

Wireless Roadside Inspection Phase II Final Report



U.S. Department of Transportation
Federal Motor Carrier Safety Administration

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FOREWORD

The Federal Motor Carrier Safety Administration (FMCSA) Wireless Roadside Inspection (WRI) Program is demonstrating the feasibility and value of electronically assessing truck and motorcoach driver and vehicle safety at least 25 times more often than is possible using only physical roadside inspections. WRI Pilot Tests were conducted to prototype, test, and demonstrate the feasibility and benefits of electronically collecting safety data messages (SDMs) from in-service commercial vehicles and performing WRIs using three different communication systems.

The results of this program have been used in conjunction with the results of complementary independent evaluations to support an overall assessment of the feasibility and benefits of WRI in enhancing motor carrier safety (reduction in crashes) due to increased compliance (change in motor carrier and driver behavior) caused by conducting frequent safety inspections electronically, at highway speeds, without delay or need to divert into a weigh station. This WRI Phase II final report is intended to capture and summarize the key results of interest to stakeholders as they review the benefits and costs of WRI and assess whether and how to support further development and testing and, potentially, deployment. This final report addresses the following topics:

- Introduction and Overview.
- Description of WRI and this project.
- WRI Pilot Test Results.
- Evaluation Goals and Methods.
- Findings and Assessments.

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SI* (MODERN METRIC) CONVERSION FACTORS

TABLE OF APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yards	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	1,000 L shall be shown in m ³ milliliters	ml
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or "metric ton")	mg (or "t")
TEMPERATURE				
°F	Fahrenheit	$5 \times (F-32) \div 9$ or $(F-32) \div 1.8$	Temperature is in exact degrees Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
Force and Pressure or Stress				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

TABLE OF APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
TEMPERATURE				
°C	Celsius	$1.8C + 32$	Temperature is in exact degrees Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
Force & Pressure Or Stress				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003, Section 508-accessible version September 2009.)

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ABBREVIATIONS AND ACRONYMS

Acronym	Definition
ALPR	automated license plate recognition
BASICs	Behavioral Analysis and Safety Improvement Categories
CDL	commercial driver's license
CDLIS	Commercial Driver's License Information System
CMRS	commercial mobile radio services
CMV	commercial motor vehicle
CSA	Compliance, Safety, Accountability
CVII	Commercial Vehicle Infrastructure Integration
CVISN	Commercial Vehicle Information Systems and Networks
CVSA	Commercial Vehicle Safety Alliance
DMCU	DSRC Mobile Communication Unit
DSRC	dedicated short-range communication(s)
ELD	electronic logging device
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulation
FOT	field operational test
FY	fiscal year
GHz	gigahertz
GOS	Government Office System
HOS	hours of service
ID	identification
L&I	License & Insurance
LPR	license plate reader
LTCCS	Large Truck Crash Causation Study

Acronym	Definition
MCMIS	Motor Carrier Management Information System
MHz	megahertz
NAS	North American Standard
ORNL	Oak Ridge National Laboratory
POA&M	plan of action and milestones
POC	Proof of Concept
PRISM	Performance and Registration Information Systems Management
RF	radio frequency
RSDM	Roadside Safety Data Message
SDM	Safety Data Message
SMS	Safety Measurement System
UCR	Unified Carrier Registration
USDOT	U.S. Department of Transportation
VIN	vehicle identification number
WRI	wireless roadside inspection

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EXECUTIVE SUMMARY

For a commercial vehicle today, the likelihood of undergoing a physical safety inspection is far less than undergoing a weight inspection. When inspections do occur, it is very likely that a violation will be found. According to Federal Motor Carrier Safety Administration (FMCSA) statistics for FY 2012,⁽¹⁾ more than 3.2 million roadside inspections were conducted, with an out of service (OOS) rate of approximately 20 percent. This can be contrasted with the number of weight measurements taken (more than 200 million, including both static scales and weigh-in-motion) and violations detected (less than 1 percent).⁽²⁾ Increased safety inspections would be expected to substantially improve compliance, and, consequently, also substantially improve commercial motor vehicle (CMV) safety. Commercial vehicle roadside safety inspections represent one of the most effective tools for monitoring and regulating the condition of the in-use commercial vehicle fleet, as well as for auditing and enforcing driver and operational-related safety practices, including hours of service (HOS), proper driver credentialing, and other safety aspects of commercial vehicle equipment and operations. New technologies such as advanced sensor and onboard diagnostics as well as wireless communications offer the potential for dramatically improving the effectiveness and efficiency of the roadside commercial vehicle safety inspection process.

This report provides a summary of the results of the Wireless Roadside Inspection (WRI) Program Phase II Pilot Testing, where the objective was to prototype, test, and demonstrate the WRI system using different communication methods and to demonstrate its operational feasibility. The results of this phase of the effort demonstrate the capability to increase commercial vehicle inspections and to potentially realize significant improvement in commercial vehicle safety without increasing the burden on enforcement or compliant operators.

WRI is designed to follow processes similar to physical safety inspections, but it does so electronically. As a commercial vehicle travels, it encounters a predetermined WRI location at which a roadside transceiver, a license plate reader (LPR) system or “geofence boundary” is located. Rather than detour the CMV into a physical weigh station, public sector entities (e.g., officers, inspectors, and systems) issue an electronic request for driver and CMV compliance data without impeding the vehicle’s travel.

Similar to a driver providing log books to an inspection official at the roadside, with WRI the vehicle, or perhaps the motor carrier office system, compiles driver hours-of-service data and vehicle condition sensor data and delivers the data electronically through wireless and/or Internet communications to the government WRI system. This all takes place while the vehicle travels on its route at highway speed, avoiding lines and delays at weigh stations.

The Phase II pilot tests demonstrated that the WRI pilot was successful in delivering real-time data to assist in automated inspections. In many ways, each of the pilot test platforms operated independently during the testing. Though there were many technical, operational, and implementation challenges, the lessons learned from the tests demonstrated that these challenges could be overcome, and they set the stage for the next phase of development and implementation.

This pilot test evaluated three platforms, all in imperfect test environments based in Tennessee, Kentucky, and New York. The CMRS (TN) platform produced the most data, but also encountered data delivery challenges and relatively long latency times. The Universal ID (KY) platform produced some desirable results, but included manual steps that proved untenable, and the automated license plate recognition (ALPR) system was unsuitable in poor weather situations. DSRC (NY) produced very limited results and did not connect with the GOS. Moreover, the data were not formatted in a way that could be accepted by the GOS. Nonetheless, the limited performance was promising and worthy of further investigation. Finally, the GOS's strict data validation requirements presented many challenges with accepting and processing data from all platforms. Even in the context of a pilot test with active partners, the data formatting was complicated and it proved difficult to provide successful inspections. An expanded test that includes less-engaged partners would require much more simplified data formatting and processing requirements.

This phase of the effort has identified broad policy, technical, and legal/statutory issues that face FMCSA in moving forward with WRI. The major issues that are recommended for consideration include outstanding policy issues, regulatory and legal/statutory issues, U.S. Department of Transportation (USDOT) system and technical issues, and system security and privacy issues.

Concerning outstanding policy issues, the results of this phase of the investigation demonstrate that there are multiple technically feasible communication methods that could support WRI. Decisions having budget and policy implications are necessary moving forward, including selection of communication approach(es), incorporation into field operations, use of inspection data by the CSA SMS, and carrier recruitment as discussed below.

Concerning USDOT system and technical issues, WRI is a complex system of systems that exchanges data between multiple existing government and private systems. A number of system and technical issues in establishing secure, reliable communications would need to be addressed to move forward with WRI, including WRI System Standards and Compatibility, Integration of GOS with FMCSA Infrastructure Systems, and support for key operational scenarios.

Lastly, concerning system security and privacy issues, Phase II of the WRI program highlighted a number of security issues that must be addressed prior to moving forward to a field test or national implementation. These include privacy concerns on the part of motor carriers and drivers, the need to authenticate system users, and addressing outstanding recommendations from FMCSA's Security Team.

Cost-benefit evaluation was performed to develop comprehensive estimates of the societal costs and benefits of the WRI program. FMCSA identified two sources of potential benefits from WRI: safety benefits from reducing the number of CMV crashes, and cost savings from avoidance of needed repairs from infrastructure damage caused by overweight large trucks. Safety benefits are associated with the detection of violations to the Federal Motor Carrier Safety Regulations (FMCSRs) when the occurrence of a violation corresponds to the cause of a crash. Two types of costs are included in this analysis: costs associated with the deployment of WRI technology and the cost to motor carriers to increase compliance with the FMCSR and applicable State regulations. The cost-benefit analysis evaluated eight policy options for WRI encompassing

two different methods for transmitting data, DSRC and CMRS, and the following four types of SDM:

- WRI Low is the most basic alternative, comprising a minimal SDM. Under this alternative, available information in the SDM is limited to the unique identification of the carrier, vehicle, and driver (driver license country, jurisdiction, ID, and date of birth; tractor vehicle identification number (VIN); tractor unit number; tractor license plate country, jurisdiction and ID; carrier USDOT number; carrier name; trailer/equipment unit number; and trailer/equipment license plate country, jurisdiction, and ID).
- In the WRI Medium alternative, a report from the electronic logging device (ELD) would supplement the data captured in WRI Low, including all hours-of-service (HOS) logbook information.
- In addition to identification and ELD data, the WRI High alternative would include in the SDM a reading of in-vehicle weight sensors to assess compliance with weight regulations; additional onboard sensors to assess the status of brakes, lighting, and safety belts; and readings of tire pressure and temperature and vehicle location.
- A fourth alternative, WRI Medium + Weight, would add to the WRI Medium configuration only the information from onboard weight sensors.

Since the subset of regulatory violations that could be identified through a “Level WRI Inspection” defined for purposes of this program depends solely upon the contents of the SDM, the alternatives discussed above would afford the identification of a progressively broader set of violations, with the exception of WRI Medium + Weight, which is a hybrid of the WRI Medium and WRI High configurations.

Certain options for deploying WRI appear to have a positive net societal benefit, while others do not. Due to the high cost of the 5.9 GHz transmitters needed for each CMV and the accompanying receivers required by enforcement personnel, DSRC does not exhibit positive net benefits even with the best possible safety outcome. However, large positive net benefits are associated with on-vehicle weight sensors due to their bringing cost reductions from damage to roadway infrastructure that are much greater than the cost of the sensor technology. These specific net benefits are large enough to yield positive net benefits if coupled with the DSRC WRI medium configuration. The results for the analysis of CMRS were qualitatively the same, except that without the expense of DSRC transmitters and receivers, the CMRS medium option could provide a positive net benefit.

WRI is a complex system of systems that exchanges data between multiple existing government and private systems. While a number of system and technical issues in establishing secure, reliable communications would need to be addressed, no fundamental technological obstacles were found that would prevent the successful further development and deployment of WRI. The implementation of WRI used in Phase II is not sufficiently mature for deployment; however, the technical challenges moving forward could be addressed through careful and skilled engineering analysis and design. A great deal was learned in the Pilot Test effort that could be applied moving forward to revise, simplify, reduce cost, and improve benefits to the level at which WRI would be mature and ready for nationwide deployment and implementation. Perhaps the greatest

challenges moving forward would be institutional, in terms of building the collaboration and support of Federal and State agencies and motor carriers to implement the interfaces and communication between government and private systems that support reliable and secure implementation.

1. INTRODUCTION

The Federal Motor Carrier Safety Administration (FMCSA), in cooperation with its partners and customers, strives to reduce crashes, injuries, and fatalities involving large trucks and buses. A key element of FMCSA's safety strategy is the roadside safety inspection program wherein commercial vehicles are physically inspected for compliance with laws and regulations intended to ensure safe operations. Truck numbers and mileage grow each year, but roadside safety inspection resources remain constant. Augmenting the current roadside physical inspection program with wireless inspection in which the compliance of driver and vehicle with safety regulations is verified electronically, while the commercial motor vehicle (CMV) travels at highway speed, is intended to increase compliance and safety performance, as well as improve motor carrier efficiency, without increasing the burden on either enforcement or compliant operators.

For a commercial vehicle today, the likelihood of undergoing a physical safety inspection is far less than being weighed. When inspections do occur, it is very likely that a violation will be found. According to FMCSA's statistics for fiscal year (FY) 2012,⁽¹⁾ more than 3.2 million roadside inspections were conducted, with a violation rate of approximately 69 percent. This can be contrasted with the number of weight measurements taken (more than 200 million, including both static scales and weigh-in-motion) and violations detected (less than 1 percent).⁽²⁾ Increased safety inspections would be expected to substantially improve compliance, and, consequently, also substantially improve CMV safety.

As stated in FMCSA's request for information on new commercial vehicle safety inspection concepts:⁽³⁾

“Commercial vehicle roadside safety inspections represent one of the most effective tools for monitoring and regulating the condition of the in-use commercial vehicle fleet, as well as for auditing and enforcing driver and operational-related safety practices, including hours of service, proper driver credentialing, and other safety aspects of commercial vehicle equipment and operations. New technologies such as advanced sensor and onboard diagnostics as well as wireless communications offer the potential for dramatically improving the effectiveness and efficiency of the roadside commercial vehicle safety inspection process.”

This report incorporates additional analyses outside of the pilot tests. The results of this phase of the effort demonstrate the capability to increase commercial vehicle inspections and to potentially realize significant improvement in commercial vehicle safety without increasing the burden on enforcement or compliant operators. The remainder of this introduction summarizes WRI concepts, its benefits, and this pilot testing phase. Subsequent sections of this report provide more detailed descriptions of the pilot testing and their conclusions and resulting recommendations. References are provided for more detailed and comprehensive reports on the Phase II testing and independent evaluation.

1.1 WIRELESS ROADSIDE INSPECTION CONCEPTS

Of the hundreds or even thousands of CMVs that approach a typical weigh/inspection station in a given shift, each inspector may select only 6 to 10 CMVs for a thorough safety inspection. New WRI technologies and enforcement strategies could dramatically increase the number of times a CMV and its driver are examined without the need to detour into a weigh station, leading to better-targeted enforcement, safer operations, and reduced numbers of truck and bus crashes.

Today a vehicle is selected for inspection based on resource availability (e.g., whether an inspector is available, parking area at inspection site, traffic flow), safety history (e.g., safety fitness rating, date of last inspection), and other screening criteria (e.g., weight, visual observation of a potential problem). This approach relies heavily on the inspector's intuition, training, experience, and professional judgment. A safety inspection may take 30 to 60 minutes to complete, limiting the number that an officer can conduct in a day, and possibly preventing the CMV and driver from reaching their destination on schedule.

According to the Large Truck Crash Causation Study (LTCCS),⁽⁴⁾ 56 percent of fatal truck crashes are linked to a truck driver-related crash factor. Today's inspection selection process does not generally consider the active driver's condition or history. The WRI process would enable automated assessment of driver hours of service (HOS) as well as carrier- and vehicle-specific factors to facilitate better use of limited enforcement resources.

In a WRI, public sector entities (e.g., officers, inspectors, and systems) electronically request driver and CMV compliance-related data from onboard electronic equipment. The vehicle, and perhaps the motor carrier owner office system, compile driver HOS data and vehicle condition sensor data and deliver the data through direct wireless and/or Internet communications to the government WRI system, all while the vehicle maintains its planned route and highway speed. The system conducts an assessment against a set of WRI criteria and electronically issues a WRI report on the truck and driver to the requesting entity and to the motor carrier for full system transparency. If enforcement officers receive a negative WRI result, they may use WRI data in screening to determine whether to pull the vehicle in for further scrutiny, use it to supplement a traditional inspection, use it to trigger interception, or choose to take no action. Data from the WRI assessment process could be used in the Compliance, Safety, Accountability (CSA) Program Safety Measurement System (SMS) for motor carriers and drivers, managed by FMCSA. WRI supports multiple enforcement activities including real-time screening, inspection selection, and traditional inspection processes as well as non-real-time interdictions.

WRI is based on the fundamental precept that inspections encourage compliance with safety regulations and that compliance improves safety. Safe motor carrier operations benefit the traveling public and society at large. Whether physical or wireless, the expectation of frequent inspections is expected to encourage motor carriers and drivers to maintain compliance and operate more safely. Furthermore, compliant and safe motor carrier operations are considered to be cost effective for the trucking industry and for enforcement as a whole. While some operators fail to comply in an attempt to gain competitive advantage, such actions increase overall cost due to crashes, injuries, and fatalities, as well as increasing the cost burden for enforcement.

Many of today's trucks are equipped with sensors that monitor system performance characteristics in real time and are also equipped with electronic logging devices (ELDs—previously known as electronic onboard recorders) that help drivers comply with the HOS regulations. Also, many equipped vehicles have onboard communication systems that relay data to motor carrier operations centers for fleet management and maintenance purposes. This existing and growing commercial base of technology could support WRI with minimal incremental cost, thus supporting the rapid implementation of the WRI system and rapid capture of its benefits.

1.2 BENEFITS OF WIRELESS ROADSIDE INSPECTION

WRI could benefit enforcement, Federal, State, and local agencies, the CMV industry, and society at large. The overall benefits of WRI include improved CMV safety and corresponding reductions in crashes, property damage, injuries, and fatalities. Safety benefits also support improved mobility for the trucking industry and the traveling public by reducing congestion and delay caused by crashes, as well as reducing environmental emissions and energy use. WRI has the potential to enhance motor carrier productivity by reducing likelihood of physical inspection for participants leading to reduced delays in delivery, as well as reduced fuel use and emissions. WRI could potentially provide credit for positive inspections and safe operations, enabling safe, compliant motor carriers to better demonstrate an accurate view of their safety performance. The benefits of WRI are explained in more detail in later sections in this report.

Cost-benefit evaluation identified two sources of potential benefits from WRI: safety benefits from reducing the number of CMV crashes, and cost savings from avoidance of needed repairs from infrastructure damage caused by overweight large trucks. Safety benefits are associated with the detection of violations to the Federal Motor Carrier Safety Regulations (FMCSRs) when the occurrence of a violation corresponds to the cause of a crash. Some options considered for WRI appear to have a positive net benefit, while others do not. Analysis demonstrates that a WRI containing unique identification of the carrier, vehicle, and driver, a report from the ELD including all HOS logbook information, and onboard weight sensor data could provide a net positive benefit. More details are provided in a later section of this report.

1.3 WIRELESS ROADSIDE INSPECTION PROGRAM

FMCSA has developed a multi-year roadmap for the WRI Program and has organized the program into three major phases with critical “go/no-go” decision points after each. The three phases are:

- Phase I—Proof of Concept Test (Technical Concept Development and Verification).
- Phase II—Pilot Test (System and Strategy Definition).
- Phase III—Field Operational Test (Finalize Deployment Strategies and Impacts).

The program team collaborated with private-sector onboard equipment and service providers to complete a proof-of-concept test in August 2007. This report addresses the results of the WRI

Program Phase II Pilot Test (System and Strategy Definition). The third phase is planned as a field operational test of WRI, operating on multiple fleets across multiple State jurisdictions.

1.4 WIRELESS ROADSIDE INSPECTION PILOT TEST

This phase of the WRI Program has supported prototyping three different WRI communication methods and a WRI government office system (GOS) as well as testing and demonstrating all four in CMV operations. The four pilot tests conducted were:

- New York Dedicated Short-Range Communication (DSRC) WRI Pilot Test.
- Tennessee Commercial Mobile Radio Services (CMRS) WRI Pilot Test.
- Kentucky Universal Identification (Universal ID) WRI Pilot Test.
- GOS Pilot Test, supporting operations in all three States.

Together the pilot tests were designed to assess the feasibility of the WRI strategy and the ability of the prototyped WRI system to support screening, assessments, and interdiction by inspectors and enforcement. The results of the pilot test program have been used in conjunction with the results of complementary independent evaluations to support an overall assessment of the feasibility and benefits of WRI in enhancing motor carrier safety (reduction in crashes) due to increased compliance (change in motor carrier and driver behavior) caused by conducting frequent safety inspections electronically, at highway speeds, without delay or need to divert into a weigh station.

1.5 PURPOSE OF THIS REPORT AND INTENDED AUDIENCE

This document is intended as a summary of the results of the WRI Program Phase II Pilot Test for stakeholders. This phase of the investigation has leveraged the efforts of dozens of stakeholders and generated thousands of pages of results and analysis. This report is intended to capture and summarize the key results of interest to stakeholders as they review the benefits and costs of WRI and assess whether and how to support further development and testing and, potentially, deployment.

This report draws liberally and directly from a number of WRI resources in addition to the four pilot tests, an independent evaluation of the pilot tests, a cross-cutting analysis, and a cost-benefit analysis. As such, this report is a product of the efforts of the entire WRI Phase II Team. The sources and resources for this summary include the following key WRI Program and Phase II reports:⁽⁵⁻¹⁴⁾

- Concept of Operations (ConOps) for Wireless Roadside Inspection, Baseline V1.0, The Johns Hopkins University Applied Physics Laboratory.
- Wireless Roadside Inspection Phase II–New York DSRC WRI Pilot Test Final Report, New York State Department of Transportation.

- Wireless Roadside Inspection Phase II–Tennessee CMRS WRI Pilot Test, Final Report, Oak Ridge National Laboratory.
- Wireless Roadside Inspection Phase II–Kentucky Universal Identification WRI Pilot Test Final Report, University of Kentucky Transportation Center.
- Wireless Roadside Inspection Phase II–Government Office System, WRI Pilot Test Final Report, The Volpe National Transportation Systems Center.
- Wireless Roadside Inspection Phase II–Cross-Cutting Evaluation, The Volpe National Transportation Systems Center.
- Wireless Roadside Inspection Phase II–WRI Cost-Benefit Analysis, FMCSA.
- Wireless Roadside Inspection Phase II–Evaluation Final Report, University of Tennessee for the National Transportation Research Center, Inc.
- Wireless Roadside Inspection Phase II–WRI System Requirements Document (Pre-Pilot Test), Battelle for the National Transportation Research Center, Inc.
- The Johns Hopkins University Applied Physics Laboratory (JHU/APL), Wireless Roadside Inspection Interdiction Options Draft D3, published via NSTD-L-26059, Laurel, MD, January 2010.

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2. WIRELESS ROADSIDE INSPECTION PROGRAM OVERVIEW

The WRI program consists of three major phases described in the following subsections.

2.1.1 Phase I Proof of Concept

In August 2007, as part of Phase I, a Proof of Concept (POC) Test was conducted. The POC tested technology to validate the wireless inspection concept (i.e., collecting driver, vehicle, and carrier information; formatting a SDM from the information, and wirelessly transmitting the SDM to enforcement). Phase 1A of the POC testing (testing the ability to generate and format the SDM) involved a roundtrip route of a CMV from Knoxville, TN, to London, KY, to Ringgold, GA, and back to Knoxville. Phase 1B of the POC testing (testing of the transceiver's ability to transmit and receive the SDM) was conducted at inspection stations on I-81 (TN), I-40 (TN), and I-75 (KY). The successful completion of Phase I allowed the WRI team to move forward with the WRI pilot test for Phase II.

2.1.2 Phase II Pilot Test

The second phase of the WRI program, the subject of this report, involved conducting pilot tests for multiple communication paths in multiple locations. The Pilot Test goal was to test three different communication pathway concepts—DSRC, CMRS, and Universal ID—one each in New York, Tennessee, and Kentucky, respectively. These communications paths represent existing and new technologies currently in use or being tested in related programs such as the Commercial Vehicle Information Systems and Networks (CVISN) program, the Performance and Registration Information Systems Management (PRISM) Program, the Commercial Vehicle Infrastructure Integration (CVII) Program, and the USDOT Connected Vehicle Program. In addition to the three State pilot test platforms, the WRI program developed a prototype Federal GOS that accepted SDM information from each State pilot test and issued WRI reports. This Phase of the effort collected data to evaluate and support the following criteria for moving forward with WRI:⁽²⁰⁾

- At least one of the proposed technology/network options is feasible and supports the operational scenarios in a cost-effective manner.
- Based on performance, specific technology/network recommendations can be made for further development, and shortcomings can be identified.
- At least one of the proposed technologies is feasible and cost effective.
- A set of potential interdiction strategies is shown to be feasible and agreed upon by stakeholders.
- Inspection trigger points can address multiple vehicles under varying conditions.
- Projected costs of the system are within a reasonable budget.

- Benefit assumptions are validated, including increased inspection rates, improved inspection support, improved carrier productivity, and positive safety credit given to carriers for more inspections.
- All technical assumptions are valid, and no technical barriers are present.
- Performance of the system (network and field) meets acceptable operating thresholds.
- Stakeholders/user community support further development.

2.1.3 Phase III Field Operational Test

The decision to proceed to the Phase III field operational tests will come from a “go/no-go” decision that will be made in part from evaluation results from the Phase II Pilot Tests. If activated, Phase III of the WRI system would involve a wider deployment of WRI system infrastructure in more locations, with significant increases in participation among various stakeholders.

3. WIRELESS ROADSIDE INSPECTION PILOT TEST

This section builds upon the general context provided earlier and provides more details concerning WRI communication paths and data flow as demonstrated and tested in the WRI Phase II Pilot Test. The following subsections present a description of each pilot test. As the central element common to all components, the GOS pilot is described first, followed by the State pilot tests. Additional information on these end-to-end flows can be found in the WRI Concept of Operations.⁽⁵⁾

3.1 GOVERNMENT OFFICE SYSTEM PILOT

The prototype GOS was essentially a processing unit for receiving and identifying SDMs from Federal, State, and motor carrier systems via the Internet. During the WRI pilot test, the objectives of the prototype were to:

- Receive and validate motor carrier SDMs: HOS data, driver ID, carrier ID, vehicle ID, and vehicle measures and status.¹
- Assess the SDMs for compliance with FMCSRs.
- Report results to carriers and States.
- Support follow-up data analysis by the WRI Pilot Test Evaluation Team.

As delineated in the May 2010 WRI Concept of Operations,⁽⁵⁾ SDMs related to a specific vehicle, driver, or carrier were transmitted to the GOS at various inspection trigger locations. The GOS prototype included a basic interface to provide a view for carriers and service providers of roadside data and WRI results, as well as a view for FMCSA and State agencies of data pertinent to carriers operating within their jurisdictions, WRI results, and stored data for analysis. The GOS interacted with a number of external systems, including motor carrier, third party (telematics provider), and State GOS.

Figure 1 depicts an overview of the GOS prototype and the systems with which it interacted. The external systems that provided input to the GOS are shown on the left side of the diagram; those that received outputs from the GOS are shown on the right. During the pilot test, the interaction with FMCSA safety systems and databases was simulated by using data snapshots of these systems.

¹ During the pilot test, data on vehicle measures and status were not provided in any SDMs received by the WRI GOS.

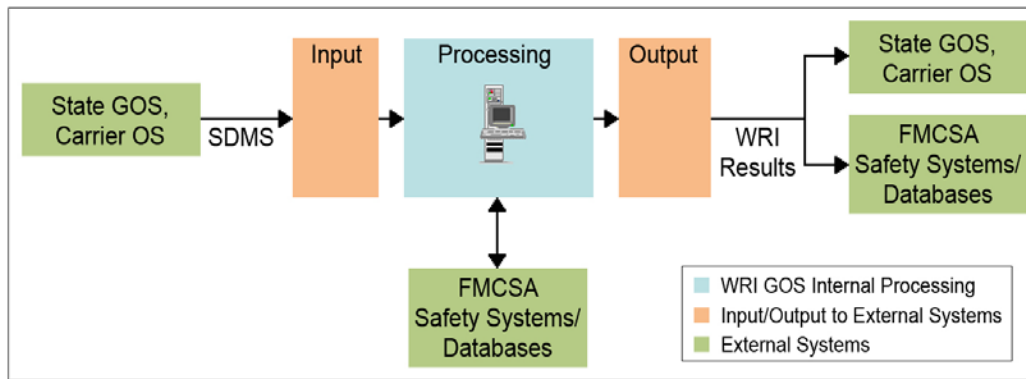


Figure 1. Flowchart. Overview of WRI GOS Prototype.

Communication with external systems during the pilot test was limited to:

- Federal systems via the Federal Intranet infrastructure (database snapshots).
- External State systems to send acknowledgments and WRI results.
- External carrier systems to receive SDMs and send acknowledgments or validation error messages. For the Kentucky Universal ID platform, communications included sending emails to carriers' registered email addresses.
- Third-party systems to accept WRI Reports and other messages.

The functionality of the GOS included receiving and validating SDMs and relaying an acknowledgment, processing SDMs to generate WRI results, providing data for analysis, and providing a simple user interface for program evaluators. The GOS prototype was designed to serve three main operational roles for WRI:

- Provide a greater quantity of data for inspection records. Under a fully operational program, these data would be sent to FMCSA databases and incorporated in the same form as traditional inspection records.
- Provide safety alerts to the appropriate State and Federal agencies should WRI results indicate an imminent safety issue. (This operational role was not implemented during the pilot test.)⁽²⁾
- Store data for future analysis of safety trends and patterns of behavior in the industry.

One of the most significant tasks in standing up the GOS was the integration of the various systems from the three test platforms, each utilizing a different communication method. From the perspective of the GOS, the pilot test can be logically divided into two phases: the Integration and Test Phase and the Data Collection Phase. The purpose of the Integration and Test Phase was to provide a period of time where the platforms would be able to interact with the GOS and

² Safety alerts were not generated because the necessary Federal and State systems did not have the ability during the test to receive the alert messages electronically; however, safety alerts were displayed in the GOS user interface.

test their integration code. This phase began on July 1, 2010, and ended on August 31, 2010, although integration efforts continued throughout the pilot test. The second phase, the Data Collection Phase, was intended to collect the SDMs and generate results that would be used to evaluate the success of the WRI Pilot Test. This phase began on September 1, 2010, and continued through January 31, 2011.

3.2 NEW YORK DSRC PILOT TEST

The New York DSRC pilot to test the WRI application was a subset of activities of the larger CVII initiative conducted by the New York State DOT, Intelligent Imaging Systems, and Volvo Technology. For the WRI task, Volvo and Intelligent Imaging Systems developed and tested in-vehicle technologies to communicate with roadside infrastructure. The New York State DOT managed the installation and integration of infrastructure with the State GOS.

The New York Pilot Test was an implementation of the DSRC concept, using the State's CVII system as a test bed. The CVII initiative includes the development and testing of four CVII Use Cases including Driver Credential Verification, which requires a CMV driver's credentials to be validated prior to allowing a parked vehicle to be started; and Wireless Vehicle Safety Inspection, which develops and demonstrates a CVII application that performs a moving WRI of a CMV. Driver credential verification includes acceptance testing with an off-line, stationary CMV. Wireless Vehicle Safety Inspection includes a series of highway-speed tests of CMVs delivering WRI data to the roadside, to the State GOS, back to the roadside, and then back to the CMV. The main communication components include an onboard DSRC Mobile Communication Unit (DMCU) that communicates with the roadside and compiles an SDM, the State GOS simulator that simulates a State GOS that validates SDM information and generates an inspection report, and serves as a communication link with the Federal GOS, and finally the WRI Roadside Equipment that provides the communication link between the State GOS and the DMCU. During this test, the onboard data were simulated and the State GOS was also simulated. There was no link to the Federal GOS. Figure 2 illustrates the communication pathways between the main hardware components.

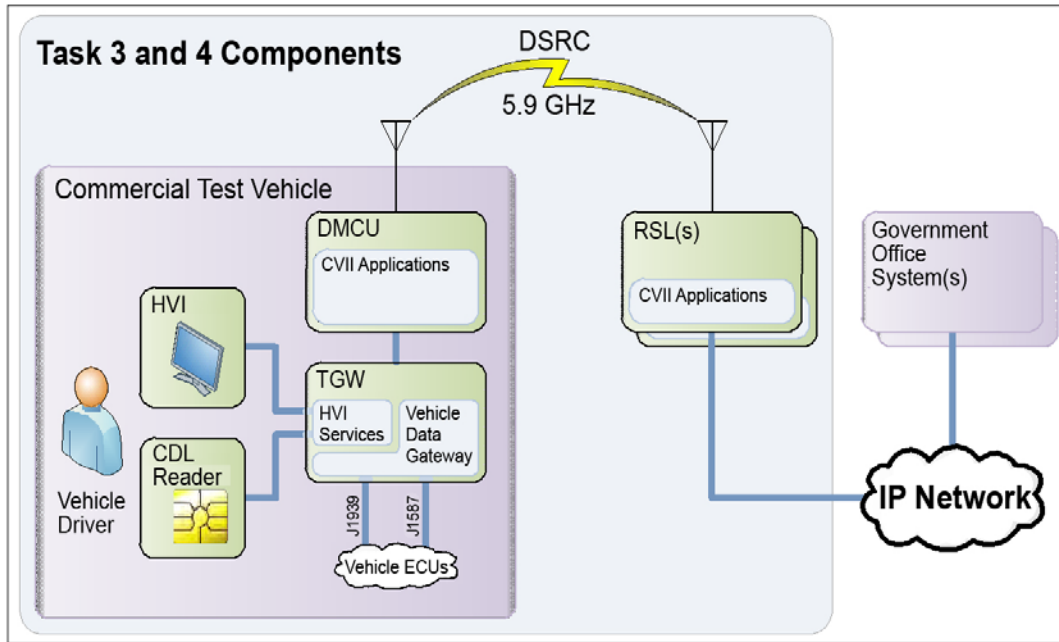


Figure 2. Diagram. New York DSRC System Components and Communication Pathways.

3.3 TENNESSEE CMRS PILOT TEST

The Tennessee Pilot Test was an implementation of the CMRS concept. The participants and stakeholders for the WRI CMRS pilot test effort included management and facilitation by Oak Ridge National Laboratory (ORNL); GOS support from Volpe Center; law enforcement advice and support from the Tennessee Highway Patrol; telematics provider support from Innovative Software Engineering, LLC, PeopleNet, Inc., and Qualcomm, Inc.; motor carrier fleet support from Bridgestone Americas Tire Operations, LLC, Greene Coach Tours, Inc., McKee Foods Corporation, Pilot Travel Centers, LLC, Tennessee Express, Inc., and the H.T. Hackney Company, Inc.; and sensor provider support from Advantage PressurePro, LLC, Hi-tech Transport Electronics, Inc. (Air-Weigh), and MGM Brakes, Inc.

There are two major differences between the nominal CMRS system design shown in **Error! Reference source not found.** and the designs actually implemented in the pilot test by the three telematics teams. First, the geofences did not originate from roadside enforcement or GOS but instead were manually distributed by ORNL. Second, the inspection report was not generated in real-time due to implementation issues.

Three inspection stations in east Tennessee actively participated in the test: two Knox County inspection stations located on I-40 near mile marker 372 (see Figure 3) and the Greene County inspection station located on I-81 southbound around mile marker 22 (see Figure 4). All of the participating CMRS partners were provided with information that allowed them to build geofences around these inspection stations.



Figure 3. Photo. Knox County, Tennessee, I-40/I-75 Eastbound and Westbound Inspection Station Geopoints.



Figure 4. Photo. Greene County, Tennessee, I-81 Southbound Inspection Station Geopoints.

The system designed by telematics team 1 was very similar to that envisioned for the CMRS platform in general. As shown in Figure 10, the telematics team 1 system was designed to implement a pull-in/bypass functionality. Based on analysis of the submitted SDM, the driver was provided real-time instruction regarding whether or not to stop for additional inspection.

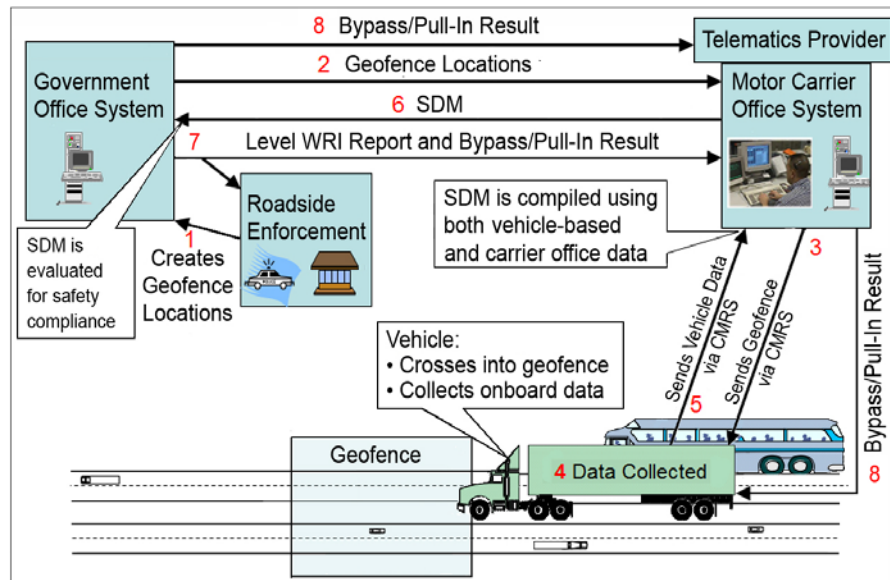


Figure 5. Flowchart. Overview of Data Flow for Telematics Team 1.

Unlike the other telematics teams, telematics team 2's system was designed to submit the SDM directly from the vehicle to the GOS without the use of the telematics provider's office system to facilitate the data transfer. This data flow is shown in Figure 11.

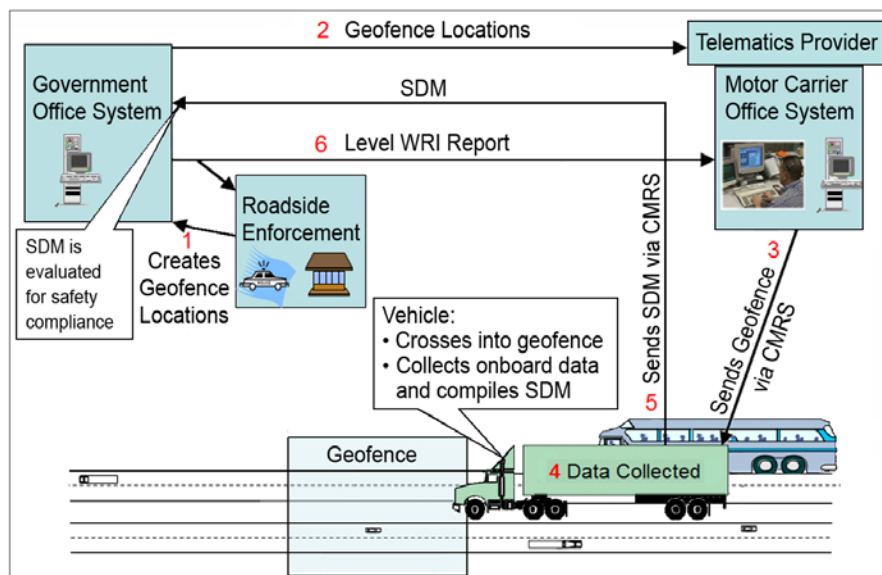


Figure 6. Flowchart. Overview of Data Flow for Telematics Team 2.

Telematics team 3's system is similar to the telematics team 1 system (Figure 5), except that the geofence was not used as a trigger. Instead, the telematics office system monitored the onboard system at regular intervals and made a geofence determination based on the global positioning system (GPS) data received. The SDM was then assembled and submitted to the GOS if the vehicle was found to be within a designated geofence.

3.4 KENTUCKY UNIVERSAL ID PILOT TEST

The Kentucky platform pilot test is an implementation of the Universal ID Concept as outlined in the WRI Concept of Operations. The Kentucky Universal ID WRI pilot test was a team effort directed by the University of Kentucky (UK) Transportation Center's Intelligent Transportation Systems staff. The project required the contribution of numerous participants including members of the Kentucky Transportation Cabinet's Office of Information Technology, the Kentucky State Police Commercial Vehicle Enforcement Division, staff from the Volpe Center, and the ORNL Computational Sciences and Engineering Division (ORNL-CSED). The carrier participants included Grammer Industries, Inc. (Grammer, IN) and Mercer Transportation Company, Inc. (Louisville, KY).

The Kentucky Universal ID WRI pilot test built upon an existing automated screening system located on the entrance ramp to the Boone County, Kentucky, weigh/inspection station located on I-71 southbound near mile marker 75. At the time of this test, the local PRISM Automated Screening System included an automated license plate recognition (ALPR) system, a 915 megahertz (MHz) DSRC device to read transponders, and a scene camera to capture a digital image of each passing vehicle. The ALPR system and 915 MHz DSRC transponder reader were located just downstream of the on-ramp entrance to the station. As a truck diverges from the mainline and starts up the weigh/inspection station entrance ramp, it approaches the roadside sensors for the PRISM Automated Screening System. The system sensors collect information from the passing CMV and communicate that information to the screening computer located in the scale house. A 915 MHz DSRC reader reads the vehicle transponder (if the CMV is so equipped), and sends the 915 MHz DSRC transaction message, or transponder's unique number, to the screening computer. An in-ground loop detector triggers the LPR and overhead scene camera simultaneously. Two images from the front of the truck, the license plate decode information, including the plate's alphanumeric string, jurisdiction, and confidence level, and a digital photograph of the truck are relayed to the screening computer.

The screening computer correlates data from various sensors into a single transaction record which is displayed on the user interface for the enforcement personnel. Enforcement personnel have an opportunity to make corrections (if needed) to the OCR result for the license plate number and/or jurisdiction. As part of processing the transaction record for any vehicle determined to be a participant in the WRI pilot test, the PRISM screening computer sends a Roadside SDM (RSDM) containing the carrier and vehicle identity to the Kentucky GOS for transmission to the Federal GOS. If the PRISM screening system receives a WRI SDM for a participating vehicle from the Kentucky GOS, the additional information provided by the WRI SDM is attached to the transaction record for that vehicle. The Federal GOS prompts the carrier to populate the driver information for a particular inspection and, once received, generates an inspection record and Level WRI report. The SDM and report are displayed on the Federal GOS

Web interface. The record (which may or may not have additional data provided by a WRI result message) is returned to the Kentucky GOS server and stored for enforcement access, follow-up action, and evaluation.

4. EVALUATION GOALS AND METHODS

The independent evaluation for the WRI Phase II pilot testing was conducted by researchers from the University of Tennessee under the guidance and leadership of the NTRCI. An evaluation plan was developed to support the assessment of the WRI system for each of the three pilot test platforms. All the end-to-end data were collected, analyzed, and qualitatively evaluated. The evaluation focused on the technological feasibility of WRI systems, verifying architecture and requirements to the degree possible with the planned pilot tests, and assessing the usefulness and operational feasibility of WRI for the enforcement community and other participating stakeholders. These tasks were accomplished by conducting evaluations for both the roadside and GOSs.⁽²²⁾ Details of the evaluation may be found in the evaluation team's final report.⁽¹²⁾

4.1.1 Process of Establishing and Prioritizing Evaluation Goals

The overall goal of the evaluation was to determine if the main criteria for success of Phase II of the WRI program were met in order to make an informed decision as to whether or not to proceed to Phase III. As such, a series of goals was developed based on the exit criteria. The goals evaluated the overall technical, economic, and operational performance of the system. The technical criteria of the evaluation were based on whether the system could competently and reliably deliver the intended services with acceptable risk. The economic criteria of the evaluation were based on whether or not the system supplied the intended benefits within acceptable cost and risk limitations, and if it could be deployed in a self-sustaining manner. The operational aspects of the evaluation were based on the operational feasibility and performance requirements of the overall system. The evaluation does not include significant discussion of social, political, legal, or regulatory criteria.

4.1.2 Evaluation Goals and Objectives

The goals of the evaluation are derived from the WRI Vision and Goals Criteria⁽²⁰⁾ and were first presented in the WRI evaluation plan. Each *goal* has embedded within it one or more *objectives*. Below is a summary of the WRI goals and objectives that were the basis for assessment and evaluation of Phase II efforts and results. More detailed discussion of goals and hypotheses may be found in the Evaluation Final Report.⁽¹²⁾ The assessment of the goals is summarized in section 5.

- Goal 1: Determine that at least one of the proposed technology/network options is feasible and supports the operational scenarios in a cost-effective manner.
 - Objective 1.1: Demonstrate that DSRC, CMRS, or Universal ID technology, used under the WRI system, will provide a high percentage of accurate WRI reports.
 - Objective 1.2: Demonstrate that each Operational Scenario can be tested by one of the technology options.
- Goal 2: Based on performance, specific technology/network recommendations can be made for further development, and shortcomings can be identified.
 - Objective 2.1: Determine which technology/network system develops the fastest data results within the system between the DSRC, CMRS, or Universal ID technologies.

- Objective 2.2: Determine which technology/network system develops accurate data results within the system between the DSRC, CMRS, or Universal ID technologies.
- Objective 2.3: Determine data and functionality produced by each technology to fulfill the needs of the greatest number of operational scenarios.
- Objective 2.4: Determine which technology can satisfy the demands related to all of the data quality attributes.
- Objective 2.5: Scrutinize observations gleaned from objectives 2.1-2.4 to determine shortcomings in each technology and recommend improvements.
- Goal 3: Determine that at least one of the proposed technologies is feasible and cost effective.
 - Objective 3.1: Demonstrate that the DSRC, CMRS, or Universal ID technologies deliver timely, accurate, and complete results 95 percent of the time.
 - Objective 3.2: Demonstrate that the DSRC, CMRS, and/or Universal ID technologies reduce the cost per inspection and increase CMV and carrier productivity.
- Goal 4: Verify that potential interdiction strategies are feasible and are agreed upon by the various stakeholders.
 - Objective 4.1: Demonstrate that the established real-time or near-real-time interdiction strategies are feasible.
 - Objective 4.2: Demonstrate that the established non-real-time interdiction strategies are feasible, can support other strategies, and can be accessed at later times.
 - Objective 4.3: Stakeholders, carriers, and representatives will agree on feasible interdiction strategies.
- Goal 5: Ensure that the WRI trigger point can address multiple vehicle inputs under a variety of conditions.
 - Objective 5.1: Demonstrate that different locations can accommodate a multitude of vehicles and still obtain data results under varying technological conditions.
- Goal 6: Determine that the projected costs of the system are within a reasonable budget.
 - Objective 6.1: Determine that the initial capital costs are lower than the potential capital budget based on method and level of deployment of the WRI system.
- Goal 7: Benefit assumptions are validated.
 - Objective 7.1: The WRI system increases inspection rates.
 - Objective 7.2: Benefits are demonstrated well enough to withstand reasonable skepticism.
 - Objective 7.3: WRI can provide assumptions of increased benefit from a high number of both positive and negative inspections.
- Goal 8: Show that all technical assumptions are valid and that no technical barriers exist.
 - Objective 8.1: Adequate capacity for end-to-end inspections.

- Objective 8.2: WRI system’s technological functions are reliable during scheduled up time.
- Objective 8.3: WRI system’s technological functions work on a scalable platform with increases in demand being met with proportional increases in capacity.
- Objective 8.4: Data formats will be non-proprietary, and technology can be proprietary.
- Objective 8.5: System can evolve to accommodate innovations in technology except where technological or operational limitations prevent innovation.
- Goal 9: Determine that the performance of the system (network and field) meets acceptable operating thresholds.
 - Objective 9.1: Demonstrate the performance of the system to a predetermined operational level. (Completion of goal 1 implies completion of goal 9.)
 - Objective 9.2: Data transfer and use is secure, and network access is managed. (Completion of goal 1 implies completion of goal 9.)
- Goal 10: The Stakeholder/User Community supports further development of the WRI system.
 - Objective 10.1: Stakeholders and WRI participants support implementation of the WRI system.

4.1.3 Overview of Evaluation Approach

To assess the outcome of the WRI pilot test, the evaluation team, with input from the greater WRI project participants, developed a detailed evaluation plan that was not only specific to individual platforms, but also spanned across all platforms. This section describes cross-platform evaluation frameworks and methods.

The evaluation was performed using two different approaches: a quantitative approach and a qualitative approach. The evaluation team used a quantitative evaluation to collect and analyze the transmitted wireless data (timestamps, sensor data, etc.) and a qualitative evaluation to collect system performance information from the project participants. The manner in which these two different evaluation methods were conducted is described in sections 4.1.3.1 and 4.1.3.2.

4.1.3.1 Quantitative Evaluation

The evaluation team collected a large amount of quantitative data, then, using statistical methods, analyzed this data. The data sources are described in the Evaluation Final Report.⁽¹²⁾

The basis of the WRI system pilot test quantitative evaluation was to examine data as it moved between the various system components. As such, the scope of this evaluation was to analyze how quickly and accurately these data moved between infrastructure components and people. To this end, the three main data types collected were the platform timestamp data, platform and GOS event logs, and the SDM data itself.

Data were collected to support the Use Cases and were divided into independent sub-processes (Evaluation Cases) such that the Use Cases could be evaluated incrementally if needed:

Use Case 1. WRI fixed-site data collection and assessment.

Use Case 2. WRI mobile enforcement data collection and assessment.

Use Case 3. Post-processing analysis of WRI data and results.

Use Case 4. Carrier use of WRI data and results.

Use Case 5. Management of the WRI network.

Use Case 6. This case was omitted early in the pilot test planning stage.

Use Case 7. WRI system self-test by carrier.

Use Case 8. WRI system self-test by roadside or mobile enforcement.

Due to the independent nature of the evaluation cases, each subsystem was evaluated independently and at different times based on variations in the coordinated project timeline. Only after all the critical evaluation cases were assessed could a system evaluation be considered complete.

All SDM data were first uploaded to the evaluation team database as exact copies of Volpe's database (minus tables containing Personally Identifiable Information data). Next, all platform timestamp log files were imported into the evaluation team database. These data were validated for the purposes of error checking and data reporting. Once the validated data were obtained, it was determined whether the data were transmitted accurately and on time. The data were then statistically analyzed to estimate the successful performance of the WRI system in terms of timely delivery for inspection support. The team evaluated the validity of the data through two accuracy checks: 1) validation against an expected range of values and 2) corroboration with observed field data. The team produced 95-percent confidence intervals of the mean data processing times from the initiation of the trigger event (CMV passing a trigger point) to the delivery of the Level WRI report to roadside enforcement and the motor carrier operations center (through the Web-based interface). The results of the quantitative evaluation are summarized in section 5.1.1 of this report.

4.1.3.2 Qualitative Evaluation

A qualitative approach was used to analyze the portions of the WRI pilot tests that, by their very nature, could be done only by collecting input, observations, and feedback from the participating stakeholders and users. To do this the evaluation team conducted a series of telephone interviews with participants during the data collection period. The Evaluation Final Report⁽¹²⁾ describes the approach, the data sources for this portion of the evaluation, and the methods used to analyze the quantitative data.

For this approach, the evaluation team developed an evaluation plan that included further education of the participants on the WRI system and then obtained feedback and input from them related to their understanding and perceptions of the WRI systems and the pilot tests. In collaboration with multiple partners from the greater WRI project team, a webinar was developed to educate participants on all aspects of the WRI system and to highlight the areas of focus for the qualitative evaluation. The purpose of the webinar was to supplement the stakeholders' actual experiences with WRI and to provide them with additional information about the larger program objectives. In conjunction with the webinar development process, the group produced a set of specific questions designed to elicit insight from stakeholder participants as to how well the goals, objectives, and hypotheses were being fulfilled. After viewing this webinar, the participants were given the question set for review and consideration. Usually within 1 week, the evaluation team interviewed participants. The interviews were recorded with the full knowledge of the interviewees, then transcribed and examined by the evaluation team. General themes were drawn from the interviews and conclusions of the participants' perspectives and concerns of the project were summarized in an anonymous manner. The results of this effort are summarized in section 5.1.2 of this report.

4.2 CROSS-CUTTING EVALUATION

Through the course of this pilot test effort, the program team and stakeholders identified issues that require consideration and decisions by FMCSA prior to moving forward with WRI. A cross-cutting evaluation was performed to assess broad policy, technical, and legal/statutory issues facing the program. The goal of this effort was to capture, identify, and outline the key issues suggested for consideration by FMCSA. The following sources were considered in conducting this cross-cutting assessment:

- Concept of Operations for Wireless Roadside Inspection, Baseline V1.0.
- Electronic Onboard Recorders for Hours-of-Service Compliance; Final Rule.
- Electronic Onboard Recorders and Hours of Service Supporting Documents; Notice of Proposed Rulemaking.
- FMCSA Field Operations Training Manual.
- Results of Phase II Qualitative Assessment interviews with pilot test participants.
- Wireless Roadside Inspection Phase II Evaluation Final Report.
- Wireless Roadside Inspection Evaluation Plan.
- Wireless Roadside Inspection Phase II Pilot Test Final Reports—Government Office, Kentucky Universal Identification, and Tennessee CMRS.
- WRI Meeting Notes.
- Information obtained from other FMCSA sources, including conversations with FMCSA staff, relating to FMCSA policies, programs, priorities, and reauthorization proposals.

Based upon the information developed from the resources listed above, the results of the assessment were organized into sections addressing the following areas:

- Outstanding Policy Issues.
- Regulatory and Legal/Statutory Issues.
- System and Technical Issues.
- System Security and Privacy Issues.

These results of this assessment are summarized in section 5.3 of this report.

4.3 COST-BENEFIT ANALYSIS

Cost-benefit evaluation was performed to develop comprehensive estimates of the societal costs and benefits of the WRI program.⁽¹¹⁾ This evaluation is the first to include estimates of the costs associated with better compliance with the FMCSRs brought about by WRI. No previous evaluation included an analysis of all sources of costs and benefits. The analysis also includes an evaluation of the benefits and costs associated with the elimination of overweight truck violations as a result of WRI implementation. This evaluation is part of the larger body of FMCSA research to assess WRI.

4.3.1 Benefits Approach

FMCSA identified two sources of potential benefits from WRI: safety benefits from reducing the number of CMV crashes and cost savings from avoidance of needed repairs from infrastructure damage caused by overweight large trucks. Safety benefits are associated with the detection of violations to the FMCSRs when the occurrence of a violation corresponds to the cause of a crash. Examples of violations corresponding to the cause of a crash include the following: a driver found to have exceeded HOS limits on driving or on-duty time falls asleep while driving and crashes; or, a CMV driver is unable to brake properly due to the condition of the CMV's brakes, which fail to meet Federal standards, and crashes. Safety benefits were estimated by calculating percentage reductions in crashes using data from the LTCCS and applying these percentages to data on the current number of CMV crashes.

Safety benefits are monetized benefits using per-victim and per-crash costs calculated by Zaloshnja and Miller⁽²³⁾ and updated for inflation and current USDOT guidance on the value of statistical life⁽²⁴⁾ to be used in all USDOT reports.

4.3.2 Cost Approach

Two types of costs are included in this analysis: costs associated with the deployment of WRI technology and costs to motor carriers to increase compliance with the FMCSRs and applicable State regulations. Technology costs consist of:

- All hardware for CMVs, motor carriers, and States.

- A national computing network to gather and store WRI data.
- Labor and technical assistance or support services associated with the hardware.

Because WRI is a pilot system not yet deployed, some cost data are currently unavailable. Cost data are based on estimates from technical experts working on the WRI pilot project and, where available, market data.

Compliance costs are ordinarily evaluated when new safety regulations are issued (usually with an assumption of full compliance), but it is necessary to evaluate them in this report and for any public policy options or related program intended to improve compliance with existing regulations. This analysis used current compliance cost data applicable to WRI, but rather than use an evaluation of other FMCSRs enforced during roadside inspections, this analysis relies on vehicle maintenance costs gathered from the motor carrier trade press and assumes that increasing compliance with the FMSCRs leads to a modest increase in cost per CMV.

4.3.3 Policy Options

The cost-benefit assessment evaluates a total of eight policy options for WRI, including two methods for transmitting data (DSRC and CMRS), and the following four types of SDM:

- WRI Low is the most basic alternative, comprising a minimal SDM. Under this alternative, available information in the SDM is limited to the unique identification of the carrier, vehicle, and driver (driver license country, jurisdiction, driver ID, and date of birth; tractor VIN; tractor unit number; tractor license plate country, jurisdiction, and vehicle ID; carrier USDOT number; carrier name; trailer/equipment unit number; and trailer/equipment license plate country, jurisdiction, and carrier ID).
- In the WRI Medium alternative, a report from the ELD would supplement the data captured in WRI Low, including all HOS logbook information.
- In addition to identification and ELD data, the WRI High alternative would include in the SDM a reading of in-vehicle weight sensors to assess compliance with weight regulations; a reading of additional onboard sensors to assess the status of brakes, lighting, and safety belts; and readings of tire pressure and temperature and vehicle location.
- A fourth alternative, WRI Medium + Weight, would add to the WRI Medium configuration only the information from onboard weight sensors. Findings of the cost-benefit analysis are summarized in section 5.4 of this report.

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5. PILOT TEST FINDINGS AND ASSESSMENTS

Phase II of the WRI program was meant to demonstrate that multiple communication pathways, using different technologies, could be simultaneously deployed across multiple States. A series of goals and objectives were developed to evaluate the pilot tests' performance. Moreover, there were 10 broad exit criteria from which the goals were developed to evaluate the success of Phase II. These criteria are:⁽²⁰⁾

- At least one of the proposed technology/network options is feasible and supports the operational scenarios in a cost-effective manner.
- Technology/network recommendation for further development made.
- At least one of the proposed technologies is feasible and cost effective.
- A set of potential interdiction strategies and incentives is identified with stakeholder support for further exploration in Phase III.
- Wireless access point can address multiple vehicles' inputs under a variety of conditions.
- Projected costs of system are feasible.
- Validation of benefit assumptions from initial exploration.
- All technical assumptions are valid and there are no technical barriers.
- Performance of system (network and field) meets acceptable operating thresholds.
- Stakeholders/User Community support further development.

The Phase II pilot tests demonstrated that WRI was successful in delivering data, in real time, to assist in automated inspections. In many ways, each of the pilot test platforms operated independently during the testing, and though there were many technical, operational, and implementation challenges, the majority of the stakeholders agreed that a nationwide implementation of the WRI would be a positive move toward improved safety in the CMV industry, and that the overall outcome of this phase of the effort should be viewed as a success. The motivation for increased efficiency of inspections played a large role in the tests and in the feelings expressed by some of the stakeholder participants. On the whole, most, but not all of the criteria and goals were met. Many technologies were tested and there were many technologically successful transactions of information. As discussed in section 5.3, the many operational and institutional challenges diminished the success of the pilot tests and should be adequately addressed prior to proceeding to a larger WRI deployment. The program final reports provide a series of detailed technical recommendations that should be considered in the event that this program proceeds to a Phase III field operational test.

5.1.1 Quantitative Evaluation

The DSRC (NY) platform shows promise as a potential implementation method of WRI in a nationwide deployment. Though this platform provided only a limited amount of data for analysis, the data provided was noteworthy, particularly in demonstrating the technical feasibility of communicating between the vehicle, roadside, and State GOS. The message latency for

wirelessly sending data was less than 1 second and no data were lost (in the very limited test). This was significantly faster than the other platforms and, in a real world scenario of high speed mainline interstate CMV travel, these latencies would be sufficient to support law enforcement and compliance personnel in effectively carrying out their duties. With no feedback from stakeholders on this platform, the evaluation team is unable to provide feedback as to whether or not interested parties would find the technology promising.

The CMRS (TN) platform also shows promise for potential implementation of WRI in a nationwide deployment. Indeed, this communication pathway was arguably the most successful in sending and receiving data (including volume and content capability) in the context of this pilot test. Still, there were many technical issues with CMRS that could and should be resolved in a nationwide deployment. The *latency* performance observed could support real-time enforcement under certain situations where adequate geofence design and placement is possible. The latency requirements of supporting CSA or other non-real-time processes are met. The *accuracy* rates obtained are not viable for automated enforcement support or other automated compliance systems as they now stand, though improvements in system design could mitigate many of the challenges that were faced in this pilot. With regard to accuracy, law enforcement personnel who were interviewed made it clear that if a system was not accurate, then it would quickly be viewed as unusable and would, in fact, not be used. It appears that the technological problems encountered during the CMRS pilot tests could be addressed by thorough engineering analysis and design. A key lesson learned from the CMRS Phase II pilot tests is that careful consideration should be made in deciding where to place geopoints. Law enforcement views a moveable geopoint scenario as a tremendous advantage to their efforts.

As with the other platforms, the Universal ID (KY) platform shows potential as an effective way to wirelessly inspect CMVs (with further development). The Universal ID platform was the only platform that was able to send an SDM to the State GOS and receive a Level WRI Report. The Universal ID platform also provided a self-test feature for fleet use. The manual data input method for this would likely not be viable in a real world nationwide implementation scenario because of long latency times and the potential for fraud. If automated, several seconds could be removed from the total latency. Weather-related road debris accumulation caused serious degradation to the performance of the LPR and is a serious concern for future system development. Any technology or Operational Scenario that relies solely on LPR technology may be susceptible to relatively low read-rate accuracy. Redundant or complementary technologies could support this communication path.

5.1.2 Qualitative Evaluation

The majority of the participating stakeholders were in agreement that the WRI system holds much promise, and that it should move forward if the technological and implementation challenges can be overcome. Law enforcement was nearly unanimous in their support of future system implementation. They expressed concerns about the current systems in place and felt that, given their limited manpower and increasing numbers of CMVs on the roads, WRI could allow them to improve upon their efficiency. Furthermore, it could also level the playing field among the carriers, reduce the number of unsafe CMVs on the Nation's roads, and allow for safe carriers to be rewarded for keeping their fleets maintained at an appropriate level of safety.

Fleet feelings towards the WRI system were mixed, and it was difficult to ascertain specific motivations among the fleets regarding whether or not they viewed the WRI system as a positive or negative step in supporting CMV safety and commerce. When combining the comments from the interviews with the fleets and law enforcement, a clear picture of the present state of CMV operations was ascertained. Nationwide, many of the fleets do all they can to maintain vehicles up to the highest standards set forth by the Federal Government, while others do not. Companies who maintain a safe fleet of vehicles invest significant amounts of money to do so and may be at a competitive disadvantage in comparison to those who do not. The companies who abide by the safety regulations wish to see all CMVs and motor carrier fleets meet the regulations, thereby ensuring a level competitive playing field. A mandatory implementation of WRI could force unsafe fleets to invest in safety technology and equalize investment in safety across the industry. It is reasonable to assume that companies that do not invest in maintaining their fleets to meet safety regulations would view WRI as an added expense for their operations and would not support WRI implementation.

The telematics service providers for the CMRS platform were supportive of the WRI system and would like to see it implemented in the future. These comments should be considered in the context that telematics providers might benefit commercially from a mandatory implementation of the WRI system. It should be noted, however, that FMCSA has not proposed mandating WRI for all motor carriers at this time.

The sensor providers for the CMRS platform were extremely supportive of the WRI system and would like to see it implemented in the future. They noted that similar systems are already in place around the world and in transit systems in the United States. These comments should be considered in the context that sensor providers might benefit commercially from a mandatory implementation of the WRI system.

Finally, all stakeholders expressed strong interest in consistent technology requirements nationwide, prompting the requirement that certain technologies be regulated at the Federal level. Indeed, for there to be a widespread and voluntary participation by fleets, there must be one overarching and cost-effective technology adopted for WRI with a set of national standards and rules. Drivers, fleets, and States cannot be expected to maintain multiple pieces of equipment to accommodate State-by-State implementations of the WRI program.

This pilot test evaluated three platforms, all in imperfect test environments. The CMRS (TN) platform produced the most data, but also encountered data delivery challenges and relatively long latency times. The Universal ID (KY) platform produced some desirable results, but included manual steps that proved untenable and the identification technology (LPR) was unsuitable in poor weather situations. DSRC (NY) produced very limited results and did not connect with the GOS. Moreover, the data were not formatted in a way that could be accepted by the GOS. Nonetheless, the limited performance was promising and worthy of further investigation. Finally, the GOS's strict data validation requirements presented many challenges with accepting and processing data from all platforms. Even in the context of a pilot test with active partners, the data formatting and security authentication method was complicated and it proved difficult to provide successful inspections. An expanded test that includes less-engaged partners would require much more simplified data formatting and processing requirements.

5.2 ACHIEVEMENT OF GOALS AND OBJECTIVES

The goals for the Phase II program, introduced in section 4.1.2, are composed of several objectives, each tested by a series of hypotheses. By combining the results from the quantitative approach with the common themes from the qualitative approach, each of the hypotheses were assessed in the context of the WRI Phase II Pilot Test. The expectation was that, by addressing the hypotheses, conclusions about the ability to meet larger objectives and goals of the WRI system could be determined. The results of the analysis, by platform, are discussed below and focus on the ability of each platform to meet the required objectives and ultimately the goals of the WRI pilot test. Because of the imperfect nature of this real-world data collection effort, many of the hypotheses were not explicitly tested. However, conclusions can be drawn about the technologies' ability to meet the goals and objectives based on a combination of system performance and stakeholder discussion. Indeed, many of the failures of the system were due to design limitations and were not technology limitations. As such, the evaluation team conjectures that some of the hypotheses that were not explicitly tested would be successful, based on the experience of this pilot test. All 10 goals are grouped below into 1 or more assessment types.

5.2.1 Technological/Functional Assessment

5.2.1.1 Goal 1. Determine that at least one of the proposed technology/network options is feasible and supports the operational scenarios in a cost-effective manner

The CMRS and Universal ID platforms both prove feasible and able to support key operational scenarios. The DSRC platform did not provide sufficient information with which to arrive at any conclusions. Due to limitations encountered during the Phase II pilot tests, only a subset of the operational scenarios were tested. The CMRS platform fulfilled a greater number of the operational scenarios tested during the Phase II pilot tests. Still, all platforms had limited ability to perform a large number of operational scenarios. Given the acceptable performance of those tested, it is reasonable to conclude the operational scenarios that were not specifically tested during the pilot test could perform in a reasonable manner as well. The cost-benefit analysis below discusses the cost effectiveness of the proposed technology options.

The CMRS platform demonstrated better results for this objective as compared to the Universal ID platform. Neither platform produced significant numbers of full inspection reports, but both submitted SDMs. Neither CMRS nor Universal ID met the basic standards set forth to prove its ability to meet this objective. However, the GOS, with relaxed validation rules, was able to quickly produce inspection reports during the post-processing with CMRS data.

5.2.1.2 Goal 2. Based on performance, specific technology/network recommendations can be made for further development, and shortcomings can be identified

The stakeholder participants identified shortcomings and provided several positive recommendations for future WRI system development. The Phase II pilot tests provided a rich environment to evaluate and assess WRI and identify key areas of improvement.

5.2.1.3 Goal 3. Determine that at least one of the proposed technologies is feasible and cost effective

The CMRS and Universal ID platforms both prove feasible and able to support key operational scenarios. The DSRC platform did not provide sufficient information with which to arrive at any conclusions. More engineering design work is needed to refine the WRI process and implementation, but no fundamental technological *obstacles* were found that would prevent its successful development and deployment. Cost effectiveness is discussed in section 5.3.

5.2.1.4 Goal 5. Ensure the WRI Inspection Trigger Point can address multiple vehicle inputs under a variety of conditions

The WRI system was tested using multiple vehicle inputs, under varying conditions, and it was found that the pilot implementations of the CMRS and Universal ID platforms were not capable of addressing this goal. More engineering design work is needed to refine the WRI process and implementation, but *no fundamental technological obstacles* were found that would prevent it from achieving this goal.

5.2.1.5 Goal 7. Benefit assumptions are validated

The benefit assumptions were not validated during the Phase II pilot tests, either from the quantitative analysis or from stakeholder feedback. It was, however, determined that the benefit assumptions were reasonable for an adequate nationwide deployment. It was shown in the Phase II pilot tests that the WRI system may have the capability to increase inspection rates.

5.2.1.6 Goal 8. Show that all technical assumptions are valid and that no technical barriers exist

All technical assumptions were found to be valid and no technical barriers were found to exist. The Phase II pilot tests showed that adequate technical capability exists for end-to-end inspections. All technologies provided acceptably formatted data. The challenge lies with the ability to process in the GOS format and the security authentication method.

5.2.1.7 Goal 9. Determine that the performance of system (network and field) meets acceptable operating thresholds

The CMRS and Universal ID platforms have the ability to meet the acceptable operating thresholds. There were technical failures, but no fundamental technology barriers were found with the system.

5.2.2 Operational Feasibility Assessment

5.2.2.1 Goal 4. Determine that potential interdiction strategies are feasible and are agreed upon by the various stakeholders

Law enforcement personnel from the CMRS and Universal ID platforms agree the interdiction strategies are feasible. No other stakeholder groups were questioned as to their opinions on this goal. The Phase II pilot tests demonstrated that the non-real-time interdiction strategies are

feasible, that they support other strategies, and that they can be assessed at later times. Mixed results were found in regard to whether successful interventions could be carried out after WRI assessment results were returned.

5.2.3 Cost-based Feasibility Assessment

5.2.3.1 *Goal 1. Determine that at least one of the proposed technology/network options is feasible and supports the operational scenarios in a cost-effective manner*

5.2.3.2 *Goal 6. Determine that the projected costs of the system are within a reasonable budget*

Certain options for deploying WRI appear to have a positive net benefit, while others do not. Due to the high cost of the 5.9 GHz transmitters needed for each CMV and the accompanying receivers required by enforcement personnel, DSRC does not exhibit positive net benefits, even with the best possible safety outcome. However, large positive net benefits are associated with on-vehicle weight sensors due to their bringing cost reductions from avoided damage to roadway infrastructure that are much larger than the cost of the sensor technology. These specific net benefits are large enough to yield positive net benefits if coupled with the DSRC medium configuration. The results for the analysis of CMRS are qualitatively the same, except that without the expense of DSRC transmitters and receivers, the CMRS medium option could provide a positive net benefit.

When considering the business case to industry for voluntary participation in WRI rather than a policy mandate, aggregate safety benefits accruing to carriers are less than the costs of compliance with the FMCSRs and the required equipment. About 3.4 million inspections are administered each year, and even if all of them were eliminated, the value of that savings to carriers is not sufficiently large to compensate for the costs of WRI. However, the analysis did not quantify perceived benefits to fleets that would voluntarily participate in a WRI system and receive credit (positive and negative) to their CSA SMS results from WRIs being counted at some level.

5.2.4 Stakeholder Support Assessment

5.2.4.1 *Goal 10. The Stakeholder/User Community supports further development of the WRI system*

The law enforcement community participants support the creation and implementation of a nationwide WRI system. Some of the telematics providers and fleets wish to see the creation and implementation of a nationwide WRI system. The participating Phase II pilot test stakeholders provided differing opinions as to whether or not they felt that the WRI system should be implemented.

5.3 OUTSTANDING TECHNICAL, POLICY, AND INSTITUTIONAL ISSUES

As discussed earlier, the Phase II pilot tests demonstrated that WRI was successful in delivering real-time data to assist in automated inspections. While there were many technical, operational,

and implementation challenges, the majority of the stakeholders agreed that a nationwide implementation of the WRI could help improve safety and that the overall outcome of this phase of the effort should be viewed positively. This phase of the effort has identified broad policy, technical, and legal/statutory issues that face FMCSA in moving forward with WRI. The major issues that are recommended for consideration are described below under the following topics:

- Outstanding Policy Issues.
- Regulatory and Legal/Statutory Issues.
- USDOT System and Technical Issues.
- System Security and Privacy Issues.

5.3.1 Outstanding Policy Issues

The results of this phase of the investigation demonstrate that there are multiple communication methods that could support WRI. It is technically feasible and could be accomplished in various ways. Decisions are necessary moving forward which have budget and policy implications. These include selection of communication approach, incorporation into field operations, use of inspection data by SMS, and carrier recruitment as discussed below.

5.3.1.1 Single versus Hybrid Communication Approach

A core issue to be addressed moving forward from Phase II is whether WRI would pursue a single communication path or a hybrid approach. In considering these issues, FMCSA should carefully weigh the benefits and costs to each stakeholder, including motor carriers, service providers, States, and FMCSA enforcement. Moreover, FMCSA may wish to consider the options for voluntary participants in the program as opposed to those carriers that would be required to participate.

5.3.1.2 Integration into Existing Field Operations

If WRI is to be implemented nationwide, FMCSA would need to address a number of policy issues with regard to its operational use in the field. Among these issues are how WRI would be incorporated into existing procedures for roadside inspections, use of data from vehicle sensors during an inspection, integration of PrePass and other electronic screening programs, and real-time interdiction of carriers for violations identified in WRIs.

Currently, 30 States use PrePass to select CMVs for a roadside inspection; another 7 States use NORPASS, and 3 run their own electronic screening systems. These services allow some participating transponder-equipped CMVs to bypass designated inspection stations if they meet the screening standards. FMCSA would need to establish policy and guidance to clarify how WRI would affect go/no go decisions from electronic screening systems.

5.3.1.3 Use of Level-WRI Inspection Data by the Safety Measurement System

FMCSA currently estimates that WRI may increase the number of inspections from 3.4 million to 85 million annually. This would allow FMCSA to measure the safety performance of a large

number of carriers that currently do not have enough inspections to be assessed by FMCSA's SMS. FMCSA will need to assess the data quality and timeliness of the WRI data and then consider how the SMS could be modified to accommodate the results of WRIs, including possible changes to its weighting and scoring methodologies.

5.3.1.4 Carrier Recruitment

Recruiting carriers into the program to enable a valid field operational test would require that FMCSA carefully considers which carriers are predisposed to participate in WRI voluntarily, the degree to which FMCSA could offer real incentives in the form of credit under SMS for WRIs, the reduced likelihood of future inspections, and improved SMS assessments.

5.3.2 Regulatory and Legal/Statutory Issues

Implementation of WRI could require regulatory changes and consideration of legal and statutory issues, including the following:

5.3.2.1 ELD Rule

A key benefit of implementing WRI would be the automated collection of driver HOS data from ELDs. However, the driver data elements required by this proposal may not include all of the information needed for a WRI. FMCSA would need to insert the required data elements in the final ELD rule as reflected in the WRI SDM.

5.3.2.2 Issues with Statutory Authority

Implementation of WRI may raise issues with respect to FMCSA's statutory authority, in particular FMCSA's ability to set standards for WRI equipment and to determine motor carrier safety fitness based in part on WRI results. Moving forward, FMCSA would need to determine whether WRI-compatible equipment would require Federal standards and certification, or whether carriers and vendors may self-certify.

FMCSA is currently drafting a proposed rule that would base a motor carrier's safety rating, called a safety fitness determination, in large part on roadside performance data, such that results of WRIs could be a factor in these fitness determinations. A January 18, 2008 legal opinion of the FMCSA Chief Counsel found no perceived legal barriers to national implementation of WRI for use as an investigative or inspection tool. However, it is not clear that this opinion covers the use of WRIs to determine a motor carrier's overall safety fitness and ability to continue to operate. As part of planning for national implementation, FMCSA may need to revisit this legal opinion to clarify FMCSA's legal authority to use WRIs for safety fitness determination.

5.3.3 System and Technical Issues

WRI is a system of systems that exchanges data between multiple existing government and private systems. A number of system and technical issues in establishing secure, reliable communications would need to be addressed to move forward with WRI.

5.3.3.1 WRI System Standards and Compatibility

The WRI Phase II results highlight the need for uniform standards in a number of areas prior to full implementation. A particular issue is the need to ensure compatibility among the multiple Federal, State, and private systems comprising the WRI network. A principal problem that arose during the pilot test was the incompatibility between the prototype GOS and telematics provider, motor carrier, and State systems. Other areas in which standards and compatibility are needed are the contents and format of the SDM, time synchronization among the various system servers involved in sending, receiving, and relaying messages, and the location and spacing of geopoints.

5.3.3.2 Integration of Government Office System with FMCSA Infrastructure Systems

During the Phase II pilot test, the GOS employed snapshots of data from the Commercial Driver's License Information System (CDLIS) and Motor Carrier Management Information System (MCMIS) to generate safety evaluation findings. Moving forward, the government office system would connect to live CDLIS and MCMIS to use fresh data. It would also upload the results of WRIs to update carrier and driver information in MCMIS and other FMCSA systems. The high volume of data generated by WRI may place a burden on these existing FMCSA resources. In particular, FMCSA's DataQs system may be overloaded with data challenges as a result of WRIs. For a field test or national implementation, FMCSA should investigate integrating the WRI GOS with the FMCSA Portal and with FMCSA infrastructure systems, including MCMIS, Licensing and Insurance (L&I), Aspen, and SafetyNet, as well as other systems, such as CDLIS. Moreover, FMCSA should assess the impact of WRIs on the capacity of these and other legacy systems.

5.3.3.3 Support for Operational Scenarios

Phase II identified a number of considerations in terms of the operational scenarios that WRI has been designed to support. During the next phase of system testing, FMCSA should fully test all operational scenarios it intends to support with the goal of improving accuracy and data transmission rates. Operational scenarios include:

- Unstaffed automated safety enforcement, compliance, and assessment.
- Screening support.
- Traditional inspection support.
- Mobile safety check.
- Routine safety analysis or special study.
- Carrier and driver use of SDMs.
- Use of SDMs in transportation planning and management.
- Managing the WRI network.

5.3.4 System Security and Privacy Issues

Phase II of the WRI program highlighted a number of security issues that must be addressed prior to moving forward to a field test or national implementation. These include privacy concerns on the part of motor carriers and drivers, the need to authenticate system users, and addressing outstanding recommendations from FMCSA's Security Team.

5.3.4.1 Privacy Concerns

The prospect of WRI has raised privacy concerns among motor carriers and drivers wishing to protect their sensitive information. For their part, motor carriers wish to protect data concerning shippers, loads, routes, and other competitive details. Drivers desire to protect personal identification and travel information. Moreover, because an SDM typically would include Personally Identifiable Information, such as driver name, license number, and date of birth, there are valid privacy concerns regarding the protection of this data. Moving forward, FMCSA would need to ensure the protection of sensitive data.

5.3.4.2 Authentication of System Users

FMCSA would need to define and implement a method for authenticating the senders of SDMs prior to the start of Phase III. This method would influence the design of the WRI platform.

5.3.4.3 FMCSA Security Team Recommendations

FMCSA conducted a security and privacy assessment of the prototype GOS for Phase II of the WRI Program. This assessment yielded a Plan of Action and Milestones (POA&M) with approximately 30 recommendations for improvement. Among the areas addressed by the recommendations were monitoring and vulnerability detection, privacy impact assessment, security testing, contingency planning, handling of logon accounts, and system use certification. Eighteen of these recommendations were deferred to be reevaluated for a field test. Prior to a field test or national deployment, FMCSA would need to address the deferred POA&M recommendations. Moreover, another security assessment would have to be conducted, and could generate additional recommendations. All POA&M recommendations would need to be considered early in the development process.

5.4 COST-BENEFIT KEY FINDINGS AND ASSESSMENTS

Certain options for deploying WRI appear to have a positive net benefit, while others do not. Due to the high cost of the 5.9 GHz transmitters needed for each CMV and the accompanying receivers required by enforcement personnel, DSRC does not exhibit positive net benefits even with the best possible safety outcome. However, large positive net benefits are associated with on-vehicle weight sensors due to their bringing cost reductions from decreased damage to roadway infrastructure that are much larger than the cost of the sensor technology. These specific net benefits are large enough to yield positive net benefits if coupled with the DSRC medium configuration. Other added sensors (brake sensors, tire pressure monitoring systems) do not provide enough added benefit to justify their additional expense. The results for the analysis of CMRS are qualitatively the same, except that without the expense of DSRC transmitters and

receivers, the CMRS medium option could provide a positive net benefit. Benefits for DSRC and CMRS are assumed to be the same, but those for CMRS might be lower for all three safety messages because it has been assumed that passive, wireless transmission of the data under DSRC would be more reliable and timely than CMRS data transmission. There appears to be little justification for the WRI low SDM because the medium SDM requires no additional cost and would capture a far larger number of violations and therefore accrue substantially higher safety benefits. A cost benefit analysis for WRI will be conducted and published in FY 2014 and will use the same assumptions as in the Regulatory Impact Analysis for the Supplemental Notice of Proposed Rulemaking related to electronic logging devices.

WRI MATURITY FOR DEPLOYMENT

Commercial vehicle roadside safety inspections represent one of the most effective tools for monitoring and regulating the condition of the in-use commercial vehicle fleet, as well as for auditing and enforcing driver and operational-related safety practices, including HOS, proper driver credentialing, and other safety aspects of commercial vehicle equipment and operations. WRI, using advanced sensor and onboard diagnostics as well as wireless communications, offers the potential for dramatically improving the effectiveness and efficiency of the roadside commercial vehicle safety inspection process. Its benefits include improved CMV safety and corresponding reductions in crashes, property damage, injuries, and fatalities. Safety benefits also support improved mobility for the trucking industry and the traveling public by reducing congestion and delay caused by crashes, as well as reducing environmental emissions and energy use. The Phase II pilot tests demonstrated that WRI was successful in delivering data, in real time, to assist in automated inspections. The majority of the stakeholders agreed that a nationwide implementation of the WRI would be a positive move toward improved safety in the CMV industry and that the overall outcome of this phase of the effort should be viewed positively. Despite imperfect test environments, many technologies were tested and there were many technologically successful transactions of information. The operational and institutional challenges identified would need to be addressed prior to proceeding to a larger WRI deployment.

WRI is a system of systems that exchanges data between multiple existing government and private systems. While a number of system and technical issues related to establishing secure, reliable communications would need to be addressed, no fundamental technological obstacles were found that would prevent the successful further development and deployment of WRI. The implementation of WRI used in Phase II is not sufficiently mature at this point for deployment; however, the technical challenges moving forward could be addressed through careful and skilled engineering analysis and design.

Development of a design model of WRI electronic communications is recommended as a next step toward successful implementation. In its full implementation, WRI will be a large and intensive data collection, analysis, and management system. It is expected that there will be thousands of electronic truck inspections per hour across the country, each one requiring rapid data lookups and assessments, and providing information to enforcement and inspection officials in real time. The design model should describe the complete, nationally deployed system and support analysis of its development and incremental deployment on a State-by-State and fleet-by-fleet basis. A comprehensive modeling tool could guide designers in developing a system that

provides the capacity and speed that could address the challenges of nationwide WRI implementation.

A major advantage of WRI is that it can use existing or planned equipment, networks, and databases without the need to build a completely new infrastructure. However, WRI may place substantial new demands upon existing systems, such that their capacity and speed may need to be upgraded. A comprehensive modeling tool could also guide developers in defining the upgrades and enhancements that will be necessary on existing equipment, networks and databases.

A great deal was learned in the pilot test effort that could be applied moving forward to revise, simplify, reduce cost and improve benefits to the level at which it would be mature and ready for nationwide deployment and implementation. Both technical and institutional issues must be addressed in developing and implementing WRI. Perhaps the greatest challenges moving forward would be institutional, in terms of building the collaboration and support of Federal and State agencies and motor carriers to implement the interfaces and communication between government and private systems that support reliable and secure implementation.

5.5 NEXT STEPS

The next step is to conduct a large-scale field operational test (FOT) to validate the viability of a national WRI system and to provide a bridge between the pilot tests and the FOT. A bridge is necessary because critical portions of the pilot tests were not completed or fully tested and the government system for processing the inspections was not fully developed. This next phase will include system validation within the FOT to develop and test a complete end-to-end system with multiple fleets, multiple vehicles, and multiple technology partners by leveraging what was accomplished in the pilot tests, streamlining the complexity of such an effort, exploring and abating risk areas, and relying on the pre-existing hardware and systems available within private industry.

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