Replacing In-Pavement Loops With Video Detection

By Robert L. Kenny, PE; ITE - Fellow Member; City of Colorado Springs

This paper relates the experiences of a municipality that recently converted many actuated signals from in-pavement loops to video detection. It provides information on specifications and recommended procedures for a conversion project, and guidelines based on the experience of the author managing a project to install over 1300 cameras at 421 intersections over 3 years. It also provides information that can be used to justify the conversion based on costs, service level and other useful features of video detection. The experience noted in this article could help other agencies avoid difficulties and install better working video detection at lower cost.

Introduction

Colorado Springs, Colorado, with the surrounding area, has a population of approximately 500,000 and serves as a major center of activity for much of southern Colorado. With over 300 days of sun, rolling to hilly terrain and an elevation of from 6000' to 7000', the climate causes severe conditions for roadway maintenance and in-pavement loops. The high altitude & sunny weather results in extreme temperature changes daily, with day to night temperature changes of 50 degrees F common. During the fall, winter and spring, the road surface experiences frequent freeze-thaw cycles that reduce the life of typical in-pavement loops to 5 years or less, resulting in an average annual failure rate of 20%. The signal system includes 465 signals, 44 fixed time (downtown). Geometrics of the 421 actuated intersections vary from 2 lane vs 2 lane to 6 lane vs 6 lane plus auxiliary right turn and dual left turn lanes, requiring from 2 to 24 loops per intersection. With an average of 10 loops per intersection, the system depended on over 4,000 loops prior to the video project. The loop failure rate resulted in a need to replace an average of 800 annually, work contracted out to private industry at a rate that would cost $800,000 each year. However, typical of many cities, the maintenance budget has not kept up with demand. Therefore, service levels had been dropping, to the point where some loops were not repaired for a period of over 2 years.

In-pavement loop failures place a constant call on the approaching cross street or left turn phase regardless of actual traffic present. This results in a significant reduction of intersection efficiency and capacity, providing max green time for non-existent traffic, and interfering with effective, traffic responsive timing plans. The "phantom" calls also cause of a lot of irritation and negative phone calls from the public, especially during off-peak times. As volume to capacity ratios on many arterials exceed 85% and both congestion and accidents were increasing, city staff initiated research to find ways to increase efficiency of the roadways, especially signalized intersections. In addition to typical TSM improvements, (adding turn lanes, accel / decel lanes, etc) the city needed to find a cost effective solution to the loss in efficiency from the loop failures, reduce maintenance costs, and keep up with rapid roadway lane configuration changes caused by the growth in traffic volumes.

Project Initiation - Specifications & Installation Process

Various solutions have been considered by many agencies to replace failing loops – microwave detection, under pavement "permanent" loops, in-pavement loops using modified installation techniques and/or materials, and video detection. Since frequent changes in lane configuration (minor widening for left turn lanes, converting to dual lefts, construction and maintenance activities, etc) requires a system that can be modified easily and inexpensively, the various in-ground products were eliminated for consideration. With the improvements in video detection technology in the past 10 years, the city tentatively chose video as the best system to replace the loops. During late 2000, a few intersections were converted for evaluation, and in April of 2001 the city advertised for what has become one of the largest video based detection projects in the US.

The equipment and installation were bid separately because I felt we would have better control over what equipment was provided and who would do the work. Often a signal contractor will have an exclusive working relationship with one supplier who sells or promotes just one brand of equipment, so labor rates could dictate the equipment used. I preferred to review all the equipment options, limit the equipment bid to those manufacturers who met stated needs and provided features for future uses, and let all the contractors bid on installation separately.

For the equipment supply bid, performance, or functional specs were used instead of specific hardware specs. The problem with specific detailed hardware specs is that most are brand-specific, including a proprietary or unique connector, or gauge of wire, input keyboard, or something else, often minor and not really related to the function of video detection. A unique item can result in a spec that is proprietary and exclusionary. All of the "sample specifications" provided for the city had this flaw. Colorado Springs did, however, have two hardware based conditions: #1 – the video image processor (VIP) had to install directly into a 170 input file, because the city's older cabinets did not have room for any adapters or "black boxes", and #2 - all the intelligence must be in the cabinet, using "dumb"cameras. This condition was included because the rapidly changing video camera industry will improve the detection abilities in the future, and the city wanted to be able to switch out cameras now and in the future without having to change any of the in-cabinet video processing equipment. There was also concerns about being tied to any one brand of camera for replacement, and it could help to keep costs down.

The equipment bids opened in April 2001, and the west coast importer of Traficon equipment, Kargor from Salem, OR was the low bidder. The equipment purchase contract included cameras, brackets, dual and single camera input VIP units, wireless remote cameras (1000' range), viewcom

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communication modules (allowing one module to communicate with the entire rack from the traffic operations center), software, training and support. All the equipment had to have a 2 year warrantee, including free upgrades during the warrantee period. Combination video wire with power, focus, zoom, heater and video signal in one cable was purchased separately by the city.

Two local contractors who had previously worked on signals were pre-qualified, then required to send personnel to training conducted jointly by Traficon and city signal maintenance technicians. The contractors were used for the initial installations on a "time & materials" basis. However, a significant amount was saved on the second and later intersection groupings by adding additional contractors and having them bid for the installation. Labor was bid as a "lump sum" for each group of 8-12 intersections. The lump sum bid included bucket truck usage, a licensed and unlicensed installer, miscellaneous materials & supplies, and traffic control. Installation details were provided to the bidders using a site survey for each intersection, which was provided two weeks prior to bidding.

Using the broken loop list, and complaints from the public, intersections were prioritized and put into bid groups by area of town. This method was well received by the contractors, as they would be solely responsible for the traffic control, equipment, labor and minor materials for the entire set of intersections, and if they miscalculated too high or too low on any one intersection, it would not have such a significant impact on their total profit or costs for the group. Each intersection was reviewed in the field to create a small drawing, or site survey identifying phases in recall vs actuated, each camera location and phases for the camera input, along with any other required work, such as addition of street lights, or conduit replacement.

Since each group of intersections was treated as a separate contract, more than one contractor could be working at the same time, if they split the bids. As it turned out, that was usually the case, with one contractor getting 2 or 3 groups each time. They were given 28 calendar days to complete installation, which seems fast, but after the initial group, none of the contractors had a problem with time count. This competitive method of bidding installation labor saved $2000 - $3000 per intersection, or approximately $1,000,000 over the entire project. Since we had previously purchased the equipment and wire, the installation went relatively quickly, with an average of 2 days per intersection. Installation was followed up by our 2-man video tech crew to fine tune the installation using a 19" high resolution monitor from inside a custom built video van.

Originally the contractors set up the cameras, but with the profit motive putting demands on their time, the city obtained better results with our own crews doing the fine-tuning. This process improved the aim, zoom & focus of the cameras, and made a significant improvement in detection. Then the VIPs were programmed with the various layouts of "virtual" loops, making sure outputs were correct, as well as other features, such as delay on right turn lanes, extension, or different configurations needed by time of day.

Costs of video conversion varied, based on type of intersection (span wire vs mast arm), number of cameras (from 1 to 8) and additional work required, such as adding street lighting. Over the past 421 intersections completed, the average cost for all materials, equipment, and installation labor, not counting city staff time, has been slightly over $9,000 per intersection, with an average of 3.2 cameras per intersection. This is lower than typical costs for video, but it is based on a very large group of intersections. However, it does include the extra city costs of a custom built video van, an additional bucket truck, and various testing equipment. Significant savings have occurred by using the process of bidding video wire directly, keeping the labor and equipment bids separate, and using city forces to do the fine-tuning. Prior to using this procedure, costs on the initial 15 test intersections were approximately $17,000 per intersection. By committing to a large project, and following these procedures, the total project with 421 actuated intersections will be completed for about $3,800,000, compared to $7,200,000 estimated cost based on the initial intersections using the traditional method of bidding video installation with the contractor providing everything. This is a project savings of approximately $3,400,000.

Upon completion, maintenance needs will be approximately $100,000 per year, saving $700,000 annually for loop replacement. Over the past three years the city has experienced a maintenance rate of about 5% for video compared to the 20% for loops, including all causes of service call, from accident caused knock-downs to equipment failure. The 5% is made up of 0.67% failure of VIP's, 1.5% failure of cameras, and a little over 2% caused by wind or traffic accidents. This a significant reduction in service needs compared to loops, it has resulted in greatly improved level of service, improved capacity, reduced delay, air pollution, fuel usage, accidents and citizen complaints.

Tips For Sucessful Video Installation

After installing over 400 intersections, we have learned that video installation is as much art as science - camera placement cannot follow set standard layouts. Absolutely every camera location at every intersection must be established by a field trip, to visualize what the camera will "see". It helps significantly if the person creating the site survey has a background in video or still photography along with traffic engineering, so they can visualize the scene from a variety of camera placements, and will be aware of the lighting conditions expected over a 24 hour period. Site lighting is very important, especially the background, as it can affect the auto-iris in many cameras. The vertical angle of each camera vs the rising or setting sun, taking into account seasonal variations is important. Mast arm locations are much easier, as often span wire poles are shorter and placed further off the traveled roadway, creating more difficult viewing angles. Low mounting heights result in cameras installed nearly horizontal, which can lead to more snow or rain on the lens, and cause more glare, especially

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at night, from approaching headlights on wet surfaces. Many trouble calls are from the camera being blinded by the sun, for only a few minutes, and for just a few days in the spring and fall, but it still needs to be solved. Often problems can be reduced by increasing camera height for a better vertical angle. "Side shooting" can solve some difficult angles, although this should be done with care, as large trucks in the opposite direction travel lane can "swamp" the camera image eliminating detection calls.

Large horizontal angles can cause problems when vehicles in one lane block or put in a false call in another lane. Worn, polished and shinny pavement, especially at night and in wet conditions can allow reflections or glare from a vehicle to cause false calls in adjoining lanes. This is more likely if the camera chip does not control image bloom, or if the camera is shooting across a left turn lane to detect through moves. Each intersection is a unique environment, and taking adequate time in the field to create an effective site survey is critical to the success of the project, and best not left up to your contractor.

Some suggestions:

- Keep the camera as high as possible, and zoom in to avoid unnecessary background
- Keep the view as straight on as possible to eliminate blocking the view by adjacent vehicles
- Never have the horizon in the picture (or bodies of water or other large reflective surfaces)
- Buy the best, highest resolution B / W camera available with a good quality auto iris lens
- Use a fast CCD chip without smear, bloom or memory
- Make sure the housing has internal heating (for cold climates)
- Buy or make hood extensions to eliminate sun glare when necessary and eliminate snow
- Get a good monitor for set-up (19" min, high resolution) and modify a van for video only
- Include your signal techs in the project, but limit the setup to one person if possible
- Instead of shooting across too many lanes, install additional cameras to eliminate occlusion
- Make sure your supplier will provide training for your technicians, contractors and staff
- Don't over sell the project to politicians or the public – it replaces loops, it doesn't fix bad signal timing!

Also, inform the public what you are doing and why. Even after creating a short public information video on the project for the local cable TV, I still get a lot of calls such as "Why are you spying on me?", "Will I get a ticket for running the light?", or "I need a copy of the video tape, we had an accident and I am sure it wasn't my fault." We are frequently explaining that we do not record anything, the video signal is used only by the video processor and signal controller.

Summary & Conclusion

Upon completion of the project, we firmly believe video was the right choice to replace in-ground loops. The project has improved service to our citizens, reduced delay caused by broken loops, and reduced signal maintenance costs. During construction projects, different "virtual loops" can be set up to match temporary traffic control plans when traffic has to be shifted - then it can be shifted back after the work is done using alternate configurations – takes about 20 seconds to load. Other different configurations, such as third car actuation for left turn phases during off-peak hours, advance loops for volume-density, and other configurations can also be put into memory (the system allows up to 4 different configurations and 4 time of day schedules). Video loops have all the features of in-pavement loops, such as extension, delay, etc. without the drawbacks.

Staff has started to explore the other features of the system – count loops can be set up independently of the phase detection loops for turning movement counts, and a "Viewcom" module can allow us to communicate from our Traffic Operations Center to the individual intersection over phone, fiber or radio, which allows remote download / upload of different configurations, pick up traffic counts, make sure the camera is working, check for glare or false calls, etc. Colorado Springs now has more flexible, less expensive and more dependable detection for our actuated signals.

For additional information, contact Robert Kenny, 719-385-7618, or email at bkenny@springsgov.com

Robert Kenny, Senior Traffic Engineer & project manager with the City of Colorado Springs, Colorado has 30 years transportation engineering experience working for the state of Colorado, Boulder County, and the cities of Boulder, Longmont, Colorado Springs, and Gallup, NM. He has been responsible for municipal traffic engineering, urban & rural roadway design, construction management, pedestrian & bicycle safety, accident reduction, traffic signal modernization and ITS projects. He is a registered professional engineer in Colorado, and is a Fellow member of ITE.

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