NCHRP 03-101

COSTS AND BENEFITS OF PUBLIC SECTOR CONNECTED VEHICLE DEPLOYMENT

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03DEC2014

THE NATIONAL ACADEMIES
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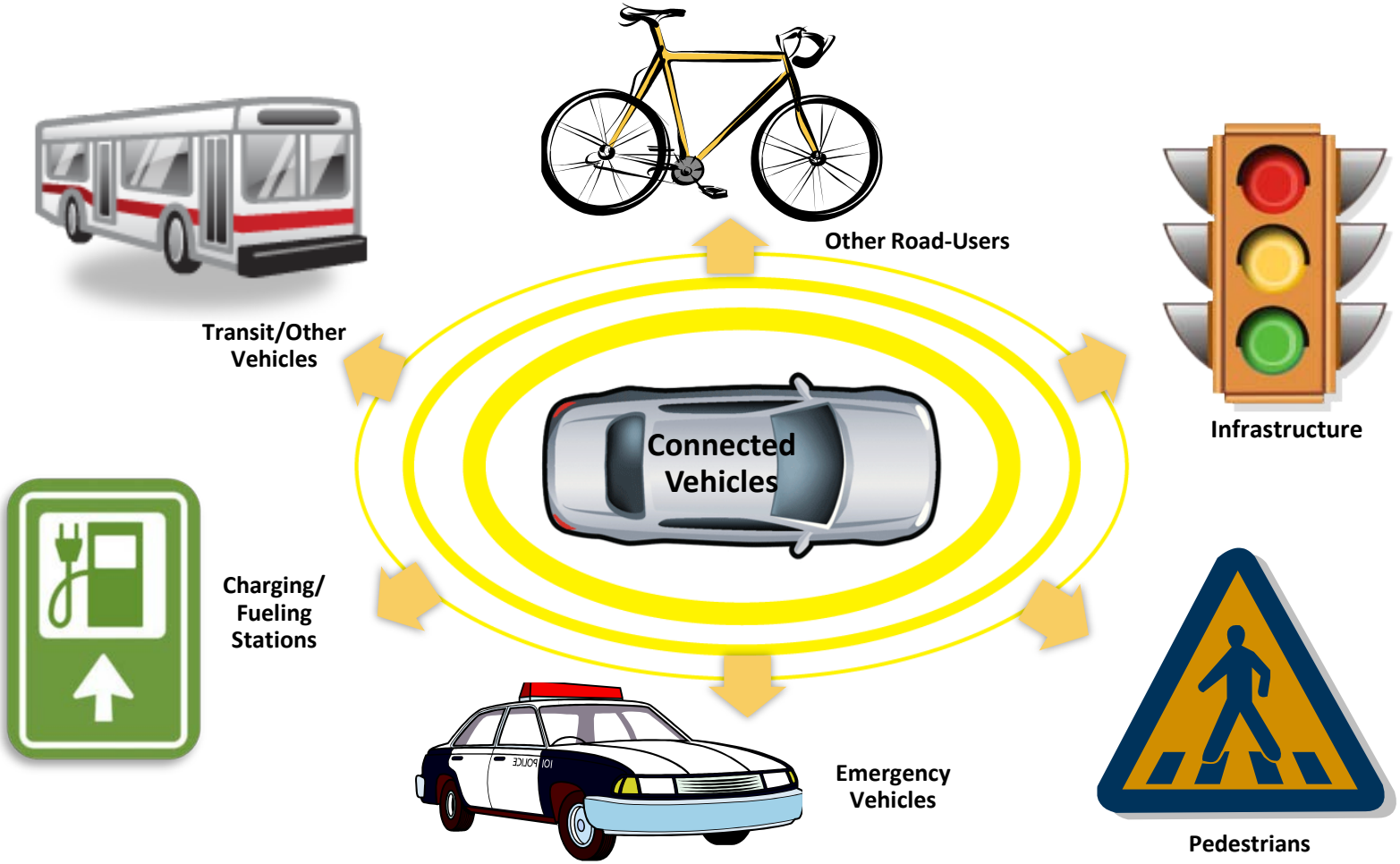
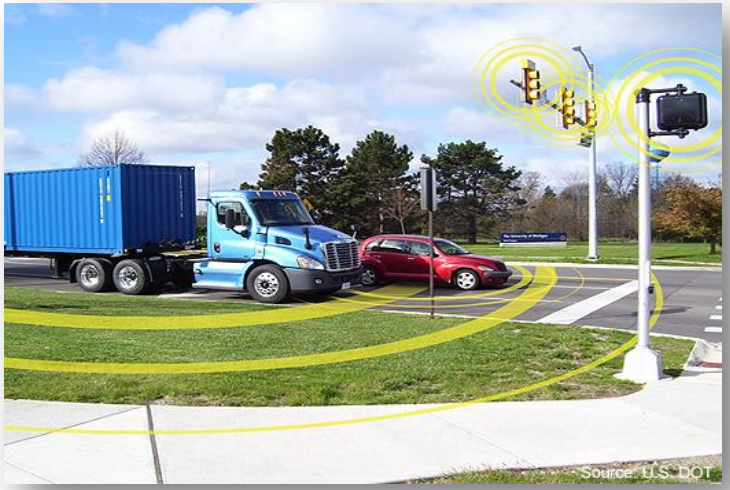
WHAT ARE CONNECTED VEHICLES?



Could potentially address up to 80% of non-impaired driver crash scenarios

USDOT CONNECTED VEHICLE PROGRAM

- Understand how connected vehicle applications work and their potential benefits
- Prepare for USDOT decision on requiring vehicle-to-vehicle (V2V) technology on new vehicles

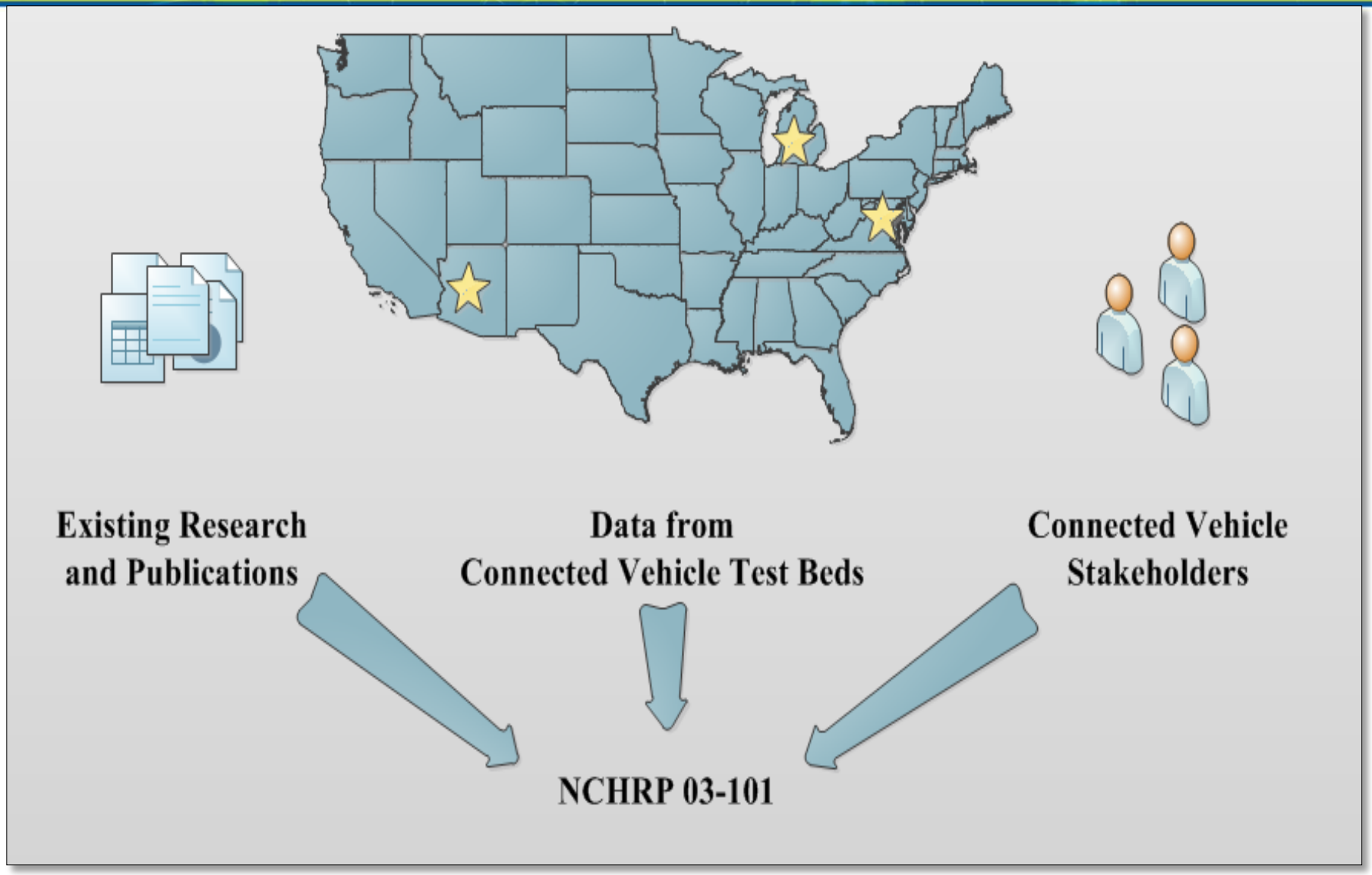


***Goal*: Advance the Connected Vehicle Program to an earliest possible deployment readiness state**

AASHTO'S ROLE

- Developed a Strategic Plan and Action Plan for the Connected Vehicle Program
- Identify departments of transportation (DOT) needs
  - Evaluate and document the benefits and costs of public sector investment in vehicle-to-infrastructure (V2I) technologies
  - Equip agencies to develop deployment plans and justify necessary investments to decision-makers

LEVERAGING EXISTING SOURCE INFO



NCHRP 03-101: ABOUT THE STUDY

- **Purpose**: Describe agency benefits and costs associated with connected vehicle technologies to assist DOTs with deployment decisions
  - Benefits: Safety, Mobility, and Environment
  - Costs: Deployment, Operations, and Maintenance
- **Inputs**:

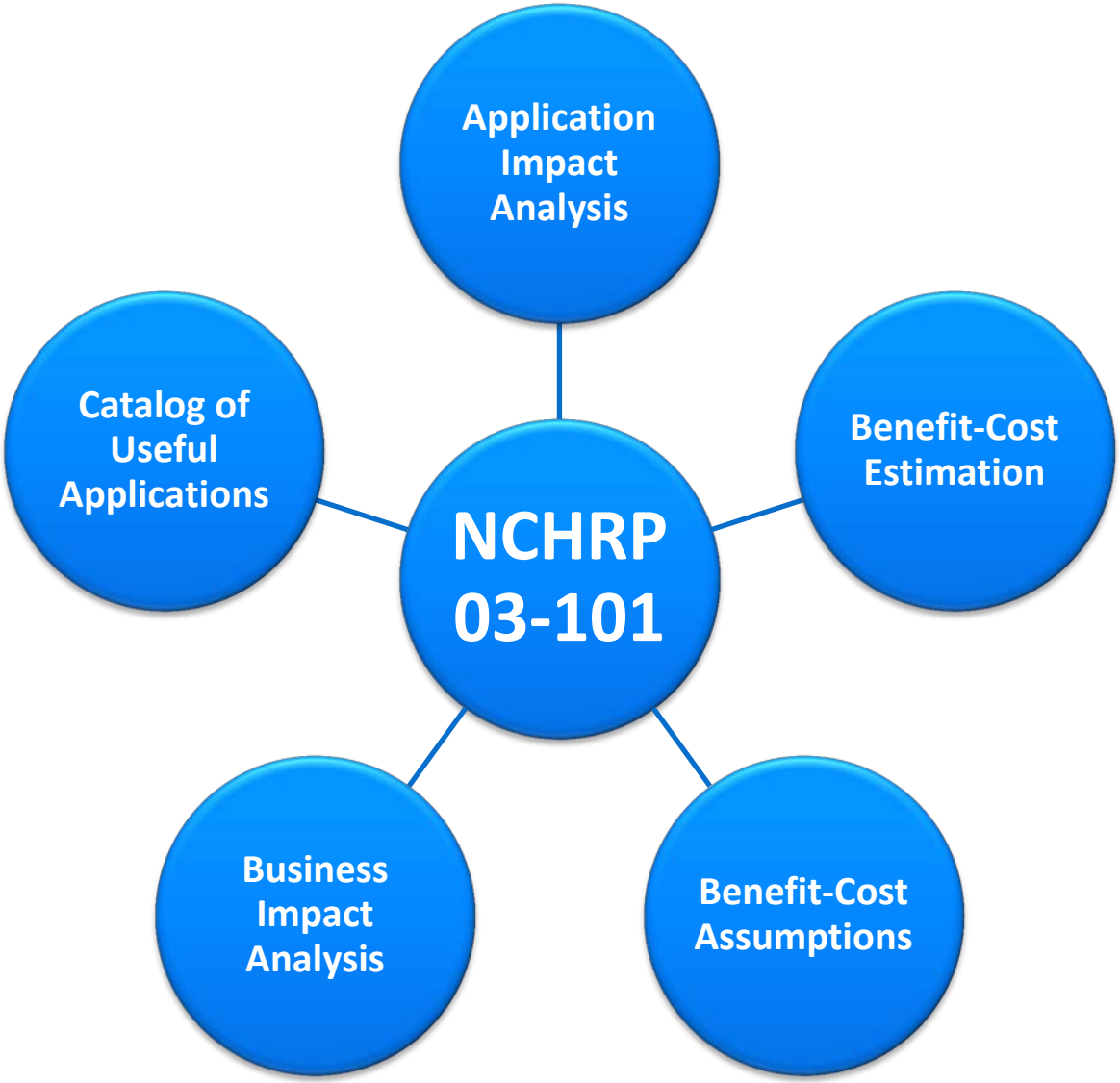
Structured interviews with early adopters

Cost-benefit analyses for three case studies

Connected vehicle deployment guidance

Assessment of DSRC technology readiness to support deployment

NCHRP 03-101: PROJECT OBJECTIVES



NCHRP 03-101: METHODOLOGY

1

Select and Analyze Three Deployments

- Michigan Test Bed
- I-66 (Virginia) Test Bed
- Maricopa Countywide (Arizona) Deployment

2

Collect Data

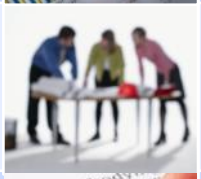
- Actual cost data for each deployment
- Specific benefits related to each deployment

3

Conduct Sensitivity Analysis

- Focus on the most critical factors of the project
- Decide where to invest any additional efforts

NCHRP 03-101: BENEFITS

Quantifiable Benefits		Other Potential Benefits	
	Reduced need for traveler information system infrastructure		Improved access to data for planning studies
	Reduction of traffic monitoring infrastructure		Potential for improved long-term planning, program management
	Lower cost of pavement condition detection		Faster, more cost effective response to public issues/policy change
	Crash response and clean up cost reduction		Ability to measure performance of DOT operations on an accelerated schedule
	Work zone accident clean up and project impact reduction		Cost savings to transit agencies by better optimizing fleet
	DOT vehicle fleet insurance reduction		Reorganization of DOT roles
	Adaptive Lighting		

CASE STUDIES DIRECT MONETARY BENEFITS

- Crash clean up cost reduction
- Work zone accident reduction
- Lower cost of pavement condition detection
- Reduced winter maintenance costs
- Reduction of infrastructure required to monitor traffic

Virginia

Benefit	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Crash clean up cost reduction	$0	$0	$1,538	$3,264	$6,822	$13,830	$26,466	$45,999	$70,017	$92,453	$108,632	$369,021
Workzone accident reduction	$0	$0	$287	$608	$1,271	$2,577	$4,931	$8,571	$13,046	$17,226	$20,240	$68,756
Lower cost of pavement condition detection	$0	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$40,000
Adaptive Lighting	$0	$22,776	$22,776	$22,776	$22,776	$22,776	$22,776	$22,776	$22,776	$22,776	$22,776	$227,760
Reduced need for 511 infrastructure	$0	$0	$0	$0	$0	$0	$0	$0	$0	$61,050	$61,050	$122,100
Reduction of infrastructure required to monitor traffic	$0	$0	$0	$0	$0	$0	$51,300	$102,600	$153,900	$205,200	$256,500	$769,500
Total Benefits	$0	$26,776	$28,600	$30,648	$34,869	$43,183	$109,473	$183,946	$263,739	$402,705	$473,198	$1,597,137

Michigan

Benefit	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Crash clean up cost reduction	$0	$0	$0	$913	$1,937	$4,049	$8,207	$15,706	$27,298	$41,552	$54,867	$154,529
Workzone accident reduction	$0	$0	$0	$181	$385	$805	$1,631	$3,122	$5,426	$8,259	$10,905	$30,714
Lower cost of pavement condition detection	$0	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$10,000
Reduced winter maintenance costs	$0	$1,550	$1,550	$1,550	$1,550	$1,550	$1,550	$1,550	$1,550	$1,550	$1,550	$15,500
Reduction of infrastructure required to monitor traffic	$0	$8,792	$8,792	$8,792	$8,792	$8,792	$8,792	$8,792	$8,792	$8,792	$8,792	$87,915
Total Benefits	$0	$11,342	$11,342	$12,436	$13,663	$16,195	$21,180	$30,170	$44,066	$61,152	$77,114	$298,658

Maricopa County

Benefit	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Crash clean up cost reduction	$0	$241,869	$505,570	$1,024,922	$1,961,358	$3,408,957	$5,188,903	$6,851,622	$8,050,601	$8,763,335	$9,139,394	$45,136,530
Workzone accident reduction	$0	$62,306	$130,236	$264,022	$505,250	$878,155	$1,336,674	$1,764,994	$2,073,854	$2,257,456	$2,354,330	$11,627,280
Lower cost of pavement condition detection	$0	$59,000	$59,000	$59,000	$59,000	$59,000	$59,000	$59,000	$59,000	$59,000	$59,000	$590,000
Transportation Management Systems Saving	$0	$0	$0	$0	$0	$0	$0	$532,000	$585,200	$643,720	$708,092	$2,469,012
Total Benefits	$0	$363,175	$694,806	$1,347,945	$2,525,608	$4,346,112	$6,584,577	$9,207,616	$10,768,655	$11,723,511	$12,260,817	$59,822,822

CASE STUDIES NON-RECURRING COSTS

- Program Oversight
- RSE-equipment buys
- Installation
- Comm set-up
- Integration
- Testing
- Incidentals

CASE STUDIES RECURRING COSTS

- On-going oversight
- Maintenance

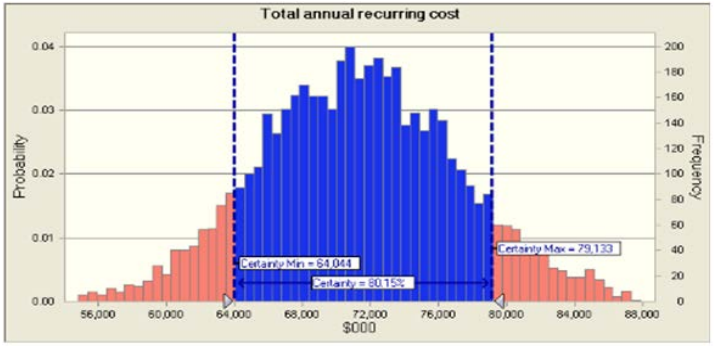
Case study allocations based on equipment costs

Virginia ~12.5%

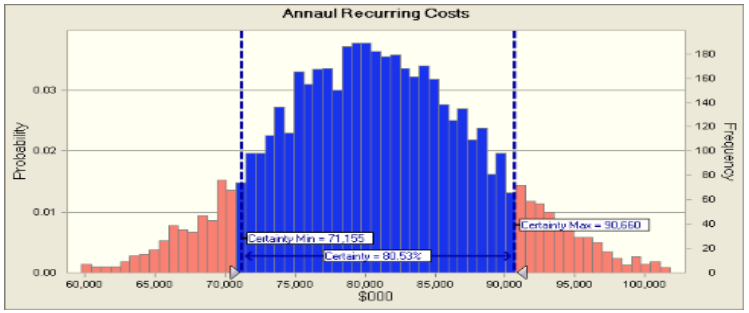
Michigan ~3.5%

Maricopa ~15%

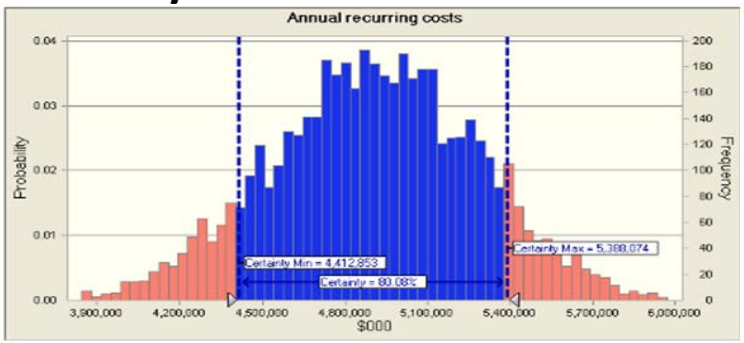
Virginia



Michigan



Maricopa County



CASE STUDIES RSE NUMBERS & UNIT COSTS

Case Study	Number of RSEs	Initial Cost (per unit)	80 Percentile Range of Recurring Costs (per unit)	
			Low	High
Michigan	50	$17,360	$1,430	$1,813
Virginia	55	$12,327	$1,157	$1,435
Maricopa County	2,680	$11,940	$1,646	$2,012

CASE STUDIES RSE HW-SW-INSTALL COSTS

Hardware

- RSEs
- Signal Phase and Timing (SPaT) Listener
- RSE trailers
- Back end servers

+

Software

- RSE Monitoring System (RMS)
- Security Credential Management System (SCMS)
- SPaT Messaging
- Data management systems

+

Installation

$11,000 - $20,000 per installation

$1,200 - $2,000 annual recurring costs

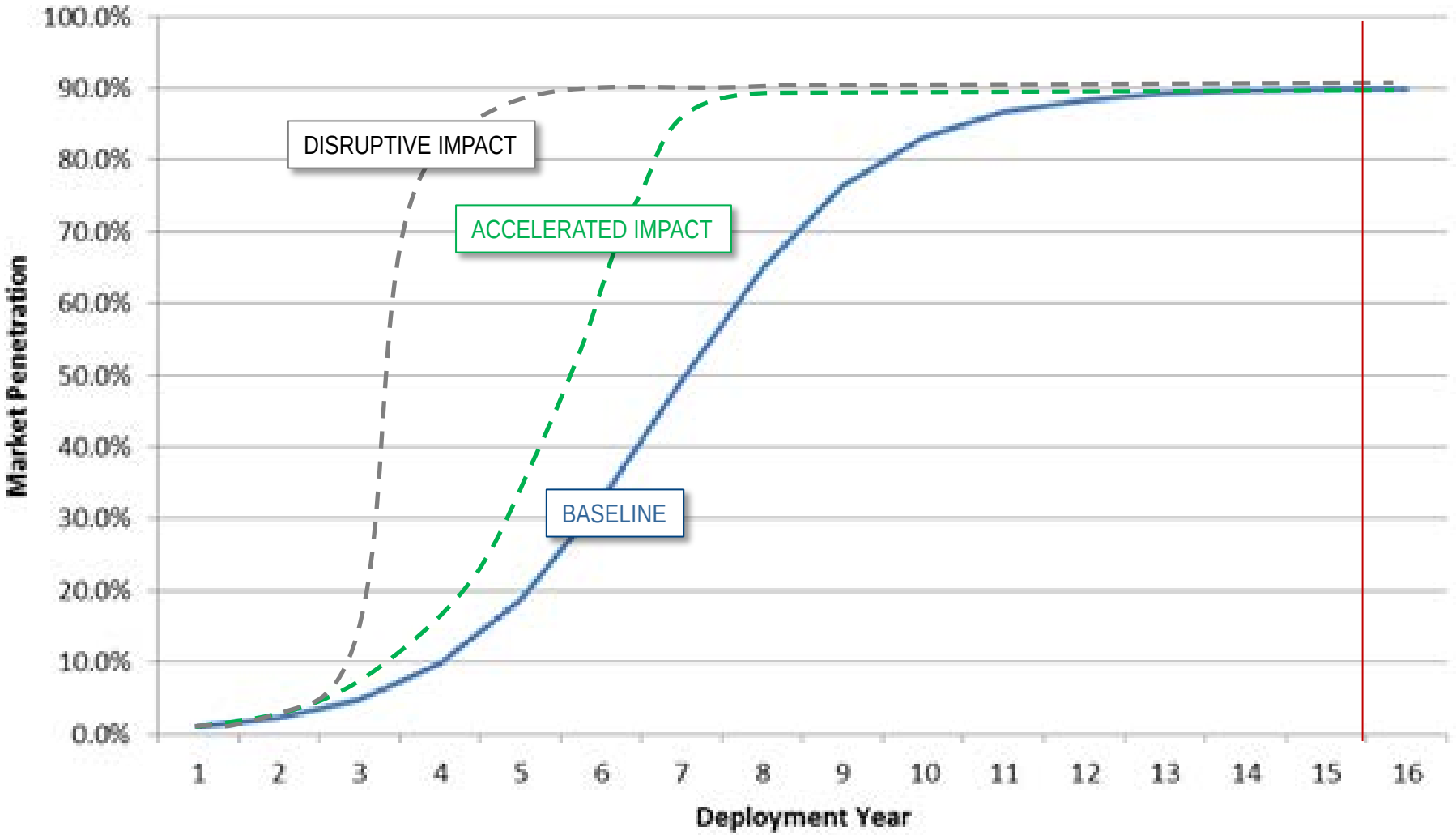
GLOBAL ASSUMPTIONS

- Crash response and cleanup costs have a mean of $500 and a range between $200 and $5,000
- The average cost associated with a work zone accident is $3,687 based on previous studies
- Accident reduction from connected vehicles technology is modeled as a singled side normal distribution with a
  - maximum value of 26% at full market penetration of DSRC technology equipped vehicles
  - minimum value of 10% representing the assumption of a crash reduction of up to 26%
- Market Penetration of DSRC technology will reach 90 percent in 15 years

SPECIFIC ASSUMPTION REFERENCES

Assumption	Value	Reference
Accident Rate Reduction	Up to 26%	Najm, W.G., Koopmann, J., Smith, J.D., & Brewer, J. (2010). Frequency of Target Crashes for IntelliDrive Safety Systems. Washington, DC: United States Department of Transportation.
Accident Response and Cleanup costs	Crash requiring a single police officer generally costs $200 for the officer while a crash that requires fire/EMS costs an average of $800. Assume each occur with equal frequencies.	The Florida Senate Issue Brief 2009-303: Cities and Counties Charging “Accident Responses” Fees to Drivers and Insurers.
Average Cost of Work Zone Accidents	$3,687	Determining the major causes of highway work zone accidents in Kansas, Yong Bai, Ph.D., University of Kansas, October 2007.
Market Penetration Curve		This is based conversations with AASHTO members at the November 19th 2012 meeting in Pittsburgh, PA on the potential of a mandate for DSRC technology in new vehicles, and on the rate of new vehicle replacements derived from NADA data.
Virginia I-66 Connected-Vehicle Test Bed Backhaul Costs	Backhaul setup costs: $1,956 Annual recurring backhaul costs: $846	U.S. Department of Transportation, Research and Innovative Technology Administration, Task 3 Draft Report: Modeling of Promising Options for Secure Communications Data Delivery Systems, Booz Allen Hamilton, September 2012.
Maricopa County RSE Installation and Backhaul Costs	Various	Arizona Emergency Vehicle Infrastructure Integration: Field Demonstration Evaluation and Benefit-Cost Analysis; Soyoung Ahn, Ph.D., Srivatsav Kandala, and Douglas Gettman; January 21, 2010.

90% MARKET PENETRATION ASSUMPTION



NCHRP 03-101: COST-BENEFIT ANALYSIS

VDOT Test Bed Cost-Benefit Results

Costs	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Net Benefit/Cost	-668	-44	-42	-40	-36	-27	39	113	193	332	403	223

Michigan Cost-Benefit Results ($K)

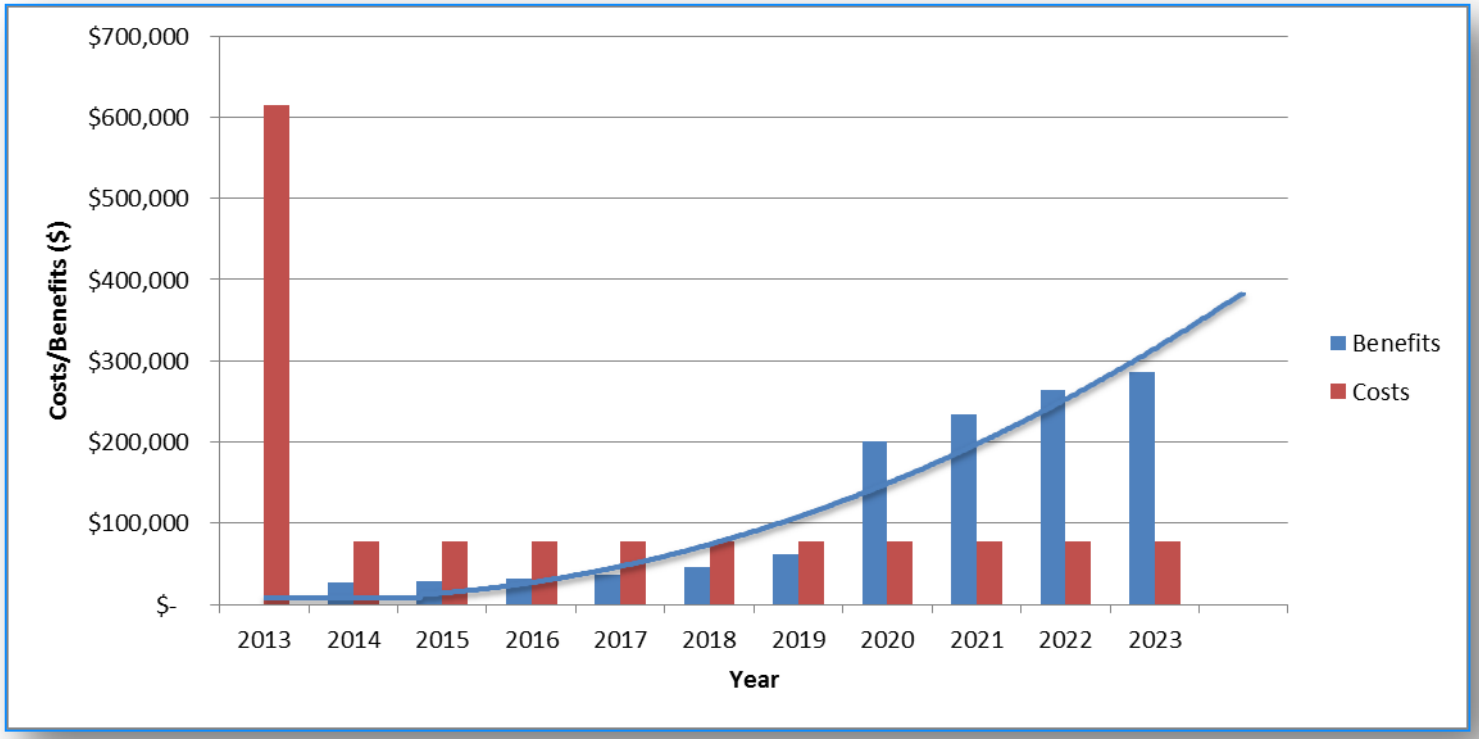
Costs	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Net Benefit/Cost	-868	-69	-69	-68	-67	-64	-59	-50	-36	-19	-3	-1,372

Maricopa County Region Cost-Benefit Results

Costs	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Net Benefit/Cost	-31,718	-4,594	-4,262	-3,609	-2,432	-611	1,627	4,250	5,811	6,766	7,304	-21,467

REDUCING AND OFFSETTING COSTS TO DEPLOY

- RSEs will be become less costly through maturing technology, competition, and mass production
- As concentration of connected vehicles increases, benefits can offset the operational expense required to maintain the RSE and some initial capital investment



THE VALUE OF DEPLOYMENT

- ✓ Reduce crash response and cleanup costs
- ✓ Reduce work zone accidents
- ✓ Lower cost of pavement condition detection
- ✓ Produce savings related to traveler information systems or traffic monitoring systems
- ✓ Improve agency business practices

Benefits will gradually offset a significant portion of the annual cost, and over time produce savings that outweigh annual operations and maintenance costs

THE RISK OF FORGOING DEPLOYMENT

- Loss of time to ramp up on potential infrastructure needs in the event of a positive NHTSA ruling
- Miss out on benefits related to:
  - Safety
  - Mobility
  - DOT operations/asset management
  - Data collection and analysis
  - Environment
  - Safety is the area that connected vehicles will most impact

Current technology and operations methods in the field will become obsolete – connected vehicle technology may replace these methods

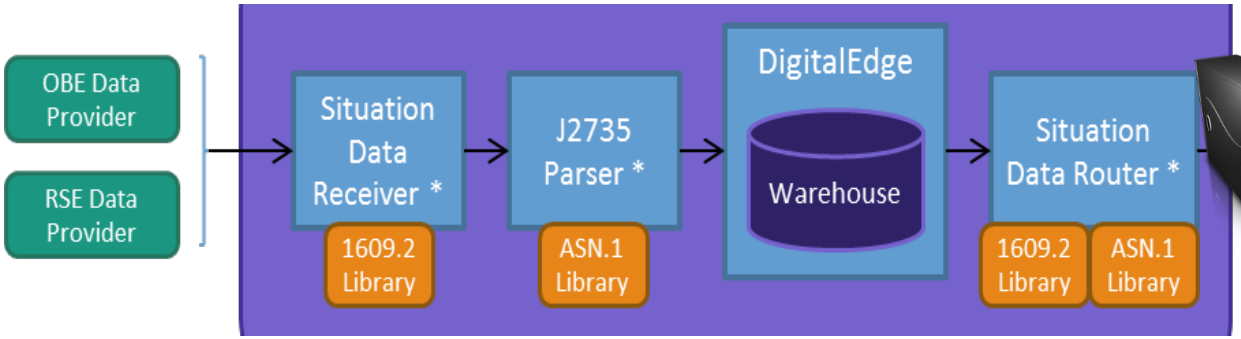
ACCELERATING CV ADOPTION

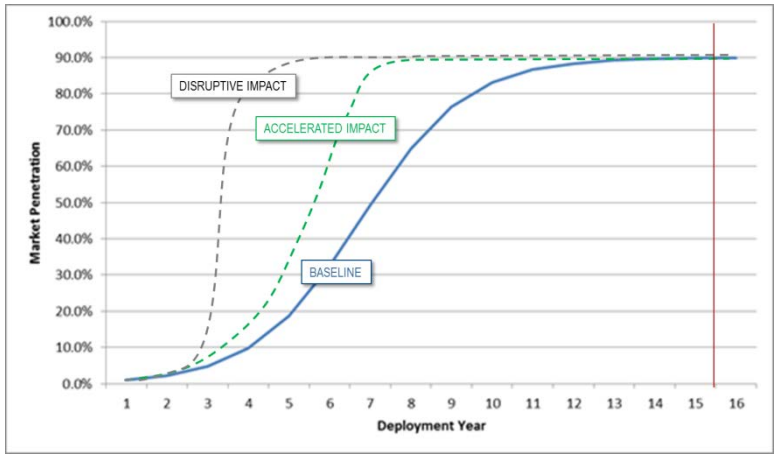
Launching new services that leverage CV technology that consumers pay for receiving the benefit enabling proliferation and self-sustainment

- Freight dispatching and in-transit visibility
- Critical infrastructure security
- Roadway signage communications
- Parking
- Airport ground services

DISRUPTIVE CV ADOPTION

CV Situation Data Warehouse





OBD-2

~190-200 Million Licensed Drivers

~150-160 Million Smartphone Users

NEW CONSIDERATION

Evaluate the potential benefit and potential issues associated with the transmission of probe and safety messages from hand-held mobile devices via cellular communications and compile and describe current and emerging technology trends influencing the role of mobile devices within the context of a connected vehicle deployment

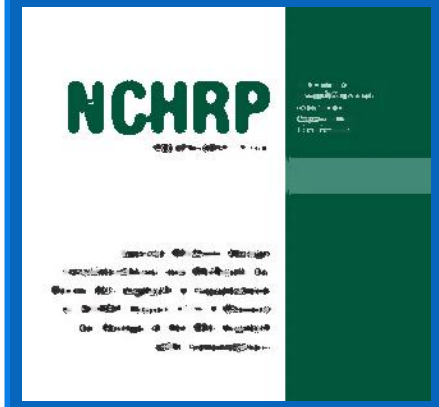
FINAL REPORT – NEW CHAPTER ADD

Chapter 6: Cellular Considerations

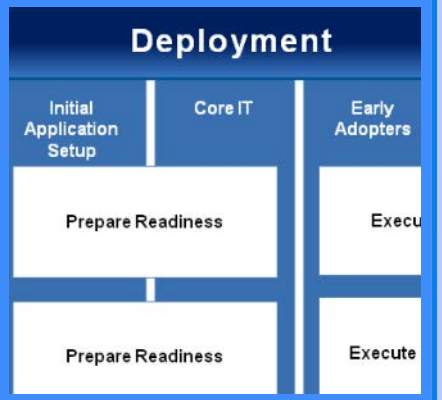
Describe the Operational Concepts and Costs for a Cellular Communication Approach in Connected Vehicle Applications

- Investigate/describe the OEM models for the cellular/Connected vehicle approaches (e.g. GM describes theirs as the "Connected Consumer")
- Investigate/describe the carrier models for cellular/connected vehicle approaches (look at impacts of HERE, INRIX, others)
- Investigate/describe current data storage and "common software interface" model to see if compatible with industry approaches
- Investigate/describe cost centers for cellular communications, i.e. capitol, operational, maintenance for agencies
- Provide examples on possible operational scenarios for agencies using cellular for the V2I applications

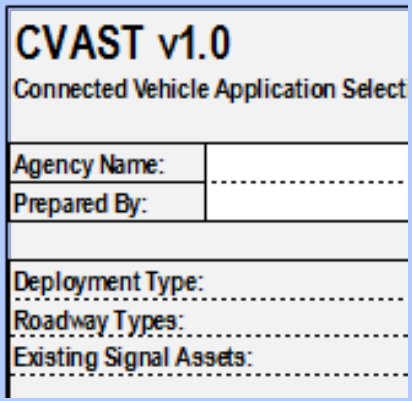
AVAILABLE RESOURCES



NCHRP Final Report



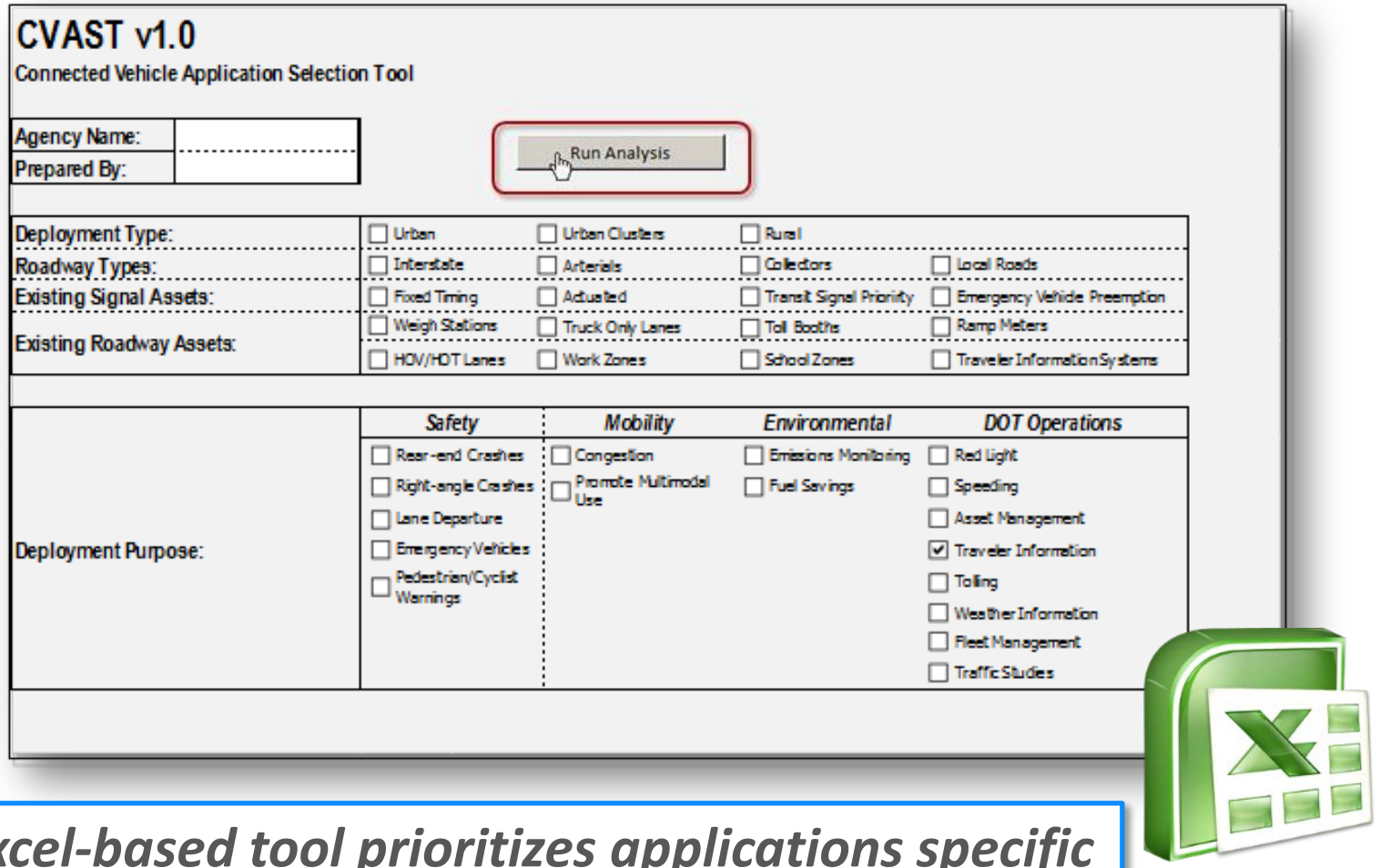
Deployment Plan



CVAST v1.0 Tool

Deployment Guidance

CVAST V1.0 – APPLICATION SELECTION TOOL



Excel-based tool prioritizes applications specific to needs and interest of the deploying agency.

FOR MORE INFORMATION

- TRB NCHRP Reports - http://www.trb.org/Publications/PubsNCHRPProjectReports.aspx
- AASHTO Subcommittee on Systems Operations and Management - http://ssom.transportation.org/Pages/default.aspx
- USDOT ITS Joint Program Office Connected Vehicle Research - http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm

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