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Assignment Title: Innovation and Technology Report
Project Choice: Project 1 (Light Vehicle Greenhouse Gas Emission)
Due Date: October 4th, 2020
Word Count: 2848

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1. Introduction:

Metallic Micro-Lattice is one of the world's lightest metal that was invented by Boeing on October 6th, 2015. This piece of technology provides huge benefits to revolutionize automotive engineering or aero engineering (Rashed et.al. 2016). It is introduced that the material has a density of 0.9 kg/m^3, where the material is deduced to be 100 times lighter than Styrofoam and 99.99% hollow (WESTFIELD 2020). The material is internally formed by an ultra-light metal foam that is contained in a synthetic porous metal material. Furthermore, a very innovative and smart geometrical orientation utilized on the mechanical properties of the metal enhances the stiffness of the material, ratio of its strength over weight and its capability to absorb energy. Hence, the metal is elastic and durable when being impacted by a very high force.

This piece of technology would be very beneficial for light vehicle greenhouse gas emission project. Since, this would reduce the weight of cars/vehicles internally (e.g. battery, frame, etc.) and externally (e.g. vehicle main body, etc.). It is a simple physics that by reducing weight of vehicles, this would reduce the overall CO_2 emission, fuel efficiency is increased, while drag on vehicle is reduced. The lighter a vehicle can get, the less energy consumed or fuel burned to accelerate or climb uphill. Provided, that by reducing a car weight of 100Kg able reduce CO_2 emission approximately by $7.6g/Km^2$ (European Federation for Transport and Environment 2004). Furthermore, with the material's capability to absorb energy, durability, and elasticity toward high impact, it would enhance safety benefits for the vehicle despite its lightweight body. The benefit outcome expected from the material is to enhance the capability of petrol-fuelled vehicle to be more eco friendlier, judging by the fact that the number of petrol usage is superior to electric vehicle (EV).

2. Business Cases & Risks

2.1 Heilmeir Catechism Approach

1. *What are you trying to do? Articulate your objectives using absolutely no jargon. What is the problem? Why is it hard?*

Reduce light vehicle greenhouse gas emission by vehicles weight reduction via metallic micro-lattice as the main foundation for the vehicle's material. This will create opportunities to gain economic benefits for Australia by reducing fuel cost as vehicle becoming more fuel efficient.

The problem why this project is essential is due to the fact that Australia has recently experience server bush fire in the beginning of 2020 due to the progress of global warming. Furthermore, Australia is dependent on imported fuel, hence high fuel cost. Followed by 40%-60% premature death from vehicle pollution that leads to asthma (Whitehead 2019).

It is hard to reduce greenhouse emission because personal vehicle footing is increasing by the increase of population and jobs in Australia, where public transport alone won't be sufficient to reduce number of used of private vehicles.

2. *How is it done today, and what are the limits of current practice?*

Electric vehicle (EV) is utilized to minimize the main aforementioned problem. However, limited station to recharge the vehicle, limited amount of distance travel, and followed time-consuming charge time would be the limitation of the current practice. Thus, it leads number of populations to access petrol-fuelled vehicle. Hence, petrol-fuelled vehicle dominates car market in 20th century due to its ease of access and time for fuel, and long distance travel (ESAA 2020).

3. *What's new in your approach hand why do you think it will be successful?*

The approach is to reduce its fuel consumption by reducing weight, where it leads to minimum amount of emissions from petrol-fuelled vehicle. On the other hand, the approach allows for a light weight vehicle to acquire an enhanced level of safety due to its ability and flexibility to absorb energy caused by vibrations, shock, and static/dynamic impact.

It is believed to be successful as the ability of the material has been tested and trusted to be world's lightest metal and able to be manufactured additively (cost efficient). By continuous research and development done on the material, this will enhance or bring out more of the material's undiscovered capabilities to enhances automotive technology which will be very beneficial in long term.

4. *Who cares? Should mention key stakeholders.*

External stakeholders:

1. Government
2. Environmentalist
3. Foreign Fuel Company
4. Pedestrian
5. Indigenous community (Cultural benefits)
6. Australian vehicle manufacturer or automaker company

Internal stakeholders:

1. Engineers
2. Marketing department
3. Finance department
4. Project partners (Boeing)

5. *If you're successful, what difference will it make? What impact will success have? How will it be measured? What is the risk of doing nothing?*

If the project is to be successful in the upcoming future, this would enable Australia to gain economic opportunities/benefits through minimum fuel and power consumption (reduced emission), and reduce Australia's dependence on imported fuel (less fuel cost). On the other hand, it enables Australia to stay competitive with US and European in tackling greenhouse gas reduction and meet Paris Agreement Obligations in 2030. Where the difference of this proposed technology is to enhance the ease of utilizing petrol-fuelled vehicle due to its minimal impact to the environment.

Furthermore, the proposed technology's level of success will be measured by the increase of fuel or power efficiency, and by how many percent of emission has been reduced per year.

While, the risk of doing nothing will result in the increase of global warming progress rate as people getting busier and increase the usage of personal vehicle where it increases footing and CO_2 emission.

6. *What are the risks and the payoffs?*

Risks:
The potential risks diagnosed from the proposed technology/project are the lack of attention, high industry competition, time constraint, and potential progress delay due to COVID-19.

Payoffs:
However, the payoffs of the project would have resulted in a greener petrol-fuelled vehicle with integrated energy efficiency, safety, and agility. Where, it provides opportunities for the country's economic advantage in long-term, and stay competitive globally, by becoming a stand out and strong contender in the industry.

7. *How much will it cost?*

Estimated total Project Cost ~ $5.3 - 6.2 million

8. *How long will it take?*

Approximated 4 or 5 years till product launch

9. *What are the midterm and final "exams" to check for success? How will progress be measured?*

Initially, the concept of micro-lattice vehicle will perform as a milestone to proof that this can be applied as the internal and external structure/component for a vehicle, and able to enhances vehicle's fuel efficiency and reduces emission by the existing data of the material's capability.

Finally, metallic micro-lattice vehicle will demonstrate its abilities in term of fuel efficiency, safety, durability, and reliability to reduces CO_2 emission.

The progress will be measure of how well the technology being utilize in general public and how many percent of emission reduced by the petrol metallic micro-lattice vehicle per year.

2.2 Business Canvas Approach

<table>
<tr>
<td rowspan="2">Who will help you?
Key Partners

Boeing

Australian Government

Australian automaker company

Media</td>
<td>How do you do it?
Key Activities

R&D to convince and acquire approval for foundation for the approach proposal

Partnership contract

Modelling and testing and expected to provide product's prototype

Reduce petrol-fuelled vehicle (reduce weight of engine, body, and frames.)

Finalize prototype and develop final product.

Vehicle manufacturing and sales</td>
<td rowspan="2">What do you do?
Value proposition

Reduce Drag on Vehicle

Increase fuel efficiency, and thus less CO_2 emission

Enhances vehicle's agility and capabilities to absorb energy that improve vehicle's level of safety, despite being the lightest metal in the world.

Revolutionary material that provide opportunities for competitive advantages

Proposing to utilize a material that is strong as airplane while acquiring the lowest density among all metal.

Long term fuel cost reduction to provide opportunities for Australian economic benefits

Opportunity to minimize Australian CO_2emissions.</td>
<td>How do you interact?
Customer Relationship

Communicate development of technology to keep external stakeholders updated

Communicate the benefits of the technology

Website that allows costumer to interact with the organization

Customer service, self-service, & automated service

Prototype demonstration</td>
<td rowspan="2">Why do you help?
Customer Segment

Mass vehicle market

Citizen (Workers)

Government</td>
</tr>
<tr>
<td>What do you need?
Key Resources

Manpower (e.g. Engineer mechanical, material, etc.)

Metallic Micro-Lattice

Financial support (fund)

Partnership

Modelling and testing equipment</td>
<td>How do you reach them?
Distribution Channel

Automaker company

Social Media

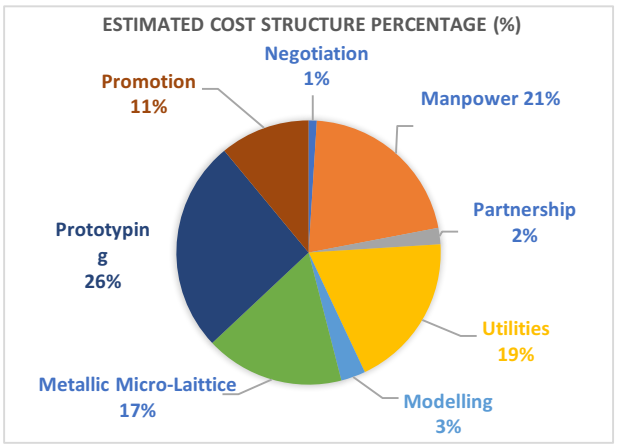
Word of mouth

Online purchases (Official organization's website)

Delivery (for COVID19 safety procedure)

Product Insurance

Product costumer review system</td>
</tr>
<tr>
<td colspan="3">What will it cost?
Cost Structure

Estimated total project cost ~ $5.3 - 6.2 million</td>
<td colspan="2">How much will you make?

Revenue Stream

Savings per year ~ $2500

Fuel savings per year ~ $830

Saving from life of vehicle per vehicle ~ $8500

Vehicle usage per person ~ $40, 000</td>
</tr>
</table>

Table 1. Metallic Micro-Lattice Business Canvas 2020

3. Long-term Innovation and Technology Management:

3.1 Setting Horizons

The desired goal is to develop and provide an innovative technology that enhances Australian petrol-fuelled vehicle's capability to reduce greenhouse gas emission. Hence, slowing down the progress of global warming. Furthermore, to create diversification on Australian's approach to reduce gas emission by new material technology, new skills, knowledge, innovative development, culture, and agility. In the end, the goal is to enhance petrol-fuelled vehicle to be environmental friendlier, stronger, lighter, and more safety. Thus, it enables drivers to utilize petrol-fuelled vehicle without worrying how it will negatively impact the environment, and ensuring safety.

3.2 Industry Forecasting

Below is the industry's road map of what should be done and achieved in the future through the development of metallic micro-lattice vehicle.

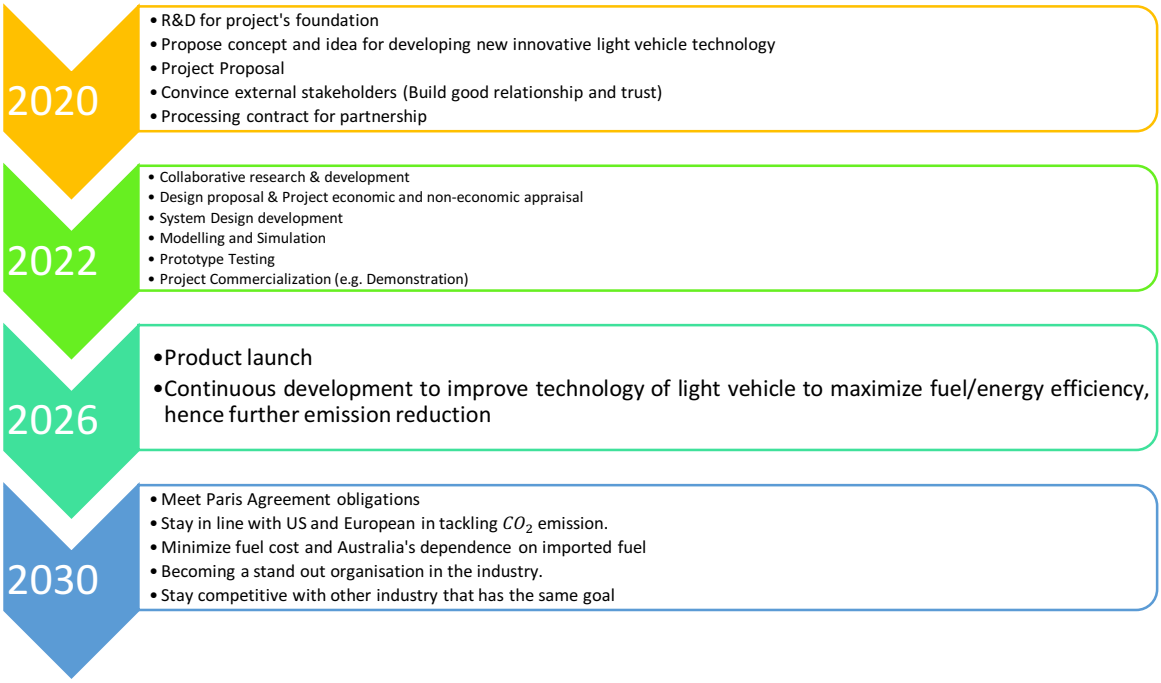


Figure 1. Industry road mapping 2020

3.3 Technology Positioning

Strength:	**Weakness:**
- As strong as airplane - Lightest metal in the world - Excellent ability for energy absorption (Vibration, Acoustic, shock, static and dynamic loading) - Durable and elastic metal material. - Spread impact loading and reduce peak of stress (Ozdemir et.al. 2015) - 100 times lighter than Styrofoam - Revolutionary material - Invented by Boeing (Trusted) - Mechanical material properties and structure that can be manufactured - Flexibility to adapt and react to various environment and unpredicted loading (Yang et.al. 2018) - High performance as thermal insulator which is highly advantageous for main engine of vehicles (Ozdemir et.al. 2015) - Additive manufacturing is the preferred material production process, and hence more cost efficiency due to less wastage (Rashed et.al. 2016) - High Macroscopic yield strength (Tancogne-Dejean et.al. 2016)	- Haven't been applied on vehicle. - Hasn't been mass produced (Limited). - Mechanical Properties and quality of material are highly dependent on manufacturing process (Rashed et.al. 2016).
Opportunities:	**Threats:**
- Develop an innovative car model while reducing CO_2 emission - Fuel efficiency (Less drag and fuel burned or electricity consumed to accelerate) - Light vehicle (reduce car weight by battery, body and frame material) - Enhances level of safety - Competitive advantages in the market - Collaboration with Boeing that will enhances competitive advantage (Commercial advantage) - Opportunities to build good relationship and trust with Boeing for further collaboration on future engineering projects. - Avoid premature deaths caused by excessive vehicle CO_2 emission (Whitehead 2019) - Opportunity for Australia's economic benefits via fuel savings. - Preventing/slowing the progress of global warming - Sandwich structure applied on the material will enhances its mechanism efficiency to dissipate impact from blast impact (Cui et.al 2012)	- Time for partnership agreement - Time consuming on testing and prototyping. - High cost on testing and prototyping - Time delay due to COVID-19 - Re-design product if and only if the prototype is a huge failure

Table 2. Metallic Micro-Lattice SWOT Analysis

According to the SWOT analysis, in short term, the reward and risk for metallic micro-lattice to be applied on vehicle will be placed in Q1 since level of risk can be quite high as the approach to utilize this metal as the foundation for petrol-fuelled vehicle is quite radical. Whilst, the reward is expected to be high in term of due to fuel saving, competitive advantage, and the reduction of CO_2 emission. Provided, that by performing continuous development of the material will provide opportunities to build new knowledge for further improvement that enhances the material's ability and flexibility to improve petrol-fuelled vehicle technology. Thus, the ability of the material will be more advance by the progress of time. Therefore, in long term, the technology proposed will reach Q2 where level of risk is minimised, while level of reward is maximised.

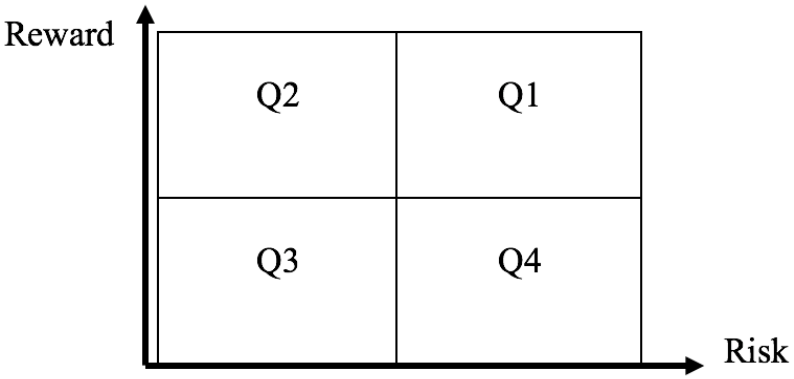


Figure 2. Risk and Reward Diagram (Bateman 2020).

3.4 Technology Availability

The source of material is able to be externally sourced from Boeing (licensed or bought). However, it will be a wise decision to joint venture or build partnership with Boeing to develop metallic micro-lattice vehicle. The readiness level of the technology (Figure 3) is to be at TRL 7 as the material has already pass through tests and demonstrations which makes the metallic micro-lattice ready for its application as main material for vehicle. Hence, opportunities to build prototype to attract attentions and supports from external stakeholders through updated information of progress, demonstration and commercialization.

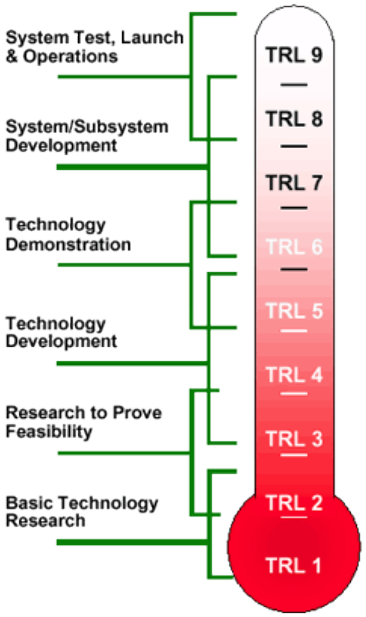


Figure 3. Technology Readiness Level (Straub 2015)

3.5 Appropriating Technology

The knowledge of how this technology is structured and capabilities provided by the material have been publicised. Where the best method to integrate this technology into the business is to conduct continuous simulation and modelling. By building partnership with Boeing, this will enhance the strength of R&D department for both parties via extended man power (e.g. engineers, and researchers) and knowledge to develop the technology. Finally, it allows for the technology's enhancement and its readiness for application and mass produced.

Furthermore, it is essential to develop a metallic micro-lattice vehicle prototype that will be tested in term of the overall engineering systems, designs and how well it performed in the market (via demonstration & commercialization). The process must be done prior to further development of the vehicle, as it gives the organization insight of the technology's strength and weakness from stakeholder's point of view. Therefore, it will provide support and confidence to the organization for further development and develop final products. On the other hand, the advantage of prototype demonstration is to prove the concept and progress of the technology to the stakeholders. With this method, the opportunities to gain support fund from external stakeholders (e.g. government) that interested in the technology is possible.

3.6 Managing Technology

Firstly, to maximize the value of this technology overtime, this can be done by integrating designs and systems of metallic micro-lattice vehicle. Through the partnership, continuous development with more manpower increase rate of the material's abilities development. Furthermore, by practicing its application on land vehicle, this will provide feedbacks and data of what can be improved from the material. Hence, refining the quality and reliability of metallic micro-lattice on its application in any kind of vehicle.

Secondly, building partnership with Boeing will also give them benefits by building the organisation's confidence to develop metallic micro-lattice air vehicle by integrating data gathered from the development of land metallic micro-lattice vehicle. This is considerable, in the sense that the risk for air vehicle is higher than land vehicle. Thus, helping hands in developing the technology from each party will build satisfactory relationship, trust and growth. On the other hand, this will enhance the readiness level of the material to gain profit, supported by integrated data on its capabilities that has been proven and improved through its application on land vehicle.

Finally, communicating the development of the integrated vehicle will keep stakeholders updated and encourage their interest and support towards the technology. This would ensure the technology to be a success in the market and interest Australian government.

4. Intellectual Property (IP) Management

Intellectual property (IP) defined an invention, artwork, music, design, symbols, names, or ideas that resulted from the mind/creativity of the creator. For creators, this is an intangible asset, and they have right to protect their creation from unauthorised sale/use (Sharma 2014). At this point, intellectual property rights (IPR) would be granted to the creator, which legalize and protect creation and its owner. IPR can be informed of patents, copyrights, trademarks, and etc. Thus, an IP can be sold, bought, licensed or exchanged which resulted in multiple benefits for the owner and other IPR holder. Hence, providing financial benefits for the owners/creators

and improve revenue streams. On the other hand, exchange/barter expand network of an owner as an organisation/a person able to access other's protected IP that being exchanged with. Finally, improving the opportunities for the IP holder (owner/creator) for external engagement with world class productive collaborators that may improve his/her career or an organisation's reputation (Prabaharan 2020).

In this case, the intellectual properties that will be suitable for this proposed technology would be processes, data, design, models, trade secret and of course patent. In order to legally market metallic micro-lattice vehicle, as the main material is originally invented by Boeing. This is an integral notion that needs to be considered to protect the information of how Boeing create this material, or protect "their formula" outside the partnership. On the other hand, it provides long-term benefits, since disclosing any traded information with each other will beneficial for both parties to build good relationship and trust, keep each other updated (update each other's data), and provide competitive and economic advantages. Since the main country relevant to this proposed technology is Australia, while Boeing is not an Australian company, then it gives more reason why these intellectual properties are essential.

5. Organisational Culture, & Key Stakeholders

FORD is an automaker company that focuses to deliver vehicles that benefits all walk of life. There are 7 components that form the organisational culture of FORD which is to put people first, the needs to be curious, built the toughness for the product offered by the company, one ford where workers unite as one, competitive to win, create opportunity for better tomorrow, and do the right thing (FORD Motor Company 2020). The organisational culture represented by FORD is considerable to be adopted or referenced as an inspiration that focuses the main goal that the project must achieve in the future. On the other hand, such culture is beneficial to promote the project and gain support and interest from media, people, government, and target partners (Boeing).

Therefore, target stakeholders are generated, judging by the goal, form, and abilities of the proposed technology for the project.

<u>External stakeholders that must be influenced:</u>

1. People
2. Government
3. Supplier
4. Investor
5. Environmentalist
6. Tax payer
7. Foreign Fuel Company
8. Pedestrian
9. Indigenous community
10. Vehicle Manufacturer

<u>Internal stakeholders that must be influenced:</u>

1. Engineers
2. Marketing department
3. Finance department

4. Managers
5. Directors
6. Project partners (e.g. Boeing)

These are stakeholders that are need to be influenced in order to ensure project or technology's success in term of performance, and competition in the market and how efficient does it reduce emission in long term so that it supports Australia to meet Paris Agreement by 2030.

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