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Evaluation of Laser Video Speed Measurement Equipment

Study SD97-12
Executive Summary

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DISCLAIMER

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16. Abstract

High rates of speed are a large problem in construction work zones nationwide. Speeding puts the construction workers and the drivers of the vehicles in grave danger. Unfortunately, traffic accidents occur every day in rural and urban construction work zones, and some of them cause severe injuries and even death.

The LaVideo™ system used in this study utilizes a video camera to capture the image of the speeding vehicle, and Laser to measure speed.

For the Evaluation of Laser Video Speed Measurement Equipment project, four objectives were chosen to fully study the methods proposed to fix the speeding problem in construction zones. Those four objectives were:

1. To evaluate the effectiveness of the Video/Lidar system in work zones
2. To evaluate the functional capabilities and limitations of the Video/Lidar system in work zones
3. To evaluate the cost effectiveness of the Video/Lidar system in work zones
4. To develop recommendations for other applications of the Video/Lidar system

Recommendations:

1. Much more effective if used as intended – to issue citations
2. Much more effective use of law enforcement. Officers are free to pursue more serious matters.
3. Manufacturer must provide more user-friendly system – fewer cables.
4. Replace poorly built cables in video system.
5. Continue use of DOT COP program.
6. Continue use of HP officers – Enforcement presence is still the most effective method.

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Executive Summary

High rates of speed are a large problem in construction work zones nationwide. Speeding puts the construction workers and the drivers of the vehicles in grave danger. Unfortunately, traffic accidents occur every day in rural and urban construction work zones, and some of them cause severe injuries and even death. Efforts have been made to use various technologies to make drivers aware of work zones and to reduce speed prior to driving through them.

This study evaluated the LaVideo™ system. LaVideo™ utilizes a video camera to capture the image of the speeding vehicle rather than flash cameras. In addition, this system measures vehicle speed via Lidar™, which is a narrow beam laser unit that has the ability to select a small automobile out of a group of larger vehicles.

Four objectives were identified to study the effectiveness of video/lidar to reduce speeds in construction zones. Those four objectives were:

- To evaluate the effectiveness of the Video/Lidar system in work zones
- To evaluate the functional capabilities and limitations of the Video/Lidar system in work zones
- To evaluate the cost effectiveness of the Video/Lidar system in work zones
- To develop recommendations for other applications of the Video/Lidar system

Recommendations

1. Video/Lidar is effective if used as intended – to issue citations
2. Video/Lidar allows more effective use of law enforcement. Officers are free to pursue more serious matters.
3. Manufacturer must provide more user-friendly system – fewer cables.
4. Replace poorly built cables in video system.
5. Continue use of the DOT COP program.
6. Continue use of SDHP officers – Enforcement presence is still the most effective method.

Problem Description

High rates of speed are a large problem in construction work zones nationwide. Speeding puts the construction workers and the motorists in grave danger. In the years 1993 through1998, maintenance and construction work zone accidents have cost 7 lives, 312 injuries, and $7,535,400 in damages[1].

There have been studies performed in the past in South Dakota that have shown that the presence of highway patrol vehicles reduces speeds in the construction zones. One problem is that there are not enough officers to continuously enforce the work zones throughout the state. In addition, the traffic at construction work zones is congested at times, and enforcement within the zone would slow the traffic flow even further.

Automated speed enforcement equipment, consisting of a narrow-beam radar speed detection unit and a flash camera, has been shown to be effective at reducing speeds and increasing the awareness of speed limits in other states.[2] These systems photograph vehicles that have been measured to be traveling at excessive rates of speed. The photograph shows the license plate and speed of the vehicle. The owner of the vehicle is mailed a copy of the photograph and a citation. Because the owner of the vehicle is mailed the citation - not necessarily the driver - the violation is not assessed against the owner's driving record.

Background

The LaVideo™ system used in this study is different from the previously mentioned radar speed detection units. LaVideo™ utilizes a video camera to capture the image of the speeding vehicle rather than flash cameras. In addition, this system measures vehicle speed via Lidar™, which is a narrow beam laser unit that has the ability to select a small automobile out of a group of larger vehicles.

Preliminary work was performed during the summer of 1997 to evaluate two laser video units. The study was done in a joint effort between the SDDOT and the South Dakota Highway Patrol. Warning letters were sent to individuals who were videotaped while speeding through construction work zones. Over the course of the evaluation of the two laser video units, only five warnings were issued.

Automated speed enforcement systems have never been widely used in construction work zones. If these systems can be shown to reduce vehicle speeds in work zones, they could save the lives of many people.

Unfortunately, before this study was completed, the manufacturer of the LaVideo system, Kustom Signals, Inc., stopped marketing the system in the United States because the laws in many states do not allow the use of the system.

Objectives

Four objectives were identified to fully study the methods proposed to fix the speeding problem in construction zones. Those four objectives were:

- To evaluate the effectiveness of the Video/Lidar system in work zones
- To evaluate the functional capabilities and limitations of the Video/Lidar system in work zones
- To evaluate the cost effectiveness of the Video/Lidar system in work zones
- To develop recommendations for other applications of the Video/Lidar system

First, the effectiveness of the Video/Lidar system in work zones was tested. This portion of the study focused on how well the Video/Lidar system deterred motor vehicle operators from speeding in construction zones. The objective was accomplished by first finding a base line for the average speeds through that particular zone. Then, several different types of deterrents, including LaVideo™, were tested to see how well they lowered the average speeds through the zone from the base line speeds. This showed a comparison between the Video/Lidar system's ability to reduce speeding to other forms of deterrents.

Next, the function capabilities and limitations were determined. One aspect that this project needed to cover was how well this system performs in the field. This objective could be considered a product evaluation of the LaVideo™ system. There were four important portions of the objective to study. The first area was how easy the product was to use. Secondly, the researcher determined how reliable the system was in regards to finding and documenting speeding vehicles. Next, one needed to determine how portable the instrument was. Finally, it was important to know how well the LaVideo™ system withstood the environmental conditions found in South Dakota.

The third objective was to evaluate the cost effectiveness of the LaVideo™ system. By determining the cost effectiveness of Video/Lidar, one could also find the approximate amount of money it would cost to implement these systems across the state. Once again, all the deterrent methods were compared for this objective. After the costs for each method were found, they were rated from best to worst solely on an economic basis.

The final objective was to develop recommendations for other applications of the Video/Lidar system. Once the feasibility, reliability, and ability to deter speeding were found, the researcher was to recommend how the SDDOT can best use the LaVideo™ system. To that end, it is important to determine other locations where vehicles travelling at an excessive rate of speed are endangering pedestrians, workers, or other vehicle operators.

Work Plan

Several tasks were determined to properly perform the Evaluation of Laser Video Speed Measurement Equipment project. These tasks were chosen to accomplish each objective. Below is a list of the tasks that were performed for this project. A short explanation also accompanies most of those tasks.

Task 1 *Conduct a literature review to obtain knowledge about the Video/Lidar system.*

The search included the internet, specifications of LaVideo™ produced by KUSTOM Signals, Inc., and users of Video/Lidar devices.

Most of the literature found during the search documented testing done on photo-radar systems for use at intersections and railroad crossings. These systems are very effective at detecting and recording motorists who speed and run red lights. The reason for their effectiveness is they are used for enforcement purposes – the violator receives a ticket in the mail.

An internet search on video/lidar revealed only vendors who sell devices that, when placed over a license plate, masks the license number from the camera.

No literature documents the use of video/lidar use in work zones. The technology has only been in use since 1996.

Literature was found that stressed the importance of choosing speeds on roads that are appropriate. "Abusive practices include using unreasonably low speed limits, and leaving reduced speed limits in place after the work activity is removed". This study suggests that speed reduction on rural freeways should be 5 to 15 MPH. On South Dakota interstates, work zones have regulated that speeds are 45 MPH, or 30 MPH slower than the posted speed limit of 75 MPH. "It is very important that the design speed is not significantly lower than what drivers will reasonably expect or tolerate." "If an unreasonably low speed is encouraged by the highway agency, drivers will quickly lose respect for the speed control effort".[3]

Other studies were done to study the impact of photo radar on driving behavior in Canada over a period of several years. The Victoria Police in British Columbia conducted a controlled study on the impact of photo-radar in collaboration with the Victoria Transportation Department. The results of their study indicate photo radar was effective in reducing speeds at the study sites both when the camera was in actual operation and when only the threat of use was present.[4]

The difference between the Canadian studies and this one are that the photo radar systems are permanently installed at intersections and data is collected over an extended period of time. In this study, video/lidar is not extensively used. In fact, only one system was used and evaluated in temporary work zones for a short period of time.

Task 2 *Meet with the project's technical panel to review the project scope and work plan.*

The researcher met with the panel on a number of occasions to discuss the project and the work plan.

Task 3 *Develop a work plan.*

Task 4 *Identify work zones to be used for the evaluation.*

The test section was on Interstate 90 between Plankinton and Mt. Vernon, SD. The extent of the test sections varied slightly throughout the six-week measurement period.

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Task 5 *Develop a base line speed survey in work zones without visible enforcement presence.*

For this portion of the study, three traffic counters using road tubes were programmed and placed on the pavement to measure the average vehicle speeds across those points. One set of sensors was placed approximately one mile prior to the point where the two lanes tapered into one. Another set was placed at the beginning of the taper, and the third set was placed after the taper within the construction zone.

The data for this experiment was collected between the hours of 9 a.m. and 5 p.m. The base line study took place on Monday July 13, 1998, and Tuesday July 14, 1998. The other tests for this project took place on the Mondays and Tuesdays that followed the week in which the base line study took place.

The average speeds per period of time for each set of tubes was determined. These average speeds were the basis for the rest of the study. The base line values were later compared to those values found when the various speed deterrence systems were in place. To properly develop this base line, no other system could be in operation that may cause the drivers to slow down. Any such interference would have caused inaccurate results.

Task 6 *Measure and compare speeds present with each of the following:*

- Decoy car
- Highway Patrol presence only
- DOT cop only
- Sign "Video radar used in construction zones" used in conjunction with the Video/Lidar system
- Video/Lidar system with enforcement downstream from work zone

Once the base line was completed, the average speeds for each of the situations shown above needed to be found. This was done by setting up the particular situation and taking measurements with the road tubes in the same manner as that used for the developing the base line. The project's technical panel decided to set the chronological order of the five tests to run from the least intrusive method to the most intrusive. Once all five situations had been tested, the average speed values for each variable were compared to the base line, and the situation which best deterred motorists from speeding was determined.

The decoy car used for this project was a South Dakota Highway Patrol car. The vehicle was unmanned, but it was in plain site so motorists could easily see it. The purpose for the decoy car was to cause motorists to believe law enforcement patrolled the construction zone, and would therefore slow down prior to reaching the zone.

Both tests that involved Video/Lidar took place when a DOT cop is present. At the time the study took place, only the DOT cops were allowed to operate the LaVideo™ systems. Video/Lidar was being used both with and without enforcement so that it could be determined if the Video/Lidar system caused behavior changes, or if the changes were solely due to the presence of law enforcement.

Highway Patrol officers were present for the manned HP car and Video/Lidar with enforcement trials. The manned Highway Patrol car was being used to verify how well that presence alone discouraged speeding.

Task 7 *Determine the system's characteristics with respect to:*

- *Environmental factors*
- *Portability*
- *Training/usability*
- *Reliability*

Each of the four items listed above was evaluated. By knowing how those factors affect the system and its user, one can determine if it is a worthwhile product in which to invest. For instance, if it was determined that LaVideo™ will only work in special weather conditions, it probably would not be wise to place a unit in every work zone around the state.

Due to time constraints, the Video/Lidar system itself was only tested for four days during the summer of 1998. This did not provide the opportunity to test the system in different weather conditions. Inspection of the electronics housings and cable connectors indicates that the system is prone to malfunction in wet weather, and the system requires waterproof seals before it would be reasonably reliable.

The portability was relatively easy to check because the system had to be set up and taken down each day it was used. In this regard, the system was fairly simple to set up and operate. The cables and connections were somewhat cumbersome, and should be clearly labeled to avoid confusion.

Usability of the system was found by interviewing the DOT cops who used the LaVideo™ systems. Because the DOT cops are the only personnel who use the system, they were the sole source of information on the training and usability of the system.

The reliability was tested in several different ways. The vehicle speeds measured by the system compared favorably to those measured by the road tubes. In fact, previous studies have shown that Lidar is highly accurate at measuring speeds. On two occasions, the video system would not work at all because the cable between the video recorder and camera failed. The factory cable was poorly built, and was probably the sole reason for any problems with this system.

The video portion of the system was examined at the end of each day during the test period to ensure that the correct portion of the vehicle was being recorded. The resolution of the video was good. The vehicle and its license plate could clearly be identified. This is an important aspect in the event that citations are mailed to violators.

The DOT cops were interviewed on the various characteristics. They use the system the most and they probably know the most about the operation of LaVideo™. Therefore, they probably had the best insight on Video/Lidar.

Task 8 *Estimate cost effectiveness of the Video/Lidar system and compare to existing methods of issuing citations.*

The cost effectiveness of the Video/Lidar system could be determined by looking at the cost per citation. One question that needed to be answered in order to determine the feasibility of Video/Lidar was who will be in charge of processing the potential citations. Once that was known, an estimate could be made on the cost that would be included with the issuing of the fines with the LaVideo™ system.

The total monetary value it requires to issue a citation with Video/Lidar was compared to the cost for the various other methods. To make a proper comparison, the researcher needed to find the costs of the other methods. Once all costs are known, each system was ranked on how inexpensive it was to operate.

Because citations were not issued during the evaluation, cost effectiveness was determined based on how many citations *could* have been issued.

Task 9 *Develop recommendations for use in other applications.*

Video/Lidar is well suited for use in work and construction zones. Its ability to catch speeders on tape makes it a useful tool for any location where speeding vehicles pose a threat. To be useful, though, the manufacturer must make the component housings, cables and connectors more robust and waterproof.

Video/Lidar can be a great asset to enforcement personnel in areas of high population concentrations such as schools, college campuses, shopping malls, and congested downtown areas where visibility may be restricted.

Task 10 *Develop report including conclusions, findings, and recommendations.*

This report is the product of task 10.

Task 11 *Make executive presentation to the Research Review Board.*

The Video/Lidar System

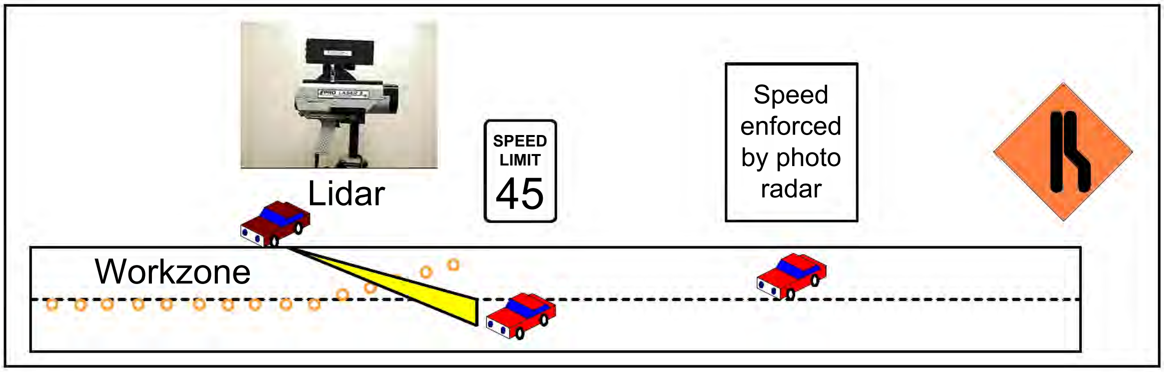

Figure 1 Overview of Video-Lidar used in a work zone.

Use of photo radar in a typical work zone is illustrated above. As motorists approach a work zone, a sign advises them that photo radar is being used. The regulatory speed limit is also clearly posted.

After vehicles have entered the work zone, their speed is accurately measured by a narrow-beam radar unit. (A narrow beam is important to avoid confusion between vehicles.) If the vehicle's speed significantly (the threshold speed is set by the operator) exceeds the posted speed limit, the camera in the photo radar unit photographs the front or rear of the vehicle so its license plate can be identified. The vehicle is not stopped at that time. If the vehicle is not speeding, no photograph is taken.

Films of the speeding vehicles are promptly processed and citations are issued. If the driver can be identified, he may be cited for a speeding violation. Otherwise, the vehicle's owner may be assessed a civil penalty. Currently, citations and penalties assessed from video or photographs would require legislation.

The Speed Survey

The main objective of this study was to measure the effects of using the video/lidar system to issue citations to motorists who speed through work zones. Ideally, when a police officer working in the DOT COP program would capture a motorist speeding through a work zone on videotape, a citation would be issued and sent through the mail to the vehicle owner. But because the state of South Dakota does not have legislation to allow SDDOT to issue citations through the mail, the focus of this evaluation shifted from the effects of sending citations through the mail, along with a public awareness campaign, to the effects of the presence of the video/lidar system alone.

The evaluation consisted of a speed survey to measure the speed reduction of motorists in response to five levels of speed detection, or presence of enforcement. These levels of detection were visible to motorists at the beginning of the work zone at five different times. The least noticeable types of detection were used first. The various levels of detection were as follows:

- No detection
- Video/Lidar – Plain clothed operator
- Unmanned Highway Patrol car
- DOT COP using video/Lidar
- Manned Highway Patrol car issuing citation

The study took place in work zones on Interstate 90 in South Dakota, between Mileage Reference Markers 306 and 319, near the towns of Plankinton and Mount Vernon. There was only one major interchange in this section of highway, the intersection with US 281, but this had no effect on traffic flows or speeds within the work zone. In each of the surveys, the pavement was dry and driving conditions were good. Each survey was done for two days, usually Monday and Tuesday of each week for five weeks.

The speed survey was performed using traffic counters and road tubes placed at three locations. The first location was roughly a mile ahead of the taper at the beginning of the work zone, where drivers could see the first "Work Ahead" signs, but not the work zone itself. This counter collected "free flow" traffic speeds. The second counter was placed 1000 feet ahead of the taper, and the last counter was placed just after the taper.

The researcher was careful to choose a work zone that was not affected by on- or off-ramps. Unfortunately, due to the study being spread over six weeks, the work zones moved over several miles, and some work zones used were westbound and some were eastbound. Even though the study was not completed in the same work zone, the researcher believes the speed data is accurate and representative of the traffic present.

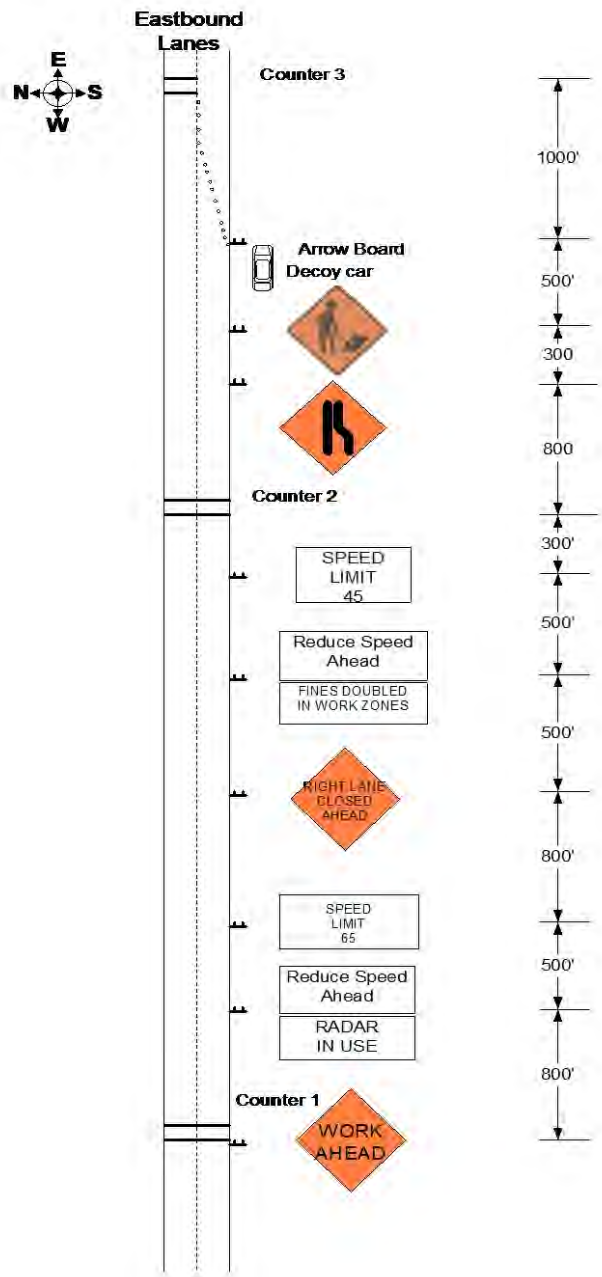

Figure 3 Traffic counter and sign placement for a work zone with decoy car.

The 85th percentile speeds and mean speeds were collected and recorded for each location in each workzone.

Table 1Video/Lidar 85th Percentile Speeds

Location	85th Percentile Speed (mph)	
	Before	After
1 mile in advance of taper	79.2	79.3
Beginning of taper	67.4	52.0
End of taper	68.6	53.1

Table 1 shows that the use of the Video/Lidar system operated by a uniformed DOT Cop at the beginning of the taper to the workzone resulted in a 5.6 mph reduction at the taper and a 16-mph reduction after the taper in the workzone. The video/lidar system is normally operated in this manner; with the video/lidar unit on a tripod next to the patrol car, with the uniformed officer standing behind the lidar. The speed reduction is the effect of the presence of the person and vehicle.

Table 2 Highway Patrol 85th Percentile Speeds

Location	85th Percentile Speed (mph)	
	Before	After
1 mile in advance of taper	79.2	86.4
Beginning of taper	67.4	59.7
End of taper	68.6	54.8

Table 2 indicates that 85th percentile speeds in advance of the taper (free flow speeds) were slightly higher during the speed survey done while the Highway Patrol was present. But at the beginning of the taper, speeds were reduced by nearly 8 mph, and at the end of the taper inside the workzone, 85th percentile speeds decreased by 14 mph with the Highway Patrol presence.

Table 3 Decoy Car 85th Percentile Speeds

Location	85th Percentile Speed (mph)	
	Before	After
1 mile in advance of taper	79.2	78.5
Beginning of taper	67.4	56.4
End of taper	68.6	47.6

Table 3 shows that the presence of a decoy car reduced the 85th percentile speeds after the taper by 21 mph. This was the largest speed reduction of the three scenarios. It at first is puzzling that the Highway Patrol presence does not create a larger reduction in speed. But remember that when a Highway Patrol officer leaves his position to pursue a speeder, he may not return to his position at the beginning of the work zone for at least 15 minutes.

Cost comparison

A major benefit of the Video/Lidar system is its ability to measure the speed and record the image of many vehicles in a very short time. *Every* vehicle that drives past the Video/Lidar system may be recorded. If citations are being issued through the mail, the owner of *every* car that exceeded the speed limit of a work zone can be fined for the violation. It is otherwise impossible for conventional enforcement to chase and ticket 100% of violators.

According to the South Dakota Highway Patrol, when a trooper is parked at the beginning of a work zone, at least 15 minutes are required to chase a speeder, write the ticket, and return to his post. Therefore the trooper is limited to four tickets an hour.

Using a Video/Lidar system, however, every one of the 200 vehicles traveling through the work zone per hour could be ticketed and fined if they were speeding. This makes far better use of enforcement, freeing them to pursue more serious offenders.

A typical Highway Patrol officer makes $40 an hour, including overhead and benefits. Using that number, a ticket can cost $5 to $10 to write, and $30 to $40 to process. It can cost $100 if the citation is challenged.

Workzones are active about 4 months through the summer. DOT cops typically work about four days a week, totaling 64 days of enforcement. The speed survey revealed that about 200 vehicles traveled through the work zone in an hour. The survey also revealed that during the Video/Lidar usage, 88% of the traffic was over the 45 mph posted limit.

User Interviews

DOT cops were interviewed regarding their impressions of the reliability and usability of the system.

One DOT cop claimed that it wasn't feasible to use the video portion of the system because, without a deterrent such as mailing citations, the system had little effect on motorists. Instead, the Lidar portion of the system was used to measure speed. A violator would then be pursued and issued a citation by the officer.

The system was easy to set up, and it held up well in poor weather, but cables were poorly marked and poorly assembled. There were several occasions when the system was down due to poor connections in the cabling.

Findings and Conclusions

Use of the video/lidar system without issuing citations is no more effective than visible enforcement alone. When DOT COPs are present on work zones, they are very effective at reducing speeds. Motorists also tend to slow down when there is a large amount of construction equipment and personnel perceived in the work zone. The benefit of using the video/lidar system lies in its ability to detect and record many citations every minute, while a Highway Patrol officer is limited to about four citations an hour. Video/lidar allows a much more effective use of law enforcement. Officers are free to pursue more serious matters.

The true results of using video lidar cannot be directly measured because it is only when the public as a whole realize that work zones in South Dakota are being actively surveyed to detect speeders. The immediate effect of using video lidar is a speed reduction when motorists see the device on a tripod manned by an enforcement officer.

When motorists were recorded by video lidar while speeding, warning letters were sent to the owners of the vehicles. While this did notify the motorists that they were "caught" speeding, the fact that they were not sent a citation might have the same effect as receiving no letter at all, or even a negative effect. After receiving two or more warning letters, a habitual speeder will understand that the State of South Dakota is detecting speeders in work zones, but is not concerned enough to enforce the laws.

Video Lidar is an efficient enforcement tool that forces motorists to realize that it is illegal to speed through workzones – if citations are issued.

> "Enforcement works primarily through the principle of deterrence. The fundamental idea is that credible threats of punishment deter unwanted behavior. More specifically, the proscribed behavior is discouraged by the perception that legal punishment is "swift, sure, and severe" (Ross and LaFree 1986, 132)".[5]
>
> "The effectiveness of deterrence depends on several factors. First, the proscribed behavior must be definable, understandable, and detectable, not only by the individuals to be deterred but also by those who are expected to enforce compliance and penalize those who do not comply (TRB 1987, 91). In the case of speeding, police officers must be able to reliably verify vehicle speeds and provide evidence that will hold up in court.
>
> "Second, the effectiveness of deterrence depends on the perceived risk of apprehension. For the risk to be credible, drivers must believe that they have a nontrivial chance of being apprehended if they engage in the proscribed behavior. Thus, some minimum level of enforcement leading to actual apprehension is necessary. A well-designed publicity campaign coupled with visible enforcement will expand the perception of risk to a large segment of the target population.
>
> "Third, the effectiveness of deterrence depends on the swiftness, certainty, and severity of the punishment. Empirical research suggests that the perceived certainty of punishment is a more powerful deterrent than the severity of the penalty. One explanation is that, if the risk of punishment is so low that the violator regards the threat as negligible, then the severity of the punishment is irrelevant."

There was no attempt in this study to determine whether Lidar would be more effective at detecting speeding than conventional radar. But, according to "Managing Speed", "Laser speed measurement presents an attractive alternative to law enforcement agencies because it offers the ability to target individual vehicles more accurately on multilane roads and is more difficult to detect than conventional radar."

Recommendations

1. Continue to pursue legislation that will allow use of video/lidar. Video/Lidar will be much more effective if used as intended – to issue citations. It multiplies the effectiveness of law enforcement by enabling the detection of most violators in work zones.

2. Require the manufacturer to provide a more user-friendly system – one with fewer cables. The system used for the study was not labeled, did not have proper strain-relief, and was vulnerable to moisture.

3. Continue use of the DOT COP program. This is a cost-effective way to utilize existing law enforcement and make work zones safer.

4. Continue the use of Highway Patrol officers and decoy cars – an enforcement presence, or perceived presence, is still the most effective method.

5. Use video/Lidar in areas of high population concentrations such as schools, college campuses, shopping malls, and congested downtown areas where visibility may be restricted. Because of its ability to detect most speeders, video/Lidar allows a single law enforcement officer to effectively reduce speeds in these areas.

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[5] Managing Speed, Transportation Research Board Special Report 254, p 140, National Academy Press, 1998.