CONNECTED VEHICLE PILOT
Deployment Program

Preparing an Effective Performance Measurement Plan

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ITS Joint Program Office
Agenda

- Purpose of this Technical Assistance Webinar Series
  - To assist early deployers of connected vehicle technologies to conduct Concept Development activities

- Webinar Content
  - Performance Measurement Concepts, Challenges and Potential Solutions
  - Stakeholder Q&A
  - How to Stay Connected

- Webinar Protocol
  - Please mute your phone during the entire webinar
  - You are welcome to ask questions via chatbox at the Q&A Section
  - The webinar will be recorded except the Q&A Section
  - The webinar recording and the presentation material will be posted on the CV Pilots website within a week
CV Pilot Deployment Program Goals

Spur Early CV Tech Deployment

Wirelessly Connected Vehicles

Mobile Devices

Infrastructure

Measure Deployment Benefits

Safety

Mobility

Environment

Resolve Deployment Issues

Technical

Institutional

Financial
Sites Selected – 2015 Awards

ICF/Wyoming

- Reduce the number and severity of adverse weather-related incidents in the I-80 Corridor in order to improve safety and reduce incident-related delays.
- Focused on the needs of commercial vehicle operators in the State of Wyoming.

New York City

- Improve safety and mobility of travelers in New York City through connected vehicle technologies.
- Vehicle to vehicle (V2V) technology installed in up to 10,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.

Tampa (THEA)

- Alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the transportation challenges.
Deployment Schedule

- **Overall Deployment Schedule**
  - Phase 1: Concept Development
    - Creates the foundational plan to enable further design and deployment
  - Phase 2: Design/Deploy/Test
    - Detailed design and deployment followed by testing to ensure deployment functions as intended (both technically and institutionally)
  - Phase 3: Maintain/Operate
    - Focus is on assessing the performance of the deployed system
  - Post Pilot Operations (CV tech integrated into operational practice)

- **Public webinars to share the concept development activities from the three sites**
  - Concept of Operations Webinar (February – March 2016)
  - Performance Measurement Webinar (May – June 2016)
  - Deployment Plan Webinar (August 2016)
Webinar Objectives

- Define and distinguish between performance measurement, system deployment impact evaluation, and independent evaluation
- Establish need for performance measurement and evaluation
- Identify common challenges and issues with performance measurement and evaluation
Performance measurement is a means of assessing the progress made towards attaining established goals.

- Goals can be financial (e.g., cost levels), operational (e.g., reduction in travel time), etc.
- Broad stakeholder consultation required in establishing appropriate and realistic goals.

Performance measurement isn’t only about collecting data but using the data to understand the system.

Performance measurement is a part of an overall transportation system management.
Monitoring and Reporting the Impact of the Deployment

- System deployment impact evaluation conducted by the system deployer is the process of interpreting results to understand the impacts that investments and policies have had on performance
  - Assesses robustness, effectiveness, usability, and acceptance of the application as deployed
Independent Evaluation

- Performance evaluation is conducted by an *independent party* who has no vested interest or stake in the project
  - Evaluation will be projected over time and geographic scope, and for varying market adoption rates of application and driver compliance rates
Motivation

- Provides the basis for evaluating the impacts of the deployed system
- Enables an agency to improve its internal operations
- Allows decision-makers to provide accountability for public expenditure
- Enhances the decision-making process for both short-term and long-term transportation investments
- Helps identify the location and severity of problems (e.g., congestion)
- Provides means to inform the travelling public of the effectiveness of deployed system
- Helps to determine how the transportation system is performing with respect to goals, overall vision and adopted policies
Types of Performance Measures

- **Quantitative performance measures**
  - Provide numerical estimates as an evidence of how a transportation system is performing
  - Enables comparison with established targets to determine progress/regress
  - Usually verifiable and yield similar results for repeated trials (when everything else is kept constant)
  - Can be continuous (e.g., average travel time, average speed, etc.) or discrete (e.g., average vehicle throughput, average person throughput, etc.)

- **Qualitative performance measures**
  - Represent subjective perceptions and satisfaction levels of users or customers
  - Complement quantitative measures to help improve service
  - Examples: user satisfaction, driver compliance, driver frustration
Key Terminologies

- Control group
  - Group that does not receive any treatment
  - Serves as a comparison point to evaluate the magnitude and significance of treatment

- Treatment group
  - Group that receives the treatment or the intervention
  - Exposed to the application or strategy being tested
  - Similar to the control group with respect to all factors except the treatment

- Confounding Factors
  - Variable(s) that completely or partially accounts for the apparent association between an outcome and a treatment
  - Variable(s) other than the independent variables of interest
  - External to experiment; hence, not monitored
  - May result in erroneous conclusions on the impacts of treatment
Common Issues and Solutions

- Performance measures of convenience, not of value
  - Choosing the wrong measures can result in distorted view of the system
  - Solution: Use performance measures that can help to gain insights

- No agreement on what “good” looks like
  - Stakeholders not agreeing on what good performance targets to achieve
  - Solution: Stakeholders need to reach an agreement or consensus on the measures and targets.

- Stovepipe approach to data collection
  - Collecting different types of data (e.g., arterial/freeway data, weather data) with different time resolutions at different time periods and storing in separate databases without integration
  - Solution: A data management process should be developed and multi-source data should be integrated into a common format and database
Data gaps
- Failure in hardware can result in missing data
- **Solution:** Data gaps can be addressed using simple heuristics and imputation techniques

Limited data quality verification
- Limited resources often lead to limited data quality checks and this may result in invalid performance measures
- **Solution:** Both automated and manual data checks necessary

Measurement Uncertainty Due to Equipment
- Wear and tear and environmental conditions may impact the performance of data collection equipment
- **Solution:** Regular calibration will ensure equipment accuracy. Diagnostic checks should be in place to detect equipment failures.
Common Issues and Solutions (cont.)

- Poor experimental design
  - A poor experimental design can lead to flawed analysis and inaccurate representation of the system performance
  - *Solution*: Experimental design must be carefully pre-planned to account for potential confounding factors
Potential Confounding Factors

- Change in weather or unusual weather events
  - Comparisons should be made between similar (adverse/non-adverse) weather conditions
- Construction/work zone activities during pre/post-deployment periods
  - Will alter traffic conditions and traveler behavior
- Unusually high/low crashes or incidents
- Change in travel demand
  - Significant changes will impact the performance measures
- Change in vehicle mix (e.g., size, in-vehicle technology, personal devices)
  - It may affect underlying traffic conditions and traveler behavior
- Change in truck percentage in the vehicle mix
  - Pilot is truck-centric; significant changes in truck percentage will impact performance measurement
Potential Confounding Factors (cont.)

- Concurrent deployment of synergistic or conflicting non-CV Pilot applications
  - Deployment of similar or conflicting applications should be delayed
- Change in on-time delivery criteria
- Changes in fuel prices and economy
  - This may influence traveler behavior and mode choice
- Change or shift in population
- Self-selection of participants
  - Individuals with special interests or motives may introduce bias
- Participants exploiting the limits of applications
  - Taking unnecessary risks
Process for Performance Measurement and Impact Evaluation

- Identify Stakeholders
- Identify Needs
- Define Goals and Objectives
- Identify Performance Measures
- Set Performance Targets
- Develop Evaluation Design
- Acquire and Collect Data
- Verify Data Quality
- Archive Data
- Measure Performance
- Conduct Benefits-Costs Analyses
- Report Performance

Source: Updated Freeway Management and Operations Handbook (DRAFT)
Performance Measurement Methods

- Field data and user survey data
  - Field data (connected vehicle messages and complementary weather, road sensors, signal control data, etc.) provide accurate estimates of system performance when integrated
  - Survey data helps to obtain user perspectives on transportation system
  - Refer Traffic Analysis Toolbox Volume VI for example techniques
- Analytical tools
  - Useful when measures cannot be observed directly
- Sketch planning tools
  - Useful for general order-of-magnitude estimates without in-depth engineering analysis
- Deterministic tools
  - Uses deterministic and static analytical procedures (e.g., HCM)
- Traffic simulation tools
  - Effective in evaluating dynamics of congestion in transportation systems
  - Capable of modeling variability in driver/vehicle characteristics
  - Capable of effectively controlling for confounding factors
Types of Impact Evaluation Designs

- Non-Experimental Design
- Randomized Experimental Design
- Quasi-Experimental Design
Non-Experimental Design

- Has no control group; hence, the weakest design type
- Involves the repeated measurement of one or more indicators (e.g., average vehicle throughput) over a specified time period
  - Time period may include both pre-deployment and post-deployment
- Impact of deployment is assessed by examining any changes in the post-deployment period given the trend in the pre-deployment period
- Does not account for confounding factors
  - May lead to false conclusions
- Examples: Time Series studies, Before/After studies, longitudinal studies
Randomized Experimental Design

- Study subjects are randomly assigned to the control group and the treatment group
- Randomization ensures that control and treatment groups are equivalent with respect to all factors except the deployment and are unbiased
- Control group serves as the “counterfactual” of what would have happened in the absence of the deployment, which is a key requirement in determining whether a deployment caused a particular outcome
- Classic design uses pre-test/post-test design
  - Ensures control and treatment groups are similar in both pre and post-deployment periods
  - Data for each group are collected for both pre-deployment and post-deployment periods
- Provides the most assurance that outcomes are the result of the deployment
Quasi-Experimental Design

- Approximation of randomized experimental design
  - Uses pre-test/post-test design *but no random assignment*

- Control and treatment groups cannot be assumed to be similar
  - Agencies must assess the differences during the pre-test and account for the differences in the analysis
  - An assessment of the characteristics of members of the control and treatment groups is conducted during the pre-test period to determine the differences between the two groups
Potential Solutions for Controlling for Confounding Factors

- Randomized experimental design
  - Pros:
    - Uses real-world data (real subjects)
    - Most effective in controlling for confounding factors
  - Cons:
    - Limited ability to provide system-wide measures
Potential Solutions for Controlling for Confounding Factors (cont.)

- Traffic simulation tools
  - Pros:
    - Can ensure consistency in weather, travel demand, travel patterns, vehicle mix, isolate impacts of construction activities, and applications
    - Provides cost-effective approach to calculating performance measures that cannot be easily measured in the field (e.g., queue length, throughput)
    - Provides system-wide measures
  - Cons:
    - Calibration of the models can be time consuming and expensive
    - Lack of driver behavior models in the presence of connected vehicle technology
    - Uses data generated by virtual environment
Potential Impact Evaluation Design

- Use randomized experimental design with treatment and control groups in both BEFORE and AFTER periods.

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<thead>
<tr>
<th></th>
<th>Pre-deployment (BEFORE)</th>
<th>Post-deployment (AFTER)</th>
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<tbody>
<tr>
<td>Treatment Group</td>
<td>TB1, TB2, ..., TBn</td>
<td>TA1, TA2, ..., TAn</td>
</tr>
<tr>
<td>Control Group</td>
<td>CB1, CB2, ..., CBn</td>
<td>CA1, CA2, ..., CAn</td>
</tr>
<tr>
<td>Randomization</td>
<td></td>
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</tr>
</tbody>
</table>

LEGEND
- TB1, TB2, ..., TBn: BEFORE data collection/measurement pts for treatment grp
- CB1, CB2, ..., CBn: BEFORE data collection/measurement pts for control group
- TA1, TA2, ..., TAn: AFTER data collection/measurement pts for treatment group
- CA1, CA2, ..., CAn: AFTER data collection/measurement pts for control group
Stakeholder Q&A

- Please keep your phone muted
- Please use chatbox to ask questions
- Questions will be answered in the order in which they were received
- This Q&A section will neither be recorded nor posted to the website
Contact for CV Pilots Program:
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Join us for the Getting Ready for Deployment Series

- Discover more about the 2015 CV Pilot Sites
- Learn the Essential Steps to CV Deployment
- Engage in Technical Discussion

February 2016 Webinars

Technical Assistance Webinars

- 2/10/2016, 2:30 – 4:00 pm EST
  SCMS Proof-of-Concept Interface Requirements for Connected Vehicle Deployments

Please visit the CV pilots website for the recording and the briefing material of the previous webinars.

Website: http://www.its.dot.gov/pilots
Twitter: @ITSJPODirector
Facebook: https://www.facebook.com/DOTRITA