TICKET TAKER AUTOMATION

Final Report

Experimental Features Project OR 98-02

by

Eric W. Brooks, E.I.T.
Research Specialist

and

Liz Hunt, P.E.
Research Coordinator

Prepared for
Oregon Department of Transportation
Research Group
Salem, Oregon

and

Federal Highway Administration
Washington, D.C. 20590

March 1999

Technical Report Documentation Page

1. Report No. OR-EF-99-22	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Ticket Taker Automation Final Report		5. Report Date March 1999
		6. Performing Organization Code
7. Author(s) Eric W. Brooks, E.I.T. and Liz Hunt, P.E.		8. Performing Organization Report No.
9. Performing Organization Name and Address Oregon Department of Transportation Research Group 200 Hawthorne SE, Suit B-240 Salem, OR. 97301-5192		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. EF-98-02
12. Sponsoring Agency Name and Address Oregon Dept. of Transportation Department of Transportation Research Group and Federal Highway Administration 200 Hawthorne SE, Suite B-240 Washington, D.C. 20560 Salem OR 97301-5192		13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The Oregon Department of Transportation requires an ODOT employee to collect weigh slips from delivery vehicles on road construction. These delivery vehicles may be hauling asphalt mix or aggregates. The person, usually a temporary employee, is given the job title "ticket taker". The job is one of the most dangerous jobs on the construction project. The purpose of this project was to eliminate the dangerous ticket taker job with an automatic system.

The ticket taker automation system is a very high frequency radio operating at 2.45 GHz. An interrogator unit attached to a laptop computer, transmits data to a small transponder that can store 256 bytes of data. Transponders were attached to the trucks hauling asphalt mix. At the hot mix plant, a signal is sent to the transponder and stored. At the jobsite, the interrogator reads the signal and stores the data in the attached computer. Both a scale unit and a job site unit are required for this system.

This project was a preliminary test of the system in a road construction environment. The results of the study indicate that the limited range of the system (20 m) would require an operator to move the system as the job progressed forward. Ticket taking would not be eliminated, but made safer by automation. Based on the results of the study, the system is not suitable for implementation at this time.

17. Key Words Pavement, automation		18. Distribution Statement Available through the Oregon Department of Transportation, Research Group	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 25	22. Price

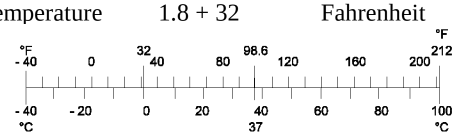
SI* (MODERN METRIC) CONVERSION FACTORS

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	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

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	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



***** SI is the symbol for the International System of Measurement

(4-7-94 jbp)

ACKNOWLEDGEMENTS

The authors would like to thank the following Oregon Department of Transportation (ODOT) personnel for their contributions and help gathering information for this report: Russell Olson, Byron Inman and Bob Thatcher. In addition, the authors thank Micron Communications, Inc. for supplying technical data and River Bend Sand and Gravel Company for their permission to tag the asphalt trucks.

DISCLAIMER

This document is disseminated under the sponsorship of the Oregon Department of Transportation and the United States Department of Transportation in the interest of information exchange. The State of Oregon and the United States Government assume no liability of its contents or use thereof.

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official policies of the Oregon Department of Transportation or the United States Department of Transportation.

The State of Oregon and the United States Government do not endorse products of manufacturers. Trademarks or manufacturers' names appear herein only because they are considered essential to the object of this document.

This report does not constitute a standard, specification, or regulation.

TICKET TAKER AUTOMATION
Final Report

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

Current practice by the Oregon Department of Transportation (ODOT) on hot mix asphalt paving contracts requires an ODOT employee to collect weigh slips from the delivery vehicles in order to document receipt of the material. This receipt is used to verify pay quantities. The ODOT worker is usually a temporary employee and is referred to as a "ticket taker." Ticket taking is one of the most dangerous jobs on a construction project. Further, temporary employees are usually not accustomed to being around construction equipment. ODOT has been trying to find an alternative for this position. A *remote intelligent communications (RIC) system* was evaluated as an alternative to a ticket taker.

ODOT Region 3 originally worked with a software design company to produce a scanner-type data logging system that would be suitable for replacing ticket takers. Their FM system worked well in transferring data from the scale to truck transponders. However, the computer used at the delivery site broke down several times due to overheating. The Federal Highway Administration (FHWA) was involved in that project and continues to support the concept. The results of the study are documented in the report, *Eliminating the Use of Ticket Takers,* available through the ODOT Research Group.

The current study tested the MicroStamp RIC system to replace ticket takers on ODOT construction projects. The RIC tag is shown in Figure 1.1. Note the small size of the device as compared to a nine-volt battery. This recently-developed system has not been used in construction environments. It has been successfully used in inventory control by reading tags on trucks going slowly through gates at storage facilities and garbage trucks being weighed at landfills.

The system was bench tested and demonstrated on selected pavement projects. This report documents the results of that testing.

Figure 1.1: The MicroStamp 10ML tag shown next to a nine-volt battery.

2.0 SYSTEM DESCRIPTION

The MicroStamp 4000 system is composed of a host computer, an interrogator unit, and a RIC tag as shown in Figure 2.1. One complete system is needed at both the material plant and on the job site. The system sends a signal that includes batch time, truck number, job contract number, drivers name, mix weight, and material type to the tag mounted on the truck. At the construction site, another system reads the tag information and stores it in the host computer. In this test, only one system was used because of the experimental nature of the project.

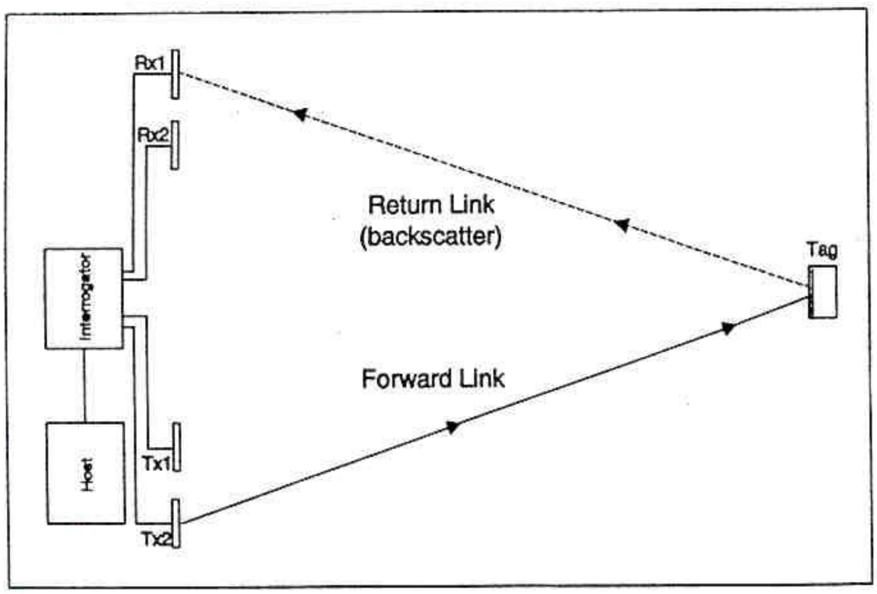


Figure 2.1: MicroStamp 4000 System (courtesy of Micron Communications, Inc.)

The host computer used was a Hewlett Packard OmniBook 5700CT operated by a Windows 95 system. The interrogator was a MicroStamp model 4000 and the RIC tags were the 10ML by Micron Communications Inc. Other equipment included four “patch” antennas, an inverter (DC to AC converter), a power strip, antenna mounting brackets and a Dodge Van (see Figure 2.2).

The laptop computer was setup on the front seat of the van. The interrogator was set up in the rear of the van on the shipping case in which it was delivered. A long serial cable connected the interrogator to the computer. An extension cord from the inverter supplied the operating power. Power for both the computer and the interrogator was taken from an inverter connected to the cigarette lighter. The patch antennas were mounted on an aluminum light bar on the rear of the van roof with the connecting cables routed through the rear door window to the interrogator. These antennas could be aimed in azimuth and elevation.

Figure 2.2: The patch antennas, mounted on the rear light bar of the van.

2.1 SET UP TIME

The equipment setup time was twenty minutes. Each day before the testing began, the laptop, inverter and antennas were carried to the van and connected. The longest single-item setup time was connecting the three antennas to the roof brackets by two wingnuts each. The cable from each antenna was then fed through the rear door window and connected to the rear of the interrogator. Power was applied to the system and a test tag was read.

On the job site more time was required to find a suitable parking space for the van. The van operator needed to talk with the project inspectors to determine the plan of operation for the day. The van was then parked and a test tag on a tripod was placed in the truck travel area to check the angle needed for the antennas.

2.2 POWER CONSUMPTION REQUIREMENTS

The system was powered by an inverter (a direct current multi-vibrator) connected to the cigarette lighter outlet. A power strip was attached to the inverter, and both the laptop and interrogator were plugged into the power strip. A first attempt was made to use a ”y” adapter from the cigarette lighter outlet, but the interrogator would not respond correctly after a few hours of operation. The system consumed about 72 watts of power. The laptop required 4 amperes and interrogator about 2 amperes. Since the van has a 12-volt system the power required would be calculated as:

$$12 \text{ volts} \times 6 \text{ amps} = 72 \text{ watts.}$$

With a rotobeam operating, the battery of the van would soon be drained if the engine were not left running.

2.3 TAG MOUNTING

The mounting of the tags on the trucks was found to be critical. On the first trial run, the signaling range was less than 10 m. After consulting with Micron, the tags were modified with a back plane. This back plane consisted of a 39 mm by 74 mm rectangular piece of aluminum. A styrofoam spacer, 30.6 mm deep, was placed between the tag and the back plane (see Figure 2.3). This spacing is a quarter wave-length of the 2,450 MHz frequency signal. In theory, the wave sent from the back of the tag is reflected from the back plane, reinforcing the forward wave at half wavelength. Rough estimates for this project indicate that the receiving range was doubled.

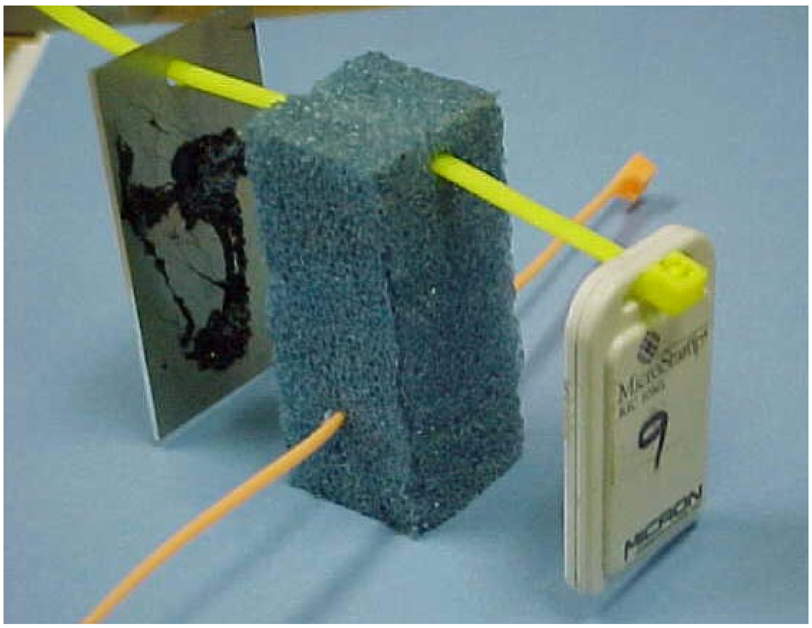


Figure 2.3: Modified Tags. The MicroStamp 10ML tag is right, styrofoam spacer center and back plane left.

Tags were attached to the left side mirror bracket on the asphalt trucks. Nylon cable ties were used to secure the tag to the post in a vertical position and the tag was aimed out and ahead with the back of the mirror at near right angles to the tag as seen in Figure 2.4.

2.4 ANTENNA MOUNTING AND OPERATION

The antenna array was suggested by Micron. The Dodge van had three 2.5 m aluminum bars mounted on top, used for roto beams or for transporting objects on the van top. The rear-most bar was used to mount the antennas. Two receiving antennas were placed at opposite ends of the light bar with one transmitting antenna mounted between. The mounts made for the antennas consisted of two brackets bolted together so that they could be adjusted in the vertical plane as well as the horizontal plane.

Figure 2.4 The arrow points at the MicroStamp 10ML tag.

The operator needed to use caution when aiming the antennas, because even though the power output from the system is low; the frequency is in the microwave range and enough exposure can cook the operator’s hands. In addition, the FCC radio frequency exposure limits may be exceeded at distances closer than 130 mm from the antenna during normal operation. When the interrogator is transmitting, the transmit light on its front panel will be flashing. A non-conductive object such as plastic straight edge should be used to orient the antennas while the interrogator is transmitting.

3.0 SOFTWARE STATUS

The Research Group received the MicroStamp 4000 system in April of 1998. The staff tried to use the program to operate the interrogator for several months but made no progress. In August the consulting firm of Stewart, Inc. was contacted for training, and a three-day crash course in Visual Basic was provided. Also, a demonstration of the system operation with newly written software worked well in the Research Group parking lot. However, the software was not completed to meet the requirements of the workplace.

The Research Group staff attempted to complete the software programming, but it was not finished when the paving jobs started in October. The system was tested anyway with the unfinished software package. The software was adequate for the purpose of testing the systems effective reading range, but it did not have a good database for storage of daily records. Also, the data format requested by the project manager was not completed. Both the data format and the viewing screen required by the field crew should be specified prior to additional study of the system. Input from FHWA about the required documentation should also be sought.

For the current study, no provisions were made to automate the placement location of a given load. Unless the tags could be read at the paver, placement location would need to be collected with another system or manually.

4.0 FIELD TRIALS

Field trials were completed in the fall of 1998. The details, which are covered in the Appendix, are only summarized in this section. The ticket taker system was used at paving jobs on five different days. The first experience was on the north unit of the I-5 widening project through Salem while the rest of the trials were completed on the south unit. While neither job was the typical paving operation anticipated for this system, valuable information was gained from both.

4.1 NORTH UNIT OF I-5

At the north unit of the I-5 project, parking space for the van was limited because of the staging of construction and the high concentration of private property. This forced the van operator to park the van too far from the asphalt trucks and at a right angle to the trucks. This reduced the amount of time the tag was in the viewing field of the interrogator. As a result, only one tag ID was read and all data was missed.

After the first trial, the antenna array mounting system and the tags were modified to improve the reading range. The antennas were mounted on the roof of the van with a bracket that allowed them to be aimed in both azimuth and elevation, as shown in Figure 2.2. Also, the addition of a back plane doubled the reading range of the tags (see Figure 2.3).

Tags were also written at the River Bend Sand and Gravel Company plant with the temporary setup in the van. No problems were encountered when transmitting to the tags at the asphalt plant. The tags were later read on the paving project to verify the accuracy of the writing operation. A permanent setup would require an additional host computer interfaced to the electronic scale system at the hot mix plant, as well as an interrogator.

A visit with the River Bend scale operator was made on the last day of field trials. The operator had been on the job for 25 years and was very efficient. The company used a computer system to weigh trucks and print out material tickets automatically. The scale operator had only to type in the truck number. Trucks were assigned to jobs at the beginning of each day. This assignment data along with truck data such as owner, PUC number and hauling capacity were stored in a file that was merged with the scale data at the time the truck was weighed and a ticket was printed. New assignments could be made on-the-fly for orders called in later in the day. When the operator was asked if the MicroStamp tags would be of any help, she replied no, because she already had all the information she needed in the truck file.

It would appear that, for a less experienced operator, having the truck's ID appear on the computer screen when it approached the scale would be helpful, especially at night. River Bend's Texas Instrument printer was also slow, compared to the automated process of pushing one button on the computer key board and having the data written to a RIC tag.

4.2 SOUTH UNIT OF I-5

The improved system was tried on the south unit with some success. The tags were readable across the new pcc pavement section with the van on the left shoulder and asphalt trucks on the right shoulder. However, success was limited, as the van had to be maneuvered to read the tags because the read angle and distance for all trucks was not the same. Similar applications would require an operator which would defeat the purpose of an automatic reading device.

Other van setups were also tested, including reading the tags while the trucks were making a turn and while they were accelerating to merge with freeway traffic. Neither of these was successful.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The MicroStamp data collection system works but is not fully automated. A trained operator is needed to position and monitor the equipment in order to insure that all tags are read in the field. Also, an operator is needed to collect the asphalt concrete placement location (station).

The system data collection range is only about 20 m making it difficult to find a suitable set-up location. Further work needs to be done with software in formatting the laptop screen and creating databases. Also, additional equipment and software will be required for automating ticket writing at the asphalt plant.

A permanent-mounting bracket could improve the performance of tags mounted with nylon pull ties. The mounting brackets could keep the tags aimed in a consistent direction, limiting the amount of moves required for the antenna. The contractor should be involved with attaching the tags to the trucks.

The MicroStamp System may be beneficial to plant operation. It would provide automated truck identification and relay information to the truck (through the tag) more efficiently than a ticket.

5.2 RECOMMENDATIONS

Further investigation into this system is not recommended at this time. The following improvements to the MicroStamp System would make it more functional for a ticket taking application:

- Increase the size of the tag to improve the probability that the tag data will be captured on a paving project. We understand that Micron continues to make improvements to the tag design.

- Improve the mounting bracket to also increase the probability that the tag data will be captured.

- Reconfigure the system to be more portable, possibly developing a back-pack mounted or hand-held device that an operator could aim at a truck tag. After scanning the tag, the operator could then enter the placement station.

APPENDIX

FIELD TRIALS

1. FIRST FIELD TRIAL FOR THE MICROSTAMP 4000 SYSTEM.

On October 11, 1998, a field trial for the MicroStamp System was performed on the Hayesville Interchange job. Trucks were tagged at the River Bend AC plant at the south end of Lancaster Drive. Truck drivers were asked for their permission before a tag was attached. Tags were attached to the right side mirror bracket using a one-way pull tie. The orientation of the tag was less then ideal: some turned at right angles so the narrow side of the tag was exposed to a side view. The data on the tags had been written earlier in the office and did not reflect the current load. Five trucks were tagged and the truck numbers were recorded.

The next operation was performed at the paving site on Portland Road. The paving was being done in the northbound lane while traffic used the southbound lanes. Paving came up to the curb so that the only place to park the van was on a side street by a BP gas station. Other places closer to the operation were on fenced-in private property and were not accessible. The distance to the right side of the curb lane was about 3 m. The trucks, however, were pulling off two lanes over so the distance to the trucks was over 21 m. The curb lane had been paved earlier in the evening while testing was underway at the paving plant. Only one tag was read at the BP station. Only the tag ID was picked up; the rest of the data was missed. After 1 1/2 hours this site was abandoned.

The field test operation returned to the paving plant. The van was parked at an angle to the exit from the paving plant silo. After receiving a load, the driver would stop at the ticket station to receive his load invoice. The wait time was about one minute, which provided an opportunity to tag the trucks without slowing down the operation. It was also a good time to retrieve the tags placed earlier in the earning. The antennae were set up on the front bumper of the van at about the same height as the tags were mounted to the mirrors. Four of the five-tagged trucks were read by the MicroStamp System. The fifth tag was found to be blank of all data except the tag ID.

2. SECOND FIELD TRIAL FOR THE MICROSTAMP 4000 SYSTEM

On December 8, 9, 10 and 17, additional field trials for the ticket taker system (MicroStamp 4000) were completed. The system, including the antenna array was setup in a full-size Dodge van. Trucks were tagged at the River Bend AC plant at the south end of Lancaster Drive and an attempt was made to read the tags on an I-5 paving job near Salem. The key to reading the tags was the positioning of the equipment van, which had to be changed frequently.

During the four days of operation, several different locations for the van were tried. The paving was being done on the shoulders and the northbound on-ramp. The new lanes of I-5 northbound are 11 m of continuously reinforced concrete. The asphalt shoulders are 2.5 m or more wide. On the first day, after the trucks were tagged at the plant, the tags were read on the grade. The tags had been mounted on the right mirror but the paving was being done on the right shoulder. The van was driven ahead of the trucks near the right shoulder. Using this method, nine out of nine tags were read. Later during the day, the contractor asked the van operator to stay on the left shoulder while the paving was being done on the right shoulder. Only two trucks were read as they were turning to climb back on to the PCC. Because of the angle that the tags were mounted, the actual distance to the tags was greater than 30 m.

Later the first day, the van was parked near the exit point of the job. Concrete barriers protected the new construction while the main traffic on I-5 passed by on a detour. Near the north end of the job, the median barriers ended and the main I-5 traffic was diverted back to the original travel lanes. Most of the trucks observed at this point were accelerating to merge with the I-5 traffic. Only one truck was read at this location, when it stopped near the van for truck bed cleaning. The distance of the van to the exit lane was about 2 m, with a read angle set about 30 degrees, which would bring the tag into the view field at about 32 m. On all other trucks, only the ID of the truck was read, the rest of the data was missed.

The second day, most of the action was at the River Bend Plant. Four trucks were outfitted with blank tags. These tags were written to using the equipment mounted in the parked van. All four were later successfully read on the exit road at the plant later in the day. There was some problem of positioning the van, because of the dual set up of the plant. Trucks were getting their tickets on the east side air tube box, so that the van had to be parked in the west lane of the ticket receiving area. Because another job was hauling from the west side, the van had to be moved after each tag was written. A permanent setup would be possible with the co-operation of the paving company. On the I-5 paving job later in the afternoon, the setup was the same as the first day; however, all the tags were read. The difference between the first and second day set-up may have been the antenna orientation.

The third day's challenge was to locate a parking spot for the van. Paving was being done on the new northbound on-ramp. At first, the van was placed near an entry point to the job behind some of the contractor's equipment. The trucks slowed down to cross a temporary ramp from the gravel shoulder to the new concrete pavement. Four trucks were read at this point, then the paving operation changed direction and the paving machine began running from north to south rather than paving north, the direction of normal traffic flow. This left the van out of position to detect any of the trucks because they were lining up on the grade in front of the paving machine and leaving the job by turning off the new C-line onto the existing C-line. The van was then moved to the gore area between the travel lanes of I-5 and the existing C-line. At this point only tag IDs could be read because of the speed of the trucks.

Later in the third day the paving operation on the I-5 right shoulder resumed. The tagged trucks were first driven by the van at a distance of about 7 m, while the trucks lined up on the right shoulder in front of the paving machine. Five out five tags were read on this pass. Next the van was moved to the left shoulder and driven past the trucks as they waited to dump their loads. The van to truck distance on this pass ranged from 20 to 42 m.

On December 17, 1998 the paving operation moved to the D-line, which is a curved on-ramp from Hwy 22 eastbound to I-5 northbound. The asphalt trucks were entering the job from the existing temporary on ramp with flagged traffic control. The van was first set up near the new bridge end in a no-paving area. Tags were easily read at this location because the sight distance was less than 10 m and the trucks were stopped as they waited to dump their loads. As the paving progressed around the curve, the van was moved to the gore point between the temporary off and on ramps. Only two truck tags were read at this point, when they were slowed down by traffic. All other trucks were missed. Three trucks were read across the on-ramp near the bridge end as they dumped their loads into the paving machine. This opportunity soon ended when the operation moved around the curve and out of the line of sight.

One other position was noted near the area where traffic was being stopped by the flagger for the asphalt trucks to backup the new on-ramp to the paver. A fill of large rocks on the south side of the ramp was not being worked on and would have been a good spot for a four-wheel drive vehicle to park. Also a hand-powered cart with large bicycle type wheels could have been positioned at this point. The trucks would have been easy targets as they backed up the ramp.