Prospectus

Human Powered Recumbent Tadpole Tricycle
(Technical Topic)

Sociotechnical Network Influencing Dyson's East-Asian Electric Vehicle Project
(STS Topic)

By

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11/20/2019

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction (sociotechnical problem)

Air pollution is a serious risk that poses long and short-term health problems to both developed and developing countries. The emissions of fuel-burning vehicles are significant contributors to air pollution; in Malaysia, from 1998 to 2003, motor vehicles accounted for 70-75% of the total air pollution (Afroz, Hassan, & Ibrahim, 2003). Motor vehicles are known to emit harmful chemicals and elements such as Ammonia, Nitrates, particulate matter, organic carbon compounds, Magnesium, Aluminum, and Manganese (Wang et al., 2016). These emitted pollutants can have many detrimental effects, including decreased lung function, lung disease, asthma attacks, increased risk of cancer, and ocular and olfactory irritation, among many other potential health hazards (Borken et al., 2005). A 2010 study estimated that in 83 urban areas in the United States, the monetary cost associated with mortality attributable to motor vehicle congestion was $31 billion (Levy, Buonocore, & Stackelberg, 2010). If an alternative form of transportation that does not use the combustion of fossil fuels is not developed and widely utilized, air quality and respiratory health will continue to deteriorate. To address this issue technically, I am designing a semi-recumbent tricycle that is entirely human powered. The vehicle will incorporate an RPS for safety and recumbency for ease of use and will utilize both market and biometric research to be accessible to a wide audience.

However, only developing a technically sound solution fails to reveal the socio-technical network in which the vehicle operates. There is a complex network of living and nonliving actors that makes up every transportation network, which includes the people that are traveling, the machines they use, the support system in place to service and repair the machines, the system of traffic laws, and many more actors. Understanding the intricacies of the network will help to discern how the technical solution will fit into the network, or whether it even fits in the first

place. On the other hand, failing to understand the network in which the technical solution will work may result in a technical artifact that does not fit and has no use in society.

In order to adequately address the pressing issue of air pollution from motor vehicles, it is paramount that the solution incorporates both the technical and social facets of the problem. I will explain the design of a semi-recumbent, human powered vehicle to provide a realistic alternative to motorized personal transportation, and I will use the sociotechnical framework of actor-network theory to highlight the potential risks of not understanding a piece of technology in the context of the broader network in which it operates and the resulting inability of the technical artifact to function adequately.

Technical Research Project

Air quality and air pollution is a large concern for both developed and developing countries around the world. As previously stated, motor vehicles can be significant contributors to airborne pollutants and a decline in air quality. One of the most important engine emissions is fine particulate matter with diameters 2.5 micrometers and smaller ($PM_{2.5}$), which can cause serious health problems when inhaled, like cardiopulmonary issues and lung cancer. Recently, Boldo et al. (2006) attributed $PM_{2.5}$ to almost 17,000 annual deaths in 23 European cities by the Health Impact Assessment. Despite the efforts to reduce emissions of fuel burning vehicles, as population sizes increase, the effects of air pollutants from vehicles will continue to increase.

Currently, alternatives to motor vehicles include electric vehicles and human powered vehicles. Electric vehicles include Tesla's electric sports cars and Rivian's electric adventure vehicles. There are also human powered vehicles such as bicycles, scooters, and skateboards. However, electric vehicles are often much more expensive than their fuel burning counterparts, and many human powered vehicles can be uncomfortable, arduous and downright dangerous to

drive when sharing the road with larger vehicles like cars and trucks. Even if the rider of a human powered vehicle drives safely, regular and recumbent bicycles' low profiles can cause other drivers to overlook riders and cause accidents which can often be serious (Johnson, Charlton, Oxley, & Newstead, 2010). If a cost effective, safe, and user friendly alternative to transportation is not found, the air quality of cities will continue to deteriorate and the costs in terms of healthcare and human well-being will continue to mount.

The goal of this technical project is to create a human powered vehicle that combines the cost effectiveness of a bicycle with the safety, comfort, and user friendliness commonly found in cars. The vehicle will be a semi-recumbent tadpole tricycle (two front wheels and one rear wheel), which will ensure both stability at high and low speeds, and maintain accessibility to potential riders with back or upper body injuries. The vehicle will incorporate a rollover protection system (RPS) and a full fairing to reduce drag, totally enclose the rider, and provide a much greater level of safety in the event of a collision or rollover. While developing this design, finite element analysis (FEA) and computational fluid dynamics (CFD) will be used to check failure modes and aerodynamics. Biomechanical research will be conducted to generate a single frame design to fit a multitude of heights, from 5'4" to 6'3." Furthermore, consumer research will be conducted to determine design aspects that best fit in the current network of transportation and maintain sustainability in designing and manufacturing the vehicle. These two methods of research will ensure that the interests of potential customers will be represented and that a wide range of body types can fit into the design.

STS Research Project

In 2016, James Dyson, founder and chief executive of Dyson Ltd, a high-end household appliance company, announced plans to create an electric car in Singapore. Unfortunately, in

October of 2019, despite investing over two billion pounds into the project, Dyson announced that it would be shutting down the electric vehicle while continuing developmental work on the innovative solid-state batteries that the vehicle would use (Leggett, 2019). Many financial analysts and news networks attributed Dyson's failure to its unwillingness or inability to push more money into the project as other electric vehicle companies like Tesla and Volkswagen do. These analysts cite the high cost of manufacturing electric vehicles and the lack of initial profitability as driving factors for the need to push funds and investments into electric vehicle projects.

While this view of the issue may be accurate in a narrow sense, it fails to contextualize Dyson's development of its electric vehicle within the technical, cultural, and social transportation network of Southeast Asia. To better understand the network of transportation in Southeast Asia, it is imperative to understand the network of small motorized vehicles that includes mopeds, motorcycles, and motorized tricycles, sometimes referred to as tuk-tuks. In 2008, there was an estimated 100 million motorcycles in Asia, with approximately half of them using two-stroke engines, each of which produces air pollution equivalent to around 40 four-stroke engines (Kushner, 2008). It is also important to understand the cultural significance of the motorcycle and motorized scooter in Southeast Asia. Scooters have developed into an icon of style and popular culture; scooters and motorcycles are a way for people to express themselves and differentiate themselves (Ritz & Szu, 2015). The extensive network of support for motor vehicles is also an integral actor to consider. There are countless fueling stations and repair shops to service motor vehicles when needed; many motorized scooters and motorcycles have similar parts that can be easily replaced if something breaks.

If the intricate network of transportation is not considered, the interactions and power dynamics between the variety of actors that comprise the technical artifact of Dyson's electric vehicle and the environment in which it was intended to be operated will not be understood. Additionally, the effects of rogue actors could be neglected when analyzing Dyson's electric vehicle.

I will utilize actor-network theory to analyze the transportation network of Southeast Asia and the failure of Dyson to implement an electric vehicle within that network. Actor-network theory is an approach that treats technology and its environment as a web of relationships between all kinds of actors, both human and nonhuman (Alexander et al., 2009). In actor-network theory, all technologies are systems of many different parts, or actors, that are brought together into an integrated whole by a network builder that is attempting to accomplish a goal. Engineers creating the technology must also understand the social environment that needs to exist for the technology to function as it is intended. Actor-network theory is especially pertinent in Dyson's case, because many of the relationships and actors that helped the stability of existing transportation methods were not present, and 'rogue actors' like the motorized scooters and motorcycles helped to destabilize the network of Dyson's electric vehicle, and result in its ultimate failure to coalesce.

Conclusion

The technical report will bring forward a novel design of a human powered vehicle that will be accessible for many different riders. The recumbency of the vehicle will ensure that pedaling does not put undue stress on a user's back or upper body, and a comfortable seat will also reduce stresses while seated. An integrated rollover protection system and fairing will enclose the rider and contribute to a feeling of safety when sharing the road with larger vehicles.

The STS research paper will provide important insights into the network of actors that can impact the success of a technology by analyzing the failure of Dyson's electric vehicle project. By understanding the complex web of relationships that affect the progress of a new technology, it is easier to appropriately allocate time and effort into the development and maintenance of those relationships, and success of the technical project becomes more likely.

The results of the technical report will provide a viable vehicle to be an alternative to motorized vehicles, which will help the issues of air qualities in cities. The STS paper will help provide guidance on factors to consider to ensure that the design is viable and stable so the technical design performs as it is supposed to and fits into current transportation networks.

Word Count: 1725

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