Prospectus

Assuring Safety and Eco-driving Facilities Management's Fleet through Big Data Analytics and Education
(Technical Topic)

The Lone Star Tick, an Actant in the Actor-Network of the US Army
(STS Topic)

By

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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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I. Introduction

The University of Virginia Facilities Management maintains a fleet of over 260 vehicles that are used around grounds to maintain buildings and landscaping. Every week employees drive these vehicles around and risk injury by driving on public roads such as Alderman Road and Jefferson Park Avenue. Vehicle related incidents are dangerous to the employees and increase operating costs by requiring new vehicles. UVA also has a number of sustainability goals, such as reducing greenhouse gas (GHG) emissions. Poor driving habits can increase the amount of GHG emissions and the cause a higher number of vehicle related incidents. To combat these issues, this technical project attempts to use data collected from the vehicles, through Geotab software, to develop a safety improvement and eco-driving improvement program for the employees. If the project meets these goals, it will reduce the risk associated with their job as well as further UVA's commitment to the planet.

The STS research paper aims to develop a link between the lone-star tick and the actor network of the US Army. The US Army is a huge actor-network within the US. The US Army is the primary land force of the US military, meaning soldiers spend time in the field. Due to this mission, the Army has identified readiness as a primary focus. The soldier's exposure ticks are why the tick is an actant within the Army's actor-network system. Tick bites can cause a number of health issues by introducing illnesses to the hosts, impacting the readiness of the force.

II. Technical Topic

In 2018, the transportation sector accounted for 28.2% of greenhouse gas emissions which primarily includes "burning fossil fuels for cars, trucks, ships, trains, and planes" which accounts for the greatest proportion of emissions in the United States (US EPA, 2018). To lower

these emissions, eco-driving programs have emerged to influence changes in driving behavior around topics such as braking, driving speed, and the impacts of idling on overall fuel consumption (Huang et al., 2018). Such changes in behavior can lead to a decrease between 5-20% in overall fuel consumption which helps drivers both save money and lower their carbon footprint (Rakotonirainy et al., 2011).

The University of Virginia's Facilities Management department is one organization that has begun using in-vehicle monitors as a way to track the performance of their vehicle fleet. Currently, UVA Facilities Management does not have a suitable method for using driver performance data to improve fleet safety and sustainability by altering driver behavior. A leading cause of Facilities Management's complacency is their lack of a comprehensive driver training program.

Over the past few years, UVA Facilities Management has installed Geotab telematic tracking sensors on every vehicle in their fleet. These in-vehicle sensors constantly collect and compile a broad range of driver performance metrics such as harsh acceleration, hard braking, hard cornering, speeding, fuel consumption and seat belt usage. This data is then stored on a server and management can pull all of the raw data directly, or choose to produce scorecards which highlight the number of incidents that occurred based on specified criteria and thresholds. These incident counts are then normalized based on distance driven and standardized to be between zero and one hundred (Geotab, 2018). Finally, a weighting system is applied to these metric scores to obtain a single vehicle score that can be used to classify and compare the performance of different vehicles.

The development of a comprehensive driver education program must be supported by relevant prior research, as well as an extensive analysis of UVA-specific driver performance

data. “Performance” in this context can be understood as the extent to which a driver complies with safety laws and engages in sustainable driving behavior. Facilities Management has specified that vehicle drivers must comply with seatbelt laws and speed limits at all times. As such, driver compliance will be measured by the frequency of speeding and seatbelt misuse incidents. As a result, driver safety will be measured by both the degree of driver compliance along with the frequency of harsh acceleration, hard braking and cornering incidents. In terms of measuring sustainability, or “eco-driving”, driving speed and idling have been shown to be among the most crucial metrics to consider in regard to fuel consumption (Huang et al., 2018). In the context of this technical project, vehicle speed and idle fuel consumption will be used to classify driver behavior in terms of their contribution to the sustainability of the overall fleet.

Using these various methods of classifying driver behavior, the developed personalized training program will be curated to identify opportunities for improvement for individual drivers. In order to evaluate the efficacy of a personalized training program, a multi-week pilot test will be conducted with a selection of UVA drivers and vehicles. Driver performance will be measured before, during, and after the implementation of the pilot program. Results of the pilot test will be compiled and analyzed with the intention of improving the training program through further iterations. This project’s final deliverable will be a fully developed training program that could be implemented across UVA Facilities Management’s entire vehicle fleet to improve the fleet’s safety compliance and eco-driving behavior and will be delivered.

III. STS Topic

The Army has identified readiness as one of its primary focuses, which requires keeping soldiers healthy and trained, requiring the Army to account for health in the field. Ticks are a small arthropod that spread disease through their bites. The lone-star tick, *Amblyomma*

Americanum, is a tick that originated in western Texas and now spans to Maine. It is reported that 10 soldiers had over 100 of these ticks in a two-week period during a training event at Little Rock AFB in Arkansas (Goddard & Varela-Stokes, 2008). This expansion of range and exposure to tick borne illnesses is why the lone-star tick is an actant in the actor-network of the Army.

The lone-star tick has symbiotic relations with two common genera of pathogens. The first is the *Rickettsia* genus of bacteria, which are responsible for Rocky Mountain Spotted Fever (RMSF) and American Boutoneusse Fever, both of which have been confirmed by transmission studies. The second type is the *Ehrlichia* genus, which are responsible for Human Ehrlichiosis and Human Monocytic Ehrlichiosis, these have also been verified by transmission studies (Goddard & Varela-Stokes, 2008). This existing relationship between the tick and these pathogens can be used to theorize new relationships. As previously theorized in Australia, ticks could be responsible for spreading a red meat allergy (Commins & Platts-Mills, 2014). In this 2014 study, the relationship between RMSF and the tick was used to link the red meat allergy and the lone-star tick, which has been further developed through the rise in allergy cases and lone-star tick bites.

The alpha-gal allergy, commonly red meat allergy, is spread by the lone-star tick. This tick-borne illness causes the host to develop immunoglobin E (IgE) titers towards the sugar structure galactose-alphas-1,3-galactose which is found in beef, lamb, and pork *(*Khoury, Khoury, Schaefer, Chitnis, & Hassen, 2017). This 2017 study notes the allergy is typically self-diagnosable although there are laboratory tests, which characterize the allergy as IgE antibody levels higher than 0.35 kU/L. The patients in the study reports the IgE levels in follow on tests and related complications disappear when they stop consuming red meat.

The Army uses meals-ready-to-eat (MRE) as its current field ration. These are precooked meals that come in vacuum sealed bags and contain an entree, snacks, and dessert item. In the 2019 menus, the Army has 24 varieties of MRE menus and 14 of those have a form of red meat whether it is meatballs or a beef patty (Defense Logistics Agency, 2019). This source details the available menus going back to 2015; with 2018 having 15 out of 24 containing red meat; 2015, 2016, and 2017 each have 14 red meat main meals. Additionally, in the 24 total halal and kosher menu offerings, eight contain a red meat main meal (Defense Logistics Agency, no date). This means the majority of MRE offerings contain red meat, meaning affected soldiers have much fewer MRE choices available.

The lone-star ticks' range is from Texas to Maine, which covers the southern US as well as the East coast. In the early 2000s, it was found that 20% of patients and controls had IgE titers towards alpha-gal in southern states of Virginia, Tennessee, North Carolina, Arkansas, and southern Missouri (Commins & Platts-Mills, 2014). This is significant because of the amount of US Army bases located in this area. Virginia and North Carolina stand out because Virginia and Georgia have the most Army bases, with seven bases (US Army, 2016). North Carolina stands out because it is home to Fort Bragg, where approximately 57,000 soldiers call home and is one of the largest military bases in the world (US Army, 2018). The high number of soldiers living and training in the tick's range cause the illnesses and bites to be significant.

A survey of troops conducted from 1984 to 1988 found that 70% of those surveyed had problems with arthropods in field environments, including problems from bites to disrupting movement (Mehr, Echano, Rutledge, & Gupta, 1997). The survey found 28% of participants ranked ticks and chiggers to be the most troublesome pests and found 21% had gone to sick call due to these pests (Mehr, Echano, Rutledge, & Gupta, 1997).

In order to combat tick exposure, the Army started to impregnate field uniforms with permethrin which combats the lone-star tick at its recommended doses. Laundering the uniforms removes the permethrin over time so to mitigate this, a study was conducted in 2006 by Faulde and Uedelhoven to find the best impregnation method. The findings of this study indicated fabrics that were polymer coated with permethrin showed the same residuals after 100 launderings as the US Army IDA-kit did after six launderings (Faulde & Uedelhoven, 2006). This means that polymer coated uniforms are active in fighting ticks during the life of the uniform.

The Army mandated permethrin treated uniforms in 2013, with exceptions for allergies to the chemical and maternity uniforms. Since the uniform is in contact with skin, permethrin is absorbed and metabolized by the body into 3-phenoxybenzoic acid, 3-PBA, and urinated out (Maule, Scarpaci, & Proctor, 2019). This study used data from two US Army cohorts by collecting urine samples and comparing the 3-PBA levels to the average levels of Americans found in the National Center for Health Statistics. Comparing these two data sets, shows the Army cohorts had much higher concentrations of 3-PBA with the soldier's median concentration being three to four times higher than the 95th percentile of average US citizen. The effect of long-term exposure still requires tracking to be accurately determined (Maule, Scarpaci, & Proctor, 2019). As demonstrated, the tick effects on the Army's readiness in multiple ways.

Tick-borne illnesses can degrade the readiness of the Army by disqualifying soldiers. I propose to research the role of the tick as an actant in the social technical system of the United States Army because ticks affect soldiers' health on multiple levels with dietary restrictions and chemical exposure. This project is significant because ticks transmit illnesses to their host which

degrades the Army's ability to complete its mission. This topic is personally significant because I will commission as an Army officer following graduation.

IV. Timeline and Expected Outcomes

The technical project's deliverable is a fully developed training program to the facilities management fleet to improve the safety compliance and eco-driving behaviors of the drivers. This will be done by developing a pilot program at the end of the fall 2020 semester. The results in behavior changes will be recorded and used to adjust the training program. The final training program will be completed in the spring 2021 semester. The team will compile a detailed technical report to present the Systems and Information Engineering Design Symposium (SIEDS) in April 2021.

The STS project will build a concrete link between the lone-star tick as an actant in the actor network of the Army. A successful thesis for this will inform how the tick affects readiness through dietary modifications and chemical exposure through uniforms. This research will be carried out during the 2020-2021 academic calendar and completed in April 2021.

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