**Prospectus**

# CubeSat Remote-Sensing Solution to unifying data streams for improving roadway safety

(Technical Topic)

# Social, Political, and Cultural Agendas of Drivers in the Realm of Highway Transportation

(STS Topic)


By

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## Introduction

From the first roads paved in the late 18th century (Virginia Department of Transportation, 2006) to the numerous highways within Virginia's borders today, roadway transportation is an integral part of every Virginian's daily routine. More so, the choice of car as a means of transportation has never been higher due to the COVID-19 pandemic and the reluctance to share close spaces with other strangers. Despite the pandemic, one aspect of daily life has remained the same for many Virginians—inclement weather. While Virginia does not find itself in the path of tornadoes or earthquakes, its proximity to the Atlantic Ocean can lend itself to severe storms and the occasional hurricane. Precipitation-related weather events represent a majority of weather-related accidents (Liu, 2013) and as a result are the most imminent problem to the commonwealth in ensuring roadway safety. To prepare for inclement weather in Virginia, the precautions one can take are to obtain a short-term weather forecast via the Internet or radio and map out potential routes and their respective time of arrivals.

The weather and navigational data accessible to many Virginians originates from satellites, local ground-based sensors, and human-reported observations (National Oceanic and Atmospheric Administration, n.d.), yet these streams of data are presented to users in a separate manner. To address the technical deficiencies of real-time weather data to expand roadway safety, I will propose a remote sensing solution that allows the combination and delivery of a unified data stream that not only allows for users to use navigational services but to also dynamically adjust for constantly changing weather conditions—which could impact roadway safety. However, as further investigation into the problem at hand occurred, it became evident that the project had a multitude of other factors that had been neglected in the past—a series of social and political factors at play that exacerbate the task at hand.

Developing a remote-sensing solution that involves more tracking of users and providing suggested courses of action, as a result, could improve roadway safety, however, certain people might be averse to increased government surveillance, not trust data solely on political affiliation, or even ignore help due to an internally developed sense of complacency. The numerous non-human factors at play highlight how the current technology used to collect and relay weather data neglects the aforementioned human factors—specifically the current attempts by the Trump Administration to privatize weather data collection (Davis, 2020). By failing to acknowledge the non-technical actors at play, there stands a possibility that roadway safety is not significantly improved, but possibly worsen due to the increasingly sporadic nature of Virginia's weather. In reiteration, an effective solution to implementing real-time weather data for roadway safety requires attention to both technical and social aspects. In the following pages, I propose the use of a CubeSat as means for collecting real-time data as well the use of Actor-Network Theory (ANT) to effectively analyze the vast network of human and non-human actors in the network of real time weather data collection for the sake of improved roadway safety and a less vulnerable network.

**Technical Problem**

Virginia has one of the largest state-maintained highway systems in the United States, behind the states of North Carolina and Texas (Virginia Department of Transportation, 2019). Given the expansive nature of Virginia's infrastructure, it plays a pivotal role in the economic development of the commonwealth as well as the quality of life for every Virginian. One issue the Commonwealth faces is severe traffic congestion, as seen in the Northern Virginia and Hampton Roads regions. The traffic congestion, primarily due to lapses in driver judgment and weather conditions, cost Virginia \$6.4 billion due to traffic incidents in 2018 (TRIP, 2020).

Currently, Virginia acquires their weather data in the same manner as most of the continental United States—through a synthesis of data collection from the National Oceanic and Atmospheric Administration (NOAA) Geostationary Operational Environmental Satellite (GOES), local ground stations, and physical observation (National Oceanic and Atmospheric Administration, n.d.). The satellites NOAA uses boast the ability to support 1-2-day forecasts and severe storm monitoring. They can offer 3x more imagery with up to 4x better resolution compared to previous generations of weather satellites, can scan the Western Hemisphere every 15 minutes, the Continental U.S. every five minutes, and areas of severe weather every 30-60 seconds, all at the same time (National Weather Service, n.d.). The accuracy of weather data has never been better, with the ability to create extremely reliable short-term forecasts and augment the accuracy of longer-term weather outlooks (National Oceanic and Atmospheric Administration, 2019). Similarly, navigational information is delivered through the use of GPS satellites as well as prior user data to provide time-dependent estimates on route durations. As it currently exists, both data streams exist independently of each other.

The mutually exclusive nature of both weather data and GPS data births the problem of neglecting the impact of weather conditions on the safety of a certain route. Nearly all traffic engineering guidance and methods used to approximate highway capacity assume clear weather—an invalid assumption to make considering a majority of states encounter inclement weather conditions for a significant portion of the year (Agarwal, 2005). Furthermore, it has been identified that adverse weather conditions are a primary cause or underlying circumstance in vehicle crashes each year. There has been a plethora of incidents, such as in Fancy Gap, Virginia, where excessive driver speed in the dense fog caused 17 distinct crashes on March 31, 2013 (Ashley et al., 2015).

Although a human decision is at the core of every traffic incident, there is a lack of understanding of current weather impacts on road safety for the average commuter. It was found that the average driver employs anywhere from two to four sources of weather information, and a subsequent 34% of people modified their actions thereafter. By incorporating real-time weather data into navigational platforms and quantifying their impacts on roadway safety, time, money, and human lives can be saved. Virginia's road systems are also continuously evolving due to the growth of electric vehicles and autonomous driving capabilities. Currently, 2% of passenger vehicles in Virginia are electric, yet this metric is expected to balloon to 46% by 2040 (TRIP, 2020). This growth of electric vehicle usage, which introduces autonomous driving features, would further benefit from a combined stream of data in optimizing their routes and increasing passenger safety.

My team proposes to develop a remote-sensing solution, in the form of a CubeSat, to monitor the on-road accumulation of precipitation and calculate average speed changes to provide users with in-app weather warnings as well as real-time route delays and alternatives. A CubeSat is a miniature satellite comprised of 10 cm x 10 cm x 10 cm units housing avionics for a certain mission. The CubeSat will be placed in Low Earth Orbit (LEO) to allow for high-resolution imaging and data collection over a particular area. To validate the design, we will verify rain accumulation detected by our satellite with that of real-time observations by local observers and ground-based sensors in the vicinity. Additionally, we will seek to integrate data collected from our satellite directly with road conditions corroborated by Virginia's Department of Transportation, and popular navigation apps, such as Waze, Google Maps, and Apple Maps to better serve Virginia's population.

**STS Problem**

Weather data is collected through a plethora of aerial and ground-based devices such as satellites, Road Weather Information System (RWIS) sensors, Doppler Radar, and even human observation from ground stations (National Oceanic and Atmospheric Administration, n.d.). Information from these sources is analyzed, verified, and summarized in a multiday forecast that can be received via the Internet, radio, or a local TV news station. Yet with the plethora of available information to the average user, there remains a significant proportion of the population—66%—who neglect to change their mannerisms when faced with the warning of adverse road conditions, such as severe weather (TRIP, 2020).

Currently, local and federal government agencies occupy the domain of collecting and presenting weather data to the public (National Weather Service, n.d.). In its current form, the National Weather Service (NWS), as well as local government agencies, act as the primary network builders for real time weather data. The goal of this network is to deliver accurate weather forecasts and updates to the American public in a timely manner. The network presently is operational, however there are other factors aside from the non-unification of weather data streams that contribute to the vulnerability of the network. Specifically, there have been several attempts of network destabilization, ushered in by President Trump and his administration, which seek to compromise the integrity of the real time weather data network, primarily through the attempt to privatize and undermine the legitimacy of government weather reporting services, like the NWS (Davis, 2020). There are some visible consequences from the weaknesses present in the network as it stands, such as the $6.4 billion of economic loss for the Commonwealth of Virginia in 2018 as result of traffic crashes (TRIP, 2020). As the effects of climate change continue to intensify and science finds itself in political crossfire, the accuracy and integrity of data collection and reporting must be upheld. By failing to acknowledge the non-human and rogue actors present in the current network, a better understanding of why the network remains to be vulnerable cannot be achieved.

To understand why the current network is operational, yet vulnerable in its present state, I seek to take advantage of Actor-Network Theory (ANT) to better capture the nature of real time weather data collection, the numerous network builders involved, the intricate relationships between drivers and the multitude of data streams collected on weather and roadway safety, and ensuring the attempts of rogue actors to privatize the weather data collection process can be eliminated. In employing ANT, I will also seek to analyze the power dynamics amongst human and non-human actors associated with the network to accomplish a particular goal (Cressman, 2009) to ensure a safer roadway system and stable real time weather data network can be accomplished. Within the scope of Cressman's definition of ANT, a network is a system of interrelated actors associated together for a common purpose. Actors in these networks are heterogeneous—human and non-human—with actors possessing the ability to be both a network and an actor. Furthermore, analyzing individuals who are influential to the process of weather data collection, as well as their professional affiliations and motives, could allow better understanding of why the current network is vulnerable.

**Conclusion**

The technical report will attempt to outline a new cost-efficient method for collecting real-time data to improve roadway safety and further integrate multiple data streams into one. This design will rely on the use of a CubeSat as means for remote sensing and also redesign navigational interfaces (e.g. Waze, Google Maps, etc.) for future users. Through successful testing and development of the proposed technical solution, on-road accumulation will be detected in a timely manner and relayed to drivers to improve roadway safety. The STS document will aim to capture the numerous relationships between drivers and the multitude of data streams collected on weather and roadway safety to understand and identify current weaknesses of the network. The results from the STS report will highlight the importance of approaching real-time weather data and developing user interfaces that improve user engagement and adherence to roadway safety suggestions.

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