Final Evaluation Report: Task Order #2 -Evaluation of the POP
UP™ Programmable Delineator

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Final Evaluation Report

Task Order #2 - Evaluation of the
POP UP™ Programmable Delineator

prepared by
Center for Urban Transportation Research
College of Engineering
University of South Florida

June 1997

The opinions, findings, and recommendations expressed in this report are those of the Center for Urban Transportation Research and the University of South Florida and not necessarily those of the Florida Department of Transportation. This report, serving as the final report for Task Order #2, has been prepared in cooperation with the Florida Department of Transportation-Office of Toll Operations, in partial fulfillment of (Electronic Toll and Traffic Management Retainer Services) Contract No. B-A900, State Job Nos. 97000-1322 and 99900-5000, Journal Trans. 4920265500648900700, and CUTR Account No. 21-17-248-LO-zero.

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Executive Summary
The use of orange cones to delineate highway lanes has become common practice throughout North
America. These cones are inexpensive, portable, can withstand impacts from vehicles traveling at
high speeds, do not damage vehicles, are easily recognized, and their meaning is understood by the
driving public. Currently, Florida’s Turnpike uses them to delineate its reversible lanes at certain
toll plazas. This practice works well, but with the addition of electronic toll collection and high
speed traffic at these plazas it will become dangerous for toll plaza attendants to venture into the
lanes to move these cones around. This report examines an alternative to the orange cones --
retractable highway lane delineators (RHLDs), which automatically raise up from and lower into the
ground without anyone needing to work in traffic.

It was found that only one company, TELE-SPOT Systems of Stamford, Connecticut, produces such
a device in North America. It is called a POP UPTM delineator. However, at the time of this report,
there is no working installation of these devices. There is one planned installation of the device on
I-15 near San Diego; however the manufacturing of the POP UPsTM is well behind schedule and they
have not been shipped to the site yet. Therefore, information gathered on the device was provided
by TELE-SPOT representatives, other agencies that tested the device, and our own brief examination
of the device.

The POP UPTM appears to work very well, automatically raising and lowering by remotely changing
the amount of power flowing to the device. Lab testing by CalTrans indicate it will be able to handle
the harsh road environment and will not become clogged with sand or grit easily. The device can
withstand impacts from vehicles traveling up to 55 mph and will not damage the vehicles. It is
easily seen and can even be equipped with an internal light. It is a great deal more expensive than
orange cones (including the cost of the labor to move these cones), but exact cost estimates vary
widely (between $2,000 and $6,000 per device) because the device is very new. The device may
prevent accidents from occurring to a toll plaza attendant moving cones, thus justifying the high cost.

The lack of sufficient funds in the Turnpike’s 1997/1998 budget to purchase these delineators may
work to the Turnpike’s advantage. The Turnpike will be able to learn from the installation on I-15
in California, the price of the POP UPS™ may decrease as more are produced, and most importantly,
the true need for these devices and reversible lanes can be better examined. Since electronic toll
collection (ETC) will greatly improve the throughput of the toll plazas there may not be a need for
reversible lanes at any of the toll plazas. Therefore, CUTR recommends that computer simulation
modeling be performed on the toll plazas with reversible lanes in order to determine the need for
both reversible lanes and the POP UPTM delineators. This modeling may save the Turnpike millions
of dollars by proving there is no need to purchase the delineators.

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Evaluation of the POP UP™ Programmable Delineator
1.0 Introduction

The use of fluorescent orange cones has long been a standard method to delineate highway lanes. Cones are simple and inexpensive traffic control devices and are well suited for those situations where lane usage and delineation often changes and the delineators must be easily relocated. However, there are some drawbacks to these cones, the primary one being that a person must enter the travel lanes to place the cones, creating a potential safety hazard. To overcome this problem with orange cones, retractable highway lane delineators (RHLD) have been developed.

This report documents the potential uses, costs, and benefits of these RHLDs. Performance specifications, warranties, installation, and interoperability issues surrounding the device will be examined. An in-depth look at the TELE-SPOT Systems POP UP™ delineator and a brief examination of its installation in Southern California is undertaken. Finally, the report makes recommendations on the applicability of the devices for use on Florida’s Turnpike.

1.1 Purpose

Traditionally, orange cones are used to safely guide vehicles into the correct travel lanes. These cones require personnel to manually place, move, and remove them whenever a new lane configuration is required. In comparison, RHLDs are designed to be remotely raised above the pavement and then lowered to become level with the pavement (see Figure 1).

These new devices may prove particularly useful at toll plazas that have reversible lanes. These lanes are designed to accommodate traffic in one direction during the morning rush and in the opposite direction during the evening rush. Under normal circumstances, toll plaza attendants have to venture out into the travel lanes to move the cones that divide directional traffic flows. This is a time-consuming and, more importantly, dangerous operation. This operation becomes even more dangerous if the toll plaza uses electronic toll collection (ETC). ETC allows vehicles
to remain at highway speed while traveling through the toll plaza as the toll is paid electronically. This greatly increases the risk of a severe or fatal accident occurring to a toll plaza attendant while moving cones. In addition, both reversible lanes and ETC dedicated lanes are generally the leftmost lanes in the direction of travel, further increasing the likelihood of an accident.

With SunPass (Florida’s Turnpike’s ETC system) rapidly approaching implementation, the Turnpike has taken a proactive look into RHLDs. With up to 60 toll plazas having both ETC and reversible lanes, there is a sizable safety concern, as well as a concern over equipping so many toll plazas with an unknown device. These concerns prompted this in-depth investigation of RHLDs and, in particular, the POP UP™ delineator by TELE-SPOT Systems, Inc.
1.2 Advantages and Disadvantages of RHLDs

RHLDs have several advantages (and some disadvantages) when compared to the traditional orange cones. The devices can be deployed and retracted quickly, saving manual labor. The cost associated with moving cones at the Cape Coral Bridge in Lee County, Florida, is less than $2,500 per year. This toll plaza is quite large (10 lanes), requires many orange cones, and changes lane configurations seven times per weekday. The speed at which the attendants move the cones, and their relatively low hourly wage, results in the low cost of this activity. It should be noted that the moving of cones is one of the toll attendants' least favorite tasks and eliminating this chore might improve morale.

The primary advantage of RHLDs is safety. Toll plaza attendants are put in a very dangerous situation when they are asked to go out into the lanes and reposition cones. With the addition of ETC and vehicles traveling at higher velocities, this risk becomes much greater. Surprisingly, this has not been a major issue with toll authorities. Several large toll authorities in the United States that have ETC lanes were contacted and the following information was found:

- The Orlando Orange County Expressway Authority has reversible lanes and moves cones manually. There is concern for the safety of toll attendants during this operation but they have never had an accident due to moving the cones.
- The Georgia State Tollway Authority does not have reversible lanes.
- The Cape Coral Bridge in Lee County has a low speed ETC system with multiple reversible lanes. There have been no accidents due to the moving of cones, but the authority is concerned about safety.
- The Kansas Turnpike Authority has reversible lanes and moves the cones manually. They have had no accidents from moving the cones, but have expressed a great deal of interest in the TELE-SPOT device as they are concerned for their toll plaza attendants.

The International Bridge Tunnel and Turnpike Authority (IBTTA) was also contacted and they knew of no serious accidents any of their membership had with regard to moving cones in traffic lanes.
Toll authorities have a genuine concern for the safety of their toll attendants as they move cones out in the travel lanes. Fortunately, there have been no accidents at the above toll plazas due to this operation.

The disadvantages of the RHLDs, when compared to orange cones, include their cost, maintenance, and potential for failure. It is difficult for any device to be less expensive, require less maintenance, or be any less susceptible to failure than the manual placing of orange cones.

Another problem occurs when the RHLDs must be raised out of the ground. It will be necessary for the toll plaza attendant to wait for a break in traffic in order to raise the devices. The devices can also be set to raise and lower automatically based on the time of day. They are controlled by a simple software program that regulates the flow of power to each delineator. The POP UP™ will rise when there is 24 volts applied to the device and lower when there is 12 volts.

The devices are built to withstand and bounce back from vehicle impacts at speed of up to 55 miles per hour. Also, if during the raising of the device it encounters resistance, the device will automatically lower itself into the ground. The device will attempt to rise automatically three times, after which it will indicate an error has occurred and wait for a manual override. However, if the devices are raised when there is traffic this could cause confusion for motorists. Attendants moving the cones are able to indicate to the motorist what is happening. Without the attendants, drivers unfamiliar with the toll plaza lane configuration may become confused.

1.3 Other RHLDs

An extensive literature search was performed to determine if there were any RHLDs available or in use other than the TELE-SPOT device. The following data sources were consulted:

- Transportation Research Information Service (TRIS) search
- International Bridge Tunnel and Turnpike Authority
• 1997 International Intelligent Transportation Systems (ITS) Index (a listing of thousands of ITS companies and organizations along with the devices they manufacture)
• ITS America (by calling them and searching their database on the world wide web - http://www.itsa.org )
• Institute of Transportation Engineers
• ITS Online (the best source of ITS information on the world wide web - http://www.itsonline.com )
• CUTR’s Resource and Information Center
• University of South Florida’s library

These sources yielded no information on RHLDs and surprisingly little on the traditional lane delineators/markers.

Next, industry professionals that may have some knowledge of RHLDs were contacted. In all cases listed below, the people contacted had no knowledge of RHLDs, had never heard of such devices, and were generally of the opinion that the devices were an excellent idea. The agencies contacted included (see Appendix A for a full list of names and numbers):
• Kansas Turnpike Authority
• Flexstake - manufacturer of advanced and unique, but not automatic, lane delineators in Fort Myers, Florida
• Quick Kurb, Inc. - worldwide manufacturer of advanced lane delineators with a local office in Lakeland, Florida. They had no automatic devices
• Transportation Industries, Inc. - company with contacts throughout the transportation industry specializing in direct product line networking
• Deleuw Cather in New York City - a consulting firm working with reversible lanes and bus lanes for the Port Authority of New York and New Jersey
• Port Authority of New York and New Jersey - many projects they are involved with lend themselves to the use of RHLDs
• JB Harper Contractor, Inc. - contacts and ties throughout the transportation industry
• Safety Hit Corporation - a company that deals with roadway safety equipment
• Mike Stanley, North Carolina State University - working on the automatic/robotic deployment of standard (for example the orange cones) delineators
• Dan Rathbone, Editor of the Urban Transportation Monitor - examining the use of intelligent road studs at intersections

The only person with knowledge of the POP UP™ delineators was Art Korfin of Barrier System, which designs and builds large moveable barriers, such as the moveable jersey barriers on the Tappan-Zee bridge in New York. He knew of no other manufacturer of RHLDs. A company in the United Kingdom, APT Controls Limited, was found to build a device called a bullard. This is similar to the POP UP™ delineator but it is made out of steel and is not meant to be resistant to vehicle impacts. The fact so few people knew of the POP UP™ delineator is not surprising as the company has done almost no advertising of the product. Once the initial installation of the devices occurs on the I-15 near San Diego, and TELE-SPOT is better produce the devices in mass quantities, then more aggressive advertising will begin.

The other method used the Internet in an attempt to gather information. A question was posed on three large, transportation-based mailing lists:
  • the ITS mailing list
  • the Department of Transportation (DOT) mailing list
  • the Transportation list server

These mailing lists have thousands of readers world wide, all with some connection to the transportation industry. The question asked for any information regarding RHLDs. Responses were received from all over the world, but none had any information regarding RHLDs. The majority of replies were from manufactures of devices designed to serve a similar purpose as the RHLDs. For example, there were numerous responses from companies that build moveable barriers. However,
to move these barriers often requires a large piece of machinery to work in the travel lanes, and the
barriers are larger and more expensive than what is needed by FDOT. There is also research being
done into the use of illuminated road studs. These delineators are very similar to the “cats-eye” road
studs that protrude about an inch above the pavement. They can be illuminated in various colors or
non-illuminated in order to guide motorists to the correct travel lane. These devices are very new
and research is being conducted into their effectiveness. However, these devices are not appropriate
for the high-speed toll plaza application that Florida’s Turnpike is examining because something
more substantial should be placed between the vehicles traveling at high speeds in opposite
directions.

1.4 Pneumatic RHLDs in California

This extensive literature search revealed only two sites in the United States currently using any form
of RHLDs, both located in California, one on Route 163 in San Diego and the other on the Caldecott
Tunnel near San Francisco. In the mid 1980s, the Southwest Construction Company installed
pneumatic RHLDs at both of these sites. Southwest Construction has since ceased operations and
replacement parts for the delineators are ordered from numerous companies. The original equipment
and installation cost could not be found. However, persons involved with the construction of these
delineators and with the installation of the new POP UP™ delineators feel that the electro-
mechanical POP UP™ delineators should be much cheaper to build and install.

According to the people charged with maintenance of the pneumatic delineators, these devices
require little maintenance and are very reliable. Along Route 163 there are a total of 180 delineators
installed at three sites. The delineators serve to open and close high occupancy vehicle lanes to
traffic along eight miles of this roadway. There have been relatively few maintenance problems
associate with these devices, but the following should be considered when purchasing and installing
RHLDs:

• No part of the device should be built of a material that can rust.
• Any part of the device that may require frequent maintenance should be placed either above ground or in an easily accessible location below ground.
• A drain must be installed at the base of the device for water to drain out.
• If a delineator is struck by a vehicle no damage should be done to the vehicle or the delineator. When struck, the delineator should simply bend down while the vehicle passes over it and pop back up once the vehicle has passed.

These pneumatic RHLDs are the only devices similar to TELE-SPOT’s POP UP™ delineator found during this extensive literature search. Since TELE-SPOT is currently the only manufacturer of RHLDs, the costs and benefits of the POP UP™ device must be compared to the current practice of manually moving orange cones.

As mentioned previously, the actual costs of moving (and even purchasing) orange cones is very small (each cone costs approximately $10, and yearly cost of moving cones at one Lee County toll plaza is less than $2,500), while the cost of these delineators is greater than $2,000 each (this price continues to fluctuate significantly with estimates of up to $6,000 per POP UP™ delineator when including all the power supplies, controller, and installation). The Turnpike estimates 22 toll plazas may need 60 POP UPs™ each for a total of 1320 delineators. However, the cost of a serious accident (primarily the injuries involved, but also the associated delays for other users) more than outweighs the cost of these delineators.

1.5 Potential Uses

Some potential uses for the RHLDs include:
• Reversible lanes at toll plazas;
• At grade highway-rail intersections. The delineators would work in conjunction with gates to keep vehicles from traveling across the railroad track. The delineators could be
placed so that it is more difficult for vehicles to circumvent the gates. Union Pacific is considering testing these in the near future;

- High occupancy vehicle (HOV) lanes, reversible highway lanes, and any other highway lanes that must be blocked off and opened at regular intervals. For example, RHLDS can be used to ensure traffic can only use the HOV lane during certain times of the day or only allow vehicles to travel in a certain direction on the HOV lane;

- For use at special events, at stadiums or any type of special event center that hosts events often. RHLDS can be used to help direct traffic in and out of the parking lot.

RHLDS can be used anywhere orange cones are used on a regular basis. However, due to the high cost of the RHLDS, they are best suited to permanent sites where there may be some risk to the people placing the orange cones.
2.0 The TELE-SPOT POP UP™ Delineator

Since TELE-SPOT Systems, Inc.'s POP UP™ delineator is the only RHLD that was found to be available on the market today, its performance can be measured only the theoretical goals of a RHLD device. These goals include increased safety, reasonable cost, easy installation, interoperability with current toll plaza systems, and adequate warranties.

2.1 POP UP™ Specifications

Some of the technical specifications for the POP UP™ are shown in Table 1. Additional specifications can be found in Appendix B: Specifications for a Model 2 Programmable Delineator System.

The base model can be improved by the addition of several optional features. For example, the delineator can have an internal light source that can be individually controlled for each delineator. This light would most likely be off while the delineator is retracted (underground), flashing when the delineator is rising or lowering, and continuously lit when the delineator is fully extended. The POP UP™ can also be equipped with a heating supply to allow use in areas where the temperature drops below freezing. A retro-reflective material can also be applied to the delineator to improve visibility.¹

Table 1: Technical Specifications of the POP UPTM Delineator

<table>
<thead>
<tr>
<th>Delineator</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>material</td>
<td>LD polyethylene</td>
</tr>
<tr>
<td>diameter</td>
<td>3.0 inches</td>
</tr>
<tr>
<td>height</td>
<td>32 inches extended</td>
</tr>
<tr>
<td>weight</td>
<td>1.4 pounds</td>
</tr>
<tr>
<td>rise time</td>
<td>variable from 8 to 30 seconds</td>
</tr>
<tr>
<td>Casting</td>
<td></td>
</tr>
<tr>
<td>material</td>
<td>PVC or ABS stainless steel plate anodized aluminum collar</td>
</tr>
<tr>
<td>diameter</td>
<td>6.25 inches</td>
</tr>
<tr>
<td>height</td>
<td>53.5 inches</td>
</tr>
<tr>
<td>wall</td>
<td>0.2 inches</td>
</tr>
<tr>
<td>Cartridge Unit</td>
<td></td>
</tr>
<tr>
<td>material</td>
<td>PVC or ABS</td>
</tr>
<tr>
<td>diameter</td>
<td>4.25 inches</td>
</tr>
<tr>
<td>height</td>
<td>40 inches</td>
</tr>
<tr>
<td>weight</td>
<td>16 pounds (without post)</td>
</tr>
<tr>
<td>Wiring</td>
<td></td>
</tr>
<tr>
<td>voltage</td>
<td>24 volts AC</td>
</tr>
<tr>
<td>current</td>
<td>4.0 amps maximum</td>
</tr>
<tr>
<td>cable</td>
<td>12 AWG twisted pair sheltered</td>
</tr>
</tbody>
</table>

Source: TELE-SPOT Systems Inc., The POP UPTM programmable delineator brochure, Stamford, CT

According to the manufacturer of the delineator itself, it can withstand impacts of up to 55 mph. It will simply bend over when the vehicle strikes it and pop back up to a vertical position once the vehicle has passed over it. In the event that a vehicle drives over a raising delineator, and it becomes lodged
in the vehicle, then delineator will simply detach from POP UP™ device. This should not damage
the vehicle or the POP UP™ device. In the event of power loss the POP UP™ will simply remain
in its current position until power is returned or the device is manually manipulated. The device can
be raised and lowered manually; however, raising the device manually is difficult. The POP UP™
will also display its current status/position at the control location.

2.2 POP UP™ Performance

One of the primary goals of any RHLD is to eliminate the need for toll plaza attendants to venture
into the travel lanes and move traditional lane delineators. If the POP UP™ delineator functions
as its specifications indicate, it will perform this goal.

Several years ago, an earlier version of the POP UP™ delineator was tested by employees at
California’s Department of Transportation (CalTrans). Dave Roper, a former district engineer at
CalTrans, was the inventor of the device and sold the patents to TELE-SPOT. The POP UP™
did not perform well in these tests, primarily because it failed to stand up to the harsh environmental
conditions that it would encounter in the roadway environment. For example, sand, grit, and water
could penetrate the device and cause it to malfunction or not function at all.² TELE-SPOT worked
on revising the design and now has a device that appears to be able to resist the invasion of sand,
grit, and water. The CalTrans employees that rejected the device several years ago now feel it has
overcome its deficiencies, due in large part to an internal test performed on the device. This test was
very small scale and did not follow official CalTrans guidelines. Nevertheless, the test was a good
indication that the device can function in harsh roadway conditions. The following is an exact copy
of the CalTrans memorandum regarding the test:

² Conversations with Jerry Meis and Stu Harvey of the California Department of

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The POP UP™ was placed in a water tight 8 inch diameter PVC pipe to mimic the hole it would be placed in a real world installation. The POP UP™ and the pipe were then placed in a 55 gallon drum and surrounded with dirt so that the POP UP™ would remain vertical. The POP UP™ was then hooked to a lap top and a power supply. The software controlling the POP UP™ was set in automatic mode so that the POP UP would move up or down once a minute.

The first stage of the test, the 'dry stage', had the POP UP™ running in automatic mode for 11 days without any water or foreign material added to the POP UP™ cylinder. The POP UP™ was raised and lowered a total of 6,720 times without failure. However, the computer software failed three times, stopping the test. The software was fixed by rebooting the laptop. The problem is believed to have been caused by either a computer or power failure.

The second stage of the test, the 'wet stage', tested the POP UP™ under harsh conditions. The POP UP™ tube was completely filled with water and road sand grit was added. The unit was run up and down for eight days for a total of 5,833 cycles. No software problems occurred this time. However, on the last day of the test the POP UP™ would not go completely down. The POP UP™ was removed, flushed with water, and replaced solving this problem.

The unit was run a total of 12,553 times during this test. This would be the equivalent of running the unit for 8.6 years if the unit was raised and lowered twice a day.

The successful results of this small, in-house test convinced members of CalTrans to allow these devices to be used on a small scale. They were installed at an Immigration and Naturalization Service checkpoint on I-15, 50 miles north of the Mexican border. Section 2.5 examines the experiences to date of this field installation.

TELE-SPOT has provided three prototype POP UPs™ to CUTR (see Figure 2) for testing, and none have worked upon their arrival at CUTR. The first POP UP™ shipped was damaged by UPS and did not work when it finally made it to the CUTR office. It was then sent to Bolton, Ontario, where the primary manufacture and design of the POP UP™ is performed, for the TELE-SPOT engineers to examine and repair.
The next two POP UPs™ sent to CUTR came directly from the Port Authority of New York and New Jersey. The Authority had them for several months but did not run them (according to a TELE-SPOT engineer). These POP UPs™ did not function until their main electrical wiring was bypassed and the POP UPs™ were hard wired directly from the power supply. TELE-SPOT Engineers feel that the most probable explanation for the failures that were occurring is that the Port Authority must have rewired the devices. TELE-SPOT has also changed some of the inner workings on the POP UPs™ for the production models so that they will be more tolerant of being jarred and tossed.
around. For example, the electronics board which controls the motor inside the POP UP™ is now glued in place but will be screwed in place in the production model.

The delineator itself (the plastic tube that sticks up above the ground) is manufactured by The Line Connection, Inc., in Sacramento, California. This company was contacted and sent a standard price list, a brochure, and a delineator to CUTR. Their delineators are built and tested to withstand multiple hits from vehicles traveling at 55 mph. The delineators simply bend over and pop back up when struck by a vehicle. The delineators come in white, orange, and yellow but can be custom ordered in almost any color. See Appendix C for information from The Line Connection Inc.

2.3 Cost of the POP UP™

Due to the newness of this device, its cost is still fluctuating significantly. Additionally, the cost of the power supplies needed to power the devices, will depend on improvements to the design of the device. Currently, each power supply can only power eight POP UPs™. These power supplies are quite large (approximately two feet by three feet by one foot) and need to be placed in an accessible location. Often times at toll plazas there is no room for many of these power supplies. If the design can be changed so that an unlimited number (or at least a large number, for example 60 - 80) of POP UPs™ can be powered from one source this could substantially reduce the cost of an entire installation. In addition, these power supplies can be placed only a limited distance (500 feet) from the POP UP™ devices themselves, which can cause installation difficulties. Finally, since all locations are different, installation costs will vary widely from site to site. Current estimates for the immigration and naturalization service (INS) installation on I-15 are around $282,000 (approximately $6,000 per unit) when taking into account the entire installation, power supply, controller, and POP UP™ devices.
2.4 Warranties

The INS installation has been offered a two year warranty with an option to extend this to five years. The warranty covers all parts. TELE-SPOT does not yet have a standard warranty on its POP UPTM devices. Due to the fact TELE-SPOT does not have an office in Florida it would probably be most cost effective if Turnpike maintenance staff are trained in the repair and replacement of the devices rather than attempt to have TELE-SPOT employees fly down every time a repair is needed.

2.5 The I-15 Installation

Currently, the only planned installation of POP UPTM delineators will be at an INS checkpoint located approximately 50 miles north of the Mexican border on Interstate 15. All vehicles traveling along I-15 must pass through this checkpoint, often causing significant delays. To help reduce congestion at this checkpoint and allow pre-qualified users to speed through the checkpoint without having to stop and wait, a new program has been developed. The Pre-Evaluation Automated Lane (PEAL) program allows qualified users to purchase a transponder for their vehicle. This device transmits a unique radio frequency signal between it and a reader located at the INS checkpoint plaza. If the transponder signal has been pre-qualified to be part of the PEAL program, the user can continue through the checkpoint, never having to slow down. This system is very similar to electronic toll collection (ETC). ETC uniquely identifies the vehicle to the toll plaza and the vehicle is then allowed to pass by the toll plaza without having to stop while the toll is paid electronically.

To accommodate this new program and the new lane configurations, INS and CalTrans have decided to use the POP UPTM delineator. The primary reason for using an RHLD was the accident potential of having INS officers move the orange cones around in a high speed lane. The POP UPTM was chosen over attempting to find someone to install pneumatic RHLDs as it was felt the POP UPTM would cost significantly less. The delineators will be used to open and close lanes for traffic flow along this highway. This application has some similarities to a reversible lane installation, in that
high speed traffic will be guided by the POP UPs™. However, this installation will not involve changing a lane from one direction to another or have the added confusion of a toll plaza.

The POP UP™ delineator extends to a height of 32 inches above the pavement (see Table 1), lower than the minimum CalTrans standard delineator height of 36 inches. Since the delineator replaced much shorter orange cones and it is only four inches less than the minimum, CalTrans decided to proceed with the use of the POP UP™ despite this problem.

The option of having the self illuminating POP UP™ was not chosen. It was felt this additional lighting would cause the string of POP UPs™ to create a runway effect at the checkpoint, distracting drivers and possibly causing accidents.

The POP UP™ delineators were subjected to the standard 30 mile-per-hour impact test. They passed these tests, but some people involved in the project would have liked too have seen how the POP UPs™ would have performed under a high-speed impact.

Due to delays on the part of TELE-SPOT this report was completed prior to the installation of the POP UPs™. Originally planned to be in the ground and operating by early to mid April, they had not been shipped as of June 13. Due to this delay there will be no real test phase for these devices, and they will be used with live traffic soon after installation.

2.6 The Future of the POP UP™ Delineator

According to John Mauro, president of TELE-SPOT, there is a great deal of interest in the POP UP™ delineator. This is not surprising because almost everyone contacted during this project thought the idea of an RHLD was excellent. Currently, Mr. Mauro has been talking with several organizations interested in using the POP UP™ including:
Mr. Mauro has indicated it has been difficult getting the first of the delineators produced and shipped to the client. The main problem with this first deployment is the sub-vendor in charge of making the circuit boards for the POP UPs™ is well behind schedule. However, once the production line is set up he feels confident that the process of building POP UPs™ will become fast and efficient. Two things that will be looked into are reducing the cost per unit and increasing the number of units that can be supplied by one power supply. If these two advances can be made CUTR feels the device can be successful.
3.0 Investigation of Traditional Delineators

CUTR has conducted a search to identify some of the vendors and their devices in the field of traffic delineation systems. Over 20 corporations were contacted to learn about lane delineators. Much of the information in this section is derived directly from vendor brochures and quotes.

Orange cones are designed to be flexible and durable so as not to inflict any damage to the vehicles that might hit them. The Federal Highway Administration’s Manual on Uniform Traffic Control Devices (MUTCD) Section 6-C has established a number of standards to be followed in the design and development of traffic cones. The manual says that, these devices should be a minimum of 18 inches in height with a broadened base and can be made of various materials to withstand impact of vehicles hitting them, and they should be a minimum of 28 inches in height for freeway applications. Usually, traffic cones are reflectorized or equipped with some sort of lighting device to provide greater visibility. According to MUTCD “... for nighttime use they (cones) shall be reflectorized or equipped with lighting devices for maximum visibility. Reflectorized material shall have a smooth, sealed outer surface which will display the same approximate color day and night.” MUTCD also established several standards on the extent and type of reflectorization.

Although a number of corporations are involved in the design, development, and installation services of traffic delineation systems, there are no significant technical differences among the various systems developed. The majority of these devices work much like the orange cones and include specially-made cones, barrels, or flexible posts. Some manufacturers are also working on digital display boards, switchable lane markers (LED display boards), and laser based delineators; however, it is believed that they do not provide sufficient protection from high-speed traffic traveling in opposite directions at electronic toll plazas.

Quick Kurb, Inc., a German based company, is one of the leading corporations in the design and development of traffic delineation systems. They developed and installed several types of traffic delineators.
delineation systems for both toll booths, railroad crossings, and bridge installations. The systems developed by Quick Kurb included permanent delineation systems to restrict traffic in turn lanes (Miami, Florida), and movable systems to handle traffic near toll plazas (Stuttgart, Germany), railroad crossings (Newell, North Carolina), and bridge construction (Pensacola, Florida.) (See Appendix C for photographs of these installations.) In the case of movable systems, a fixed number of markers/delineators are inserted into the slots made on a specific length of a plastic base plate, and all the markers on a particular base plate can be moved at once. Although this system reduces the need to move each and every cone, this system will not eliminate manual operations and hence can not be expected to serve the needs of the FDOT. Additionally, long section lengths are very heavy and awkward to move.

Figure 4: Quick Kurb Installation at a Toll Plaza
Work Area Protection Corporation, an Illinois-based company, makes high visibility cones with varied specifications. They use fluorescent pigmentation in the development of high visibility traffic cones and these cones are available in different heights ranging from 6 to 36 inches. These cones have also been provided with three to thirteen inch wide reflective collars in accordance with MUTCD specifications. This company has also developed wide body cones (18, 28, and 36 inches in height) to be used with flag adapters. The price of these devices varies depending on height and weight, a six inch high, 0.25 pound device costs $2.50, while a 36 inch high, 12 pound device costs $17.

Reflexite, a Connecticut-based company, specializes in the development of reflective collars for traffic cones. They are extremely durable and provide brilliant reflectivity. They are also capable of withstanding repeated flexing and impacts without losing physical or reflective properties. These devices satisfy all the requirements of MUTCD standards.

Barrier Systems, Inc., has developed a “movable barrier system” consisting of a chain of concrete Jersey barriers that can be moved by a machine (see Figure 5). This machine is designed to move the barriers from one side of a lane to the other at an approximate speed of 5 mph. However, the capital and installation costs associated with this type of delineation system is high (about $750,000 per mile) and still requires lane blockage to move them.

Astro Optics Corporation, an Illinois-based company, has developed several delineation devices including channeling markers, pavement markers, curb markers, and rebounder flexible posts. The rebounder flexible posts are surface-mounted and provide channelization, delineation, and durability. These devices, made with a strong polycarbonate base, a fluorescent polyethylene tube, and a unique elastic hinge design, offer extreme durability after being struck continuously. The tubings are designed to be replaceable on the job site to save both money and time.
Vari Spec, a California-based company, has developed three types of traditional traffic delineation devices; movable deluxe delineator posts, delineator tubes, and maxi-posts. The deluxe delineator post is an extremely durable interlocking post with a octagon base. The delineator tube, available in 26, 36, and 42-inch sizes, is an all-temperature tube with a 1-inch silver reflective band and plastic base. The maxi-post provides greater visibility with a 4-inch diameter and 42-inch high post with two, 3-inch reflective collars. Vari Spec has also developed a passive message changing delineator that changes messages by remote control.

A number of corporations outside the United States are also working on the development of various types of traffic delineation systems. They include Martronics in the UK, Harding Traffic Systems in New Zealand, and the Road and Traffic Authority (RTA) in Australia. Martronics has developed a “switchable lane marker” for use at toll plazas, HOV lanes, and airport terminals. These systems consist of high intensity LED displays indicating various signs including open/closed booths/lanes, etc. The color and flash sequencing are remote controlled and can utilize infrared signaling or be
hard wired between the units. RTA in Australia and the Ministry of Transportation & Highways, in British Columbia, Canada, are also engaged in the development of display based traffic delineation systems.

Another “display” type of delineation system, called SMART STUD, was developed by a New Zealand-based company, Harding Traffic Systems. With this system, different road studs may be illuminated, or the color of the studs can be changed by varying the frequency of the power source. These facilities are found to be very useful for tidal flow/lane-change applications, particularly at night. These devices are also used for enhanced lane delineation, hazard warning, railway crossing, and pedestrian crossings.

There are a great number of delineation options available to the FDOT, but none (except the POP UP™) meet the FDOT’s needs and criteria. The devices listed in this section are either too small/insubstantial (illuminated road studs) or too large and expensive (movable barriers) or require toll plaza attendants to work in traffic to move the delineators.
4.0 Recommendations

Due to production difficulties, the TELE-SPOT POP UP™ devices are well behind schedule and not yet installed on I-15 near San Diego. Therefore, it is difficult to produce a thorough evaluation of the device as there are no working installations. However, from the information gathered during CUTR's investigation of this device, it would appear that the POP UP™ devices will readily perform all the requirements of an RHLD. They can be remotely raised and lowered, are able to withstand vehicle impacts without the device or the vehicle, can be easily seen by motorists, and will work regardless of weather (at least Florida weather). Also, taking into account conversations with toll plaza authority personnel, there is a need and a market for these devices across North America.

However, the POP UP™ devices will likely require some changes before they will be successful:

- The power supplies will need to be improved. Currently, one power supply can only power eight POP UP™ devices, and these devices can only be located 500 feet or less from that power supply.
- A reliable production schedule needs to be established to avoid excessive delays as seen in San Diego.
- Cost per unit needs to be lowered.
- A successful, full-scale installation that other transportation agencies can examine needs to be completed.

The FDOT has already reallocated the funds that were to be used to purchase the POP UP™ devices in fiscal year 1997/1998. This delay in purchasing the devices will likely work to FDOT's advantage because:

- the Turnpike will be able to learn from the installation on I-15 in California;
- the price of the POP UPs™ may decrease as more are produced; and,
- most importantly, the true need for these devices and reversible lanes can be better examined.
Since ETC will greatly improve the throughput of the toll plazas, there may not be a need for reversible lanes at any of the toll plazas. Therefore, CUTR recommends that computer simulation modeling be performed on the toll plazas with reversible lanes in order to determine the need for both reversible lanes and the POP UP™ delineators. This modeling can be performed by CUTR staff and may save the Turnpike millions of dollars by proving there is no need to purchase the delineators.
### Appendix A: List of Contacts

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Phone Number</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carol Goldwasser</td>
<td>Lee County DOT</td>
<td>941-489-1825</td>
<td>in charge of day to day operations at Lee County’s bridge toll plazas</td>
</tr>
<tr>
<td>Steve Pustelnyk</td>
<td>OOCEA</td>
<td>407-425-8606</td>
<td>Orlando Orange County Expressway Authority</td>
</tr>
<tr>
<td>Mike Berma</td>
<td>Post, Buckley, Schuh &amp; Jernigan, Inc.</td>
<td>407-467-7275</td>
<td>performs work for OOCEA</td>
</tr>
<tr>
<td>Tom Wright</td>
<td>Georgia State Tollway Authority</td>
<td>404-816-9514</td>
<td>works on the Georgia 400 toll plaza</td>
</tr>
<tr>
<td>Gary Parks</td>
<td>Kansas Turnpike Authority</td>
<td>316-682-4537</td>
<td>head of toll operations</td>
</tr>
<tr>
<td>Bob Hughes</td>
<td>Flexstake</td>
<td>800-348-9839</td>
<td>lane delineator manufacturer in Fort Myers, FL</td>
</tr>
<tr>
<td>Bob Schindler</td>
<td>Quick Kurb, Inc.</td>
<td>800-324-8734</td>
<td>lane delineator manufacturer in Lakeland, FL</td>
</tr>
<tr>
<td>Joan Cornell</td>
<td>Transportation Industries, Inc.</td>
<td>800-321-7870</td>
<td>knows the transportation industry</td>
</tr>
<tr>
<td>Leon Goodman</td>
<td>Delew Cather</td>
<td>212-266-8500</td>
<td>working with reversible bus lanes for the Port Authority of New York and New Jersey</td>
</tr>
<tr>
<td>Robert Parisi</td>
<td>Port Authority of New York and New Jersey</td>
<td>212-435-8257</td>
<td>many projects involving RHLDs</td>
</tr>
<tr>
<td>Name</td>
<td>Company</td>
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<td>Comments</td>
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</tr>
<tr>
<td>Mike Stanley</td>
<td>North Carolina State University</td>
<td>919-733-9790</td>
<td>working on automatic deployment of standard delineators</td>
</tr>
<tr>
<td>Dan Rathbone</td>
<td>Urban Transportation Monitor</td>
<td>703-764-0512</td>
<td>examining the use of intelligent road studs</td>
</tr>
<tr>
<td>Dermot Murphy</td>
<td>APT Controls Ltd.</td>
<td>011-44-181-421-2411</td>
<td>England manufacturer of Bullards</td>
</tr>
<tr>
<td>John Tatterson</td>
<td>The Line Connection, Inc.</td>
<td>916-366-5752</td>
<td>distributor of the delineator used in the POP UP™</td>
</tr>
<tr>
<td>Benny Herrera</td>
<td>CalTrans</td>
<td>619-467-4007</td>
<td>maintenance person for pneumatic delineators in California</td>
</tr>
<tr>
<td>John Mehtlan</td>
<td>CalTrans</td>
<td>619-688-4234</td>
<td>involved with the installation of the pneumatic delineators</td>
</tr>
<tr>
<td>Ronald</td>
<td>Catching Engineering Inc.</td>
<td>708-344-2334</td>
<td>spare parts supplier for pneumatic delineators</td>
</tr>
<tr>
<td>Bill Tanner</td>
<td>CalTrans</td>
<td>619-467-4010</td>
<td>tested the new POP UP™ delineator</td>
</tr>
<tr>
<td>David Perkel</td>
<td>IBTTA</td>
<td>202-659-4620</td>
<td>accident statistics person</td>
</tr>
<tr>
<td>Laura Hazen</td>
<td>ITE</td>
<td>202-554-8050</td>
<td>information on uniform traffic control devices</td>
</tr>
<tr>
<td>Jerry Mies</td>
<td>CalTrans</td>
<td>916-654-4551</td>
<td>involved in the selection of the pneumatic delineators</td>
</tr>
</tbody>
</table>

*Evaluation of the POP UP™ Programmable Delineator*
<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Mauro</td>
<td>TELE-SPOT</td>
<td>203-964-0575</td>
<td>president of TELE-SPOT</td>
</tr>
<tr>
<td>Gabriel</td>
<td>TELE-SPOT</td>
<td>905-857-5544</td>
<td>mechanical Engineer for the POP UP™</td>
</tr>
<tr>
<td>Michael Speadman</td>
<td>TELE-SPOT</td>
<td>905-857-5544</td>
<td>electrical engineer for the POP UP™</td>
</tr>
<tr>
<td>Stu Harvey</td>
<td>CalTrans</td>
<td>619-467-3000</td>
<td>tested the POP UP™ several years ago</td>
</tr>
<tr>
<td>Gavin Wong</td>
<td>D.M.J.M.</td>
<td>213-381-3663</td>
<td>design work on the I-15 project</td>
</tr>
<tr>
<td>Ann Nelson</td>
<td>CalTrans</td>
<td>619-688-2574</td>
<td>CalTrans manager for the I-15 installation</td>
</tr>
<tr>
<td>Ricardo Jimenez</td>
<td>Army Core of Engineers</td>
<td>619-430-0741</td>
<td>in charge of day to day construction at the I-15 site</td>
</tr>
<tr>
<td>Jatin Desai</td>
<td>Immigration and Naturalization Service</td>
<td>213-452-3721</td>
<td>project manager at the I-15 site</td>
</tr>
<tr>
<td>Al Palmer</td>
<td>Palmer &amp; Associates, Inc.</td>
<td>805-484-4308</td>
<td>toll road and bridge expert</td>
</tr>
<tr>
<td>David Perkel</td>
<td>IBTTA</td>
<td>202-659-4620</td>
<td>accident statistician</td>
</tr>
<tr>
<td>Laura Hazen</td>
<td>ITE</td>
<td>202-554-8050</td>
<td>information on uniform traffic control devices</td>
</tr>
<tr>
<td>Gary Kinberg</td>
<td>Astro Optics Corp.</td>
<td>847-428-3181</td>
<td>sales and marketing manager</td>
</tr>
<tr>
<td>Larry Sparks</td>
<td>Vari Spec Inc.</td>
<td>619-569-4999</td>
<td>president of Vari Spec</td>
</tr>
<tr>
<td>Cliff Offman</td>
<td>Trantex, Inc.</td>
<td>281-448-7711</td>
<td>sales</td>
</tr>
</tbody>
</table>

Evaluation of the POP UP™ Programmable Delineator
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<tbody>
<tr>
<td>Cindy Horton</td>
<td>Flex Stake</td>
<td>800-348-9839</td>
<td>marketing director</td>
</tr>
<tr>
<td>Jim Crowley</td>
<td>Energy Absorption Systems, Inc.</td>
<td>312-467-6750</td>
<td>sales</td>
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<tr>
<td>Jim Zillox</td>
<td>Flasher Handling Corp.</td>
<td>800-451-9636</td>
<td>sales</td>
</tr>
</tbody>
</table>
Appendix B:

SPECIFICATIONS

FOR A

MODEL 2

PROGRAMMABLE DELINEATOR SYSTEM

800189-001
January 11, 1995

TELE-SPOT Systems - T-S Display Systems Inc. - 76 Progress Drive - Stamford, Ct 06902
SPECIFICATIONS FOR A
PROGRAMMABLE DELINEATOR SYSTEM

1 GENERAL DESCRIPTION

These items of work shall consist of furnishing and installing a programmable delineator system in accordance with these special provisions.

The purpose of this remote control system is to provide motorists a clear indication of lanes of travel and restrict travel in unauthorized areas. It shall provide for channelization and immediate changes in traffic patterns. This automatic system shall preclude the requirement for personnel to manually cone the roadway and direct traffic. The system shall be applicable to roadways at toll plazas, railway crossings, reversible lane applications, and in tunnels and on bridges, among other applications.

The system shall be installed and made operational within eight months from the date of approval of shop drawings.

The system shall provide automatic traffic control using programmable delineators operable from a central control center. The delineators shall be capable of being individually controlled in a programmed sequence under the control of an operator at the central control center.

Major features of the system shall include:

* A delineator to be capable of extending to a height of 32 inches above the roadway.

* A remotely controlled programmable technique based on an electric motor and screw technology to raise and lower the delineator.

* A programmable speed in an ascending and descending motion within a range of 8 to 30 seconds.

* A technique using only two wires to provide both control and power to the delineators operating at a maximum of 30 volts AC.

* Ability to report status regarding the position of each delineator.

* Ability to provide an internal illumination inside the delineator to enhance the visibility of the delineator.
1. **System Operation**

   All programmable delineators shall be controlled remotely from a central control location by a PC. Pairs of delineators shall also be able to be controlled from within 500 feet of the central control location by wireless remote devices.

   A power pack shall be provided for each circuit of delineators. A circuit shall be considered to be the delineator units, parallel connected over a pair of wires to a single power pack and communication repeater. Delineator units shall be able to operate up to a distance of 500 feet from the power pack and communication repeater.

   The connection between the central control system and the communications repeater shall be an RS232 interface for distances up to 500 feet. For greater distances, a pair of 202 type modems shall be used. The communication speed shall be 1200 baud, with full duplex operation.

   The microprocessor shall be used with application software to individually control up to 64 programmable delineators. The system shall allow for a high degree of control of the delineators and status information reporting from the delineator units by means of the PC central control system.

   A power pack and communication repeater shall be provided for each 6 to 12 programmable delineators (depending on simultaneous operation and sequencing requirements defined in the

   - Ability to control up to 64 delineators individually.
   - Ability to quickly field replace a delineator or delineator assembly when required with minimal tools and equipment.
   - Ability to withstand an unintentional impact from vehicles without permanent damage to the vehicle or the delineator.

   The major components of the system shall be:

   - A microprocessor based central control computer system complete with user interface and serial communication channels.
   - Power packs within 500 feet of the associated delineators.
   - Delineator units as called for in the plans.
   - Wiring to interconnect the components.
plans. It shall serve to provide power (24 VAC) to the delineators and carry the data communication on the power line. The delineator units shall be paralleled on the two wire connections with the maximum distance between power pack and programmable delineator not to exceed 500 feet.

Communication between the Power Pack/Communication Repeater and the Programmable Delineator Units shall be at 1200 baud, half duplex.

Status Information shall be provided according to the following requirements.

* It shall be reported at the central control location, via the status response, whether the delineator is in the "UP" position, the "DOWN" position or in between, for each unit.

* It shall be reported at the central control location, via the status response, if each unit has a complete delineator properly installed in it, up to the time it completed its last cycle (ascending and descending).

* It shall be reported to the central control location during a status response, if there is an accumulation of liquid in the motor/control compartment so that appropriate shut down action can be accomplished before any permanent damage occurs.

* A continuous self test of all memory, power supply voltages and motor drivers shall be performed by the programmable delineator and the status reported back to the central control location during the status response.

3 CENTRAL CONTROL SYSTEM

The Central Control System (CCS) shall be furnished and installed at the location shown on the plans. This equipment shall consist of as a minimum: a 486 PC compatible computer including one megabyte of RAM, MS DOS operating system, 2 serial ports, keyboard and color monitor. Also provides for wireless remote control (up to 32 remote control units) communicating through one of the PC serial ports.

The CCS shall be capable of remotely operating a minimum of 64 programmable delineators.
3.1 Communications Channels

The CCS shall be capable of supporting 4 wire full duplex private wire system. Communication data rate of 1200 bits per second shall be used.

3.2 Security

The central control system shall require entry of a user name and password before a user can gain access to the system. A minimum of 16 password records shall be able to be stored in the central control system.

3.3 Power Failure

Upon recovery from a power failure at the central location, the Central Control System shall come back up ready to operate with the correct time and date. It shall automatically begin polling to determine the current status of the programmable delineators.

3.4 Polling and Status

The CCS shall periodically poll each delineator. A current status for each delineator shall be kept in memory at the CCS for immediate viewing on the computer monitor.

3.5 System Capacity

The system shall have these minimum capacities:

* The system shall operate a minimum of 64 delineators.

3.6 Wireless Remote Control

Remote control of the CCS shall be possible through one of the serial ports of the PC. Up to 32 wireless remote control devices shall be supported by the CCS.

Each wireless remote control device shall be contained in a table top type enclosure approximately 10 inches long by 6 inches wide by 3 inches high with a rear mounted 12 inch high antenna.
The front panel shall contain one pushbutton marked "OPEN" to retract or lower delineators associated with that device and one pushbutton marked "CLOSED" to raise delineators associated with that device. One green status LED shall acknowledge the "OPEN" command, one red status LED shall acknowledge the "CLOSED" command and one amber LED shall indicate power status. Address switches within the device shall specify the location of the device.

The communication of the wireless remote control device shall be RF, FM modulation at 1200 baud, half duplex with Character Sensed Multiple Access with Collision Detect (CSMA/CD). The range shall be 500 feet line of sight, with 100 mw maximum. The input power shall be 120 VAC, 60Hz. The CCS and Wireless Remote Control devices shall operate within a temperature range of 0 to 30°c ambient, up to 95% RH, non condensing.

4  DELINEATOR CONTROLLER

Each delineator unit shall be operated by a self-contained microprocessor located in a water tight compartment at the base of the delineator assembly and connected to a power pack via a single two wire communication and power cable. A maximum of two wires shall be permitted for power and communication with the delineators. Appropriate modulation/ demodulation equipment for the control and status retrieval of the delineators shall be provided.

The delineator controller shall incorporate, as an integral part, a watchdog timer to detect an out-of-program condition and reset the microprocessor.

Each delineator unit shall be assigned a unique address. It shall be capable of operating in a multi-drop mode.

All data transmitted between the Central Control System and the delineator shall be encoded in the binary representation, using one start bit, eight data bits, and one stop bit.

Upon request from the Central Control System, the delineator controller shall return a status indicating current operating conditions. Minimum information to be supplied includes:

* Device Address
* Position of delineator (Up, Down, Ascending or Descending)
* Overtemperature Alarm
* Motor Stall Alarm
* Water Intrusion Alarm
Each delineator controller shall acknowledge all transmissions from the Central Control System. A negative acknowledgement shall be sent if a check sum, or data content error is detected. A positive acknowledgement shall be sent if no error is detected.

Each delineator controller shall be provided with error detection and reporting features, which shall be utilized to guard against incorrect commands. These features are required to preclude the possibility of a hazardous roadway condition developing. The following information security features shall be provided:

* Check sum verification of all data received from the Central Control System, with positive or negative acknowledgement for all transmissions.
* A syntax and compatibility check shall be automatically performed by the delineator controller on each command received prior to any delineator action. Any error shall prevent action or movement of the delineator.

The controller shall be protected from electrical surges by gas tube transient suppression on the AC power/communication lines.

5  DELINEATOR ASSEMBLY REQUIREMENTS

5.1  Size

The delineator operating assembly shall provide for a round delineator, 3.3" + or - 10% in diameter, which will rise to a height of 32 above the roadway. The overall size of the entire delineator unit should not be greater than 60" long and 7" in diameter to support the specified delineator. The delineator shall be flexible to withstand unintentional vehicle impacts and locked in place so as not to be dislodged accidentally. The delineator tube shall be light weight (less than 2 lbs.) and be easily removable for maintenance.

5.2  Materials

The casing tubes and other plastic parts shall be constructed of ABS, PVC, or equivalent product. The top flange level with the roadway shall be constructed of a corrosion resistant material which is rugged.

The delineator tube and cap shall be constructed of a low density polyethylene or equivalent material. The delineator tube shall be capable of being bent over by vehicle impact without damage to the vehicle or the delineator. It shall pop back up after being free of the obstruction without permanent damage to the delineator or the vehicle. Consideration should be given to the delineator cap such that it will be flexible and secure enough not to be dislodged when the
delineator is struck or run over by a vehicle. A method shall be used to provide distribution of light over the length of the delineator when the illumination feature is used. The delineator shall be translucent so as to allow the light system to function effectively.

All other hardware and materials used in the unit should be stainless steel or demonstrated to be suitable for the application.

5.3 Speed

The ascending and descending speed of each delineator shall be independently programmable in the range from 8 (4.5" per second) to 30 (1.2" per second) seconds per direction. The speed shall be adjustable in the field and factory set to a default value of 8 seconds for shipment.

5.4 Weight

The weight of the delineator assembly unit shall not be more than 40 lbs.
The replaceable inner cartridge delineator unit shall weigh not more than 20 lbs.
The delineator tube shall weigh not more than 2 lbs.

5.5 Wiring

The programmable delineators shall operate on 2 wires, minimum 12 AWG stranded, using not more than 30 volts AC. The average current draw of each programmable delineator unit shall not be more than 3 amps. Up to 8 delineator units shall be able to operate simultaneously on one circuit from a single power pack and communication repeater.

If the operation of the delineators used on a circuit are sequenced, the number used on a circuit per power pack shall be able to be increased depending on the sequence interval and the speed. The maximum number of delineators shall not exceed 16 on a circuit. Any arrangement of sequencing shall be permitted provided that not more than 8 delineators are in motion at one time.

Control and status communication between the central control system and the programmable delineator units shall be over the same two wires providing power for the delineator units.

5.6 Powertrain

The delineator tube shall be raised and lowered by means of a properly sized DC motor in conjunction with a stainless steel course lead screw and a suitable follower nut.
5.7 Access

The inner cartridge delineator assembly unit (delineator to be complete with motor, screw and controller) shall be easily removable from its outer casing for maintenance and/or replacement. A secure in-ground locking technique shall be provided for the delineator cartridge unit to prevent unauthorized tampering or theft.

6 ENVIRONMENTAL REQUIREMENTS

All wiring shall be in accordance with the requirements of the National Electrical Code, and shall be color-coded. There shall be no exposed wiring.

All equipment shall operate over an ambient temperature of -30 degrees to +45 degrees C. Operation of the equipment shall not be degraded by rain, snow, or normally encountered ambient humidity conditions.

All electrical components shall be of modular, interchangeable plug-in type construction and shall be standard components where possible. The delineator unit shall be constructed with replaceable and interchangeable modules such that a faulty module can be easily replaced with a spare module group as needed.

All system equipment shall operate on a line voltage of 120 volts AC, + or -10 percent and a frequency of 60 Hertz.

"Brown-outs" shall not damage the system’s components or impair future system performance.

Complete installation of all components of the system and requisite electrical facilities shall be provided. Power and Communication links shall be installed by the Contractor.

Corrosion Protection: The field equipment and electronic components shall not be adversely affected by salt from the roadway or chemicals in the air. Corrosion protection shall be provided between dissimilar metals.

The System shall have protection to reduce and/or eliminate any high voltage electrical surges. This protection shall be present on the incoming communication lines as well as AC power supplied to all electronic assemblies. Surge suppression must incorporate both gas discharge tubes and semiconductor devices.
7 EXPERIENCE AND PERFORMANCE TESTS

7.1 Experience

Prior to the Department’s written acceptance of the system and the submission of shop drawings, the system supplier shall submit to the Department for approval, names of at least one similar system, installed and operational for at least one year. The customer references, complete with identifying information regarding personnel to contact, must also be included.

7.2 Performance Tests

Performance tests must demonstrate all the capabilities and requirements. After the installation of the entire system is completed and tested, the system supplier shall conduct an additional continuous 24-hour operating test for approval. The types of tests to be conducted will be furnished by the system supplier and approved by the Engineer, and will consist primarily of various commands and delineator operations with the appropriate status responses. The purpose of this test is to insure that the system is functioning properly.

8 TRAINING AND WARRANTY

8.1 Training

Operational and Maintenance Training for the entire system shall be provided to designated personnel through the means of practical demonstrations, seminars and other related technical teaching procedures. The training shall include the following:

* "Hands-on" operation of all control system hardware and delineators.
* Explanation of the complete repertoire of system commands.
* Explanation of all status responses.
* Instruction on required preventive maintenance procedures and minor servicing procedures.
* Instruction on system "trouble-shooting" or problem identification procedures.
* A minimum of 8 hours of instruction shall be provided.
8.2 Documentation

The system supplier shall supply a total of three sets of operating manuals, service manuals and maintenance instructions covering the entire system supplied.

8.3 Spares

Upon acceptance of the system, one spare delineator cartridge assembly unit complete with motor assembly and four delineator tubes for each group of 16 units shall be furnished to the Department's designated representative.

8.4 Warranty

The one-year on-site warranty and maintenance period shall commence on the first day after the approved 24-hour operating test period. The Department will furnish the system supplier with a letter of approval stating the first day of the warranty and maintenance period.

The warranty and maintenance period shall apply to the entire delineator system and shall include the following:

- Replacement of any spare parts used during this warranty period at the system supplier's expense, except for damage caused by vandalism and acts of nature or consumable such as lamps and delineators.
- Regularly scheduled preventive maintenance every six months for the one-year period (two times).
- Emergency maintenance wherein no more than 48 hours shall elapse between the time of notification by the Department and the time repair commences.

The system supplier shall be an acceptable firm capable of providing maintenance upon the termination of the required one-year maintenance and warranty period at the option of the Department.
Introducing the POP UP™ programmable delineator

- Eliminates crew exposure to hazardous situations during channelization changes
- Extra low voltage power means safe, easy and low cost installation
- Bounces back into position on impact, won't damage vehicles
- Power, control and status on a two conductor cable
- Custom traffic patterns available instantly
- Remote controlled or automatic operation
- Individually addressable
Easy installation

Prepare the site
Core a hole, 8 inches in diameter and 60 inches deep.
Cut a 2 inch deep slot in the pavement for the power/control cable.

Place the casing
Set the casing in the hole.
Connect the power cable and fill.

Install the POP UP™
Drop the POP UP™ cartridge into the casing and bolt down.

That's all there is to it!

Typical uses

- Toll booths
- Bridges and tunnels
- Airport and aircraft taxi ways
- Parking garages
- Railway crossings
- Reversible roadways
- Anywhere changes or redirection in traffic patterns are cyclical
- Right-of-ways where current barrier designs need visual reinforcement
**Configuration**

**Lighting**
Lighting is available and can be individually controlled. A typical use of lighting is off when the delineator is retracted, flashing while it is extending and on while it is fully extended.

**Heater**
To prevent ice and snow from restricting the operation of the delineator a heater option is available.

The heater can be controlled automatically by thermostat or manually by the operator at the control center. This option extends the operational low temperature of the POP UP™ to -20 °C.

**Retro-Reflective Material**
The visibility of the delineator can be enhanced by the use of retro-reflective material.
Appendix C: The Line Connection Inc.

Evaluation of the POP UP™ Programmable Delineator
DURA-POST® HEAVY DUTY DELINEATOR POST
As close to indestructible as you can get!

WHAT IS IT:

DURA-POST® is composed of a 100% urethane plastic which is extremely flexible and remains impact resistant down to -20 degrees F. to +140 degrees F.

DURA-POST® is available as:
• Channelizers
• K-markers
• Island markers
• White, yellow, orange, and other colors are available.
• 18" - 36" Height
• 3" and 4" Diameter
• Surface Mounted
• Soil anchor available

ENGINEERED TO LAST:
• Traffic Separation
• Traffic Islands
• Construction Zones
• Parking Lots

ENVIRONMENTALLY FRIENDLY:
• DURA-POST® is made of a minimum of 50% post commercial recycled material.
• Base is made of minimum of 50% post commercial recycled material.

COST EFFECTIVE:
• Can withstand hundreds of impacts
• Highly flexible
• Single piece construction
• Easy removal or replacement
• Rust proof
• Reduces maintenance cost
• Reduces tort liability
SPECIFICATIONS
SURFACE MOUNTED
CHANNELIZERS / DELINEATORS
(HEAVY DUTY)
DP - H36

1. USE: A durable, heavy duty, flexible, surface mounted channelizer/delineator (Dura-Post) suitable for use in marking islands, gore areas, construction zones, centerline medians or hazards.

1.1 The Dura-Post should have a minimum outside diameter of 3 inches.

1.2 The Dura-Post shall be supplied in white, yellow, or orange.

1.3 The height of the Dura-Post shall be 36 inches.

2. MATERIAL REQUIREMENTS: The Dura-Post shall be composed of a flexible plastic material which is resistant to impact, ozone, ultraviolet light, hydrocarbons, and remain impact resistant from -20 degrees Fahrenheit to +140 degrees Fahrenheit.

   Hardness, Durometer / Shore A: 85A (plus/minus 5)  
   Ultimate Tensile Strength: 5000 psi (plus/minus 500 psi)  
   Ultimate Elongation: 450%

2.1 Reflective sheeting shall be FLEXIBLE 3M high-intensity.

2.2 The ABS plastic base shall be a minimum of 8 inches in diameter and be capable of being quickly affixed to the post. The base shall be constructed so that parts are not protruding in the event the Dura-Post becomes dislodged from the base.

2.3 The Dura-Post shall be made of a minimum 50% recycled flexible plastic material.

2.4 The base shall be made of a minimum 50% recycled ABS.

3. PERFORMANCE REQUIREMENTS: Installed Dura-Post shall be capable of self-erecting and remaining serviceable after being subjected to a series of ten (10) impacts by a light duty truck traveling at fifty-five (55) mph between the wheels and five (5) impacts at twenty-five (25) mph with the wheels.

4. ADHESIVE: butyl pad, epoxy, hot melt, or Super Bundy adhesive pad.

5. TECHNICAL SERVICES: Will be provided as required.
Memorandum

To: FILE  Date: June 21, 1993

File: Posts-Channelizers

From: DEPARTMENT OF TRANSPORTATION
Division of New Technology, Materials and Research

Subject: Impact Testing of Two Channelizer Posts from The Line Connection, Inc.

On April 14, 1993 the Transportation Laboratory performed impact tests on new versions of two approved flexible channelizer posts from The Line Connection, Inc. of Rancho Cordova Calif. The posts were a 36" channelizer and a Type "K" marker. The test also included three different adhesives, a butyl pad, a new meltable black mastic and regular epoxy.

The 36" channelizer had been tested and approved by the laboratory in 1989. The approved version was cast or hand poured and the new version uses a different formulation of resin that can be injection molded. We are told that it is the same basic resin but altered to allow injection.

The 36" channelizer consists of a 3" soft thermoplastic tube which is connected to a molded base. The tube is held in place by a single 1/4" steel pin which is driven through the base and the post. The tube portion is replaceable.

The new Type "K" Marker has the 6" X 15" horizontal paddle attached to the back of the post instead of the front to prevent pull-off. The upper portion attaches to the same base as the channelizer. This item had also been previously approved but with the paddle on the other side.

INSTALLATION

Since we have no written specifications for channelizers, we have normally tested them to the most stringent impact requirements of flexible delineators. This requires 10 impacts at 35 mph and 10 impacts at 55 mph. Since these basic designs were already approved we only tested them at 55 mph. Nine channelizers and nine Type "K" markers were installed in a line for the impact tests, three each using the three different adhesives.
The testing was done at our facility at the Highway Patrol Academy using our Mustang vehicle.

TEST RESULTS

The first impact at 55 mph separated all of the 36" channelizers from their bases. It was determined that the company had substituted a fiber reinforced plastic pin for the steel pin that had been previously used. The company representatives went shopping for steel pins, replaced them and the test was begun again.

After 10 impacts at 55 mph all of the 36" posts were in good condition. They were all self erecting and showed no indication of pulling out of their bases. The sheeting was badly scuffed but it was all in place and would have passed the requirements of the MUTCD, being seen at 1000 feet using high beam headlights.

The Type "K" markers also withstood the 10 impacts at 55 mph and were in the same good condition. The sheeting was scuffed and dirty, especially the center band, but fully effective as a roadside reflector.

All of the adhesives performed equally well. There was no sign of distress in the base to pavement bond.

Based on the results of this test The Transportation Laboratory recommends that the 36" channelizer and the Type "K" marker from The Line Connection be approved.

RICHARD L. HICKMAN
Senior M&R Engineer
Office of Structural Materials

cc:B. Grottkau
B. Lane-HQ Traffic

RLH
VERTICAL K-MARKER
(Heavy Duty)

4" WIDE

21" HIGH

ITEM NUMBER W-21-4-VKM
TRAFFIC CONES
- High visibility provided by fluorescent pigmentation.
- Specifications: Heights: 6", 12", 18", 28" & 36". Weight varies according to height and body styles from 1-1/2 - 12 lbs. (6" cone weighs 1/4 lb.)
- Collars: 3" to 13" wide reflective collar with lower 4" collar to meet M.U.T.C.D. specifications.
- Additional options: Flag adapters for 18", 28" & 36" wide body cones, cone lights (CL-1) fits in top of 18", 28" & 36" wide body cones, 7 lb cone weight to stabilize cones, FB-3 & FB-4 3' & 4' rigid urethane foam barricades for use with 28" & 36" cones, stencilling on inner liner.
- Slim or wide body styles.

SOLAR MESSAGE CENTER TRAILER MOUNTED SOLAR MESSAGE CENTER
- LED lamp matrix design.
- Solar assist power 212 watt solar panel array.
- 250 Pre programmed messages, 100 sequence capability.
- 30 day autonomy.
- Efficient long life LED lamps 10 year average operational.
- 4-D deep cycle batteries, built in 115V battery charger.
- Superior truncated panel design.
- Low maintenance.

SOLAR ARROW BOARDS TRAILER MOUNTED SOLAR ARROW BOARDS
- 15 & 25 light models.
- 15 Light - 7 modes, 25 Light - 10 modes.
- 30 day autonomy.
- Amber par 46 LED lamps; 24' horiz. x 8' vert., 33' horiz. x 11' vert.; 5 year warranty, 10 years operational life.
- 4-D deep cycle batteries, 115V battery charger optional.
- Panel positioning for maximum charging.
- Low maintenance.

PLASTIC SAFETY BARREL High Performance-B400
- Dimension: Minimum 18" diameter, approximately 36" high.
- Material: Low density and high density polyethylene.
- Vehicle & barrel undamaged on impact. Top breaks away, vehicle passes over low profile base.
- Stackable with base removed for easy transportation.
- Anti-roll design even when separated from base.
- Redesigned handle for easy lifting.
- New snap-on plastic base with molded footpads for quick removal.
- Bases available: 3 lb. plastic base, 25 lb. rubber base, 40 lb. rubber base.

MANHOLE MATERIAL LIFT AND GUARD
- Lightweight and portable for raising and lowering equipment and material safely—particularly useful in emergency situations. Unit is easy to set up and requires minimal maintenance.
- Safety: Serves as a safety fence and has a safe working load of 300 lbs. with 3-to-1 built-in safety factor.
- Construction: This durable unit is constructed of high-tensile strength steel tubing. The side rails are heavy-gauge aluminum. The manhole guard and side rails are painted with a yellow finish.
- Lift unit clamps securely to the universal manhole guard.
- Lift rope is 1/2" x 35' Duraplex braided rope.
- Accessories: Manhole guard, manhole cover remover, and 8" or 12" steel leg extensions/levelers. Lift may be ordered with or without manhole guard.
RAILROAD CROSSING - Newell, North Carolina • Used to deter motorist from driving around down cross bars as trains approach.

DRAWBRIDGE INSTALLATION - Ft. Lauderdale, Florida
Attaches to grating - permanent or temporary

PERMANENT INSTALLATION
Miami, Florida
White CURB used to restrict turn lane.

DANGEROUS CURVE
Stuttgart, Germany
Permanent use at high accident area.

TOLL BOOTH FACILITY - Stuttgart, Germany
Movable - transfer traffic to open toll booths.

CONSTRUCTION - Marshall, Iowa
Interstate crossover.

BRIDGE CONSTRUCTION - Pensacola, Florida
7000 feet of CURB on narrow I-10 bridge.

CONSTRUCTION - Jackson, Mississippi
Temporary lane closure enforcement.
THE BRIGHTEST NAME IN HIGHWAY SAFETY
REFLEXITE, WORLD'S LEADER IN RETROREFLECTIVE CUBE-CORNER MICROPRISM TECHNOLOGY, PROVIDES A FULL RANGE OF PRODUCTS FOR THE CONSTRUCTION WORK ZONE

ROLL-UP SIGN BLANKS
Roll-up sign blanks made from Reflexite® "construction" orange, are tough, durable, and reflect brightly even when wet. Easily silk screened, these sign blanks can be economically converted into light weight, easy to store, roll-up signs. Meet all the requirements of the Federal Highway Administration's MUTCD.

ROLL-UP SIGN BLANKS

BARRICADE SHEETING
Reflexite® orange/white prestriped barricade sheeting meets and exceeds the daytime color and nighttime photometric requirements of both ASTM D4956 and FP 85 for high intensity grade sheeting. It is designed for use on Type I, II, and III barricades and vertical panels and offers long sight detection distance visibility. This tough faced film barricade sheeting is especially suited for the rough handling associated with construction work zones.

BARRICADE SHEETING

CHANNELIZER TAPE
Reflexite channelizer tape meets the requirements of ASTM D4956 and FP85 for reboundable high brightness materials. It is designed for use on plastic drums and posts where high impact durability is required. This material provides the longest sight detection distance of any flexible reflective material available.

CHANNELIZER TAPE

TRAFFIC CONE COLLARS
Reflexite® reflective collars for traffic cones provide brilliant reflectivity. Extremely durable, they can take repeated flexing, even impact, without losing physical or reflective properties. Reflexite® cone collars work when wet, are easy to attach and come in a full range of sizes. They also meet all requirements of Federal Highway Administration's Manual on Uniform Traffic Control Devices.

TRAFFIC CONE COLLARS

Reflexite® is a registered trademark of Reflexite Corporation, Avon, CT USA

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