Vehicle to Infrastructure (V2I) Deployment Coalition

Technical Working Group 1: Deployment Initiatives

Webinar Summaries of Connected Vehicle Benefit / Cost Projects
December 2015

INTRODUCTION

The Vehicle to Infrastructure (V2I) Deployment Coalition (DC) [Technical Working Group (TWG) 1: Deployment Initiatives](#) recently facilitated two webinars that highlighted ongoing research projects related to connected vehicle benefit/cost analyses. The intent of the webinars was to share project information with all TWGs who are working on V2I benefit/cost efforts.

This brief summary was prepared to synthesize key information presented in each webinar. It is not intended to be a comprehensive summary of all information presented. In addition, each webinar was recorded, and anyone is welcome to view the webinar recordings.

> *Webinar 1: Desk Reference and Tools for Estimating the Local, Regional, and State-wide Economic Development of Benefits of Connected Vehicles to Infrastructure*
>
> - [Webinar 1 Summary](#)
> - [Webinar 1 Recording](#)
>
> *Webinar 2: AASHTO Near TermV2I Transition and Phasing Analysis Connected Vehicle Life Cycle Cost Model (LCCM)*
>
> - [Webinar 2 Summary](#)
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Webinar 1 Summary

Desk Reference and Tools for Estimating the Local, Regional, and State-wide Economic Development Benefits of Connected Vehicles to Infrastructure

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Presented on: November 16, 2015

Presented by: Chris Williges, HDR. Presenting on behalf of Max Azizi, USDOT.

Webinar Recording Link
https://atheycreek.webex.com/atheycreek/lsr.php?RCID=6ed3d99e57c23833f0dcc75a49514147

Project Purpose:

The purpose of this project is to develop a desk reference and analysis tool to estimate the economic benefits associated with connected vehicle technologies, with an emphasis on Vehicle to Infrastructure (V2I) applications. The project has focused on user benefits and economic impacts of connected vehicles.

Planned Project Deliverables

The primary outcomes of the project are expected to include:

- *Desk reference report* – A Microsoft Word or PDF document describing the tool and providing details of the research conducted; and
- *Sketch planning benefit tool* - An interactive Microsoft Excel workbook that allows users to enter one or more planned connected vehicle application deployments and receive information about the projected benefits of each application (or aggregate benefits of multiple applications).

Details of the Sketch Planning Benefit Tool

The benefit tool is based on and shares similarities with the FHWA Tool for Operations Benefit Cost Analysis (TOPS-BC). The tool being develop for this project is intended to be a companion to the TOPS-BC, focusing on V2I applications. The following bullets provide highlights of the tool, as presented in the webinar:

- The tool is intended to be used to estimate the benefits of V2I technologies.
- The tool does not estimate the costs of V2I technologies. However, this project is coordinating with the AASHTO Life Cycle Cost Model (LCCM) Project that identifies costs of connected vehicle deployment, operations, and maintenance – see Webinar 2 Summary for additional information. A link between the LCCM and this tool would enable cost projections to be inserted automatically without the need to re-enter the data.
- The tool is a Microsoft Excel workbook. Users considering connected vehicle applications are able to enter information on single or multiple V2I deployments and receive information about the project benefits of each application.
- Definitions of V2I applications in the tool are based on the definitions found in the Connected Vehicle Reference Implementation Architecture (CVRIA).
- Benefit estimates generated by the tool are based on what the research team found in a literature search as well as results of other previous projects. For example, if the literature

search revealed a source that defined a quantified benefit of a V2I application was 10% improvement in travel time, this is the value used in the tool to generate benefits.

- The tool takes the theoretical benefits derived in previous studies and identifies steady state benefits (benefits that would be derived when you had full mature deployment of V2I applications). This research project then developed the functionality into the tool to adjust these theoretical steady state benefits using two factors:
    o Penetration of connected vehicle components in the vehicle fleet; and
    o Efficacy adjustment factor – e.g. given a certain penetration rate, what percent of benefits could occur. For some applications you can see mature benefits for low penetration rates, while other applications only achieve mature benefits with high penetration rates.
- A flat file database is used to store all the quantified benefits associated with V2I applications. Therefore, as more benefits are researched and estimated, these results can be added to the flat file to increase the V2I applications supported by the tool.

Technical challenges faced

- *Linking benefits to V2I Applications.* Identifying and linking benefits to applications is difficult. Some connected vehicle applications are in preliminary design and the definitions are still evolving, and knowledge of the potential benefits is limited.

- *Aggregating benefits of multiple applications*. Beyond considering V2I applications in isolation, when multiple V2I applications are deployed together, the concept of accruing the benefits of multiple simultaneous applications is also a difficult task. The question of how multiple simultaneous V2I applications will benefit users is an open research question. There is not a lot of research to date that has focused on multiple V2I applications deployed and operated together. Questions include:

    o Are there synergistic benefits that are bigger than the sum of individual benefits when multiple applications are deployed together?

    o Are there diseconomies where certain applications have already produced benefits and there are limited or no benefits remaining for additional applications to achieve?

- *Distributing benefits to users.* Figuring out how to distribute the benefits across stakeholders is a challenge. The timing of when the benefits are recognized, and the actual users who recognize the benefits is also a challenging question. For example, some benefits are only achieved over time, while others are recognized very soon after deployment.

- *Lack of Economic Development Benefit Research.* No existing literature attempts to measure economic development benefits. This project originally was intended to identify the following three types of V2I application benefits: user benefits, economic impact benefits, and economic development benefits. However, the project was adjusted to focus on two types of V2I applications:
    • User Benefits, and
    • Economic Impact Benefits.

- *Limited quantified benefits defined for V2I Applications.* The literature search revealed that there have only been a small number of projects that quantified and monetized the user benefits of V2I technologies. There are more studies on the safety benefits of V2I applications, however the research tends to be limiting by focusing on theoretical, rather than on specific details.

Project Status

As of November 2015, the research team has developed a preliminary desk reference and tool. These draft deliverables are being reviewed by an internal review group. The next step will be to develop case studies to test the deliverables.

The project is estimated to be completed in May of 2016. The final tool and desk reference will be posted on the FHWA website.

Conclusion

This research project will deliver a framework that will allow users to enter planned V2I applications and view a report of the likely benefits of the application deployments. When combined with the AASHTO Life Cycle Cost Model, the pair of tools will provide information on the expected costs and benefits should V2I applications be deployed.

The tool for this project uses a flat file structure that enables additional V2I application benefits (quantified and monetized) to be entered into the tool as additional information is gathered. As additional benefits are entered, the tool will take into account the additional benefits entered. Therefore, if additional research were to be conducted to identify quantified and monetized benefits of V2I applications, this tool is a resource that can take these benefits and support end users in understanding the projected user benefits, based on anticipated penetration and efficacy. Therefore, needs in the area of V2I benefits and costs understanding include:

- More studies on V2I benefits, quantifying and monetizing them to the extent possible; and
- Understanding of what happens when you have multiple V2I applications at the same time.

Webinar 2 Summary

AASHTO Near Term V2I Transition and Phasing Analysis Connected Vehicle Life Cycle Cost Model (LCCM)

Presented on: December 4, 2015

Presented by: Keith Platte, AASHTO and Dominie Garcia, Booz Allen Hamilton

Webinar Recording Link:
https://atheycreek.webex.com/atheycreek/lsr.php?RCID=fea5d81316a883d4de72d72a2e028f1b

Project Purpose

As part of a suite of tools, AASHTO is developing a life cycle cost model for V2I applications that will detail all cost components associated with deployment of V2I applications over a 20 year period. The model has researched costs included, but also has the flexibility for users to change costs. It is anticipated the cost model will be released in 2016 and will provide users with insight and detailed estimates for installing, maintaining, customizing, and operating all needed elements of V2I applications.

Summary of the Suite of Tools

This project is developing three tools that will work together, including:

- *Application Prioritization Tool* – A tool that guides users through a series of three questions to narrow down a list of suggested applications based on the responses.
- *Life Cycle Cost Model (LCCM)* – a Microsoft Excel based tool that guides users through a set of inputs that trigger a calculation of established cost components required for the planning, design, deployment, operations, and maintenance of the application(s).
- *Infrastructure Planning Tool* – A tool to provide supplemental information to assist in V2I deployments. Users answer a set of questions related to size and scope of the project, initial capital, etc. The results provide ancillary information to assist in the timing and phasing of deployments.

Details of the Life Cycle Cost Model (LCCM) Tool

The tool is an interactive MS Excel workbook. Functions are as follows:

- Users have a series of input opportunities;
- Based on the input, the user is presented with a very detailed set of component costs per application;
- Tool returns annual and aggregate set of individual component costs and total costs over a 20 year time period;
- The tool provides details to help with budgeting and planning process;
- The tool is built to support the flexibility that end users will need. A considerable amount of research has focused on cost information that are included in the tool defaults. However, users can change costs information (that serve as the basis for calculations) based on their own

experiences or knowledge. For example, if a user already has equipment and knows they will save on costs, they can adjust the costs.

Functionality of the tool

1. The tool allows users to select one or more applications from approximately 70 applications (this may be adjusted in the final version).
2. The next step asks the users to answer a set of questions about the 'Building blocks' of the applications. These are questions related to the size and complexity of the deployment (e.g. "how many drivers for transit vehicles?" "how many signalized intersections will be included?"). Note: a companion user guide accompanies the tool with definitions of each of these building blocks.
3. After answering these initial questions, the tool provides the user with a year by year, and element by element cost breakdown. Some details of the cost breakdown include:
   - Discount rate is adjustable by the user.
   - Costs include such things as training of drivers (i.e. based on the number of drivers entered by the user).
   - Costs include all aspects, including: planning, designing, installing, operations and maintenance.
   - All the component costs are changeable. They can either be left at the default value, identified as "most likely", or users can override this. There are also options to select other defaults that have been created by the research team, including: minimum, maximum value defaults.

Availability of the Tool

The tool is in the final stages of development. This version is a prototype/proof of concept tool. A final decision about the process to finalize the tool for use by end users will be determined in 2016.

AASHTO and USDOT will update members of the V2I Deployment Coalition once the tool is available for use.