266502.
- Satell, G. (2017):** Mapping Innovation, a playbook for navigating disruptive age, Chapter 3, McGraw-Hill, New
- Saunders, M., Lewis, P., and Thornhill, A., (2007):** *Research Methods for Business Students*, 4th Edition, Financial Times/Prentice Hall, Harlow
- Stoneman, Paul, (2002):** The Economics of Technological Diffusion, [REDACTED] Blackwell
- Taylor et. al., 2006: Taylor, B.J.; Kermode, S.; Roberts, K.L.,** *Research in Nursing and Health Care: Evidence for Practice*, 3rd Edition, Cengage Learning Australia, Chapter 8, pp.235
- The New York Times (2021),** Chinese regulators reprimand Tesla over growing complaints about its cars, February 2021, <https://www.nytimes.com/2021/02/08/business/tesla-quality-china.html>
- The OECD's Oslo Manual (2018):** OECD Better Policies for Better Lives, www.oecd.org/site/innovationstrategy/defininginnovation.htm
- Tidd, J and Bessant, J, 2018:** Managing Innovation: Integrating Technological, Market and Organizational Change, Sixth Edition. New York: Wiley
- Tidd, Joe & Bessant, John. (2014).** Strategic Innovation Management.
- Tien, J.M., 2017,** *The Sputnik of servgoods: Autonomous vehicles*, Journal of Systems Science and Systems Engineering, 26 (2) (2017), pp. 133-162, 10.1007/s11518-016-5325-1
- Trott, P. (2017):** Innovation Management and New Product Development, Chapter 3, 6th edition, Pearson, England
- Tushman, M.L., Anderson, P. (1986),**Technological Discontinuities and Organizational Environments. Administrative Science Quarterly, 31(3): 439-465.
- Valdez, A. [REDACTED] Brauner, P., Schaar, A. K., Holzinger, A., & Zieflea, M. (2015).** Reducing Complexity with simplicity-Usability Methods for Industry 4.0. Proceedings 19th Triennial Congress of the IEA. Melbourne, Australia, RWTH Publications, Germany. 9-14.
- Vol. 35, No. 1, Special Issue:** Technology, Organizations, and Innovation (March, 1990), pp. 9-30 (22 pages), Published By: Sage Publications, Inc.
- Winter, Sidney G. and Nelson, Richard R. (1982):** An Evolutionary Theory of Economic Change, University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship, Available at SSRN: <https://ssrn.com/abstract=1496211>

APPENDIX

Appendix 1: Research Time Chart for Company Based Research to Fulfil an MSC IIM Dissertation

	Time Chart For Company Based Research to Fulfil the MSC Dissertation	START Timing	Status
	Initial engagement with the company	Early Feb 2021	Done
	Research topic	Early Feb 2021	Done
	Research hypotheses	Mid Feb 2021	Done
	Scoping the research project	Mid Feb 2021	Done
Literature Review	Reviewing academic literature	Early March 2021	Done
	In-depth understanding of company business	Mid-March 2021	Done
Data Collection	Collection of primary data and information	Late March 2021	Done
	Collection of secondary data and information	Early April 2021	Done
Evaluation	Analyzing the data	Late April 2021	Done
	Interpreting the data	Early May 2021	Done
	Reviewing industry norm	Late May 2021	Done
	Recommending innovation options	Mid-June 2021	Done
Write up	Documenting work done into a dissertation	Mid-June 2021	Done
Submission	MSC dissertation submission	Early Jan 2022	Done

Appendix 2: Summary of previous studies quantifying the economic potential of CAVs

Reference	Estimated economic impact (in billion)	Description	Region	Timeframe
Clements and Kockelman (2017)	\$936	Economy-wide effects, including savings from reduced collisions and increased productivity	US	No timeframe - when CAVs become pervasive or hold a large share of the automotive market
	\$418	Industry-specific effects from thirteen sectors: automotive, technology, freight movement, personal transport, auto repair, medical care, insurance, law, infrastructure, land development, digital media, police, and oil and gas	US	
Alonso et al. (2020)	€434	Industry-specific effects from ten sectors: equipment, goods transport, no-life insurance, professionals concerned, technological, health, passenger transport, energy, repair and maintenance, automotive	Spain	When CAVs represent 20% of market share
	€415			When CAVs represent 50% of market share
	€433			When CAVs represent 100% of market share
Asselin-Miller et al. (2017)	\$273	Market potential between 2020 and 2030, including connectivity, autonomous hardware components, new software and autonomous driving chips	Global	2020–2030
Weindelt (2016)	\$670	Value at stake between 2016 and 2025 from the connected traveller, autonomous vehicles and the enterprise/ecosystem	Global	2016–2025
	\$3100	Societal benefits such as reduced costs of vehicle ownership, lower premiums, reduced crash costs, reduced maintenance costs, fuel savings and lower carbon emissions	Global	2016–2025
Leech et al. (2015)	£51	Annual economic and social benefits	UK	2030
Römer et al.	\$282	Annual market for new car revenues, hardware upgrades, apps and other	Global	2030

Reference	Estimated economic impact (in billion)	Description	Region	Timeframe
(2016)		digital features		
	\$558	Annual market for new car revenues, hardware upgrades, apps and other digital features	Global	2035
	\$1300	Total savings from accidents avoided, fuel savings and increased productivity	US	No timeframe
Catapult (2017)	£28	Annual market for road vehicles with CAV technologies	UK	2035
	£907	Annual market for road vehicles with CAV technologies	Global	2035
	£2.7	Annual market for CAV technologies	UK	2035
	£63	Annual market for CAV technologies	Global	2035
Leech et al. (2015)	£121	Annual economic and social benefits	UK	2040
Lancot (2017)	\$7000	Global Passenger Economy Service Revenues	Global	2050
	\$1700	Global Passenger Economy Service Revenues	Europe	2050
Securing America's Future Energy (2018)	\$800	Annual consumer and societal benefits	US	2050

Source: Own elaborations

ISO56002:2019 Innovation Management System

An **Innovation Management System (IMS)** is a collection of formalised business processes which underpin the delivery of sustainable innovation within the business. The IMS is expressed in the form of an innovation strategy - goals, policies and processes, together with the cultural environment and the resources required to promote and maintain sustainable innovation.

ISO56002:2019 Innovation Management System guidance, launched in July 2019 outlines the 7 key principles that an Innovation Management System should adhere to.

Leadership

- Senior leadership demonstrate a commitment to innovation.
- Leadership team fosters a culture supportive of innovation.

Planning

- A Strategic Plan for innovation is in place.

Operations & Delivery

- Structured operational processes are in place that are aligned to the innovation objectives.
- Mechanisms are in place to manage risks.

Support & Resources

- The organisation provides resources to support innovation.
- Staff are trained and have access to platforms, infrastructure and budget to fund innovation activities.

Performance Evaluation

- The organisation has defined Key Performance Indicators (KPIs) to measure Innovation.
- Innovation Performance is regularly assessed using the KPIs.

Improvement

- The organisation actively looks to improve its innovation effectiveness.

Organisational Context & Culture

- The organisational culture supports innovation and encourages openness and collaboration.
- The Innovation Strategy is fully aligned to the organisation's corporate vision and objectives.



Source: **InnovateXL, 2019: ISO56002:2019 Innovation Management System, The InnovateXL Innovation Management System, www.innovatexl.co.uk**

Appendix 4: Super capacitors array

Super capacitors like the ones shown on below can boost or replace batteries in vehicles, storing energy as an electrical charge



Source: Argonne National Laboratory