

Transfer Tank Longitudinal Crack Sealer Business Development Case



Final Report

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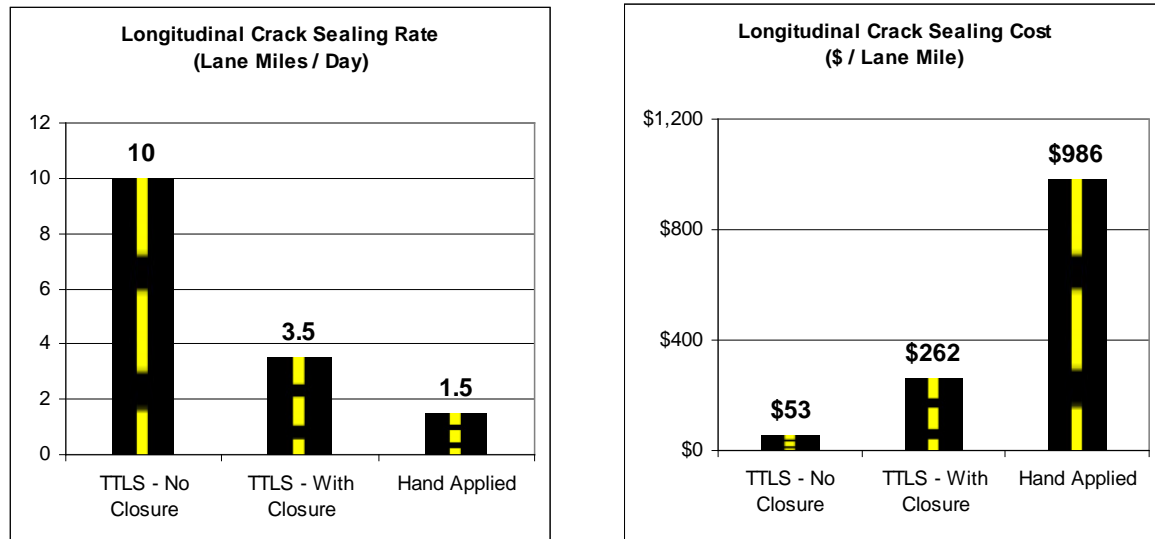
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Executive Summary

The Transfer Tank Longitudinal Sealer (TTLS) seals longitudinal cracks more than twice as efficiently as manual methods with a 73% decrease in cost per lane mile (Figure 1). It also increases safety by reducing worker exposure to traffic.

Figure 1: Production and Cost Comparison – TTLS vs. Current



Objectives

- Identify and quantify benefits to Caltrans, Caltrans maintenance workers, and society
- Identify customers beyond Caltrans
- Identify potential business models to introduce TTLS into service
- Unless otherwise noted, Caltrans and AHMCT provided the data for this report. Additional interviews were conducted with other state departments of transportation, local departments of transportation, and third-party vendors of maintenance equipment.

Value Proposition

Crack sealing is a preventative maintenance technique that can help extend the life of roadways by up to three years. Current methods limit the number of lane-miles sealed each year due to personnel and budgetary constraints.

Value to Caltrans: Increased Crack Sealing Efficiency & Extended Road Life

- Labor savings is estimated at over \$1.2 million per year
- Present value of cost savings from delay in capital expenditures for rehabilitation is \$27,394 per lane mile sealed

Value to Caltrans Maintenance Workers: Increased Safety

- Injuries are expected to decrease by approximately 17%
- Annual estimated cost savings of \$9,626 from reduction in injuries

Value to Consumers: Reduced Lane Closures

- Fixed lane closures could be eliminated by using TTLS with a change in Caltrans policy
- Fixed lane closures would be reduced by 57% with TTLS under current Caltrans policy due to increased efficiency
- Estimated current economic impact is \$5,000 per lane closure

Market Opportunity: \$98M in U.S.

In addition to Caltrans, there is significant potential value in local markets within the state, as well as local and state markets outside of California. The total potential TTLS market is approximately \$98 million.

State Departments of Transportation

- Maintain over 1.2 million lane-miles, growing at 0.8% annually¹
- 82,000 man-hours are spent annually by Caltrans on crack sealing
- Crack sealing costs Caltrans an average of \$1,310 per lane-mile

Municipalities

- Maintain 7.1 million lane-miles, growing at 0.6% annually¹
- Desire to do more crack sealing, but are limited by personnel and budget constraints

Technology

The technology consists of three parts: the application truck, the transfer tank trailer, and the rapid transfer process:

- The application truck contains a 400-gallon kettle and can seal longitudinal cracks on either side at up to 5 mph. A single operator controls sealing from inside the cab.
- The 600-gallon transfer tank trailer allows quick refill of hot sealant to keep up with the truck's increased ability to lay down sealant.
- The sealant transfer process occurs rapidly to essentially increase the truck tank's capacity to 1,000 gallons. The transfer process is monitored electronically to ensure that the smaller truck tank is not overfilled.

Economic Model

Three drivers influence cost savings of the TTLS:

- Production Rate – TTLS can seal cracks at up to 6.7 times the rate of a manual operation, assuming that no lane closures are used
- Labor Cost – TTLS only requires one operator, versus four maintenance workers under the manual method
- Lane Closure Cost – TTLS can be operated with a moving lane closure, as opposed to a fixed lane closure that costs Caltrans \$500 per day

Table 1: Cost Savings

Cost Comparison Summary	TTLS (no closure)	TTLS (with closure)	Hand Applied
Required Machines	2	5	10
Labor Cost	\$ 68,451	\$ 146,681	\$ 1,369,086
Lane Closure Cost	\$ -	\$ 325,535	\$ 759,616
Equipment Maintenance	\$ 40,000	\$ 100,000	\$ 41,480
Injury Cost	\$ 9,626	\$ 9,626	\$ 19,253
Present Value of Investment Cost Differential	\$ 391,718	\$ 1,654,294	
Total Annual Out-of-Pocket Cost Savings	\$ 2,071,357	\$ 1,607,592	

Table 1 shows that in the most likely scenario where lane closures are reduced rather than eliminated, the initial investment differential between TTLS and current machinery of \$1.65 million yields an annual cost savings of \$1.60 million that lasts for 20 years. In other words, a fleet of five TTLS machines pays for itself in about one year.

¹ Bureau of Transportation Statistics

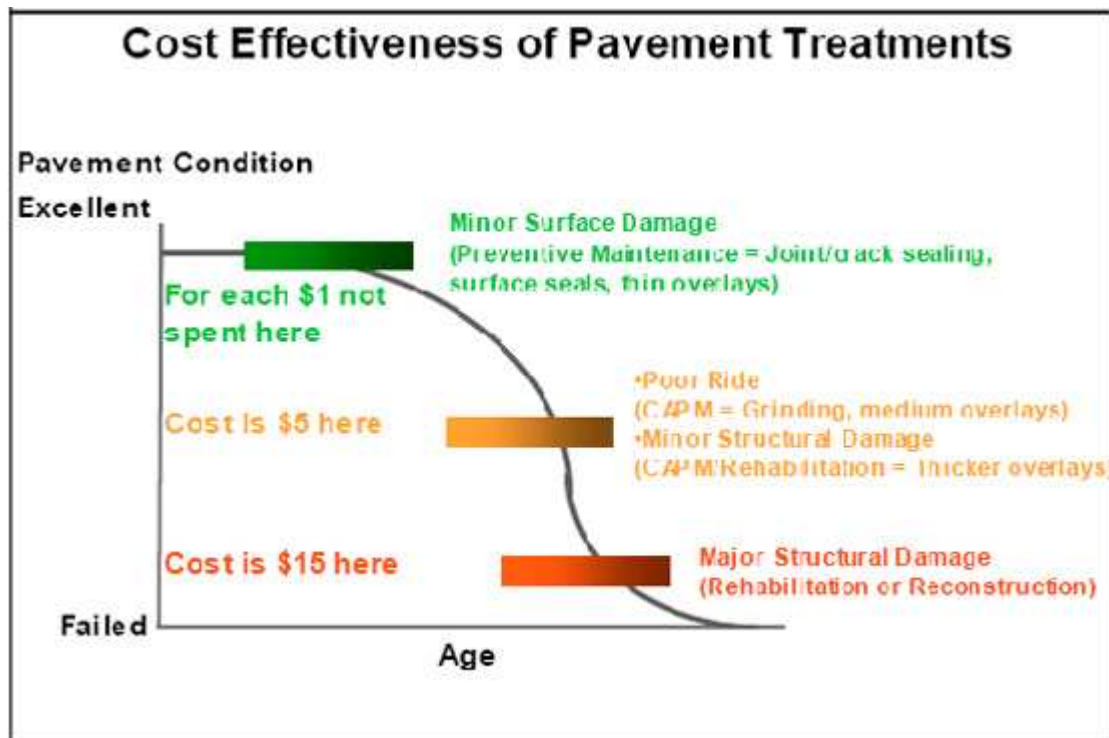
Background

U.S. Highway System

Plans for a national highway system were developed in 1944. Funding for the project was approved by Congress in 1952. President Dwight Eisenhower championed the fundraising during his first term; construction of the Interstate Highway System began in 1956. In 2005, there are nearly 8.4 million lane-miles in the United States. Roughly 1.2 million of these are Interstate Highway lane-miles under the maintenance jurisdiction of the state departments of transportation. The remainder fall under the maintenance jurisdiction of county and city municipalities. In addition to roads, the U.S. Highway System includes nearly 600,000 bridges.

In 2001, \$31.6 billion of federal, state, and local funds was spent on highway maintenance. 51% of this was spent on resurfacing roads. Another 21% was spent on road restoration. These costs could be significantly reduced with proper crack sealing preventative maintenance. Figure 2 demonstrates the advantages of roadway preventative maintenance.

Figure 2: Cost of not Performing Crack Sealing²



Caltrans

Caltrans maintains 15,000 centerline miles and 49,000 lane-miles of highway. This includes over 12,000 bridges and over 230,000 right-of-way miles. The maintenance program organization within Caltrans is divided into 12 districts. Within each district, a Maintenance Support group is responsible for coordinating the equipment assignments, a Maintenance Engineering group is responsible for servicing the equipment, and a District Division Chief of Maintenance (DDCM) allocates labor, expenditures, and equipment usage. The DDCM is also responsible for submitting the annual budget for his/her district, justifying any

² Caltrans 2003 State-of-the-Pavement report

additions, upgrades/downgrades, or replacements. These equipment mix changes are also reflected by the Equipment Service Center in the Equipment Catalog. If equipment is not in the catalog or is not immediately available in the area, it can be rented from a third party. Purchases of new equipment must go through a competitive bidding process. The alternative, sole sourcing, makes the Caltrans internal purchasing process very time consuming. However, purchasing from multiple distributors is not considered sole sourcing.

The approval process for new equipment involves the Maintenance Division and the Division of Equipment (DOE). These groups work together to determine what new equipment should be purchased. DOE develops the specifications and obtains approval through the Department of General Services. DOE then requests bids based on the specifications and makes the purchase.

The DDCM manages several Regional Maintenance Managers. Several Area Superintendents report to the Regional Managers. Below the Area Superintendents are several Territory Supervisors who are responsible for specific maintenance activities. Supervisors want equipment that helps them be more efficient and make their area look good. Caltrans maintenance operations include activities such as paving, traffic safety, vegetation control and landscaping, snow removal, and crack sealing.

Caltrans as a whole has an annual budget of \$8 billion. \$393 million is appropriated for maintenance activities; \$4.5 million is spent on crack sealing. Caltrans currently seals approximately 3,317 lane-miles of cracks each year. Approximately 96% of this is done internally, while 4% is outsourced as shown in Table 2. Caltrans is able to perform the crack sealing operations at a much lower cost than the outsourcing alternative. The need to outsource is driven by time and personnel constraints. There are more cracks to be sealed than current production rates and personnel staffing levels allow.

Table 2: Current Caltrans Crack Sealing Activity

	Lane-Miles	Total Cost	Cost Per Lane-Mile	% of Total	Source
Outsourced	144	\$629,000	\$4,368	4%	02/03 – 2003 State of Pavement
In-House	3,173	\$3,717,683	\$1,172	96%	04/05 Activity – Morrison
Total	3,317	\$4,346,683	\$1,310	100%	

Comparing Caltrans to other highway maintenance jurisdictions (Table 3), it appears that state departments of transportation (DOT) are only able to seal about 6.8% of the lane-miles under their jurisdiction yearly. Ideally, the DOTs should seal at least 10% of the lane-miles under their jurisdiction annually because crack seals typically have a 10-year life. If the DOTs could crack seal 10% of the lane-miles in each of those 10 years, the entire system would be covered every 10 years, extending the life of the roads and reducing costs. The 3.2% deficiency results in roads that are not crack-sealed needing additional maintenance sooner, such as rehabilitation, which costs roughly \$285,714 per lane-mile³.

³ Caltrans 2003 State-of-the-Pavement report

Table 3: Crack Sealing in Different Highway Maintenance Jurisdictions

Agency	Total System Size	Yearly Crack Sealing	Crack Sealing Expense	Purchase or Rent Equipment	Equipment Suppliers	Equipment Purchase Price Range	% In-house	% Out-source
Caltrans	15,000 CL 49,000 LM	3,317 LM	\$4,346,683	Purchase	Bearcat, Cimline, Crafcro, Marathon, Stepp	\$45,000 to \$50,000	96%	4%
MDOT (Michigan)	27,544 LM	1,200 Roadbed Miles		Outsource	Outsource	Outsource	0%	100%
PennDOT (Pennsylvania)	88,164 LM	5,945 LM		Purchase	Crafcro, Rosco	\$52,000 to \$160,000	99%	1%
TxDOT (Texas)	80,000 CL		\$9,610,707	Purchase (13)	ProPatch, Miller, Zimmerman	\$48,000 to \$87,000	30%	70%
City of Davis	337 LM	< 1 LM		Purchase/ Outsource	Outsource to Teichert	Outsource		
Yolo County	800 LM	1.5 LM		Purchase	Crafcro	\$20,000	100%	0%

Manual Crack Sealing Equipment

Caltrans currently uses crack-sealing trailers ranging from 125 to 400-gallon sealant capacities. These range from \$20,000 to \$40,000 in price depending on size and features. The most common manufacturers are Crafcro and Cimline, while Bearcat and Berry are smaller players.

Manual crack sealing operations require at least four maintenance workers physically on the road. One operates the applicator, while the other three are responsible for moving the kettle, monitoring the sealant temperature, and safety monitoring related to the required lane closure. There may also be two or three workers using wipers.

Longitudinal Crack Sealing Machine (LCSM)⁴

The first Longitudinal Crack Sealing Machine (LCSM) built by AHMCT consisted of a modified 350-gallon Bearcat sealant kettle trailer. The initial design did not have a dedicated truck to pull the trailer, but instead was designed to be quickly installed onto any available generic Caltrans stake side truck. In operation, the driver would slightly lean out the side window of the truck cab and steer the sealing shoe along the longitudinal crack while varying the forward speed of the truck to account for the variable width of the crack. As simple as this system was, it was very effective and quickly became the method of choice to seal longitudinal cracks in Caltrans Maintenance District 11.

The continuous faster pace nature of the LCSM operation resulted in a dramatically increased seal production rate. In field operation, the LCSM typically operated at a continuous speed of 2 mph with speeds up to 5 mph easily obtainable. The lower operational speed was a result of sealant melting capacity concerns and not sealing shoe operational limitations. The increased sealant production rate was beyond the capability of standard sealant kettles to melt sealant. The simple observation that the amount of sealant applied in a day doubled when using the LCSM along with its safety advantages, enabled the LCSM machine to succeed in the field in the beginning.

LCSM2⁴

The primary goal of the development of a second-generation Longitudinal Crack Sealing Machine (LCSM2) was to mitigate the hot sealant supply shortage issue. Since the existing LCSM spent half of the time on the highway idle, waiting for the kettle to recover, doubling the number of kettles used in the operation was expected to provide for nearly continuous operation. The LCSM2 used a double kettle trailer for twice the sealant capacity while maintaining all the advantages of operating a single trailer. The double kettle trailer was custom built and consisted of the 350-gallon Bearcat melter from the LCSM and a 200-gallon Bearcat from Caltrans fleet.

The loading ramp was an important feature employed on the LCSM to allow for remote sealant block loading while moving. In a high sealing production mode, blocks would pileup in the kettle under the loading hatches clogging the openings. To minimize clogging, it was essential that the introduction of sealant blocks be evenly distributed to all available kettle openings. Since the LCSM2 would operate the same way, a loading ramp that could load all four loading hatch openings had to be developed. A horizontal ramp with powered rollers was mounted on the trailer.

The identical PLC controls first employed on the LCSM were also utilized on the LCSM2, which provided programmable logic control capabilities to the machine. The PLC simplified the user controls and on the LCSM2 was additionally used to select which kettle output would flow to the truck from inside the cab. The sealant passages on the trailer had always been hot oil heated, but the passage on the truck half was not heated on the LCSM. The LCSM2 incorporated an electrical heater in the truck sealant passage that greatly simplified the startup process eliminating the unpredictable, time-consuming task of developing hot sealant flow.

⁴ TTLS Draft Final Report document prepared on 9/1/05 by Duane Bennett for Steve Velinsky

Development of the Transfer Tank Longitudinal Sealer (TTLS)⁴

The goal of this project was to develop a next generation machine in the line of Longitudinal Crack Sealing Machines (LCSM). The new machine would both build on the successes of the previous LCSM machines and further extend system capabilities in order to realize the full potential of this type of equipment to decrease costs, increase production, and improve the safety of highway crack sealing operations. The project deliverable was a fully functional high production crack-sealing machine to be deployed through the Caltrans Department of Maintenance for statewide operation. The intent of the new design was to mitigate several minor functional issues that surfaced with the existing equipment in the field, but would primarily focus on the development of a vastly increased hot sealant supply to meet the high production demand created when utilizing the LCSM. A sophisticated controller would be developed for the new machine as a means of mitigating operator-training issues. The new machine prototype would also be developed in such a manner as to enable Caltrans to reproduce the machine through subcontract, or through direct vendor purchase.

TTLS⁵

The Transfer Tank Longitudinal Sealer consists of a seal application truck and a sealant supply transfer trailer. One feature that both systems have in common is a smart user interface, which improves operator control and system self-diagnostics while reducing operator training requirements.

TTLS Application Truck

Sealing can be conducted off either side of the truck and the entire operation of the machine can be monitored and controlled from inside the high visibility cab. This eliminates the need for any direct worker exposure to traffic and enhances the continuous nature of the moving lane closure operation. The truck carries a 400-gallon, propane-fired, oil-jacketed sealant melter kettle, which supplies material to the application shoe through a heated line and a variable speed sealant pump. An accurate material level is obtained from load-sensing tank mountings.

TTLS Transfer Tank Trailer

High production crack sealing requires an equal ability to produce hot sealant at a high production rate. The sealant transfer tank trailer was designed to function as a hot sealant re-supply reservoir for the seal application truck. The transfer trailer is oil-jacketed, propane-fired, and has a 600-gallon capacity. The transfer tank also has a load-sensing trailer mounting to provide for an accurate material level. A flexible, large diameter, oil-heated transfer hose provides the means to quickly transfer hot sealant to the truck tank. The capacity of the trailer tank was purposely chosen to be far greater than the truck tank so the remaining hot sealant could accelerate the recovery time. Ideally, the transfer tank would recover in time to repeat the process as necessary.

TTLS Sealant Transfer Process

The TTLS transfer system was designed to quickly transfer 400 gallons of very hot sealant. To avoid potential dangers, a redundant safety system was incorporated into the transfer controller. It senses the transfer hose connection and will stop any sealant flow if the connection becomes unlocked. This prevents the possibility of leakage. The transfer controller also monitors both tank levels during sealant transfer to mitigate the potential of overfilling the smaller truck tank.

The TTLS is ideally suited to seal joint cracks between Portland Cement Concrete (PCC) slabs, as well as transitions between PCC slabs and Asphalt Concrete (AC) shoulders. Longitudinal crack sealing equipment will not seal all the cracks on a roadway, but it will seal all types of longitudinal cracks at a continuous speed of up to 5 mph. Since longitudinal cracks typically represent the largest share of highway cracks sealed, high production longitudinal sealing can play a significant role in reducing the miles of open pavement cracks, which leads to premature pavement deterioration.

⁴ TTLS Draft Final Report document prepared on 9/1/05 by Duane Bennett for Steve Velinsky

⁵ From the AHMCT Website

The Transfer Tank Longitudinal Sealer design was specifically tailored to capitalize on the advantage of operation within moving lane closures. The Transfer Tank Longitudinal Sealer was also designed to test an innovative new approach that could potentially provide a virtually continuous hot sealant supply. This could solve the insufficient hot sealant supply problem that has limited the maximum production rate of the Longitudinal Crack Sealing Machine.

Crack Sealing

Duane Bennett of AHMCT points out that if longitudinal cracks are properly sealed, random cracks are less likely to form. AC has longitudinal cracks only because the lane is continuous poured. PCC has longitudinal cracks between lanes and at transverse joints. TTLS seals longitudinal cracks, while the transverse cracks must still be hand sealed. Random crack sealing by hand requires up to seven people. The proportion of cracks that are longitudinal can be estimated by looking at the proportion of roads that are AC versus PCC and PCC section dimensions.

Bob Meline of Caltrans DRI elaborates that PCC pavement is generally built with slabs 12 ft. wide and 12 to 20 ft. long. This will have longitudinal cracks and transverse (joint) cracks, plus any other random cracks. The number of random cracks is dependent on the condition of the pavement and varies with age and loading conditions. AC is more difficult to estimate but does not initially have transverse joints. In general, it is much more likely to have random cracks.

Proportion of Transverse Cracks

The table below estimates the proportion of built-in transverse cracks in the California state highway system. Since PCC sections are between 12 ft. and 20 ft. long and 12 ft. wide⁶, the proportion of transverse cracks in PCC can be estimated. It is assumed that on average there are 1.5 miles of longitudinal cracks per lane-mile, as some lanes share seams. For AC, there are no transverse cracks, as AC is continuously poured. Approximately 68% of the state highway system is AC, with the remaining 32% being PCC. This method ignores random cracks from lack of preventative maintenance and represents a minimum level, as there is no way to estimate random transverse cracks.

Table 4: Longitudinal Cracks vs. Transverse Cracks

PCC (Rigid Pavement)	Long Slab	Short Slab	Units
Section Length	20	12	ft
Section Width	12	12	ft
Longitudinal crack length per lane mile	1.5	1.5	miles
Transverse crack length per lane mile	0.60	1	miles
% transverse - PCC	28.6%	40.0%	
AC (Flexible Pavement)			
Longitudinal crack length per lane mile	1.5	1.5	miles
Transverse crack length per lane mile	0	0	miles
% transverse - AC	0%	0%	
All Pavement			
Total lane miles	49,000	49,000	lane miles
Total centerline miles	15,146	15,146	CL miles
Average lanes	3.2	3.2	lanes per CL mile
AC proportion	68%	68%	
PCC proportion	32%	32%	
% transverse - total	9.1%	12.8%	

⁶ Caltrans Standard Plan A35A

Lane Closures

Maintenance must request lane closures from Traffic Operations, who has their own policies restricting lane closures due to traffic. Standard lane closures are 0.25 to 1.5 miles long. The out-of-pocket cost to Caltrans for an 8-hour lane closure is approximately \$500. This includes putting down cones, servicing, and picking up cones. The lane closure requires a special vehicle and a crew of 2 to 3 maintenance workers⁷. It also often requires the employment of law enforcement officers. The total economic impact, including motorist delays, is approximately \$5,000. In some cases, businesses have reported a drop in business of up to 90% due to closures.

The LCSM's performance was restricted by lane closures because lanes cannot be down during peak traffic hours. The LCSM could probably seal 10 to 12 miles in a day without the lane closure restrictions. There was only a limited window for the LCSM to operate. Moving lane closures can only be used to seal the outside joint with a shoulder of particular width.

Visual Concept



Technology

The TTLS technology consists of three parts: the application truck, the transfer tank trailer, and the rapid transfer process. The application truck contains a 400-gallon kettle and can seal longitudinal cracks on either side at up to 5 mph. A single operator controls sealing from inside the cab. Programmable Logic Control (PLC) allows the user to deliver the proper amount of sealant to the crack near the manufacturer's recommended temperature. A touch screen allows the user to monitor the tank sealant level. The 600-gallon transfer tank trailer allows quick refill of hot sealant to keep up with the truck's increased ability to lay down sealant. The decision was made not to tow the trailer behind the TTLS truck because Caltrans wanted increased mobility in and out of lane closures, which requires small size. The weight of the trailer kettle is purposely beyond the capacity of the TTLS truck to aid in the rapid heating of sealant. Using a second truck to move the trailer is not superfluous because a second vehicle is needed to transfer workers anyway. The propane burner used to heat sealant cannot be operated during transportation due to safety concerns, but can be operated while sealing. The sealant transfer process occurs rapidly to essentially increase the truck tank capacity to 1,000 gallons. The transfer process is monitored electronically to ensure that the smaller truck tank is not overfilled.

The lack of maintenance workers on the road allows for the use of moving instead of fixed lane closures. This provides a significant cost savings to Caltrans and a significant economic benefit to motorists. There are no significant savings in material by using the TTLS over the traditional method. The TTLS has an expected life of 10 years.

Cold Weather Operation

Cold weather operation is not an issue. Sealing is actually better in colder months as the cracks are wider due to thermal contraction of PCC slabs. The current propane tank will freeze in cold weather. A liquid propane burner will be implemented in a kettle design change.

⁷ Caltrans Maintenance Manual Chapter 8.24

TTLS Performance Data

There is no TTLS data as of December 2005. A trial run was conducted in September 2005 in Antioch, but there were issues with heating the kettles. Duane Bennett is working with the vendor to correct this issue. The application speed should be similar to the LCSM. However, because TTLS can seal between lanes without a fixed lane closure (unlike the LCSM or manual methods), production rates should be higher. The table below shows the performance of the LCSM over a 32-mile section of Interstate-5. The LCSM sealed 62 miles of AC/PCC joint line in 17 days on Routes 5, 52, and 125. Sealing the same number of miles of longitudinal crack by hand would have required 77.5 days, 78 lane closures, and 465 hours of exposure of employees on foot to traffic.

Table 5: LCSM vs. Manual Production Rates

	LCSM	Hand Applied
Number of employees	3	4
Average miles per day	3.5	0.8
Work days	9	40
Bare rate cost	\$4,017	\$23,820
Closures	NO	YES
Employees on foot	NO	YES

While in this comparison manual methods were able to seal 0.8 lane miles per day, the statewide average production is about 1.5 lane miles per day.⁸

Markets

Market Analysis

Market demand exists outside of Caltrans. The drivers that may temper demand are cost and availability. Both the City of Davis and Yolo County expressed interest in the TTLS. However, neither could justify the high capital cost. Municipal budgets are currently tight due to lack of state supplemental funding. Additional concerns as to availability of the machinery were raised with regards to renting the machinery because crack sealing is typically performed in the Fall as temperatures cool. Assuming a feasible schedule can be worked out at a reasonable cost to local and regional maintenance departments, there is a potential U.S. market of approximately \$98 million for manufacturers.

The total market size was derived using the following assumptions:

- 10% of PCC lane miles nationwide should be crack sealed annually
- One-third of all lane miles are PCC
- Each TTLS can seal 700 lane miles per year
- Sale price for TTLS is \$303,750

Excluding collectors, there are about 6.8 million lane-miles in the U.S, of which 2.27 are assumed to be PCC. Given that sealed cracks have a 10-year life, only 10% of these lane-miles would be sealed each year, allowing DOTs to create a continuous cycle. Dividing 10% of the total lane-miles by the number of lane-miles one TTLS can seal in one year and multiplying that by the estimated retail price of the TTLS, the market is estimated to be \$98 million. The retail price of the TTLS is the cost of \$225,000 marked up by an industry average of 35%.

Realistically local (city and county) municipalities will not crack seal more than 1% of lane miles in their jurisdiction per year because local roads tend to be used less than highways. Using this assumption, Table 6 estimates the total market near \$26 million.

⁸ Caltrans Courtney Morrison

Table 6: Total Market Estimate

	Interstate and Arterials	Local	Total
Total Lane Miles	1,244,307	5,553,475	6,797,782
Total PCC Lane Miles	414,769	1,851,158	2,265,927
% Lane Miles Sealed (Annually)	10%	1%	0.9%
Total Miles Sealed	41,477	18,512	59,988
Lane Miles Per Unit Per Year	700	700	700
Total Units	59	26	86
Total Market Size	\$ 17,998,009	\$ 8,032,705	\$ 26,030,713

Manufacturers of Similar Equipment

Crack Sealing Equipment

BearCat Manufacturing

<http://www.bearcatmfg.com/index2.htm>

Wickenburg, AZ

Contact: Mike McCarty (Customer Service), Rick Christian (Engineering)

1-928-684-7851

BearCat is the leader in the manufacturing of high production Asphalt Distributors, Aggregate Chip Spreaders, and Crack Sealers. BearCat equipment is used throughout the United States and Canada, Central and South America, Africa, Australia, and Europe.

The following prices are for crack sealing machines:

- 250-gallon kettle - \$33,990 (hydraulic)
- 400-gallon kettle - \$36,990 (hydraulic)

BearCat sells between 10 and 75 crack sealers per year. Sales are worldwide, with most sales (80%) to contractors. Competitors include Cimline and Crafcro. They rent equipment occasionally and they service equipment. Equipment has an expected life up to 25 years.

BearCat is one of the oldest manufacturers of crack sealing equipment. They no longer spend money on advertising because most of their business comes from returning customers. BearCat used to build machines for Crafcro, but now Crafcro does their own manufacturing. BearCat produces higher performance kettles (more sq. in. of heating, submerged coil instead of heated jacket). Their hoses are heated with re-circulating oil rather than electrically, which is less expensive (\$1,500 to \$2,500 to replace an electrically heated hose, \$300 to replace a BearCat hot-oil hose).

Cimline Corporate

<http://www.cimline.com/pages/products.html>

Plymouth, MN

For more than 30 years, Cimline has focused on engineering melter/applicators, direct-fire melters, and a variety of accessories designed for municipal and contractor owners who want rugged durability, operator convenience, performance, and safety.

Crafcro

<http://www.crafcro.com/>

Chandler, AZ

Contact: Cathy Summers (Marketing/Sales)

1-800-528-8242

Crafco, Inc. has been a pavement professional since 1976. The company has supplied the pavement preservation industry with quality products including crack sealant, joint sealant, patching products, geo-composites, and related application equipment. Crafco, Inc. has facilities strategically located around the United States and distributes worldwide.

Marathon Equipment Incorporated

<http://www.marathonequipmentinc.com/index.html>

Burlington, Ontario, Canada

Contact: Bob Rousseau (Owner)

905-335-0000

Since its beginning over 87 years ago, Marathon has become recognized as a leading name in the manufacture of quality road maintenance equipment, tools, and specialties. Kettle costs vary depending on options chosen, such as propane versus diesel heating and gravity feed versus hose with wand. As an example, a 400-gallon kettle can range in price as follows:

- \$18,000 – w/ gravity feed
- \$38,950 – w/ hose/wand
- \$44,000 – w/ hose/wand

Marathon's main competitor is Crafco. Marathon sells worldwide. Approximately 50% of sales are to government, and 50% of sales are to general contractors. Cities and townships tend to subcontract sealing. Marathon does not rent equipment out, but some distributors do. Equipment owners are expected to maintain and service equipment, although Marathon sells parts. The expected life of crack sealing equipment is 20 years.

Stepp Manufacturing

www.steppmfg.com

North Branch, MN

Contact: Bruce (Marketing/Sales)

1-800-359-8167

Stepp Manufacturing specializes in equipment designed to heat, melt, transport, and store bitumen and asphalt materials for highway maintenance such as crack sealing, pothole patching, and seal coating. In addition, Stepp manufactures kettles and heating and storage tanks for roofing materials.

Truck Mounted Asphalt Distribution Equipment

Rosco – A LeeBoy Company

North Carolina

<http://www.leeboy.com/rosco/index.asp?ref=ro>

Contact: Steve Simons

704-483-9721

Rosco sells and rents pothole patchers through local distributors, such as Nixon-Egli Rents in Tracy, CA. Denny Johnson of the NER sales team (510-318-2673) stated that the typical margin on a pothole patcher is 25% to 30%. He also said that a good rule of thumb for monthly rental rates is 5% to 7% of the retail price (i.e. \$300,000 retail price leads to a \$21,000 monthly rental rate).

Paint Striping Equipment

Caltrans Pavement Delineation

Water borne and solvent borne traffic paints – (05360 Striping Unit, Paint)

Hot melt thermoplastic – (05364 Striping Unit, Thermoplastic)

Graco Road Striping

Minnesota

http://www.graco.com/Internet/T_PDB.nsf/SearchView/RoadLazer

877-844-7226

Graco manufactures a RoadLazer truck mounted striping system that retails for \$33,000.

Kelly-Creswell Company
Xenia, OH
<http://www.kellycreswell.com/>
Contact: John Stute
937-372-9221

A Kelly-Creswell 120-gallon, truck-mounted striper will cost between \$100,000 and \$140,000. The cost to manufacture a \$120,000 piece of equipment would be about \$75,000 (38% margin). Kelly-Creswell sells about 12 truck-mounted stripers per year. Units are sold internationally, mostly through direct channels, to states, counties, and cities. A county and city need for truck-mounted stripers is dependent on the size of the road system and population. Equipment is normally sold through the bid process.

Kelly-Creswell does not rent out equipment, but they do perform maintenance, which is a big part of their business. Service is performed on a per-issue basis rather than via service contract. For a \$100,000 machine, \$1,200 to \$3,000 should be spent annually on proper maintenance. Paint stripers have an expected life of about 10 years depending on usage.

Kelly-Creswell does not make thermoplastic stripers, which may be more similar to a crack sealer. Thermoplastic units have a heated pot rather than a simple tank.

Trusco Manufacturing
Ocala, FL
<http://www.truscomfg.com/>
800-327-8859

Trusco walk-behind paint stripers cost between \$600 and \$4,000, depending on options. Trusco sells nationally through direct sales and distributors to state, county, and city departments of transportation for highway use. Sales are mostly through the government bid process. Trusco does not rent equipment, but they do some maintenance and service. However, the equipment owner is responsible for the majority of maintenance and service.

Crack Sealing Equipment Rental Companies (California)

Gold Star Asphalt Products
Perris, CA
<http://www.goldstarasphalt.com/index.htm>

Gold Star rents Hot Crack Fill Melters and Tack Rigs. The cost of these rentals appears below:

- 50 Gal Easy Pour 50: Day \$100.00/Week \$425.00
- 50 Gal w/ Hand Wand & Pump: Day \$150.00/Week \$525.00
- OJK 125 Diesel Fired w/ Hand Wand & Pump: Day \$225.00/Week \$1000.00
- OJK 165 Diesel Fired w/ Hand Wand & Pump: Day \$250.00/Week \$1100.00
- 210 Gal. Tack Rigs: \$200.00 Per Day & \$3.00/Gal. SSIH

Tri-American, Inc.
Milpitas, CA
<http://www.triamerican.com/index.html>

Tri-American rents Crafcro melters and applicators.

Customer Value

Caltrans

The TTLS can seal longitudinal cracks at least twice as fast as the current hand method. Compared to the manual method that requires four individuals, one maintenance worker can operate the TTLS. Increased efficiency means lower operational costs for Caltrans. The labor savings is estimated at over \$1.2 million per year. By reassigning these workers to other maintenance tasks, Caltrans can greatly reduce the backlog of work that has resulted from a staffing deficiency.

Proper crack sealing extends pavement life by an estimated three years, leading to lower annual amortized highway capital costs. More crack sealing translates into reduced reconstruction and rehabilitation costs for Caltrans. For this analysis it is assumed that the TTLS will not be used to seal more longitudinal cracks than are currently sealed (about 2221 lane miles per year).

The total annual out-of-pocket cost savings to Caltrans would be \$1.6 million assuming fixed lane closures are still used; \$2.1 million if Caltrans allows moving lane closures while the TTLS is in use.

Caltrans Maintenance Workers

A single worker inside the truck cab operates the TTLS. The current crack sealing process is labor intensive, requiring four workers on the road to perform the maintenance by hand. These hand operations are expensive and subject workers to safety risks. Limited resources at the supervisor level only allow for limited maintenance activities to be performed. By implementing the TTLS, 75% of current crack-sealing resources could be put to other maintenance uses. Additionally, the risk of on-the-job injuries would be reduced by at least 17%. This would also reduce the cost of injuries to Caltrans by \$9,626 per year.

Caltrans Customers (highway users)

Maintenance operations that require lane closures, such as manual crack sealing, lead to traffic congestion and wasted time. The TTLS can be operated using a moving lane closure, as opposed to a fixed lane closure. Eliminating fixed lane closures reduces the costs to Caltrans of closure set-up and maintenance and reduces traffic congestion for travelers. The estimated total economic impact of a fixed lane closure is \$5,000 per lane closure per lane-mile. Implementation of the TTLS would result in annual economic cost savings of \$3.8 million to \$6.6 million from reducing or eliminating fixed lane closures.

Other Customers

Most other state departments of transportation do at least some of their own crack sealing. Some counties and cities perform their own crack sealing, while most contract out crack sealing. The other maintenance jurisdictions and the general contractors that perform this outsourced crack sealing would also benefit from the use of the TTLS.

Table 7 below shows annual cost comparisons, the net present value (NPV) of the TTLS project, and the total economic benefit resulting from the TTLS. The “no closure” figures assume that Caltrans changes its policy so that fixed closures are no longer required for crack sealing operations with the TTLS. All values are for longitudinal sealing. Transverse cracks will still need to be sealed manually.

Table 7: Cost Savings Comparison – TTLS vs. Manual

Annual Cost Comparison	TTLS (no closure)	TTLS (with closure)	Hand Applied
Production Rate (lane miles/day)	10	3.5	1.5
Yearly Lane Miles Sealed	2,221	2,221	2,221
Hours Per Crack Sealing Job	8	6	6
Yearly Hours Spent Crack Sealing	1,777	3,808	8,884
Maintenance Workers Required Per Job	1	1	4
Labor Cost	\$ 68,454	\$ 146,688	\$ 1,369,086
Number of Lane Closures	-	635	1,481
Lane Closure Cost	\$ -	\$ 325,550	\$ 759,616
Required Machines	2	5	10
Estimated Yearly Maintenance Cost Per Machine	\$ 20,000	\$ 20,000	\$ 4,148
Equipment Maintenance Cost	\$ 40,000	\$ 100,000	\$ 41,480
Injuries per Year	1.4	1.4	2.7
Annual Injury Costs	\$ 9,626	\$ 9,626	\$ 19,253
Total Annual Out-of-Pocket Cost	\$ 118,081	\$ 581,864	\$ 2,189,435
Cost per Lane Mile	\$ 53	\$ 262	\$ 986

Annual Cost Differential	TTLS (no closure)	TTLS (with closure)	Hand Applied
Labor Cost	\$ 1,300,632	\$ 1,222,398	
Lane Closure Cost	\$ 759,616	\$ 434,066	
Equipment Maintenance Cost	\$ 1,480	\$ (58,520)	
Injury Cost	\$ 9,626	\$ 9,626	
Total Annual Out-of-Pocket Cost Savings	\$ 2,071,354	\$ 1,607,571	

TTLS Project Net Present Value	TTLS (no closure)	TTLS (with closure)	Hand Applied
Initial Investment	\$ 607,500	\$ 1,518,750	\$ 450,000
Present Value of Investment Cost Differential	\$ 391,718	\$ 1,654,294	
Present Value of Yearly Cost Savings (20 years)	\$ 17,634,606	\$ 13,686,158	
Net Present Value	\$ 17,242,889	\$ 12,031,864	

Total Economic Benefit	TTLS (no closure)	TTLS (with closure)	Hand Applied
Present Value of Pavement Life Savings	\$ 60,844,756	\$ 60,844,756	\$ 60,844,756
Lane Closure Economic Cost	\$ -	\$ 2,847,450	\$ 6,644,050
PV Pavement Life Savings Differential	\$ -	\$ -	
Lane Closure Economic Cost Differential	\$ 6,644,050	\$ 3,796,600	
Total PV Economic Benefit	\$ 23,886,939	\$ 15,828,464	

Cost Comparison Summary	TTLS (no closure)	TTLS (with closure)	Hand Applied
Required Machines	2	5	10
Labor Cost	\$ 68,454	\$ 146,688	\$ 1,369,086
Lane Closure Cost	\$ -	\$ 325,550	\$ 759,616
Equipment Maintenance	\$ 40,000	\$ 100,000	\$ 41,480
Injury Cost	\$ 9,626	\$ 9,626	\$ 19,253
Present Value of Investment Cost Differential	\$ 391,718	\$ 1,654,294	
Total Annual Out-of-Pocket Cost Savings	\$ 2,071,354	\$ 1,607,571	

For the annual comparisons, the assumption is made that TTLS will not seal more than the current level of 2,221 lane miles of longitudinal cracks, which is approximated as 70% of 3,173. This assumes that 30% of crack sealing activity is performed on built-in transverse cracks (less than 11% of the total system) and random cracks. It is assumed that without lane closures, the sealing window will be larger (8 hours) than if lane closures are required (6 hours). Yearly crack sealing hours are calculated using the number of miles to be sealed, the daily sealing rate and the daily sealing window in hours. Labor cost is then calculated using a \$38.53 hourly labor rate per maintenance worker that includes overhead (typically 15%). Lane closure cost is calculated by calculating the number of lane closures from the daily sealing rate, total miles sealed, and a rate of \$513 in cost per lane closure. The number of required machines was derived by assuming that the TTLS and traditional sealing kettles would be operational 150 days out of the year. Yearly maintenance cost for the traditional kettle is historical, while the TTLS yearly cost is estimated at \$20,000 (about 7% of capital cost). Figure 3 summarizes the annual cost comparison for the three different options: current manual methods and the TTLS with and without road closures.

Figure 3: Cost Comparison Graphical Breakdown



Annual cost differentials are for the hand method cost minus the TTLS cost, so that a positive number indicates a savings from using the TTLS. The \$1.2 million in labor cost savings is specific to crack-sealing activities. Caltrans would likely redistribute those personnel resources to other maintenance activities.

For NPV analysis, the initial investment assumes a TTLS cost to Caltrans of \$303,750 (manufacturer's cost of \$225,000 plus 35% margin). Since the TTLS expected life is 10 years and a traditional kettle lasts 20 years, the present value of investment cost differential assumes that TTLS's are purchased now and again in year 10, while kettles only need to be purchased now. The discount rate used is 10%.

The present value of pavement life savings is calculated using the fact that crack sealing pushes out rehabilitation expenditure from year 10 to year 13. With a rehab cost of \$285,000 per lane mile, and a discount rate of 10%, this present value of the delayed cash outflow is \$27,394 per crack-sealed lane-mile. The total economic cost of lane closures is \$5,000, including costs to travelers and Caltrans.

Business Models

Rental Business Model

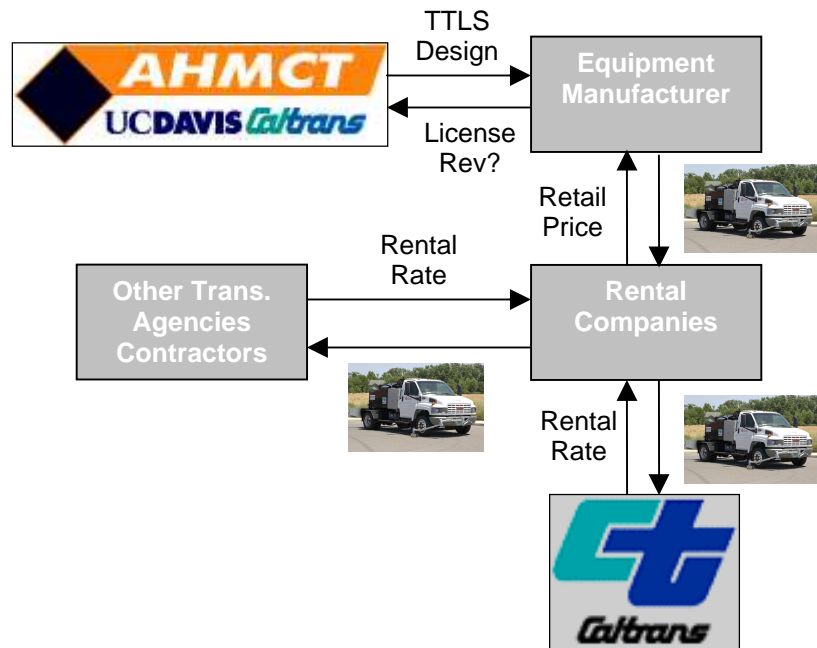
Model #1 - AHMCT works with equipment manufacturers to rent TTLS to Caltrans

Pros

- Caltrans does not service, maintain or house TTLS
- Avoids Caltrans purchasing issues
- Manufacturer can sell to other state and local agencies, contractors and rental companies
- Rental company can rent to other state and local agencies and contractors
- AHMCT can capture some license revenue if patents are filed

Cons

- Caltrans does not own TTLS, meaning that availability is not guaranteed



The total annual cost to Caltrans under this model is simply the rental cost – \$197,000 per TTLS. This assumes that the units will be rented at a cost of 7% of retail (\$303,750) per month for 9.25 months. Caltrans would still recognize the cost savings in crack sealing associated with a reduction in the number of employees assigned to crack sealing, as well as the savings associated with reduced or eliminated lane closures. Additionally, Caltrans would not be responsible for maintenance costs on the TTLS under this model.

Table 8 shows that, from the rental company's perspective, this is a very attractive opportunity, yielding 16% margins. The analysis assumes that 25% of the highway market and 1% of the local market rents a TTLS. Depreciation was calculated using a 7-year useful life. Maintenance expense was estimated based on similarly complex machinery currently in the Caltrans equipment catalog. Personnel requirements were based on the assumption that one maintenance worker could service two TTLS machines and that an additional 25% of administrative staff would be required.

Table 8: Rental Company Steady State P&L

	Caltrans	Other State DOTs	Local	Total
Units	5	14	1	20
Rental Revenues	\$ 983,391	\$ 2,753,494	\$ 196,678	\$ 3,933,563
Equipment Depreciation Expense	\$ 216,964	\$ 607,500	\$ 43,393	\$ 867,857
Maintenance Expense	\$ 100,000	\$ 280,000	\$ 20,000	\$ 400,000
Operational Expenses				
Salary Expense	\$ 312,500	\$ 875,000	\$ 62,500	\$ 1,250,000
Rent Expense	\$ 120,000	\$ 336,000	\$ 24,000	\$ 480,000
G&A Expense	\$ 78,125	\$ 218,750	\$ 15,625	\$ 312,500
Total Operational Expenses	\$ 510,625	\$ 1,429,750	\$ 102,125	\$ 2,042,500
Total Expenses	\$ 827,589	\$ 2,317,250	\$ 165,518	\$ 3,310,357
Net Income	\$ 155,801	\$ 436,244	\$ 31,160	\$ 623,205
Profit Margin	16%	16%	16%	16%

Purchase Business Model

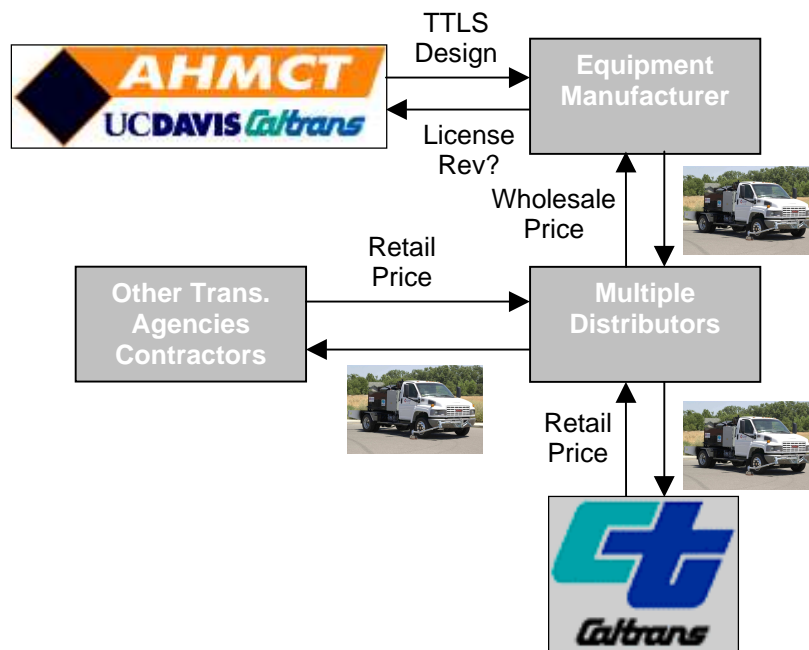
Model #2 - AHMCT works with equipment manufacturers to sell TTLS to Caltrans

Pros

- Caltrans owns TTLS, which guarantees availability
- Manufacturer can sell to other state and local agencies, contractors and rental companies
- No sole sourcing problems with multiple distributors
- AHMCT can capture some license revenue if patents are filed

Cons

- Caltrans must service, maintain and house TTLS
- Caltrans must go through long purchase process



The total cost to Caltrans under this model is the purchase cost – \$303,750 per TTLS. Additionally, Caltrans would be responsible for maintenance costs on the TTLS. Maintenance costs were estimated as \$20,000 per year based on similarly complex machinery currently in the Caltrans equipment catalog. The electronics systems of the TTLS would be covered under warranty. Caltrans would recognize the cost savings in crack sealing associated with a reduction in the number of employees assigned to crack sealing, as well as the savings associated with reduced or eliminated lane closures.

Table 9 shows that, from the manufacturing company's perspective, this is an attractive niche opportunity, yielding 12% margins. Units sold were calculated assuming that 25% of state departments of transportation adopt the TTLS. Local departments of transportation would not be able to afford these machines. Personnel requirements were based on the assumption that each salesperson could sell 8 TTLS machines and that an additional 25% of administrative staff would be required.

Table 9: Manufacturing Company Steady State P&L

	Caltrans	Other State DOTs	Local	Total
Units	5	14	0	19
Sales Revenues	\$ 1,518,750	\$ 4,252,500	\$ -	\$ 5,771,250
COGS	\$ 1,125,000	\$ 3,150,000	\$ -	\$ 4,275,000
Gross Margin	\$ 393,750	\$ 1,102,500	\$ -	\$ 1,496,250
Operational Expenses				
Salary Expense	\$ 78,125	\$ 218,750	\$ -	\$ 296,875
Rent Expense	\$ 120,000	\$ 336,000	\$ -	\$ 456,000
G&A Expense	\$ 19,531	\$ 54,688	\$ -	\$ 74,219
Total Operational Expenses	\$ 217,656	\$ 609,438	\$ -	\$ 827,094
Net Income	\$ 176,094	\$ 493,063	\$ -	\$ 669,156
Profit Margin	12%	12%		12%

Contract Business Model

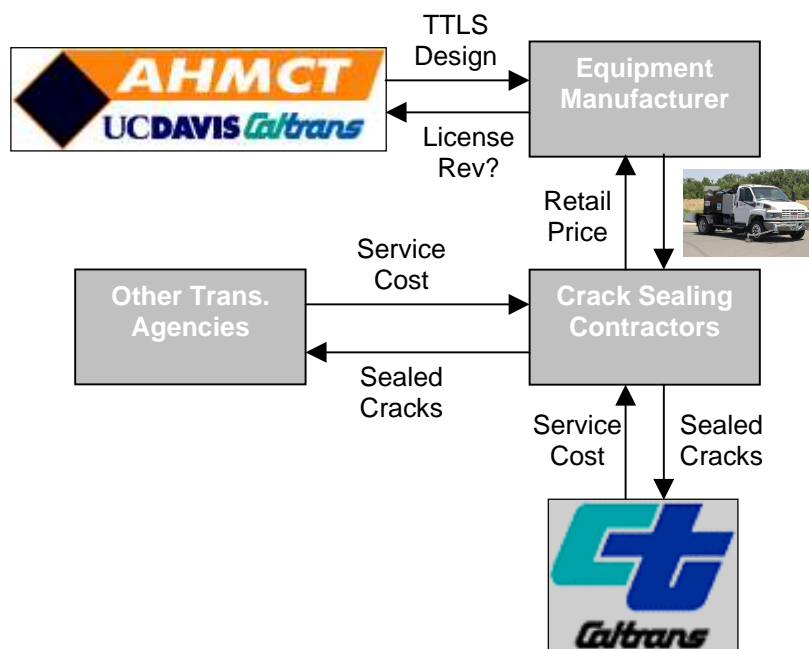
Model #3 - AHMCT works with equipment manufacturers to sell TTLS to contractors who sell crack-sealing services to Caltrans

Pros

- Caltrans does not service, maintain, house or operate TTLS
- Caltrans receives cost benefits of TTLS efficiency and speed through lower service rates
- Caltrans can have maintenance worker performing other maintenance rather than driving TTLS
- Avoids Caltrans purchasing issues
- Manufacturer can sell to other state and local agencies, contractors and rental companies
- AHMCT can capture some license revenue if patents are filed

Cons

- Caltrans loses control over crack sealing operations



The minimum total annual cost to Caltrans under this model is the service cost to operate the TTLS (rental rate and operator labor) – \$1.2 million. This model uses a service cost of \$540 per lane-mile, which is the break-even point. The service company would likely charge more than this for operating the TTLS. In addition, they would probably charge a fee for the sealant materials used. Caltrans would still recognize the cost savings in crack sealing associated with a reduction in the number of employees assigned to crack sealing, as well as the savings associated with reduced or eliminated lane closures. Additionally, Caltrans would not be responsible for maintenance costs on the TTLS under this model.

Table 10 shows break-even P&L. Units sold were calculated assuming that 25% of state and 10% of local departments of transportation adopt the TTLS. Depreciation was calculated using a 7-year useful life. Maintenance expense was estimated based on similarly complex machinery currently in the Caltrans equipment catalog. Personnel requirements were based on the assumption that one worker would be needed per TTLS machines and that an additional 25% of administrative staff would be required.

Table 10: Crack Sealing Service Company Steady State P&L

	Caltrans	Other State DOTs	Local	Total
Units	5	14	3	22
Service Revenues	\$ 1,218,214	\$ 3,411,000	\$ 730,929	\$ 5,360,143
Equipment Depreciation Expense	\$ 216,964	\$ 607,500	\$ 130,179	\$ 954,643
Maintenance Expense	\$ 100,000	\$ 280,000	\$ 60,000	\$ 440,000
Operational Expenses				
Salary Expense	\$ 625,000	\$ 1,750,000	\$ 375,000	\$ 2,750,000
Rent Expense	\$ 120,000	\$ 336,000	\$ 72,000	\$ 528,000
G&A Expense	\$ 156,250	\$ 437,500	\$ 93,750	\$ 687,500
Total Operational Expenses	\$ 901,250	\$ 2,523,500	\$ 540,750	\$ 3,965,500
Total Expenses	\$ 1,218,214	\$ 3,411,000	\$ 730,929	\$ 5,360,143
Net Income	\$ -	\$ -	\$ -	\$ -
Profit Margin	0%	0%	0%	0%

Other Business Model Ideas

- AHMCT licenses manufacturing to Caltrans, who assembles the components from prototype vendors and standard equipment manufacturers
Problem: Caltrans equipment division does not have the resources to assemble complex machinery
- AHMCT retrofits current Caltrans equipment with required custom parts
Problem: TTLS is custom enough that a retrofit of current crack sealing equipment is not possible
- AHMCT supervises Caltrans purchases of TTLS from prototype vendors
Problem: AHMCT does not have resources to supervise the assembly of multiple TTLS machines; prototype vendors are not capable of manufacturing TTLS in higher volume

Additional Financial Information

Caltrans Labor Rates

Courtney Morrison provided the following labor rates used in IMMS work orders:

- 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 \$38.53 (including 15% overhead) was constructed.

Caltrans Internal Equipment Rental Rates

Current Crack Sealing Equipment in Caltrans Equipment Catalog

- 39607 Crack Sealer, 200 Gallon, Trailer Mtd
- 39608 Crack Sealer, 400 Gallon, Trailer Mtd
- 39610 Crack Sealer, 301-400 Gallon, with Spray Bar, Trailer Mtd
- Kettle rental cost is \$25.91 a day, \$9,457 a year.
- Tow vehicle rental cost is \$32.41 a day, \$11,830 a year
- LCSM rental cost was \$58.32 a day, \$21,287 a year; this is simply the sum of the Kettle rental cost and the Tow vehicle rental cost
- LCSM service costs were \$63,860 for 157 days of crack sealing; this equates to \$406.75 rental for each day used

The most expensive piece of equipment in the Caltrans equipment catalog has a rental cost below \$150 per day. Because the TTLS is customized, it is expected that the rental cost will exceed the current equipment cost, but will not approach the \$406.75 figure above.

TTLS Manufacturing Cost

The expected manufacturing cost for TTLS is \$225,000. Adding on an industry standard 35% gross margin, the retail price would be \$303,750 (without warranty). The TTLS prototype was constructed by moving the truck from vendor to vendor. There was not a BOM of parts sent to AHMCT for assembly. The main prototype vendor was Cleasby Manufacturing; Duane Bennett at AHMCT was not happy with their performance. It is not possible to retrofit current Caltrans equipment because all the main parts are custom made.

TTLS Maintenance and Service Costs

Having repairs done at a third-party vendor might not be convenient because of geography. The typical warranty for new equipment is one year. Caltrans is reluctant to invest in new technology because of uncertainty in maintenance costs. Maintenance and service costs are unknown on TTLS, but they will factor into the Caltrans internal rental rate. TTLS electronics would be under warranty. The sealant

pump wears out every couple of years, costing about \$500 to replace. The TTLS equipment life would be about 10 years.

Based on similarly complex equipment in the Caltrans equipment catalog (Table 11), the annual maintenance cost of the TTLS was estimated at \$20,000.

Table 11: Current Equipment Maintenance Costs

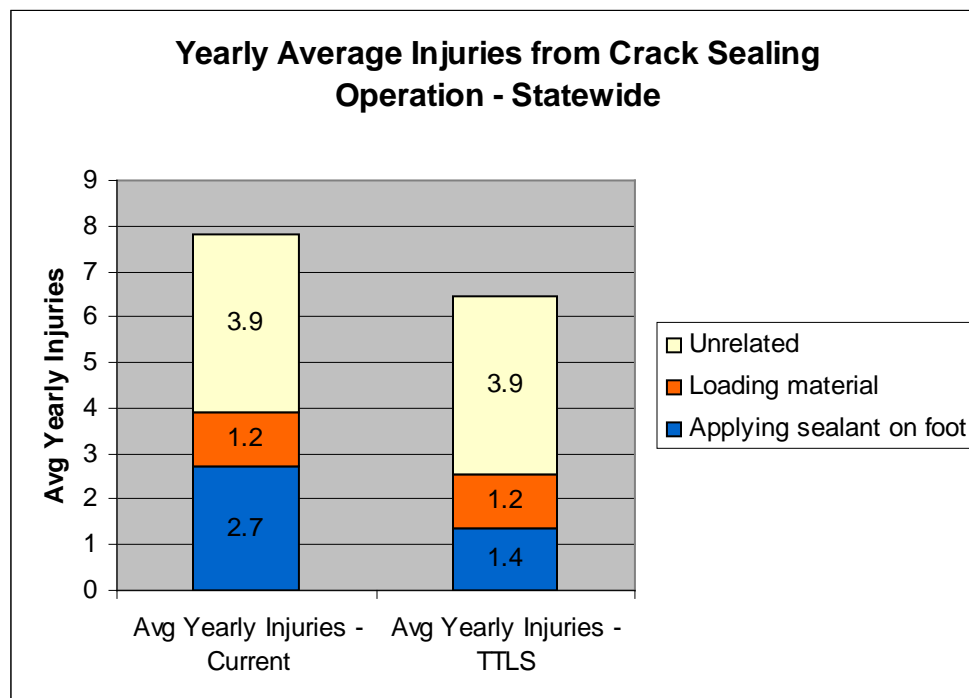
CT Equipment Number	Description	Average Yearly Mtce Cost	Capital Cost	Yearly Mtce % of Capital
02355	Cargo Body, 12', Marker, Dot, Diesel	\$9,479		
05364	Striping Unit, Thermoplastic	\$21,024		
39607	Crack Sealer, 200 Gallon, Trailer Mtd	\$3,299	\$45,000	7.3%
39608	Crack Sealer, 400 Gallon, Trailer Mtd	\$4,148	\$50,000	8.3%

Injuries

- There have been 76 injuries in the last 10 years associated with crack sealing
- 27 employee injuries resulted from applying rubberized product while on foot
- 12 employee injuries resulted from loading material
- 39 employee injuries were reported that were not related to just crack sealing

The following chart assumes that the TTLS reduces the number of injuries caused by applying sealant while on foot is reduced by 50%, leading to a reduction of 1.4 injuries per year.

Figure 4: Crack Sealing Injuries



Wayne Wolfe, a Caltrans safety officer, gathered the injury costs for crack sealing for the time period 1/1/02 through 12/31/03. Those that were possibly the result of applying sealant while on foot were assembled into a spreadsheet. The following table shows some statistics regarding costs of injuries caused by crack sealing.

Table 12: Cost of Crack Sealing Injuries

Statistic	Cost Per Injury
High	\$19,157
Average	\$7,131
Median	\$5,623
Low	\$113

Combined with the expected reduction in injuries of 1.4 per year, the annual cost savings related to injury prevention by the TTLS is expected to be \$9,626.

Total Economic Benefit

The estimated total economic benefit of the TTLS from out-of-pocket cost savings to Caltrans, increased pavement life, reduction in lane closures, and reduction in injuries is more than \$24 million (see Table 7).

Intellectual Property

- Currently there is no intellectual property protection (invention disclosures or patents) for the TTLS or LCSM
- Invention disclosures were purposely not filed out of fear that an exclusive license to a manufacturer would cause a sole sourcing purchasing issue for Caltrans (similar to Ardvac)
- Many highway maintenance and construction companies interviewed indicated that they do not hold patents on the equipment that they sell currently. Intellectual property is protected through trade secrets.
- The UC Davis Office of Technology and Industry Alliances wants all new inventions to have invention disclosures filed. Their goal is to help commercialize inventions; licenses do not always need to be exclusive. Equipment manufacturers may not want to produce equipment without IP protection.

Key Uncertainties/Unresolved Questions

It is hard to determine actual market demand for this type of machine. All maintenance jurisdictions interviewed indicated some level of interest, but were very cost-conscious. It is also unknown what the adoption curve will look like. Will end-users be comfortable to changing to advanced technology?

The lack of intellectual property is troublesome. Although it appears that the industry tends to use trade secrets more than patents, there should be some intellectual property protection put in place over the TTLS project.

Internal Caltrans restrictions prevent lane closures, thus limiting the TTLS production rate to 4 miles per day instead of 10-12 miles per day. Caltrans Traffic Operations regulations still require fixed lane closures for sealing center cracks with TTLS. If this regulation is changed to allow moving lane closures, greater cost savings and economic benefits can be realized.

It needs to be made clear to union representatives that the TTLS will not displace highway maintenance employees. It will simply allow Caltrans to reassign up to 75% of them to tasks other than crack sealing.

The TTLS still has not had a successful field trial. The result is that the most current data is from the LCSM trial several years ago.

Next Steps

List of Recommendations

- Review accuracy of numbers
- Review data from TTLS prototype field evaluation
- Find suitable manufacturers
- Identify a first adopter district
- Purchase and validate a prototype purchased through a production vendor
- Pick the best business model to commercialize TTLS

Related Publications

Transfer Tank Longitudinal Sealer (TTLS)

TTLS Technology Profile on the AHMCT website

<http://www.ahmct.ucdavis.edu/index.htm?pg=CrackSealingTTLS>

Longitudinal Crack Sealing Machine (LCSM)

LCSM Technology Profile on the AHMCT website

<http://www.ahmct.ucdavis.edu/index.htm?pg=CrackSealingLongitudinal>

AHMCT presentation given to Federal Highway Administration

<http://www.ops.fhwa.dot.gov/wz/workshops/accessibile/bosler.htm>

“Robots that Repair Roads,” Wired News, Jenn Shreve, November 12, 2001

http://www.wired.com/news/school/0,1383,48196,00.html?tw=wn_story_page_prev2

“Robots at Work Make Highways Safer,” Science Daily, September 25, 2001

<http://www.sciencedaily.com/releases/2001/09/010925071257.htm>

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AHMCT Website

<http://www.ahmct.ucdavis.edu/>

Bureau of Transportation Statistics (BTS)

http://www.bts.gov/publications/national_transportation_statistics/2005/html/table_01_06.html

Caltrans Equipment Catalog

<http://www.dot.ca.gov/hq/eqsc/EquipCatalog/>

Caltrans Rental Rate Books

<http://www.dot.ca.gov/hq/eqsc/rentalrates/RentalRate.htm>

Caltrans 2003 State of Pavement

<http://www.dot.ca.gov/hq/maint/StateOfPavement2003.pdf>

Glossary of Terms

AHMCT – Advanced Highway Maintenance and Construction Technology Research Center at UC Davis

Centerline Mile (CL) – Actual linear miles of roadway regardless of number of lanes

Lane Mile (LM) – Miles of roadway taking into account the number of lanes per centerline mile

LCSM – Longitudinal Crack Sealing Machine

TTLS – Transfer Tank Longitudinal Sealer

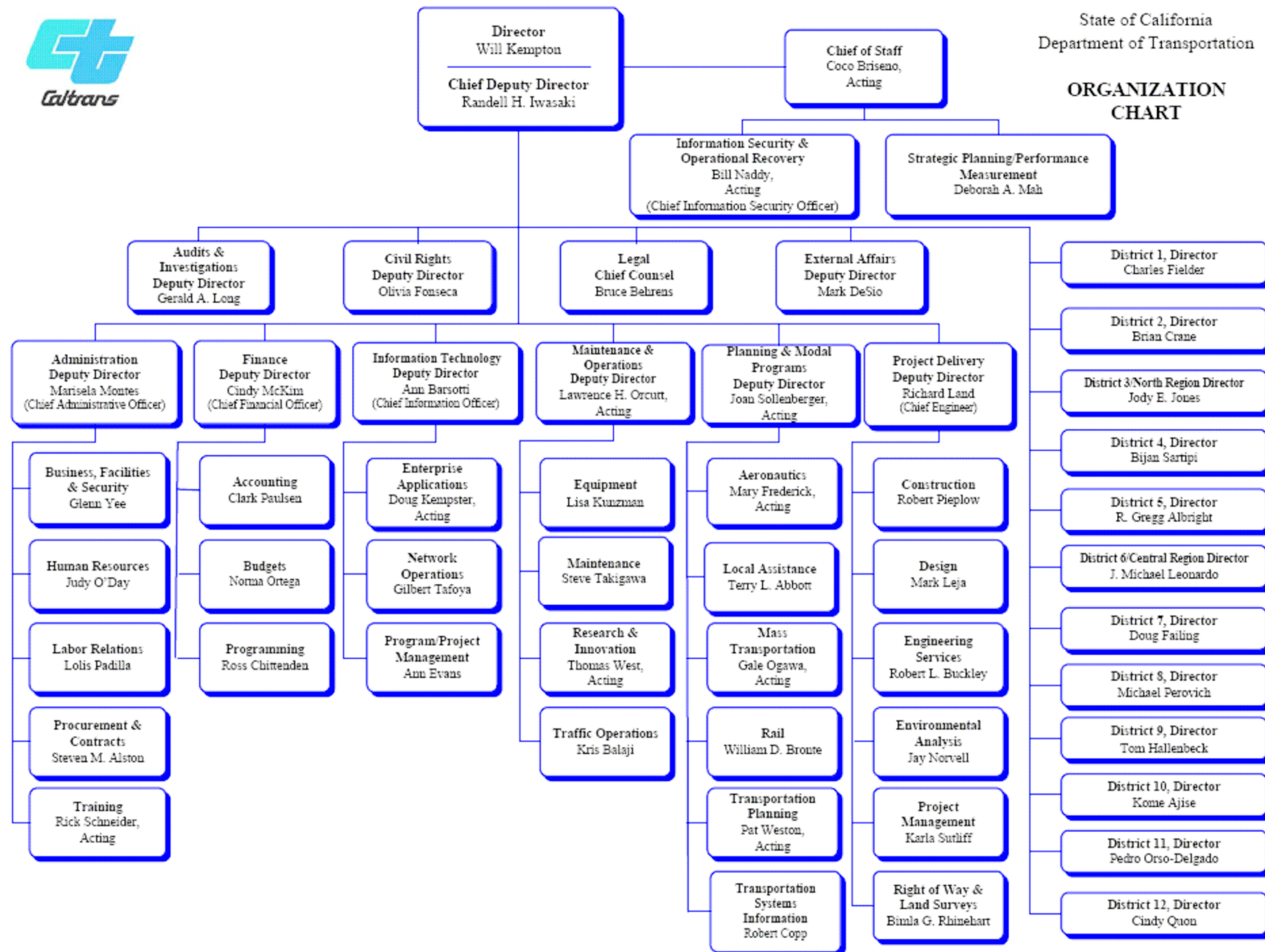
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Nancy	McKee	City of Davis	Roads	Project Engineer	Nmckee@ci.davis.ca.us	(530) 757-5673	Injury costs City of Davis info
Cathy	Summers	Crafco	Marketing/Sales			(800) 528-8242	Crafco Crack Sealing info

First Name	Last Name	Organization	Department	Position	Email	Phone	Information Provided
John	Stute	Kelly-Creswell				(937) 372-9221	KC paint striping info
Bob	Rousseau	Marathon Equipment	Executive Management	Owner Capital Preventive Maintenance Engineer Special Projects Engineer		(905) 335-0000	Marathon Crack Sealing info
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Tammy Duane	Sims Bennett	TexasDOT UC Davis	Maintenance AHMCT		TSIMS@dot.state.tx.us dabennett@ucdavis.edu	(512) 416-2476	TxDOT info TTLS Info
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