

New Hampshire
DOT
Research Record



**Investigation of the Performance of
Backing Cameras on NHDOT Maintenance
Vehicles**

Final Report

Prepared by the New Hampshire Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration

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16. Abstract This report details the trial use of backing cameras at the New Hampshire Department of Transportation (NHDOT). Several NHDOT plow routes require the plow vehicles to perform multiple backing maneuvers. Other day-to-day operations entail backing in conditions where sight conditions are never ideal. Seven vehicles were equipped with backing cameras and drivers were interviewed after approximately one year of camera use. The majority of the drivers viewed the cameras as a useful tool for safety; however the installation configurations often compromised the full effectiveness of the cameras. The knowledge gained through this investigation resulted in recommendations for improved camera placement and system configurations that would enhance the effectiveness of this technology for future maintenance operations.			
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EXECUTIVE SUMMARY

This report summarizes the trial use of backing cameras at the New Hampshire Department of Transportation (NHDOT). Several NHDOT plow routes require the plow vehicles to perform multiple backing maneuvers. Other day-to-day operations entail backing in conditions where sight conditions are never ideal. Seven vehicles were equipped with backing cameras and drivers were interviewed after approximately one year of camera use. The majority of the drivers viewed the cameras as a useful tool for safety; however the installation configurations often compromised the full effectiveness of the cameras. The knowledge gained through this investigation resulted in recommendations for improved camera placement and system configurations that would enhance the effectiveness of this technology for future maintenance operations.

INTRODUCTION

Every year thousands of accidents occur when a vehicle being backed strikes something or someone. The National Safety Council estimates that 25% of all accidents involve backing and approximately 500 fatalities occur each year due to these accidents. A significant portion of the fatalities involve children caught behind the vehicle. Large vehicles such as dump trucks have significant blind spots to the rear of the vehicle that make them more susceptible to backing accidents. In the illustration below from the National Institute for Occupational Safety and Health (NIOSH), the figures that are darkened represent people hidden in the blind spots of the vehicle.



Figure 1: Darkened figures are in the dump truck driver's blind spot (NIOSH)

The NHDOT operates many vehicles with limited rearward visibility including dump trucks, loaders, and graders. During 2006, 2007, and 2008, the NHDOT had 117 accidents involving backing vehicles costing approximately \$138,000 in damages to state and private property. While approximately 90% of these accidents were classified as preventable, the many trucks and pieces of equipment the Department operates make some occurrences inevitable. Fortunately

none of the above-referenced accidents involved serious personal injury or death but the potential for such consequences is significant.



Figure 2: NHDOT backing accident in Holderness in 2005

At the suggestion of Highway Maintenance personnel, a research project was initiated in the fall of 2008 to investigate the use of backing cameras to improve safety for the heavy vehicles in the NHDOT fleet. The Town of Bow, New Hampshire has been installing backing cameras on new trucks joining their fleet since 1997 and graciously allowed the NHDOT to inspect and operate some of their vehicles. Subsequently the NHDOT decided to do a trial installation of cameras on several vehicles to see how well the devices would work during typical NHDOT operations.

APPROACH

Various manufacturers were contacted about the possibility of providing cameras on a trial basis with an option to purchase. Two manufacturers, Safety Vision Inc. of Houston, TX, and Intec Video Systems Inc. of Laguna Hills, CA, agreed to provide their products to the Department. Both companies sell their own line of cameras and monitors designed for use in vehicle applications.

Safety Vision supplied the NHDOT with one black/white camera and one color camera. Intec supplied the NHDOT with one black/white camera and four color cameras. Intec also supplied the NHDOT with a radar proximity warning system for use with one of the cameras. This made for a total of seven systems which allowed the NHDOT to install a system on one vehicle in each of its six Maintenance Districts and on one vehicle in its Turnpikes Bureau. The vehicles to receive the systems were chosen because their designated plowing routes required either backing over long distances or multiple backing maneuvers at intersections. After a winter of operation, the Research Section conducted interviews with the drivers of the vehicles to get their opinions

on the impact of the cameras on safety as they performed their normal duties. The camera systems arrived and were installed in the summer of 2009. The NHDOT performed the installation through its Bureau of Mechanical Services with guidance from the manufacturers.

TEST VEHICLES AND CAMERA INSTALLATIONS

In Maintenance District 1, a 2006 Freightliner six-wheeled dump truck with a municipal body (does not require a spreader body insert) from the Butterhill/Franconia Patrol Section was selected. This vehicle plows several interstate ramps and as a consequence engages in frequent backing maneuvers for each run. The truck was outfitted with an Intec CVC240SHXL black/white camera with a shutter to cover the lens. In addition, an Intec CVSPV2020 pulse radar network consisting of two sensors and a wiring interface to enable the radar to operate with the camera system were installed. The monitor for this system was mounted in the cab of the truck between the seats at about seat height. The radar and camera are routed through an Intec CVS100XL single channel controller, and the monitor can be controlled with the CVR100 single channel remote. The radar is interfaced so that audible beeps are produced by the remote to indicate the proximity of the radar target to the vehicle. The monitor was Intec's CVD500LCD which is a 5" LCD display. The camera was mounted in the center of the tailgate on the body and the radar sensors were mounted on each side of the tailgate.



Figure 3: District 1 Camera and Radar



Figure 5: District 1 Sensor



Figure 4: District 1 Camera



Figure 6: District 1 Monitor

In Maintenance District 2, an International 4600 six-wheeled dump truck with a regular body from the Orford Patrol shed received an Intec CVC470HXL color camera, an Intec CVD640LCD 6.4 inch LCD color display, and an Intec CVS100XL single channel controller with the CVR100 remote control for the monitor. The remote control is mounted to the dashboard. This truck plows the Lyme Common that requires several backing maneuvers to complete. The monitor in this truck was mounted between the seats in front of the dashboard facing the driver. The camera was mounted 3 to 4 inches to the left of center above the pintle plate and below the dump body.



Figure 7: District 2 Camera



Figure 8: District 2 Monitor



Figure 9: District 2 monitor during backing

In NHDOT Maintenance District 3 an International 4900 six-wheel dump truck received an Intec CVC470HXL camera, an Intec CVD640LCD 6.4 inch LCD display, and an Intec CVS100XL single channel controller with the CVR100 remote control. The remote is mounted to the

dashboard. This truck has a plow route in Alton, NH and is required to perform several backing maneuvers during the course of its route. The monitor and camera are mounted in the same positions as the District 2 truck.



Figure 10: District 3 Camera



Figure 11: District 3 Monitor

The camera system in Maintenance District 4 was installed on an International 4900 six-wheel dump truck. This system is a Safety Vision SV500A black/white camera and a Safety Vision SV511 black/white monitor. The camera was mounted below the right side taillights on the side of the body. The monitor was mounted in the cab on the dashboard between the seats similar to those in District 2 and 3.

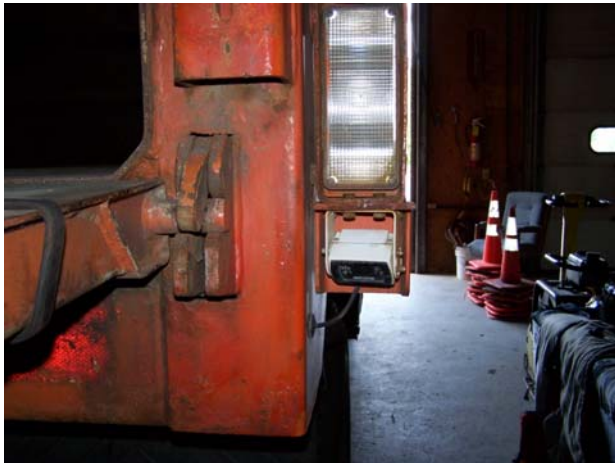


Figure 12: District 4 Camera



Figure 13: District 4 Monitor

The camera system in District 5 was mounted on a Komatsu front-end loader. This loader does a considerable amount of plowing on I-93 ramps south of Manchester and is required to perform multiple backing maneuvers. The camera is a Safety Vision SV523B color camera and the monitor is a Safety Vision SVLCD56 5.6 inch color monitor. The camera was mounted at the bottom center of the radiator grille and the monitor was mounted on the window ledge to the left of the steering column. In Figure 16, the monitor view is shown with green range markers visible to aid the driver in estimating distances.



Figure 14: District 5 Camera



Figure 15: District 5 Monitor



Figure 16: District 5 monitor showing range marks

The camera system in Maintenance District 6 was installed on a Freightliner six-wheel dump truck with a municipal body. This truck plows a route on US 1 that includes many intersections where the truck must back frequently. The camera is an Intec CVC470HXL color camera and

was mounted on the tailgate in the same position as the camera on District 1's truck. The monitor is an Intec CVD640LCD 6.4 inch color display mounted in the cab on the floor between the seats. This truck has the Intec CVS100XL single channel controller with the CVR100 remote control.



Figure 17: District 6 Camera



Figure 18: District 6 Monitor

The Bureau of Turnpikes, which is responsible for plowing several sections of interstate highway, received a camera system on a Freightliner six-wheel dump truck that operates out of the Hampton shed. This truck plows several ramps and also is required to back a quarter of a mile at one point on its route. The camera on this truck is an Intec CVC500AH color camera, the monitor is an Intec CVD500LCD color monitor, and the controller is an Intec CVS100H with a CVR100 remote control. This camera has a microphone for one-way audio so that the driver can hear what is going on behind the vehicle. The camera was mounted in the center of the truck above the pintle plate and below the body. The monitor was mounted on the dashboard between the seats.



Figure 19: Turnpikes' Camera



Figure 20: Turnpikes' Monitor



Figure 21: Turnpikes' monitor showing truck backing to trailer

For more details on each of the camera systems described above, please see Appendix B of this report.

EVALUATION

In the late summer of 2010, the drivers participated in a survey put together by the Research Section to determine how they felt the camera systems on their particular vehicle had performed over the course of the year since the cameras were installed. The survey consisted of 11 questions and was administered in the form of an interview in the field so that the specific camera system installations could also be viewed and photographed. Two drivers were unable to meet in the field so those surveys were conducted over the telephone.

The survey questions were as follows:

1. Approximate length of time camera has been in use?
2. Was the type of camera used appropriate for your vehicle?
3. Was the camera system helpful for backing?
4. Did the system prevent any backing accidents?
5. How well did the camera system work at night?
6. How well did the camera system work during daytime hours?
7. Would you recommend the continued use of these cameras?

8. Would you view going back to not having the camera favorably or unfavorably?
9. Do you feel the camera improved your personal safety and the safety of operations overall?
10. Did snow on the lens become an issue during operation?
11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).

The opinions varied widely in the survey. All drivers agreed that the cameras were better than nothing at all; however, the drivers had different opinions on the degree of helpfulness and improvement to safety contributed by the cameras. The general findings resulting from the survey are summarized below. For a complete list of survey responses please see Appendix A of this report.

- Placement of the display monitors in the truck cabs was a universal complaint. The drivers felt it was unnatural to be looking down at the floor or dash areas while backing up. In District 2 and 3, the monitors partially obstructed the state radio controls.



Figure 22: Districts 2 and 3 have to reach under the display to access their state radios

- Several drivers noted that the cameras were especially useful for operations involving trailers. Figure 21 captures a demonstration by the Turnpikes' driver showing the ease with which he could back to a trailer using the camera.
- The drivers who had monitors that displayed range markers liked that feature.
- There were no complaints with the black and white or color pictures.
- The driver of the District 1 truck equipped with the radar system thought that sometimes the system was too sensitive by picking up objects that were not actually in harm's way.
- Districts 2,3, and Turnpikes' cameras were mounted on the truck such that when the spreaders were put in for winter operations, the camera was at least partially obstructed. District 2 has configured their camera in such a way as to be able to operate it when the truck is moving forward so that they can see the application rate from the spreader. They cited this as a potentially money-saving application of the camera. District 3 uses mud flaps on their spreader and stated that the spreader made their camera useless as configured (Figures 23-26). A hired truck based out of the Alton shed in District 3 has a camera mounted *on* his spreader and reported that it works well. Turnpikes removed their camera during the winter.



Figure 23: District 3 truck with spreader



Figure 24: View with mud flaps down



Figure 25: Position of spreader and camera



Figure 26: View with mud flaps up

- District 4 and District 6 did not have problems with their cameras being blocked by the spreader, but their cameras became completely obscured by snow making them ineffective. These cameras were not equipped with automatic shutters.
- Both District 1 and District 6 have municipal bodies on the trucks utilizing the cameras. The cameras were installed directly on the tailgates of these bodies. Both operators felt that the camera mounted on the tailgate interfered with the ease of using the truck during normal non-winter maintenance operations.
- The general consensus was that the cameras did improve safety and the drivers would view going back to not having the cameras as unfavorable.
- Districts 4 and 5 expressed a desire to procure cameras for their graders. It was reported that the graders have particularly poor rearward visibility. It should be noted that the Town of Bow initiated its camera installation program after its grader was involved in a backing accident that resulted in a \$10,000 claim and a lawsuit.

CONCLUSIONS AND RECOMMENDATIONS

Based on operator interviews, the backing cameras appeared to improve operations and safety during the evaluation period. To achieve the full benefit of the cameras, however, several modifications are needed should larger-scale implementation of these devices be considered by the NHDOT.

A common refrain among operators was that a better mounting position was needed for the monitor in the cab. Following the interviews, the researchers revisited the Town of Bow to learn how they have dealt with this and other issues. The Town installs the monitors in trucks where the overhead rearview mirror would be in a normal vehicle, as shown in Figure 27. This works well and is seen by the drivers as being in a more natural position. It allows the driver to keep his head up so he can also be looking in the side mirrors. Glare shields are used to cut down on the problem of sun glare on the display screen.



Figure 27: Town of Bow typical monitor installation

The Town has also dealt effectively with the problem of camera position and spreader installation at the back of the truck. A receiver-hitch type of installation has been devised that allows the camera to be quickly detached and reattached to the truck or the spreader. This setup is shown in Figures 28 and 29. The installation includes enough extra wire so that the camera doesn't need to be unplugged when moving it from the truck to the spreader. The extra wire is looped and tied under the truck when the camera is on the truck. The extra wire is looped and stored in one the light housings when the camera is on the spreader. Bow uses 40 feet of wire for its camera installations with trucks similar in size to NHDOT.



Figure 28: Town of Bow receiver-type attachment point



Figure 29: Attachment point location on spreader

Bow equips their trucks with shuttered cameras to keep the lenses from getting obscured with snow. This is consistent with NHDOT's experience where shuttered lenses performed better than non-shuttered lenses in inclement weather. The Town has also experimented with the radar systems but does not install them as part of their program. There is a fear among managers that driver dependence on the radar could lead to bad habits or incautious backing. Finally, the Town uses only one brand of camera on its vehicles. The benefit of this approach is that there are spare parts available and the cameras can be interchanged from vehicle to vehicle.

Based upon the experiences of the NHDOT operators and lessons learned from the Town of Bow, the use of backing camera systems is considered beneficial when properly installed. Specific recommendations include the following:

- Monitors should be overhead-mounted so they are in line with a natural scan of the road and mirrors, and should be supplied with glare shields.
- Cameras should be equipped with automatic shutters to keep the lenses from being obscured by snow.
- Cameras should be mounted on the spreader during winter operation or in an unobstructed location on the truck. This can be facilitated through use of a receiver-type quick mounting system on both truck and spreader.
- Use of enough wire to allow the camera to remain connected when moving it from truck to spreader is recommended.
- Range markers are recommended for applications where distance measurement is considered critical.
- For trucks with municipal bodies, the camera should be placed on the truck chassis during the summer and on the tailgate during the winter. The jarring of the tailgate has damaged the camera in District 1 and removal of the tailgate for various operations means that the camera must be disconnected.
- In addition to plow trucks, loaders and graders are good candidates for camera systems.

REFERENCES

NIOSH [2010]. Engineering Considerations and Selection Criteria of Proximity Warning Systems for Mining Operations.
<http://www.cdc.gov/niosh/mining/topics/electrical/pwsselection.htm>. Accessed December 2010.

APPENDIX A
Driver Surveys

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS & RESEARCH
RESEARCH SECTION

BACKUP CAMERA RESEARCH PROJECT SUMMARY EVALUATION

Name: **Paul Poulton**

Date: **8/25/2010**

District: **1 (Butterhill Shed)**

Vehicle #: **H-493**

Manufacturer & Model Number of Camera: **Intec CVSPV2020 Sensor Network, Intec Monitor, Intec CVC240SHXL (shutter with camera)**

Now that the camera has been in use for a full winter and two summers we would like to have the following questions about the backup cameras answered again?

1. Approximate length of time camera has been in use:
year plus
2. Was the type of camera used appropriate for your vehicle?
 -
3. Was the camera system helpful for backing?
 - configuration in cab could have been different
4. Did the system prevent any backing accidents?
 - no
5. Did the camera system work ok at night?
 - yes, but glare of headlights from cars behind you is a problem
6. Did the camera system work ok during daytime hours?
 - yes
7. Would you recommend the continued use of these cameras?
 - maybe there are better ways to spend the money

8. Would you view going back to not having the camera favorably or unfavorably?
 - better than nothing
9. Do you feel the camera improved your personal safety and the safety of operations overall?
 - yes

10. Did snow on the lens become an issue during operation?
 - no, this camera has an automatic shutter

11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).
 - the monitor placement was a real problem, your tendency is to want to look down instead of paying attention to the mirrors, would really like to have the monitor moved to the dash or up overhead
 - right now, the camera does not work, must be a connection issue somewhere
 - sonar works but it is very sensitive and sometimes picks up things that are not there or are not dangers, does like the sonar though

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS & RESEARCH
RESEARCH SECTION

BACKUP CAMERA RESEARCH PROJECT SUMMARY EVALUATION

Name: **Peter Thayer**

Date: **9/13/10**

District: **2 (Orford Shed)**

Vehicle #: **H-664**

Manufacturer & Model Number of Camera: **Intec Color Camera and Monitor**

Now that the camera has been in use for a full winter and two summers we would like to have the following questions about the backup cameras answered again?

1. Approximate length of time camera has been in use:
2. Was the type of camera used appropriate for your vehicle?
 - yes, would have liked different winter mounting
3. Was the camera system helpful for backing?
 - yes
4. Did the system prevent any backing accidents?
 - hard to say
5. Did the camera system work ok at night?
 - yes
6. Did the camera system work ok during daytime hours?
 - yes
7. Would you recommend the continued use of these cameras?
 - yes, they are great for determining application rates and trailer operations
8. Would you view going back to not having the camera favorably or unfavorably?

- unfavorably
9. Do you feel the camera improved your personal safety and the safety of operations overall?
- yes
10. Did snow on the lens become an issue during operation?
- no
11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).
- monitor could have been better placed in the cab, had to move radio because monitor was blocking access to it
 - was great for checking application rates of deicer during the winter
 - would like some kind of quick connect system so it could be mounted right on the spreader
 - could see around spreader
 - helpful at intersections
 - super handy in the summer especially when working with trailers
 - definitely a helpful thing

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS & RESEARCH
RESEARCH SECTION

BACKUP CAMERA RESEARCH PROJECT SUMMARY EVALUATION

Name: **Don White**

Date: **8/18/10**

District: **3 (#315 Alton Shed)**

Vehicle #: **H-417**

Manufacturer & Model Number of Camera: **Intec CVC 470HXL/color monitor**

Now that the camera has been in use for a full winter and two summers we would like to have the following questions about the backup cameras answered again?

1. Approximate length of time camera has been in use:
 - 18 months

2. Was the type of camera used appropriate for your vehicle?
 - mount camera on spreader in winter
 - mount monitor overhead next time, should function as a rearview mirror

3. Was the camera system helpful for backing?
 - yes, felt could see quite a bit when spreader is not in the way
 - great for hitching up trailers
 - like the marker dots

4. Did the system prevent any backing accidents?
 - probably not

5. Did the camera system work ok at night?
 - the monitor is too bright at night and since the spreader was blocking the view, the driver just covered the monitor with a hat

6. Did the camera system work ok during daytime hours?
 - yes
 - thought it did ok during the rain

7. Would you recommend the continued use of these cameras?
 - yes, better than not having it

- better job with monitor mounting and would like to see mounted on spreader with a lens cover system
8. Would you view going back to not having the camera favorably or unfavorably?
- better than no camera
9. Do you feel the camera improved your personal safety and the safety of operations overall?
- it is helpful, but it is not a cure all
10. Did snow on the lens become an issue during operation?
- the camera was useless anyways because of where it was mounted
11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).
- the monitor should be overhead where the mirror would be
 - the monitor as mounted now interferes with the radio controls
 - likes the color monitor
 - hired truck at the shed has mounted camera on his spreader and loves it

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
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RESEARCH SECTION

BACKUP CAMERA RESEARCH PROJECT SUMMARY EVALUATION

Name: **Paul Robichaud**

Date: **8/18/10**

District: **4 (#408 Hancock)**

Vehicle #: **H-627**

Manufacturer & Model Number of Camera: **Safety Vision SV 500A/ SV 511 b/w monitor**

Now that the camera has been in use for a full winter and two summers we would like to have the following questions about the backup cameras answered again?

1. Approximate length of time camera has been in use:
 - Summer 2009

2. Was the type of camera used appropriate for your vehicle?
 - Safety Vision camera with b/w monitor

3. Was the camera system helpful for backing?
 - great for hooking up trailers
 - you still need to manually check when backing up, didn't feel it was of great benefit for the money

4. Did the system prevent any backing accidents?
 - no

5. Did the camera system work ok at night?
 - yes, monitor brightness is adjustable with this model

6. Did the camera system work ok during daytime hours?
 - yes

7. Would you recommend the continued use of these cameras?
 - yes, put them on the graders

8. Would you view going back to not having the camera favorably or unfavorably?
 - the cameras don't hurt anything

9. Do you feel the camera improved your personal safety and the safety of operations overall?

- not really
10. Did snow on the lens become an issue during operation?
- it would get covered by snow
11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).
- money could be better spent elsewhere
 - monitor placement and visibility ok
 - put it truck of someone that has backing accidents
 - put it on one of the graders
 - thought the sonar alarm might be neat to try

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS & RESEARCH
RESEARCH SECTION

BACKUP CAMERA RESEARCH PROJECT SUMMARY EVALUATION

Name: **Peter Jaskal**

Date: **8/19/10**

District: **5 (Derry #528)**

Vehicle #: **H-796**

Manufacturer & Model Number of Camera: **Safety Vision SV 620A, Safety Vision SV-LCD56**

Now that the camera has been in use for a full winter and two summers we would like to have the following questions about the backup cameras answered again?

1. Approximate length of time camera has been in use:
2. Was the type of camera used appropriate for your vehicle?
 - yes
3. Was the camera system helpful for backing?
 - very helpful
4. Did the system prevent any backing accidents?
 - yes
5. Did the camera system work ok at night?
 - yes
6. Did the camera system work ok during daytime hours?
 - yes
7. Would you recommend the continued use of these cameras?
 - absolutely, loved it
8. Would you view going back to not having the camera favorably or unfavorably?
 - unfavorably

9. Do you feel the camera improved your personal safety and the safety of operations overall?
- yes
10. Did snow on the lens become an issue during operation?
- no, this camera is on a loader and the radiator exhaust blows over it, also the camera has a partial lid and the loader does not go fast enough to suck snow onto the back of it like a truck
11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).
- driver was very enthusiastic about the camera
 - would like to get one for their grader also
 - occasionally the sun does glare on the monitor
 - the backup alarm is picked up by the camera and is quite loud
 - the camera has been an asset
 - loves it when plowing, loading truck, everything
 - likes the demarcation dots

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS & RESEARCH
RESEARCH SECTION

BACKUP CAMERA RESEARCH PROJECT SUMMARY EVALUATION

Name: **Nathan Young**

Date: **9/1/10**

District: **6 (North Hampton)**

Vehicle #: **H-680**

Manufacturer & Model Number of Camera: **Intec CVC470HXL, color monitor**

Now that the camera has been in use for a full winter and two summers we would like to have the following questions about the backup cameras answered again?

1. Approximate length of time camera has been in use:
 - installed in summer of 2009

2. Was the type of camera used appropriate for your vehicle?
 - yes

3. Was the camera system helpful for backing?
 - don't use very much due to monitor location
 - helpful for backing up small trailers

4. Did the system prevent any backing accidents?
 - no

5. Did the camera system work ok at night?
 - hard to see clearly

6. Did the camera system work ok during daytime hours?
 - yes

7. Would you recommend the continued use of these cameras?
 - yes, doesn't hurt

8. Would you view going back to not having the camera favorably or unfavorably?
 - favorably

9. Do you feel the camera improved your personal safety and the safety of operations overall?
- probably it did a little
10. Did snow on the lens become an issue during operation?
- yes, it pretty much made it useless
11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).
- monitor placed on floor and sort of underneath plow levers
 - liked the color
 - seems pretty rugged, everything is still working well
 - would be better overhead

NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS & RESEARCH
RESEARCH SECTION

BACKUP CAMERA RESEARCH PROJECT SUMMARY EVALUATION

Name: **John Steeves**

Date: **8/12/10**

District: **Turnpikes**

Vehicle#: **H-599**

Manufacturer & Model Number of Camera: **Intec 500AH/color monitor**

Now that the camera has been in use for a full winter and two summers we would like to have the following questions about the backup cameras answered again?

1. Approximate length of time camera has been in use:
 - 7/28/09 to present except for winter

2. Was the type of camera used appropriate for your vehicle?
 - wrong bracket for monitor
 - mount camera in a better spot

3. Was the camera system helpful for backing?
 - yes, but not as helpful as it could have been mounted in a different spot, bed interfered with view so the camera was tilted down and consequently had a narrow field of view

 - really helpful for hooking up trailers

 - removed during winter operations

4. Did the system prevent any backing accidents?
 - no

5. Did the camera system work ok at night?
 - needs to be brighter at night, driver would have liked a brightness setting on monitor to see if he could have seen more

6. Did the camera system work ok during daytime hours?
 - yes, driver would have liked monitor mounted overhead instead of on the dash
 - rain makes camera ineffective
 - would like to have it mounted on spreader and protected from snow backs ¼ mile

7. Would you recommend the continued use of these cameras?
 - better than nothing
8. Would you view going back to not having the camera favorably or unfavorably?
 - better than nothing
9. Do you feel the camera improved your personal safety and the safety of operations overall?
 - mixed feelings
 - would like to have opportunity to evaluate in winter
10. Did snow on the lens become an issue during operation?
 - would have
11. Any other comments or observations (i.e. monitor placement and visibility in cab, ease of operation, etc.).
 - need way to adjust monitor brightness
 - really like the color
 - markers on screen are helpful
 - red markers are set up so that if you are on those, it is too late
 - objects are closer than they appear
 - no instruction manual came with camera
 - biggest thing would be to change camera position to get better fov
 - this placement did not interfere with the tailgate

APPENDIX B
Equipment Specifications

District 1 Camera



Quality First
For Performance That Lasts

CVC240HXL

Intec's CVC240HXL Extended Life Mobile Safety Camera provides the widest field of view available for the most demanding applications. The multiple-sealed injection cast alloy enclosure and Mil-Spec connector guarantee reliable, waterproof performance which is backed by an industry leading 6 year warranty. An optional automatic shutter protects the lens area from dirt, dust and debris when not in use.

The CVC240HXL also features a built-in thermostatically controlled heater insuring reliable performance in the coldest climates and an IP68 waterproof rating. You can be sure the CVC240HXL will provide you with a clear picture of what's around your vehicle.

INTEC continues its record of technology, innovation and highest performance. Combine that with industry leading warranties and a dedicated staff ready to work with you and it's easy to see why Intec is the clear choice for your vehicle safety camera needs.



Features Include:

125° x 100° Wide Field of View
Optional Lenses Available
0.05 Lux Low Light Sensitivity
IP68 Waterproof Rating
Optional Automatic Shutter
Built-In Thermostatically Controlled Heater
Six Year Warranty
Durable Powder Coat Camera Finish

"With over 200 installs under our belt, we find the Intec camera systems to be the highest quality, and most reliable rear vision systems on the market. Intec's Sales and Service departments are always there for you."

Art Schleifman, Purchasing, Container Systems & Equipment Company, Inc. Daytona Beach, FL

District 2,3, and 6 Camera



Quality First
For Performance That Lasts

CVC470HXL

Intec's CVC470HXL Extended Life Mobile Safety Camera provides the widest field of view available for the most demanding applications. The multiple-sealed injection cast alloy enclosure and Mil-Spec connector guarantee reliable, waterproof performance which is backed by an industry leading 6 year warranty. An optional automatic shutter protects the lens area from dirt, dust and debris when not in use.

The CVC470HXL also features a built-in thermostatically controlled heater insuring reliable performance in the coldest climates and an IP68 waterproof rating. You can be sure the CVC470HXL will provide you with a clear picture of what's around your vehicle.

INTEC continues its record of technology, innovation and highest performance. Combine that with industry leading warranties and a dedicated staff ready to work with you and it's easy to see why Intec is the clear choice for your vehicle safety camera needs.



Features Include:
125° x 100° Wide Field of View
Optional Lenses Available
Crisp Color Imaging
IP68 Waterproof Rating
Optional Automatic Shutter
Built-In Thermostatically Controlled Heater
Six Year Warranty
Durable Powder Coat Camera Finish

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Turnpikes' Camera



Quality First
For Performance That Lasts

CVC500AH

Intec's CVC500AH Audio Equipped Watertight Mobile Safety Color Camera provides a large field of view for the most demanding applications. The multiple-sealed injection cast alloy enclosure and connector guarantee reliable, waterproof performance. Featuring a compact, light weight design, wide field of view and superior low light sensitivity, the CVC500AH continues Intec's long history of quality and innovation.

The CVC500AH also features a built-in microphone providing one-way audio to the operator, a built-in thermostatically controlled heater insuring reliable performance in the coldest climates and an IP68 waterproof rating. You can be sure the CVC500AH will provide you with a clear picture of what's around your vehicle.

INTEC continues its record of technology, innovation and highest performance. Combine that with industry leading warranties and a dedicated staff ready to work with you and it's easy to see why Intec is the clear choice for your vehicle safety camera needs.

You'll always see more with Intec

Imagine being able to see the entire width of your vehicle, plus several feet to either side and at just 60 feet from the vehicle the viewing area expands to approximately 170 feet wide.



Features Include:
123° x 91° Wide Field of View
Crisp Color Imaging
IP68 Waterproof Rating
One-Way Audio
Built-In Thermostatically Controlled Heater
Stainless Steel Mounting Bracket and Sunshield
Durable Powder Coat Camera Finish
Optional Flush Mount Housing



Shown above in the optional flush mount assembly

District 1 and Turnpikes' Monitor



Quality First
For Performance That Lasts

CVD500LCD

INTEC's CVD500LCD Extreme Duty Color Mobile Safety Display has been designed to meet all of the requirements of today's demanding vehicle environments. Our high resolution 5" LCD eliminates blind spots by providing you with clear sharp images. New state-of-the-art electronics enable better contrast and improved image clarity and the automatic brightness control lightens or darkens the screen brightness in accordance with the amount of ambient light around the display.

In addition, INTEC has added an integrated active radar display component. This integration affords an extra level of safety without the added expense of additional hardware and installation time.

With an IP68 rating and flexible mounting options, our displays can be installed where they're needed most, inside or outside. They are easily flush mountable and available in module form for custom and OEM installations.

INTEC continues its record of technology, innovation and highest performance. Combine that with industry leading warranties and a dedicated staff ready to work with you and it's easy to see why Intec is the clear choice for your vehicle safety camera needs.

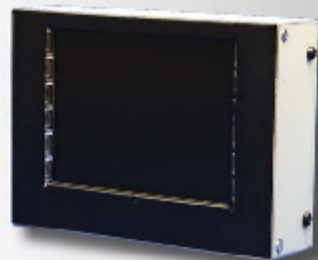


Radar Integration

"With over 200 installs under our belt, we find the Intec camera systems to be the highest quality, and most reliable rear vision systems on the market. Intec's Sales and Service departments are always there for you."

Art Schleifman, Purchasing, Container Systems & Equipment Company, Inc. Daytona Beach, FL

Features Include:
High Resolution 5" LCD
Automatic Brightness Control with Manual Override
IP68 Waterproof Rating
Integrated Radar Capability with Visual and Audible Alert
Bracket and Flush Mountable
Automatic Distance Grid - Rear Trigger Activated
Camera Position Name Displayed when Selected
Module form for Custom OEM Installs



Module Form

District 2,3, and 6 Monitor



Quality First
For Performance That Lasts

CVD640LCD

INTEC's CVD640LCD Extreme Duty Color Mobile Safety Display has been designed to meet all of the requirements of today's demanding vehicle environments. Our high resolution 6.4" LCD eliminates blind spots by providing you with clear sharp images. New state-of-the-art electronics enable better contrast and improved image clarity and the automatic brightness control lightens or darkens the screen brightness in accordance with the amount of ambient light around the display.

In addition, INTEC has added an integrated active radar display component. This integration affords an extra level of safety without the added expense of additional hardware and installation time.

With an IP68 rating and flexible mounting options our displays can be installed where they're needed most, inside or outside. They are easily flush mountable and available in module form for custom and OEM installations.

INTEC continues its record of technology, innovation and highest performance. Combine that with industry leading warranties and a dedicated staff ready to work with you and it's easy to see why Intec is the clear choice for your vehicle safety camera needs.



Radar Integration

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Art Schellman, Purchasing, Container Systems & Equipment Company, Inc. Daytona Beach, FL

Features Include:
High Resolution 6.4" LCD
Automatic Brightness Control with Manual Override
IP68 Waterproof Rating
Integrated Radar Capability with Visual and Audible Alert
Bracket and Flush Mountable
Automatic Distance Grid - Rear Trigger Activated
Camera Position Name Displayed when Selected
Module form for Custom OEM Installs



Module Form

District 1 and Turnpikes' Controller and Remote Control



Quality First
For Performance That Lasts

CVS100 Series

INTEC's CVS100 Series of controllers have been designed to meet the challenges of today's installation requirements. With heavy duty injection cast aluminum alloy cases and stainless steel mounting plates, they can be placed without concern of harsh treatment. The H and XL versions can be mounted outside the vehicle, freeing up much needed interior space.

The smart fuse circuitry and load dump protection protects critical components, even in the event of cable damage, and pinpoints the likely section, saving you time and money.

Processor Controlled video out allows you to record critical information or display it on an additional screen.



CVS100M



CVS100XL

Other features include back lit remote control buttons, for easy visibility at night and an integrated active radar component. Add to that, industry leading warranties and a dedicated staff ready to work with you and it's easy to see why Intec is the clear choice for your vehicle safety camera needs.



CVS100H

Features Include:	CVS100M	CVS100H	CVS100XL
Smart Fuse and Load Dump Protection	•	•	•
+12 or +24 VDC Operation	•	•	•
IP68		•	•
Integrated Radar Capability	•		•
Back Lit Remote Control Buttons	•	•	•
External Video In with "Hot Key" Activation	•	•	•
Processor Controller Video Output		•	•
Processor Controller Audio Output	•	•	•

CVR100 Remote Control



Dimensions:

W 2.13" x H5.83" x D1.18"

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Art Schleifman, Purchasing, Container Systems & Equipment Company, Inc. Daytona Beach, FL

District 4 Camera and Monitor

SAFETY VISION

REAR VISION AND SIDEVISION™ CAMERA SYSTEMS

SV-50065 Kit

BLACK & WHITE CAMERA

- Heavy-duty design
- Turns on when monitor is on or vehicle is in reverse
- Image reversal switch (mirror or true image)
- Water-resistant housing
- Backlight compensation
- Built-in microphone
- Built-in auto iris
- Waterproof, threaded-metallic DIN-sealed connector



SV-500

Image Device	..... Interline-transfer-type CCD
Picture Resolution	..... 270,000 pixels
Image Size	..... 1/3 inch
Sync System	..... Internal
Horizontal Resolution	..... 380 TV lines
Vertical Resolution	..... 350 TV lines
Minimum Illumination	..... 0.01 lux
Field of View	..... Diagonal 120°
Signal-to-Noise Ratio	..... Better than 47dB (AGC off)
Impact Rating	..... 10 G
Power Supply	..... 12 VDC from monitor
Operating Temperature	..... -25°C ~ 80°C (-13°F ~ 176°F)
Storage Temperature	..... -30°C ~ 80°C (-22°F ~ 176°F)
Weight	..... 0.4 kg (0.9 lb)
Dimensions	..... 69 mm × 42 mm × 60 mm
(w x h x d)	..... 2.7 in. × 1.65 in. × 2.4 in.

Supplied Accessories Camera bracket
Sun visor
Screw kit
Allen wrench

CRT MONITOR

- Turns on automatically when vehicle is in reverse
- Two camera inputs; switchable camera views
- RCA input and output jacks
- Built-in speakers



SV-511

Power Input	..... 10 ~ 26 VDC
Power Consumption	..... Maximum 25 watts
Video System	..... EIA standard signal
Sync System	..... Internal
CRT Screen Size	..... 5.5-inch, diagonal
Horizontal Resolution	..... More than 700 TV lines
Vertical Resolution	..... More than 500 TV lines
Power Connector	..... Red: positive, 10 ~ 26 VDC
	..... Black: ground
	..... Green: reverse gear, 10 ~ 26 VDC
Camera Input (2 CH)	..... 4-pin mini-DIN socket
Audio/Video Input	..... PIN jack
Audio/Video Output	..... PIN jack
Operating Temperature	..... -15°C ~ 60°C (5°F ~ 140°F)
Storage Temperature	..... -30°C ~ 70°C (-22°F ~ 158°F)
Impact Rating	..... 6 G
Weight	..... 2.4 kg (5.3 lbs)
Dimensions	..... 182 mm × 136 mm × 200 mm
(w x h x d)	..... 7.2 in. × 5.4 in. × 7.9 in.

Supplied Accessories Mounting bracket
Sun visor
Screw kit
Instruction manual
Power cable
Distance decal

Available cable lengths: 16ft (SV-530), 21ft (SV-512), 29ft (SV-513), 40ft (SV-540), 50ft (SV-522), 65ft (SV-523)
System ships with a 65-foot cable unless otherwise specified.



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888.328.8855

Southwest Office:
Dallas, TX 75085
Toll Free: 866.792.8855

Midwest Office:
Vernon Hills, IL 60061
Toll Free: 877.523.8855

East Coast Office:
Greensburg, PA 15601
Toll Free: 888.988.8855

District 5 Camera and Monitor



This collision avoidance camera system supports two water-resistant color or black and white cameras giving you complete coverage of the area surrounding your vehicle. The camera's infrared illuminators automatically activate as needed providing you with optimal image quality.

SPECIFICATIONS	
SV-LCD50 Monitor	
LCD System	5-inch
Video System	NTSC standard signal
Auto Dimmer	Yes
OSD Controls	Contrast, color, tint, image select CA1 (mirror view/true view), auto scan time, scale on/off
Resolution	960 x 234 pixels
Impact Rating	4G
Sync System	Internal
Power Requirement	10 ~ 32 VDC
Power Consumption	10W
Operating Temperature	14°F ~ 122°F (-10°C ~ 50°C)
Dimensions (w x h x d)	6.75 in. x 4.5 in. x 1.25 in. (170 mm x 115 mm x 28 mm)
Weight	2.2 lbs. (1.0 kg)
SV-620A Color/SV-500A Black and White Camera	
Image Sensor	1/3 inch interline transfer CCD
Signal Format	NTSC
Picture Elements	270,000 pixels
Field of View	130°
Sync System	Internal
Horizontal Resolution	330 TV lines (color) 380 TV lines (black and white)
Minimum Illumination	0 lux
Signal-to-Noise Ratio	50 dB minimum (color - AGC off) 47 dB minimum (black and white - AGC off)
Impact Rating	10G
Power Requirement	12 VDC
Operating Temperature	-22°F ~ 122°F (-30°C ~ 50°C)
Dimensions (w x h x d)	2.7 in x 1.6 in x 2.0 in (69 mm x 41 mm x 50.7 mm)
Weight	.80 lb. (0.3 kg)

When the vehicle starts or is placed in reverse, the system activates. With the camera's built-in microphone, people behind the vehicle can communicate directly with you alerting you to possible hazards.

Features

- Camera has integrated auto iris and microphone with water-resistant housing
- Monitor has two camera inputs with switchable camera views
- Eleven advanced infrared illuminators with automatic sensor for better image quality in low-light conditions



APPENDIX C
Equipment Costs

Equipment Costs (2009)

Safety Vision
 6100 W. Sam Houston Pkwy. N.
 Houston, TX 77041-5113
 Tel (800) 880-8855
 Fax (713) 896-6640
www.safetyvision.com

Qty	Item	Unit Cost	Total Cost
1	SV-50065 B&W Camera (Includes monitor, cable, mount kit)	\$ 450.00	\$ 450.00
1	SV-CLCD56-620 Color Camera (Includes monitor, cable, mount kit)	\$ 625.00	\$ 625.00
	Shipping	\$ 56.16	\$ 56.16
	Total		\$ 1,131.16

Intec Video Systems, Inc
 23301 Vista Grande
 Laguna Hills, CA 92653
 Tel (949) 859-3800
 Fax (949) 859-3178
www.intecvideo.com

Qty	Item	Unit Cost	Total Cost
3	CVC470HXL Color Camera	\$ 1,190.00	\$ 3,570.00
3	CVD640LCD 6.4" LCD Display	\$ 475.00	\$ 1,425.00
3	Single Channel Controller	\$ 345.00	\$ 1,035.00
3	Single Channel Remote	\$ 85.00	\$ 255.00
3	Cable	\$ 200.00	\$ 600.00
	Shipping	\$ 171.94	\$ 171.94
	Total		\$ 7,056.94
1	CVC240SHXL B&W Camera	\$ 1,075.00	\$ 1,075.00
1	CVC500AH Color Camera	\$ 400.00	\$ 400.00
2	CVD500LCD 5" LCD Display	\$ 375.00	\$ 750.00
1	Single Channel Controller	\$ 325.00	\$ 325.00
1	Cable	\$ 80.00	\$ 80.00
1	Single Channel Controller	\$ 345.00	\$ 345.00
1	Cable	\$ 190.00	\$ 190.00
2	CVR100 Single Chan. Remote	\$ 85.00	\$ 170.00
2	Radar Sensor Network	\$ 395.00	\$ 790.00
1	Radar Adapter, Cable, Brackets (2)	\$ 290.00	\$ 290.00
	Shipping	\$ 52.07	\$ 52.07
	Total		\$ 4,467.07