Thesis Project Portfolio

Supplemental Rear Wheel Power Steering System for a FSAE Vehicle

(Technical Report)

Pro-Racing vs Production: Analyzing the Importance of Formula One in Hybrid Road Car Technology Development from a Multi-Level Perspective

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Carolyn Wong

Spring, 2021

Department of Mechanical and Aerospace Engineering

Table of Contents

Sociotechnical Synthesis

"Technology developed by experts in [racing competitions] eventually finds its way into the road cars we use every day" (Budget Direct, n.d.). As a member of the University of Virginia's Formula SAE (FSAE) racing team conducting a Capstone project to enhance the performance of our competition vehicle, I understood that participation in racing competitions was valuable for improving technological design. Many innovative automotive technologies originated in the workshops of racing teams from the invention of the semi-automatic transmission which led to smoother, automated shifting and more efficient driving to the rapidly advancing carbon fiber technology that allows our vehicles to get lighter and faster with every new model (Budget Direct, n.d.). What was unclear, however, was how this knowledge transfer between the racing and production industries occurs and why companies pour millions of dollars into building competitive racing teams to participate in these competitions. Is it just for prestige and advertisement opportunities or is there a bigger motivator associated with this technology transfer? This question is what drove my STS research: investigating the role and impact of racing competitions on the development of road car technology.

For my technical Capstone project, I worked in a 5-person group to design a supplemental rear wheel steering system for our university's FSAE racecar. FSAE is an intercollegiate racing competition that involves many different track events designed to test vehicle handling and performance at various speeds. With the addition of our rear wheel steering system, our goal was to improve our vehicle's maneuverability and stability through tighter turning radii and increased steering response at both low and high speeds. Based on steering input from the driver transferred through the steering wheel, our system rotates both of the rear wheels, allowing for all four wheels to be used in the vehicle's steering instead of just the two front wheels as initially designed. To accomplish this, we designed and manufactured a rocker

and tie-rod linkage assembly attached to electronic linear actuators which rotate each rear wheel independently to the appropriate steering angles. We then programmed these actuators to be driven by a PID controller to decrease steering response time in the rear wheels. By turning the rear wheels in conjunction with the front wheels using our system, we were able to decrease the vehicle's turning radius by over 14% thereby greatly enhancing our vehicle's performance.

To narrow down the scope of my STS research, I focused specifically on exploring how participation in the Formula One (F1) racing competition directs and accelerates the development of hybrid road car technology using Geel's Multi-Level Perspective (MLP) framework (Geels, 2011). Looking closer at F1's transition to hybrid technology, I identified the three main aspects of the relationship between F1 and the production industry that showcase the importance of participation in F1: the relevancy of F1's competition rules to the market desires of the road car industry, the corporate structure of competing teams and their production company sponsor that facilitates the crucial knowledge transfer between the two sides, and the environment of the F1 competition itself which encourages fast-paced technological development. This analysis illustrates the reason behind F1's change in focus to hybrid technology development and how this decision would result in better hybrid technology in road cars. I also analyzed the effectiveness of Geel's MLP framework for evaluating major sociotechnical transitions such as F1's transition to hybrid technology.

Together, my STS research and technical project provide a fuller understanding of the process behind the development of technologies for racing competitions and the translation of these innovative ideas to the production industry. The results of my STS research reveal the connection between the development I was doing for my technical project and the real world by illustrating how this iterative design conducted in a competition environment benefits real-world

development. Through this experience, I have learned to investigate not only how technological development occurs, but also how that process and the environment surrounding that development influences the end product delivered to customers in the production world.

Budget Direct. (n.d.). *F1 Trickle Down Effect | Motoring Special Features.* https://www.budgetdirect.com.au/interactives/special-feature/f1-trickle-down-effect.php

Geels, F. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. Environmental Innovation and Societal Transitions, 1(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002