Raised Pavement Marker Automated Placement Machine

Business Development Case

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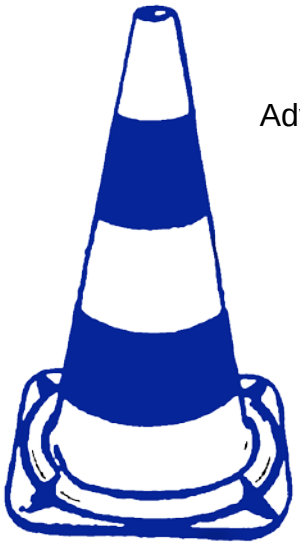

Many thanks-
Considerable Input from Duane Bennett

Program Overview

About the UC Davis Graduate School of Management (GSM):

The mission of the UC Davis Graduate School of Management is to be a leader in management research and education. As part of the world's premier public university, we pursue significance, excellence and scholarly rigor in our research, teaching and service to the people of California. We emphasize curiosity, creativity and high standards in the generation and transmission of theoretical and practical knowledge relevant for business.[1]

About the California Department of Transportation (Caltrans):

Caltrans manages more than 45,000 miles of California's highway and freeway lanes, provides inter-city rail services, assists more than 100 public general aviation airports and works with local agencies. Caltrans carries out its mission of improving mobility across California with six primary programs: Aeronautics, Highway Transportation, Mass Transportation, Transportation Planning, Administration and the Equipment Service Center.[2] Caltrans as a whole has an annual budget of $8 billion, of which $393 million is appropriated for maintenance activities.

About the Advanced Highway Maintenance and Technology Center (AHMCT):

The Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center has been developing robotic equipment and machinery for highway maintenance and construction operations. It is a cooperative venture between the University of California at Davis and the California Department of Transportation (Caltrans). The research and development projects have the goal of increasing safety and efficiency of roadwork operations through the appropriate application of automation solutions.[3]

[1] UC Davis GSM Mission Statement, http://www.gsm.ucdavis.edu/visitors_center/about_us.htm#Mission%20Statement
[2] About Caltrans, http://www.caltrans.ca.gov/aboutcaltrans.htm
[3] "Development Of A Prototype Telerobotic System For Debris Vacuum Positioning," AHMCT Research Report, 12/31/01

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1 Abstract

This project was intended to evaluate the business case for developing new machines or techniques for automating the process of placing raised pavement markers for CalTrans. It includes a brief evaluation of existing methods, and suggestions for areas of improvement. Within this paper, we look at the cost of the machines, operation cost, and savings, to determine what opportunities for improvement may be available. .

2 Project Description

2.1 Elevator Pitch

Automating the placement of raised pavement markers ma reduce costs, and initial evidence indicates that the repairs may be longer lasting.

2.1.1. AHMCT RPM Development Plan

1) Search for existing research and equipment related to RPM placement innovations (completed)
2) Develop conceptual design for new RPM placement machine and build demonstration device (current)
3) Develop proposal for funding to extend capabilities of RPM demonstration device to road demonstration unit. (June 07)
4) Field test road test device with Caltrans in limited highway dot placement operations.
5) Obtain Caltrans worker evaluations and recommendations from highway testing.
6) Develop proposal for full scale RPM placement machine design and fabrication.

2.2 Value Proposition

2.2.1 Current RPM Placement Methods

"Currently, the pavement marker placement process is time consumingand creates a number of safety hazards. In a common scenario,a truck with a specially designed operator bay travels slowlyalong the road and stops at required intervals. An operator thenapplies bitumen at 400 _F to the road via a hand controlled dispenserand places the marker on the bitumen by hand. This procedure requiresthe operator to extend his/her hand and arm into the oncomingtraffic. In addition, the slow moving truck requires lane closurewhich represents a hazard for the moving traffic."[4]

"The overall objective of the UCD/CALTRANS project is to move the operator into the vehiclecab and apply markers while the vehicle is traveling at speeds of 10 mph (16 km/hr) or more. The results of the UCD/CALTRANS project showed that it is possible to fabricate a device thatis capable of applying raised pavement markers to the road surface while a truck stays in motion."[5]

Caltrans is responsible for a combination of primary freeways and secondary highways throughout the State. The primary freeways account for a large percentage of Caltrans lane miles maintained. On high speed highways with more than two lanes, typically a lane closure is installed. On rare occasions were

[4] http://www2.ncsu.edu/CIL/CARL/Research/Pavement/PavementMarker/trpma.html

[5] IBID

only two lanes are present, two way traffic is flagged through a single lane past a moving lane closure RPM placement operation or left to back-up for brief periods. For the more common multi-lane highway RPM Placement operation the lane closure is placed with cones between the rush hour times of 10am-2pm.

RPM Research Improvements[6]

Comprehensive Research Improvements (applies to new or existing equipment)

Adhesive system upgrades:

1) Larger capacity adhesive melting pot: doubling the capacity of the kettle on the existing Caltrans truck would save approximately half an hour a day. For the new design an increase of approximately four fold would be required to keep the machine moving continuously. A more precise capacity valve would be determined from testing of the highway demonstration RPM machine. This savings value would be implicit in the overall automated machine savings value. Meaning this is a requirement for the automated machine to operate at a determined production scale which will be described later.
2) Increased melting pot heat-up time: As per Caltrans crew input approximately an hour and a half to two hours a day is spent waiting for the adhesive to heat. Being real generous, lets say during half of this heat-up time the crew is loading supplies for the day's production and assigning duties and reviewing safety procedures. The leaves 45-60 minutes of idle time for the full crew of 4 minimum.
3) Switch to propane fired melting pot heat from electric: Reduces heat-up time by at least half and eliminates the large on-board AC generator. I suspect there would be equipment cost savings, but further design would be needed to obtain a reasonable estimate.
4) Adhesive recirculation system: It's just a better method of operation. It has many benefits, all of which are difficult to place a cost benefit. Mainly it extends the life of the equipment and reduces the cost associated with repairs.
5) Adhesive material handling scheme improvement: Also represents a far better method of operation. Adhesive stored in 55 gallon drums rather than small boxes. Material handling costs drop.

2.2.2 Cost Comparison

Dot Placement Costs

The pattern dots are placed effects the cost analysis dramatically. A typical freeway lane dot pattern has reflector dots on 48ft spacing with 4 round dots placed 4ft apart centered in the 48ft gap.

Secondary highways generally use reflectors only with 10-15ft spacing. Video analysis of a Caltrans placement operation on secondary two lane highway (approximately a 14ft spacing) shows it is requiring 7sec per dot which works out to be 377 dots per mile at an average speed of 1.36 mi/hr. Caltrans crews typically place 1200 dots a day, but at this speed it would take 2.33hr to place 1200 dots. For the freeway pattern Duane Bennet drove on the highway and simulated placement. He calculated that this pattern would move at 1mi/hr and take 550 dots per mile taking 2.2hrs to place. There is clearly time missing.

Caltrans needs to conduct lane closures between 10am to 2pm on average so not to further add to slow rush hour traffic. Moving closures on secondary highways requires flagging and intermittent traffic blockages which uses about the same amount of time as installing a fixed closure. Lane closure or traffic control time takes an hour leaving three hours of work time. Since dot placement is tedious work, taking breaks to re-supply dots, fill adhesive kettle also helps the worker to recover. So that leaves 2-1/2 hours of actual dot installation time a day on average.

Since the current placement operations are running at 1-1.33mi/hr an average can be compared to our automated RPM machine designed to operate at 2mi/hr. In addition the full three hours of production time could be utilized. The automated RPM machine can be operated with one person, but Caltrans has already expressed an interest in keeping both workers on-board, a driver and a machine operator. [7]

2.2.2.1 Labor Rate

The following are labor rate data for Caltrans workers used in IMMS reporting[8].

- Maintenance Worker: $27.58
- Caltrans Equipment Operator I: $32.26
- Caltrans Equipment Operator II: $34.61
- Caltrans Maintenance Supervisor: $41.74

Typically, a 15% to 20% overhead rate is applied to hourly labor costs. Using this data, an average hourly rate of $39.15 (including 15% overhead) was constructed. Labor costs used in the South Dakota study assumed

2.2.2.2 Equipment Pricing

Comprehensive Adhesive System Upgrades

The cost of upgrading the adhesive system would be approximately the same for both the existing Caltrans RPM truck and the AHMCT automated RPM machine. Final design is too far away to offer a price at this point. Since the automated RPM machine could operate on Caltrans existing adhesive

[6] From Duane Bennet – AHMCT
[7] Directly from AHMCT researcher Duane Bennet.
[8] Caltrans Courtney Morrison

system and this design upgrade could be retrofitted on the existing Caltrans truck, we can justify leaving off costs and benefits associated with the adhesive system upgrade at this time.

Automated RPM Equipment

The automated RPM machine can be divided into four sections and what this cost represents as compared to existing Caltrans RPM truck.

1) Placement device (addition)
2) Adhesive system (already discussed)
3) Dot handling system (addition)
4) Chassis (reduction)

1) Placement device: enables RPM's to be placed at a continuous 2mph speed (current manual method is stop and go) automatically without direct worker exposure to traffic. Total cost is approximately $11,000 price breakdown as follows

Embedded Control Module	$2,000
Dispenser	$2,000
Frame Parts (plates)	$2,000
Pneumatic Parts	$1,500
Track Parts	$500
Band Cylinder	$1,500
Hardware Items	$1,000
Wheel Encoder	$500

3) Dot Handling System: Currently the worker can reach a box of dots while in the bucket. Many breaks are taken to reload boxes of dots. To create an automated RPM placement process, marker handling has to be automated. The dot handling system is an added expense for the automated process. The design of this system has not yet been investigated, but the principle is fairly common. The specifics of the design will affect the cost, especially the marker capacity. These details will be determined in the full scale machine design phase. Conservative estimates would price this around the same as the placement device, $11,000.

4) Chassis: The current Caltrans RPM body is mounted on a medium duty truck chassis. The AHMCT RPM machine will be trailer mounted. Again being conservative lets assume the cost of building the Caltrans RPM body is similar to the cost of building the trailer body with all its power systems. Then a cost savings could be represented in the cost of a medium sized commercial truck chassis. With Caltrans standard specification such a chassis would cost $40,000. A Caltrans truck would still have to tow the RPM trailer and a mileage rate would apply for its use, but that mileage rate would also apply to the

current truck based RPM body. Therefore the mileage charge would apply to any type of RPM placement equipment and could be considered a wash. Leaving the full value of the truck chassis as cost savings. The trailer based RPM placement machine design has additional safety and access advantages as well, but these would difficult to place a value on.

Synopsis - By not requiring a specialized vehicle, the cost saving of a trailer mounted unit is approximately $18,000, on purely equipment costs.

2.3 Project Objective

The purpose of this project is to develop a business case to support the deployment of spray injection pothole filling machines into the Caltrans work place. In addition, to briefly evaluate existing technologies and investigate possible improvements to be made by AHMCT for the pothole filling method.

3 Technology

Four possible principle benefits are available to CalTrans. There are possible cost savings if the machine can be made for the estimated prices, of about $18,000 per unit.
In addition, the faster speeds and elimination of down time could increase crew productivity by 90%. This would mean a crew would cover nearly twice the amount of road in a given work period, or need to devote half the time to RPM placement as previous.
A third possible benefit is decreased worked exposure to traffic and other hazards.
The forth benefit is repair durability. Early tests conducted by the AHMCT indicate that the consistent pressure applied by an automated system creates a more durable RPM than hand placement methods.

If the device can be beuilt for the estimated prices, with a 90% improvement in productivity, it would be a clear advantage to CalTrans.

3.1 Status

CalTrans and the Advanced Highway Maintenance and Technology Center have built prior test units. There is currently work being done on design for a new unit, including investigation of ideal adhesives.

4 Traffic Control Market

The traffic control market generally consists of two main groups, state highway maintenance crews, and private construction crews. Both would have extensive use for better raised pavement marker methods.

5 Recommendations

Our recommendation is for the AHMCT group to begin development of the RPM machine that can meet the above specifications. The clear cost and performance benefits, if met, will create an advantageous product for CalTrans.

6 Acknowledgements

We'd like to thanks all the Caltrans maintenance workers who patiently answered our questions. Duane Benner contributed to the bulk of this report. Also we'd like to thank Caltrans.