A SPACE-BASED SOLUTION TO IMPROVE ROADWAY SAFETY AND EFFICIENCY IN VIRGINIA: REAL-TIME WINTER WEATHER DATA FOR NAVIGATION

EXAMINING THE ADOPTION OF SATELLITE-BASED REAL-TIME WEATHER HAZARD TECHNOLOGY IN THE VIRGINIA ROADWAY TRANSPORTATION SYSTEM

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By

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SOCIOTECHNICAL SYNTHESIS

Weather hazards create dangerous driving conditions which can cause vehicular crashes. The technical project aims to improve weather-related roadway hazard monitoring in Virginia by creating a conceptual design of a prototype for a spacecraft system capable of remote, real-time, and state-wide weather condition observation. Despite the benefits that real-time satellite-based observation can bring to transportation monitoring and maintenance, it has yet to be applied system-wide in Virginia. The tightly coupled STS research aims to answer the question: given the benefits of these technologies, why do barriers to adoption still exist among transportation stakeholders in Virginia, and how can we overcome them? The project uses E.M. Rogers' Diffusion of Innovation framework to analyze barriers to adoption as well as potential solutions.

Currently in Virginia, information on weather-related roadway hazards is gathered via ground-based systems, quite often through on-site manual evaluation techniques which can be laborious and time consuming. This can cause information shared with drivers to be out-of-date, and coverage may not extend to certain parts of the state. Designing a satellite system to provide up-to-date state-wide information would buy more time for drivers to react to adverse conditions, and needless weather-related crashes could be prevented. The technical project began with a literature review to find a satellite-based solution to weather-related roadway hazards. Members were then split into functional teams, each of which were responsible for a particular part of the spacecraft design. Teams cooperated with one another to develop functional and operational requirements and integrate each team's designs.

The literature review revealed that satellites could partially improve real-time weather hazard observation, in particular by observing snow and ice conditions. It was decided for the design to prototype a satellite-based solution by focusing on the beltway in Northern Virginia for

proof-of-concept. To observe snow and ice cover across this region, it was chosen to use a spectral imager, and a low-Earth orbit at an inclination of 51.6 degrees and with an orbital period of 92.6 minutes was selected. A ClydeSpace Zaphod 6U CubeSat was chosen to carry the imager, with a ClydeSpace Optimus battery, Starbuck Nano EPS, Photon side solar panels, the CubeADCS 3-axis system, and an Endurosat on-board computer included to support necessary functions. It was decided to use Endurosat S-band and UHF antennas to quickly and reliably transmit information back to Earth, with the University of Virginia acting as the main ground station. The design should allow for the future launch of a prototype to verify whether a system of satellites could be used to monitor snow and ice across all of Virginia.

The STS research aims to answer the question: given the benefits of satellite technologies, why do barriers to adoption still exist among transportation stakeholders in Virginia, and how can we overcome them? The thesis statement states claims that the technology suffers from lack of interest, low trialability, and a high level of complexity in transportation. These barriers, however, can be lessened by improving information sharing at federal and state-wide levels and consolidating satellite programs into a centralized top-down model. To prove this statement, the Diffusion of Innovation framework was used to identify barriers to entry for satellite technology as a whole. Solutions were then devised and evaluated by reframing the adoption of satellite-based real-time observation technology in transportation through the same Diffusion of Innovation framework.

A satellite system is prohibitively expensive and building one would require funding, making the technology lack trialability. Transportation agencies like VDOT may prefer to allocate their resources to other maintenance projects, and obtaining additional funding can be needlessly complex. Thus, there is a general lack of interest in transportation applications of

satellites when compared to other fields. Much of the ongoing research and experimentation in other fields concerning real-time earth observation is directly applicable to real-time weather data use in transportation, so improving information sharing at federal and state-wide levels would aid research into transportation applications. By centralizing satellite-based technology development, the flow of information could be improved, the interests of lesser-known stakeholders would be considered at the top levels, receiving federal funding would be greatly facilitated, and trialability at the lower levels would be increased as part of a larger connected system.

Information on weather-related roadway hazards can be out-of-date or lack coverage. Developing a satellite-based real-time observation system would help alleviate this problem by covering a wider range and providing information as it is observed. It is in the best interest of transportation stakeholders to implement such a system, and action should be taken to make this feasible.

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