An Evaluation on the Economic Feasibility and Implementation of Virtual Dynamic Message Signs

Alona Green
Morgan State University
MATS UTC 2015
July 30, 2015

Agenda

- Connected Vehicle Technology (CVT)
- Traditional Dynamic Message Signs (TDMS)
- TDMS Funding and Maintenance
- Virtual Dynamic Message Signs (VDMS)
- VDMS Cost Analysis
- Cost Calculation
- Cost Calculation Examples
- Cost Comparison
- Conclusion

Connected Vehicle Technology (CVT)

- **Connected Vehicles** are a system of interoperable network of communication between vehicles, infrastructures, and motorists.
  - Dedicated Short Range Communication (**DSRC**)
  - Relies on in-vehicle or aftermarket products to relay information

- Main Goals:
  - **Reduction:** vehicle crashes, traffic operator tasks, delays, etc.
  - **Increase:** safety, mobility, fuel efficiency, etc.

Connected Vehicle Technology (CVT)

- Two categories of CVT:
  - Vehicle-to-Vehicle (V2V)
  - Vehicle-to-Infrastructure (V2I)

FIGURE 1: Illustration of V2I information broadcasting.

Traditional Dynamic Message Signs (TDMS)

- **Dynamic Message Signs (DMS)** : traffic control devices that display warnings and alerts to drivers.
  - Permanent
  - Portable

- **Uses:** incident management, route diversion, weather warnings, notice of special events, lane and ramp control, travel times, etc.

FIGURE 2: A traditional DMS sign with a ramp closing advisory message.

Traditional Dynamic Message Signs (TDMS)

- Current Issues:
  - Excessive braking
  - Speed reduction
  - Legibility distance / Line of sight
  - Lack of credibility / Ignorance
  - Comprehension issues
  - Language barriers
  - Flashing/Multi-Phase Sign Comprehension Issues
  - <u>Expensive to implement, maintain, and operate.</u>

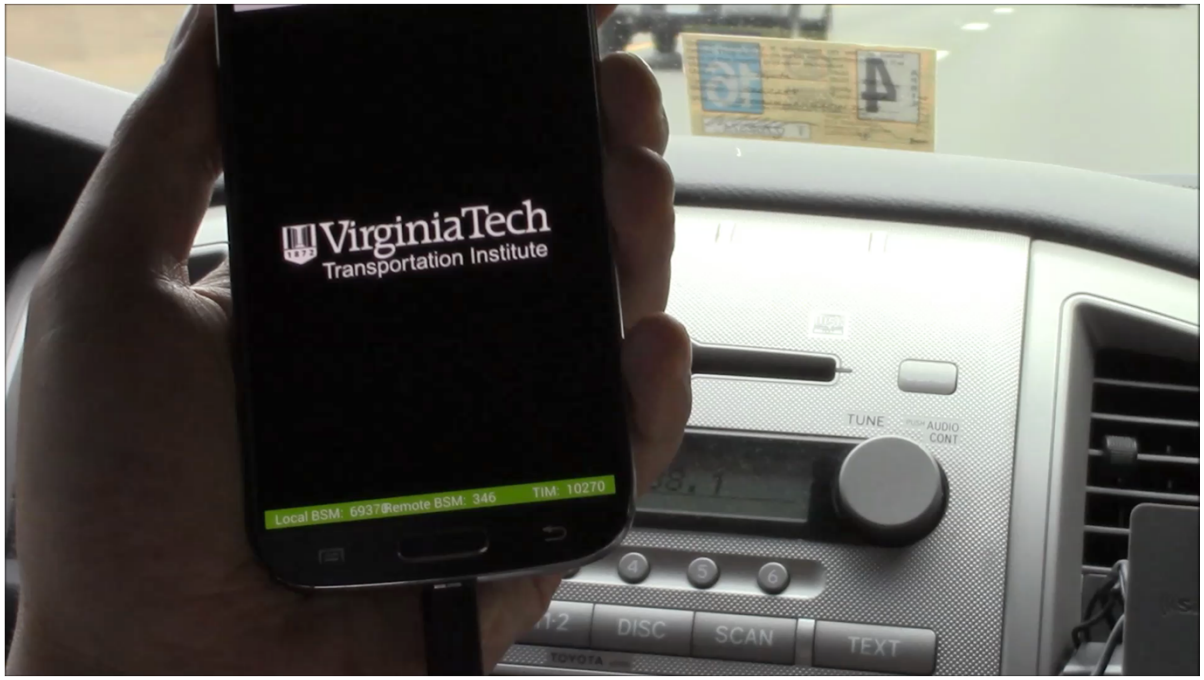
TDMS Funding and Maintenance

- Most TDMS signs are funded through the federal **Congestion Mitigation and Air Quality (CMAQ)** Improvement Program.
  - Use for state/local transportation projects that reduce mobile emissions
    - Transit improvements
    - ITS/traffic flow improvements

- Maintenance:
  - Obstructions, water intrusion, leaks, structure corrosion, ventilation, communication tests, power diagnostics, etc.

Virtual Dynamic Message Signs (VDMS)

- **VDMS:** converts TDMS messages into an audible message through a smartphone application.
  - Use of V2I technology
  - Broadcasted from roadside equipment (RSE)



Virtual Dynamic Message Signs (VDMS)

Issues

- Gaining driver confidence/acceptance
- Gaining DoT Acceptance
- Multi-Agency Cooperation
- Access issues to those without smartphones
- Rural Accessibility

Benefits

- Reduction: driver distraction, need for braking, traffic generation
- Increase: safety, mobility, message comprehension, maximum amount of words in a message
- Wider range of accessibility / communication
- Language Versatility
- Congestion Management
- Improved, real-time traffic data
- Financially superior to TDMS, while being as effective.

VDMS Cost Analysis

- Cost Analysis:
  - Traditional Vs. Virtual DMS Systems
  - Localized Benefits (I-66)
  - Statewide Benefits (Virginia)

- Assumptions:
  - Full state funding for RSEs
  - Each operator controls 8 DMSs
  - There are 190 functional permanent DMS in Virginia (2013)
  - 15 Year Project Plan: 2015-2029

Cost Calculation

- Non-Recurring Costs:
  - Capital Costs
    - Equipment/Hardware
    - Rentals for Construction
    - Installations
    - Development

- Recurring Costs:
  - Operations and Maintenance (O&M)
    - Employee Salary
    - Annual/Routine Maintenance

Cost Calculation Example (TDMS)

Category	Overall Task	Material / Task Type	Description of Use	Capital Cost Per Unit (USD)	Unit Measurement	Number of Units	Cost Type	Total Cost of Task/Element (USD)
Non-Recurring Capital Costs	Hardware/Equipment	DMS Sign	DMS are used to relay information of current situations to drivers on the roadway.	$108,500.00	--	8	Actual	$868,000.00
		Concrete Foundation	Structural support made of concrete.	$34,081.30	--	8	Estimate	$272,650.40
		Steel Structure Support	Overhead steel gantry for DMS mounting.	$81,600.00	--	8	Actual	$652,800.00
		Fiber Optic Communication Wireline	Physical communication and power connection.	$135,000.00	Per Mile	2	Actual	$270,000.00
		DMS Controller	Furnish and installation	$14,108.67	--	8	Bid Tabulation	$112,869.36
		Conduit Pull Box	A metal box installed to run conduits and the pulling of wires and cables.	$506.00	--	8	Actual	$4,048.00
		Spare Parts Kit	Spare parts for maintenance purposes.	$7,274.79	--	8	Bid Tabulation	$58,198.32
	Subtotal							**$2,238,566.08**

Table 1: Example portion of a cost calculation for non-recurring capital costs for TDMS.

Cost Calculation Example (VDMS)

Category	Overall Task	Material / Task Type	Description of Use	Capital Cost Per Unit (USD)	Unit Measurement	Number of Units	Cost Type	Total Cost of Task/Element (USD)
Non-Recurring Capital Costs	Development	Research Work	Researching Grant	$100,000.00	--	1	Estimate	$100,000.00
		Project Development	Funds to develop a prototype for a DOT	$300,000.00	--	1	Estimate	$300,000.00
	Subtotal							$400,000.00
	Operations and Maintenance	Software Training	Median Salary of VDOT Control Room Operator	$100,000.00	Years	1	Estimate	$100,000.00
Recurring Costs		Operator Labor	Salary of VDOT Control Room Operator Using VDMS	$34,000.00	Years	15	Estimate	$510,000.00
	Subtotal							$610,000.00
Total Cost for Test Area (8 DMS, One Operator)								$1,010,000.00
Total Statewide Cost (190 DMS, 24 Operators)								$13,250,000.00

Table 2: Cost Calculation for non-recurring and recurring costs for a VDMS system.

TDMS/ VDMS Cost Comparison

Test Area Existing Permanent DMS Signs	8	Total Existing Permanent DMS Signs in VA (2013)	190
Estimated Traditional Cost	$5,724,828.75	Estimated Traditional Cost	$129,472,683.44
Estimated VDMS Cost	$1,010,000.00	Estimated VDMS Cost	$13,250,000.00
Estimated Savings	$4,714,828.75	Estimated Savings	$116,222,683.44
Cost Ratio	5.668147277	Cost Ratio	9.771523278

Table 3: TDMS/VDMS Cost Comparison for Localized and Statewide Regions

Conclusion

- VDMS has several benefits over TDMS
  - Cost Effective
  - Little to No Maintenance Required
  - Can be used in areas with high congestion or accident rates
  - Wider Range of Accessibility for Broadcasting
  - Accurate, Real-Time Traffic Data
  - Versatile

- Values can be updated in future years to reflect newly published cost data

Questions?

References

1. *Costs Database Overview.* U.S. Department of Transportation. <http://www.itscosts.its.dot.gov/>
2. *Vehicle to Infrastructure Interaction (V2I).* Muegyetem: Department of Mechatronics, Optics, and Mechanical Engineering Informatics. <http://www.mogi.bme.hu/TAMOP/jarmurendszerek_iranyitasa_angol/math-ch09.html>
3. *Dynamic Message Sign Maintenance and Testing Procedures*. U.S. Department of Transportation. *<https://www.dot.nd.gov/divisions/maintenance/docs/DMS-Maintenance and Testing Procedures.pdf.>*