

# Introduction to Communications in Transportation

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## **Abstract**

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# Introduction

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As new Intelligent Transportation Systems (ITS) and vehicle-to-everything (V2X) communication technology and protocols continue to emerge, personnel in the transportation sector need training on applicable technology, functionality, and applications to ensure continued transportation safety. Discussions with infrastructure owner-operators (IOOs) have indicated that while ITS and V2X technologies have been growing exponentially in recent years, education and awareness by practitioners have not kept pace. It is critical that transportation departments have access to adequate training to maintain existing systems, plan for future implementation efforts, and ensure continued safety and security throughout the use of those systems.

The Virginia Department of Transportation (VDOT) has already worked to address this need through the creation of an online training program focusing on general topics pertaining to connected and automated vehicles (CAVs) (Smith, 2021). The CAVs training program consists of two modules titled “Connected and Automated Vehicle Awareness” and “Enabling Wide-Scale Intro of CAVs in VA” (Smith, 2021). These module cover concepts such as automation and connected vehicles and include examples such as platooning and adaptive cruise control. Additional information regarding message sets and V2X applications, such as the Virginia Connected Corridor (VCC), are also discussed.

# Background

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The VDOT Office of Strategic Innovation and the Virginia Transportation Research Council (VTRC) recently identified the need for a more specific program focusing on different communication technologies being utilized by IOOs, OEMs, and industry technology providers. A high-level overview of various types of communications and main use cases would potentially benefit a variety of roles, from project managers seeking to procure equipment to engineers considering the use, data, and functionality of the communication technologies.

To address this need, the Virginia Tech Transportation Institute (VTTI) team sought to identify key topics relating to ITS and V2X communications that could be addressed in a training program. The desired training would provide a high-level overview of the types of communications that support ITS, traffic management, and connected vehicle environments. Descriptions of the communication technologies, protocols, performance metrics, use cases, and data security were included. The target duration was set at 60 minutes and included a series of narrated modules with slides, images, charts, videos, and learning assessments.

# Method

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## Task 1: Project Management

VTTI led the project management tasks throughout the project while keeping the VTRC and VDOT members apprised of the project status. Status updates were included in biweekly VCC project meetings held via remote conferencing. The team completed quarterly progress reports and biannual activity surveys according to the work plan and contract requirements. Additionally, VTTI tracked the project budget, monitored expenses, and updated budget projections on a monthly basis. The team members worked to complete activities, milestones, and deliverables, as well as the technology transfer activities and education and workforce development activities, according to the planned timeline.

## Task 2: Instructional Design

The instructional design process encompassed the development of an outline, content creation, and the production of training materials. Content creation included the course modules, script, and questionnaires. The production of course materials included slides, videos, and audio recordings. VDOT and VTRC approval was needed to proceed with subsequent subtasks to minimize revisions and maintain the project budget.

### Task 2a: Develop and Finalize Content Outline

In Task 2a, VTTI worked in conjunction with VTRC and VDOT to outline topics and identify key communication technologies and protocols applicable to VDOT and other IOOs within the transportation sector. VTTI's Division for Technology Implementation had both subject matter expertise and real-world experience with the majority of the communications technologies ultimately selected. Background knowledge and descriptions of the communication technologies were outlined, such as key performance metrics, functionality, limitations, implementation details, real-world use case examples, and data security considerations.

### Task 2b: Content Creation

In Task 2b, VTTI first worked to develop the outlined content into a written script, identify module groupings, and create a series of quizzes. During this task, the project team also began consulting with VDOT's Learning Technologies team to ensure the planned content and deliverable formats were compatible with the VDOT University (VDOT-U) training platform.

### Script

The outline developed in Task 2a was further expanded and key points were finalized. Descriptions of the technologies were further expanded, and the script was reorganized into a series of modules. During this process, the research team utilized its own experience and conducted supplemental research with the help of an undergraduate student.

## Quizzes

Quiz assessments were created for each module with five questions, including multiple choice and true/false questions. An overall test at the end of the training with 20 questions was developed to assess overall learning comprehension of each module's main learning objectives.

## Task 2c: Production of Course Materials

In Task 2c, VTTI produced a self-paced, dual-modality series of training modules to allow students to listen to the script narration as well as view the slides and script to aid accessibility.

## PowerPoint Slides

A PowerPoint presentation was developed using the approved script with slides containing bulleted information along with images, infographics, charts, and video clips. Integrated versions were created to provide a simple format for review and to increase accessibility. This included a PowerPoint presentation with the script added as notes on each slide as well as a word document where the slides were pasted into the applicable sections.

## Images and Infographics

The images and infographics included approved materials from the United States Department of Transportation (USDOT), pictures from VTTI demonstrations, and images licensed through Adobe Stock Photos. Adobe Photoshop and Lightroom were also utilized as needed.

## Audio Recording

The audio for the script was recorded using the Blue Yeti Microphone and produced using Adobe Audition to remove background noise and adjust audio levels. Recording gaps were then removed, and the audio was edited into the requested format of one WAV audio file per PowerPoint slide.

## Video Clips

Video clips were created using approved materials from the USDOT. The VTTI media team conducted an on-site interview with Mike Mollenhauer regarding the FCC ruling on spectrum allocations. Footage from prior VTTI demonstrations was also used as B-roll footage. Audio was edited with the video clips and produced using Adobe Premiere Pro and Camtasia software.

The content was provided to VDOT to be integrated and hosted on their VDOT-U training platform. The materials will also be provided for public dissemination through the Safe-D website.

# Results

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A 10-module training program was created and covered the following topics:

1. Introduction to Intelligent Transportation Systems
2. Background Knowledge for Communications
3. Introduction to Wireless Communications

4. Connected Vehicle Technology
5. Intelligent Transportation System Technology
6. Enabling Technology
7. Introduction to Wired Communications
8. Between System Technology
9. Within System Technology
10. Intelligent Transportation System Use Cases

The following wireless technologies were included: Dedicated Short-Range Communications (known as DSRC), cellular vehicle-to-everything (known as C-V2X), cellular networks, Citizens Broadband Radio Service (known as CBRS), Wi-Fi, Bluetooth, and Low-Power Wide-Area Network (known as LPWAN). For wired technologies, fiber networks, Ethernet, Universal Serial Bus (known as USB), RS-485, and Controller Area Network Bus (known as CAN Bus) were included.

## Discussion

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Further updates to the training program may be required as the industry develops and expands the technologies and their capabilities. The VTTI team plans to address any feedback provided to VDOT or Safe-D and will make changes to the course materials if needed.

## Conclusions and Recommendations

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The VTTI team developed a 60-minute online learning program that includes a series of 10 narrated modules with slides, images, charts, videos, and learning assessments. VDOT and VTRC reviewed and provided feedback on the training materials as they were developed to ensure that the technologies were applicable, the information was comprehensive, and the level of detail was appropriate for the intended audience.

## **Additional Products**

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The Education and Workforce Development (EWD) and Technology Transfer (T2) products created as part of this project are described below and are listed on the [Safe-D website](#).

### **Education and Workforce Development Products**

The training program materials were provided to VTRC and VDOT for the purpose of educating and developing their workforce and will also be made available to other transportation agencies. The 60-minute training program was developed in conjunction with VTRC and VDOT with the goal of providing an overview of key communication technologies and protocols applicable to the transportation sector.

### **Technology Transfer Products**

VDOT will integrate the training materials into their VDOT-U training platform to allow for easy navigation, an interactive interface, real-time assessment scoring, completion tracking, and other metrics. The developed training program will be utilized by VDOT and VTRC. Safe-D will also provide the materials to students and the general public through their website. The final report for the training program will also be made available through Safe-D UTC.

### **Data Products**

This project did not generate any data. Multiple training modules were developed and can be found on the project site.

## References

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1. Smith, B. (2021). *CAV Module 1: Connected and Automated Vehicle Awareness*. UVA Transportation Training Academy. <https://ltap-cts.talentlms.com/learner/courseinfo/id:410>
2. Smith, B. (2021). *CAV Module 2: Enabling Wide-Scale Intro of CAVs in VA*. UVA Transportation Training Academy. <https://ltap-cts.talentlms.com/learner/courseinfo/id:410>