IMPROVING CONSTRUCTION COMMUNICATION

FINAL REPORT 560

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16. Abstract

The extensive use of roads and highways in the United States results in continuous maintenance and construction activities. Work zones are inconvenient for motorists and dangerous for both motorists and transportation workers. During the period 1997-2002, non-construction highway fatalities remain about constant while highway construction zone fatalities increased by 70%. The most common complaint about construction projects from the general public is the lack of information. Improving communication with the public about construction conditions will allow drivers to make safer driving decisions and will increase their satisfaction with the construction process. The safety and satisfaction of drivers is fundamental to the expansion and maintenance of transportation systems and research that improves that safety and satisfaction is vitally important. This study explores the ADOT construction communication process and how it can be improved.

This study examines data collected from ADOT customers during the State Route 51 (SR 51) project. During the $75 million project, approximately 10 miles of SR 51 between Interstate 10 and State Route 101 were renovated to include new high occupancy vehicle (HOV) lanes and rubberized asphalt. Communication was measured by customer utilization of four direct communication channels and four indirect communication channels. Satisfaction was measured by a composite score based on customer satisfaction with traffic, dust, noise, signage, and information during the construction process.

Almost all respondents relied upon at least one channel for construction communication and almost 80% of respondents reported using between one and three channels. The most frequently utilized channel was construction signs (55.9%) and the least frequently utilized channel was e-mail alerts (1.5%). Less than 4% of the respondents did not utilize any communication channel. Direct communication channels resulted in higher customer satisfaction than did indirect communication channels. Construction bulletins contributed the most to customer satisfaction, followed by the project web site. Neither television nor radio contributed to customer satisfaction. As sources of project communication, neighbors and friends had a strong but negative effect on customer satisfaction.

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SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			m
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
	ILLUMINATION			
fc	foot candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
	FORCE AND PRESSURE OR STRESS			
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	Square millimeters	0.0016	square inches	in^2
m^2	Square meters	10.764	square feet	ft^2
^{2}	Square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	Cubic meters	35.315	cubic feet	ft^3
m^3	Cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
	TEMPERATURE (exact)			
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
^{2}	$candela/m^2$	0.2919	foot-Lamberts	fl
	FORCE AND PRESSURE OR STRESS			
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

cd/m

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Executive Summary

The extensive use of roads and highways in the United States results in continuous maintenance and construction activities. Work zones are inconvenient for motorists and dangerous for both motorists and transportation workers. During the period 1997-2002, non-construction highway fatalities remained about constant while highway construction zone fatalities increased by 70%. The most common complaint about construction projects from the general public is the lack of information[1]. Improving communication to the public about construction conditions will allow drivers to make safer driving decisions and will increase their satisfaction with the construction process. The safety and satisfaction of drivers is fundamental to the expansion and maintenance of transportation systems and research that improves that safety and satisfaction is vitally important. This study explores the ADOT construction communication process and how it can be improved.

This study examines data collected from ADOT customers during the State Route (SR) 51 project. During the $75 million project, approximately 10 miles of SR 51 between Interstate 10 and SR 101 were renovated to include new high occupancy vehicle (HOV) lanes and rubberized asphalt. Communication was measured by customer utilization of four direct communication channels and four indirect communication channels. Direct communication is that which was transmitted directly by ADOT to customers, such as direct mail construction bulletins. Indirect communication is that which was transmitted to customers by intermediaries, such as news media, public relations firms, or neighbors and friends. Satisfaction was measured by a composite score based on customer satisfaction with traffic, dust, noise, signage, and information during the construction process.

Almost all respondents relied upon at least one channel for construction communication, and almost 80% of respondents reported using between one and three channels. The most frequently utilized channel was construction signs (55.9%) and the least frequently utilized channel was e-mail alerts (1.5%). Less than 4% of the respondents did not utilize any communication channel. Direct communication channels resulted in higher customer satisfaction than did indirect communication channels. Construction bulletins contributed the most to customer satisfaction, followed by the

project web site. Neither television nor radio contributed to customer satisfaction. As sources of project information, neighbors and friends had a strong but negative effect on customer satisfaction.

The following are recommended to improve communication with the public regarding construction conditions and customer satisfaction in future projects of similar scope:

- Continue to use construction bulletins. Construction bulletins were utilized by 45% of respondents and were the strongest predictor of customer satisfaction.
- Stress the importance of construction signage. Construction signs were the single most utilized source of construction information and a significant predictor of customer satisfaction.
- Expand the use and promotion of project web sites. While the SR 51 web site was not heavily utilized, it was a significant predictor of customer satisfaction among those who did use it.
- Expand the use and promotion of project e-mail alerts. The lack of significance found in this study could be reversed with greater utilization of e-mail alerts.
- Consider the effect of radio on customer satisfaction. If radio is intended to improve customer satisfaction and if it will be used in future projects, then radio promotions should be improved so that they will increase customer satisfaction.
- Examine the contribution of television to customer satisfaction. Television did not prove to have an effect on customer satisfaction, and consideration should be given as to how to make it effective.
- Improve the use of newspaper promotions. Newspapers were the weakest significant contributor to customer satisfaction, and future projects should attempt to improve the effectiveness of newspapers on customer satisfaction.
- Reduce intermediation by friends and neighbors. As sources of project communication, friends and neighbors had a profoundly negative effect on customer satisfaction, and future projects must address this indirect source of information.

Introduction

In the United States, motorists travel about 200 billion miles per month on roads and highways. This extensive use results in an increased need for the continuous maintenance of existing roads and the construction of new roads. This perpetual maintenance and construction effort takes place in work zones that operate day and night. Work zones are naturally inconvenient for travelers and dangerous for both travelers and transportation workers. Improving communication to the public about construction conditions will allow drivers to make safer driving decisions and will increase their satisfaction with the construction process. The safety and satisfaction of drivers is fundamental to the expansion and maintenance of transportation systems and research that improves that safety and satisfaction is vitally important.

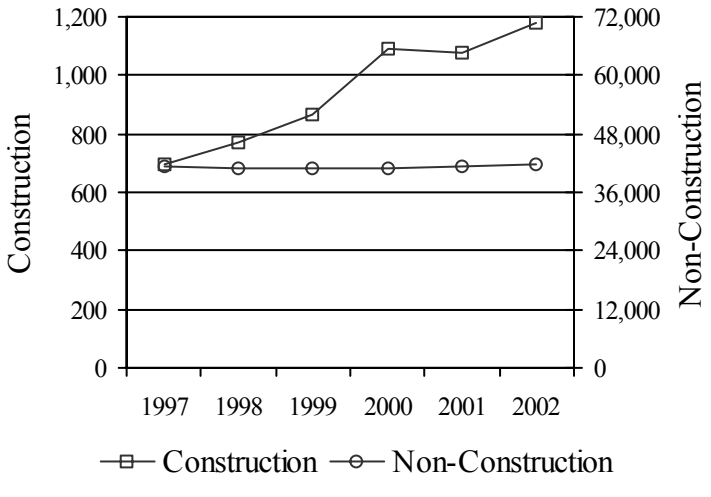
Communication has been found to increase satisfaction[2] and safety[3], and this study examines the relationship between communication to customers about construction conditions and customer satisfaction. A thorough analysis of data collected from Arizona Department of Transportation (ADOT) customers during the State Route 51 (SR 51) project will determine the extent of this relationship and allow ADOT to improve its communication with drivers. This improved communication will provide drivers with the information needed to make safer driving decisions. In addition to increasing safety, communication can also increase satisfaction. Communication establishes expectations that in turn set the threshold for satisfaction. Satisfaction is experienced when

expectations are met or exceeded. Accordingly, improving construction communication will improve customer satisfaction, and to improve construction communication, a better understanding of this process is required. This study examines the communication of construction information and how it can be improved.

Work Zone Safety

The U.S. Department of Transportation defines a work zone as consisting of four areas.[4] The advance warning area communicates to drivers the presence of workers and activity ahead. The transition area diverts traffic out of its normal path and around the workers and activity. The activity area includes a protective buffer space followed by the work space where the construction or maintenance takes place. Finally, the termination area returns traffic to its normal path and communicates the conclusion of the work zone. The National Institute for Occupational Safety and Health defines a work zone more broadly to include ancillary areas used for staging and support functions such as temporary batch plants.[5] Although these additional areas are essential to the work process, in this report they are not included in the work zone definition because motorists do not travel through these areas.

Figure 1
Highway Fatalities



Source: U.S. Department of Transportation

Work zones are becoming increasingly hazardous to those who travel through and work in these areas (see Figure 1). During the period 1997-2002, non-construction highway fatalities remained practically constant at about 41,000 per year. During the same period, there was a 70% increase in highway construction zone fatalities, from 693 in 1997 to 1,181 in 2002. Recognizing the significance of this trend and the importance of work zone safety, in 1999 the Federal Highway Administration, the American Traffic Safety Services Association, and the American Association of State Highway and Transportation Officials designated the first week in April every year as National Work Zone Awareness Week. This campaign is designed to increase awareness of the injuries that occur in work zones and how safety can be improved. The issue of work zone safety continues to receive national attention, and a recent article in the Wall Street Journal[6] recommended that drivers attend to construction information on communication channels such as web sites, newspapers, radio, and hotlines. Channels such as these can communicate the information needed to increase customer satisfaction and safety.

Case studies of work zone accidents reported by the National Institute for Occupational Safety and Health[7] suggest that work zone safety can be improved by increasing public awareness through communication.[8] In one incident, a flagger working at a resurfacing site was struck by and killed by a motorist, who also struck other workers and the milling machine. Although the accident occurred at night, the work zone was lit with floodlights and was marked with traffic signs, cones, and beacons. Similarly, a maintenance worker was struck and killed while feeding brush into a wood chipper. The accident happened during the day and the work zone was marked with cones and signs. In

another incident, a construction worker was struck and killed while installing pipes underneath a highway. The accident also occurred during the day and construction warning signs were set 2,000 feet in advance of the work area. Finally, a maintenance worker was killed during a daytime striping operation when his vehicle was struck from behind by a tractor-trailer. The striping vehicle was marked with beacons, a sign, and a flashing arrow board. In each of these incidents, workers were killed while engaging in routine maintenance and construction projects. And in each of the projects, the work zones were clearly marked with common warning lights, signs, and markers. These case studies illustrate the need to communicate construction information to drivers before they enter the work zone. If construction information is communicated in advance then drivers can anticipate the work zone or avoid it altogether.

Construction Communication

No published research has explored the relationship between communication to the public about construction conditions and customer satisfaction and safety. However, related research suggests that communication is critical to the success of construction project teams.[9] Project teams with better (e.g., frequent, detailed) communication experienced more positive outcomes (e.g., completed within budget, limited amount of rework). If this relationship can be generalized to construction communication, then better (e.g., relevant, accurate) construction communication will result in more positive outcomes (e.g., safety, satisfaction) for motorists. Because no research directly informs this area, it is useful to review how construction information is communicated at the micro (work zone) and macro (project) levels.

Communication serves various functions, but its primary function is to convey information. In the context of roadway construction, information is conveyed to motorists to influence their driving behavior in ways that will increase their satisfaction with the project and their safety in the work zone. Because communication includes the transmission and understanding of meaning, there must be both a source and a receiver of the message. Between the source and receiver are a number of factors that affect the transmission and understanding of meaning, including the message, encoding, the channel, decoding, and feedback. Each of these components and their functions are identified below.

Communication begins when the source initiates the communication process. In the context of roadway construction, the source is the cognizant department of transportation and its contractors. Contractors can also be intermediaries in the communication process. The source provides the ideas, needs, intentions, information, and purpose of the communication. In some cases, the source has multiple purposes for the information being communicated. For example, information about scheduled disruption caused by construction that is provided to local residents and businesses serves the specific purpose of communicating schedule information and also serves the general purpose of communicating sensitivity for those who will be affected by the disruption. This example demonstrates how the source of communication can convey information and develop relationships at the same time.

Construction communication that is contracted to public relations firms with experience in public works projects can improve customer satisfaction.[10] Contractors can engage in a variety of activities that communicate important ideas, needs, and

information to the public. For example, contractors can organize pre-construction meetings where the project is explained and where the public can voice concerns about the project. During the project, the contractor can provide ongoing information to the public with newsletters that detail scheduled travel restrictions and utility disruptions. Any construction project is likely to result in situations that require immediate attention, and contractors can maintain a telephone hotline that is available at all hours of the day and night. Contractors can also monitor public opinion of the construction project with surveys of residents and businesses. Finally, the contractor can compile a final report consisting of all communication with the public (e.g., newsletters) as well as the survey results. Whether construction communication is initiated by the department of transportation or its contractors, responsible sources will seek to constantly improve their communication.

The message is the meaning being transmitted by the source. In the work zone, messages are communicated to motorists in a variety of ways. The Manual of Uniform Traffic Control Devices[11] (MUTCD) defines standards for communication devices, including cones, signs, lights, and flags. Traffic cones used at night must be 28 inches tall and have two reflective bands. Construction signs, such as those warning of utility work ahead, must have a black legend on an orange background. Arrow panels used for merging and controlling drivers must emit yellow light from a black background. Flags, such as those used on high-level devices, must be orange and at least 16 inches square. During communication, inconsistency can cause confusion and the uniform design and meaning of these traffic control devices improves communication by eliminating variance in the construction and implementation of the devices.

At the project level, messages can serve a broader function. Communicating relevant meaning to motorists will improve customer relations by enhancing the credibility of transportation departments and recognizing motorists as their customers.[12] In particular, communication can improve customer relations by developing a customer-focused construction environment with outreach programs that underscore the importance of motorists to departments of transportation. Likewise, conducting focus groups comprised of motorists can send the message that their concerns are important. A focus group would consist of up to 12 participants who represent the larger traveling public and who provide qualitative insight into the effectiveness of construction communication. Focus groups are the most effective technique for collecting rich, qualitative data. Supported by a moderator, a focus group is an effective way to acquire fresh ideas and insight into a project. No less important is the increased level of work zone safety that can be achieved with timely construction messages. In general, coordinated messages will result in an informed customer base that recognizes the importance of maintained and safe roadways. Encoding is the process by which the message meaning is converted into a language. The appropriate language used to encapsulate the message depends on the message being transmitted and the channel used to deliver it. Initially, construction sign messages in the United States were encoded in English. For example, a message warning drivers that traffic would soon be controlled by a flagger might simply read "Flagger Ahead" (see Figure 2). Work zone signs encoded with graphics do not require that the motorist comprehend English. The same message warning drivers of a flagger encoded in graphics might look like the sign in Figure 3. The graphic image encoding increases the effectiveness of the communication because it reaches a broader audience

(not just those who can read English) but decreases the efficiency of the communication because its meaning is less certain (for those who can read English).

Figure 2

Figure 3

The more complicated the message, the less effective graphics are at encoding the message. For example, in work zones where explosives are being used, it is important to prevent signals transmitted by two-way radios and cellular telephones that could cause detonation. This message could be encoded in English as depicted in Figure 4. The same message could be encoded graphically, but the number of images required to include all two-ways radios and cellular telephones decreases communication effectiveness and increases work zone danger.

Figure 4

Once encoded, the message is transmitted through a channel. Transportation departments and their contractors have utilized a wide variety of channels beyond traditional signs to communicate construction information to the public, including direct mail, public meetings, and media outlets.[13] Travel information has been communicated using e-mail, web sites, multimedia CDs, and interactive kiosks.[14] The Pennsylvania Department of Transportation has successfully used a web site to communicate work zone information, including web cameras positioned in construction areas.[15] More recently, Intelligent Transportation Systems technology has been leveraged to create smart work zones.[16] In smart work zones, existing channels such as dynamic message signs, pagers, and e-mail are used to deliver real time work zone information automatically as traffic conditions change. Because people do not have constant access to every communication channel, sending construction communication on multiple channels improves communication by increasing the number of targets who receive the message.

Communication channels have varying degrees of "richness," defined as having meaningfulness and significance. The degree of richness found in a communication channel is a function of its ability to handle single or multiple cues (e.g., words and gestures), its ability to facilitate fast or slow feedback, and its ability to be personal or impersonal. Routine, unambiguous messages should be communicated over channels that are low in richness, while complex, ambiguous messages should be communicated over channels that are high in richness. During a construction project, the announcement of the date, time, and location of a public meeting should be communicated with a letter or another channel that is low in richness because feedback is not critical to that communication. During the project, a simple inquiry from a resident might be resolved

using channels of moderate richness, such as e-mail or voice mail. Complex problems would be best resolved using the richest communication channel, a face-to-face conversation. Given the numerous communication channels and their varying richness, the choice of which channel(s) to utilize that will maximize the effectiveness of different types of construction communication is critical.

The message must be decoded before it can be understood by the receiver. The decoding process for motorists is likely to be affected by the related issues of information overload and selective perception. Individuals can process only a limited amount of information and as result can be overloaded with communication from a variety of sources, such as newspapers, television, radio, and e-mail. World events, local news, advertising, and business communication all compete for limited decoding capacity. In an effort to manage this overload of information, many people ignore some channels altogether in favor of others. By ignoring television in favor of newsprint as a source of local news, drivers may not receive important construction communication. Alternatively, people may ignore channels that require some activity (e.g., searching for the project web site) in favor of channels that allow passiveness (e.g., receiving unsolicited construction bulletins). Moreover, motorists may be overloaded with information while driving through work zones. Work zones are often characterized by erratic traffic patterns and distracted drivers. When these factors are combined with the use of cellular telephones and other distractions then drivers may be overloaded with information. Communication erodes when information is ignored or forgotten as other messages are sorted and prioritized.

The sorting and prioritizing of messages is accomplished with a filter of selective perception. Selective perception is a function of the needs and experiences of motorists. The decoding process is further complicated as receivers project their own interests and expectations into the communication process. The various combinations of these needs, experiences, interests, and expectations result in an inconsistent process for selecting and decoding messages. For example, focus group participants were frustrated by the presence of "Workers Ahead" signs when in fact there were no workers ahead.[17] This experience could cause drivers to doubt the accuracy of other construction signs. Similarly, focus group participants reported that lighted variable message signs impaired their night vision. To better perceive information beyond lighted signs, these drivers might decrease their perceptions of the lighted signs by turning away when approaching them. In these two examples, the experiences of drivers in work zones could cause them to ignore important construction communication. Sources of construction communication must be aware of selective perception as they attempt to communicate with drivers.

As the target of the intended meaning, the receiver can then act on the message. The internal factors influencing the ability of the receiver to decode the message include his or her knowledge, skills, abilities, and culture. For example, most adults in the United States would have no difficulty understanding the message prohibiting bicycles in Figure 5. Given the meaning communicated by the symbols in Figure 5, these same people would likely interpret the symbols in Figure 6 to mean that bicycles are permitted. However, they would be wrong and could be seriously hurt because the symbols in Figure 6 prohibit bicycles in Europe just as the symbols in Figure 5 do in the United States. It is not the case that European traffic symbols are simply the opposite of those in

the United States, as other European signs prohibiting certain actions have the circle and diagonal stripe as depicted in Figure 5. An awareness of cultural issues does not change the ability of a receiver to understand a message, rather it allows the source to more carefully craft and channel a message that will result in increased satisfaction and safety.

Figure 5

Figure 6

Even within the United States, cultural differences can influence communication. Culture is especially important to the California Department of Transportation (Caltrans).[18] California has more federally recognized Native American tribes than any other state and recognizes them as independent political communities pursuant to the U.S. Constitution. But Caltrans takes a more inclusive approach to Native American communities by also recognizing tribes that are not recognized by the federal government as well as Native Americans not living on reservations. This recognition is formalized in the Caltrans policy regarding Native Americans. This policy requires Caltrans to: acknowledge tribes as separate government entities; minimize negative impacts on Native American resources; respect tribal rights, sites, and traditions; and consult with tribal

governments before undertaking projects that may affect them. The implementation of this policy is supported by a Native American Advisory committee that provides advice on policies and practices. Caltrans increased the satisfaction of its Native American customers by improving its communication with the awareness of cultural differences.

Feedback allows the receiver to acknowledge the understood content of the received message. If the intended communication did not take place, then the sender can use the feedback to diagnose where the communication failed and how to improve the process. Feedback requires the same communication process as original communication, where the receiver becomes the source. ADOT provides continuous feedback during construction projects. For example, providing feedback to various customer segments during the widening of SR 95 minimized construction inconvenience.[19] SR 95 is the primary transportation route in northwestern Arizona and is heavily used by motorists with destinations in Nevada. Local political leaders, business owners, and community groups expressed concerns about the project. These concerns were addressed through media alerts, brochures, a telephone hotline, and other channels. Respondents to a post-project survey indicated that the alerts were the most effective means of communication, followed by brochures and the telephone hotline. This feedback helped the contractor complete the job almost six months ahead of schedule.

ADOT has also invested in public feedback at early stages of the construction process. In northwest Arizona where U.S. Highway 60 and U.S. Highway 93 intersect in Wickenburg, a solution was needed for traffic heading for California and Nevada as well as locations in Arizona. During the design concept study for the project, a survey of local residents and business was conducted.[20] Respondents provided feedback on a variety of

topics, including methods to involve the public in the project planning effort. As indicated in Table 1, many respondents felt that newspaper articles are a very effective way to communicate and about half felt that public meetings were similarly effective. Considerably fewer respondents felt that television and web sites were effective forms of communication.

Table 1
Communication Channel Effectiveness Feedback

	Effectiveness			
Channel	Very	Somewhat	Not Very	Not Sure
Newspaper Articles	71	26	3	0
Public Meetings	53	36	11	0
Television	26	34	33	7
Web Site	18	35	36	11

Note. All values are percentages.
Source: www.wickenburg.civilnet.sverdrup.com

The most common complaint about construction projects from the general public is the lack of information,[21] and the value of a proactive approach to construction has been recognized.[22] Rather than just responding to public inquiry and complaint, a proactive approach requires taking the initiative to anticipate public concerns and then communicate information that addresses those concerns. The most proactive approach begins even before the project is designed. In the pre-design phase, engineering surveys and infrastructure analyses should be announced with flyers distributed to local residents and businesses. Subsequently, personal letters addressed to local residents and businesses should explain the need for the construction and invite them to a public meeting where the design process will be explained. At the meeting, stakeholders should be given a realistic preview of the disruption and inconvenience that will be caused by the project and what will be done to minimize these effects. Without the communication of a

realistic preview, customers may hold unrealistic expectations that will result in dissatisfaction. By communicating with stakeholders before the project begins, customers will have more information and greater satisfaction.

Communication, Satisfaction, and Safety

The dramatic increase in work zone fatalities and the creation of the National Work Zone Awareness Week has focused attention on the importance of work zone safety. Case studies of work zone fatalities suggest that work zone markings are inadequate and that construction communication needs to take place before drivers enter the work zone. Given the relatively recent increase in work zone fatalities, it is not surprising that empirical research has yet to examine the relationship between communication and work zone satisfaction and safety. However, related research suggests that improving construction communication will increase customer satisfaction and safety.

Efforts to improve construction communication could be directed at any one or more of the elements of the communication process. As the sources of communication, departments of transportation and their contractors are aware of the value of construction communication. As the receivers of communication, drivers want to experience safety and satisfaction. The message meaning is driven by the stage of the construction project. Messages are typically encoded in either English or standardized symbols and it is difficult to predict and control the factors that interfere with decoding. Given that little can or should be done to influence these elements of communication, efforts to improve construction communication should be directed at the channel (e.g., television, radio, newspaper, web site).

Satisfaction and safety are top priorities for departments of transportation and both can be improved by providing construction communication to the traveling public. Among the elements of the communication process, the channel provides the most opportunity for improving the effectiveness of construction communication. Meetings and focus groups are effective ways to channel information to the public but are not efficient for reaching large audiences. Web sites and e-mail can efficiently reach large audiences but may not effectively address the unique concerns of individuals. Given finite resources, the choice of communication channel(s) is vital to cost effective communication that will increase customer satisfaction and safety. Thus, this study will address the following research questions:

- Are ADOT customers sufficiently informed or satisfied with the amount of information that they receive through the various current means of construction communication?
- How does the satisfaction of customers who believe they are well-informed compare with that of customers who lack of sufficient construction information?
- How can communication be improved?

Method

Data collected during the SR 51 project were used to answer the research questions. During the $75 million project, approximately 10 miles of SR 51 between Interstate 10 and SR 101 were renovated to include new high occupancy vehicle (HOV) lanes and rubberized asphalt.

Respondents

Respondents in this study were individuals who lived and worked within one-half mile on either side of the project corridor. Five waves of data were collected at different times during the project. Table 2 contains the dates of survey distribution and response rates for each wave.

Table 2
Survey Distribution and Response Rate

Wave	Date Distributed	Surveys Distributed	Surveys Returned	Percent Response
A	May 4, 2003	25,000	1,931	7.72
B	July 11, 2003	25,000	1,446	5.78
C	September 12, 2003	25,000	1,509	6.04
D	November 6, 2003	25,000	810	3.24
E	January 9, 2004	25,000	1,145	4.58
	Total	125,000	6,841	5.47

Measures

The survey included a measure of respondents' reliance upon eight sources of direct and indirect communication channels (see Table 3). Direct communication is that which was transmitted directly by ADOT to customers, such as direct mail construction bulletins. Indirect communication is that which was transmitted to customers by intermediaries, such as news media, public relations firms, or neighbors and friends. Respondents indicated their reliance upon each communication channel by checking a box corresponding to each channel.

Table 3
Communication Channel Items

Direct	Indirect
ADOT Construction Bulletins	Radio
Construction Signs	TV
www.SR51.com	Newspapers
Email Alerts	Neighbors and Friends

The survey also included measures of respondents' satisfaction with traffic flow, dust control, noise control, work zone signage, and project information (see Table 4). Respondents indicated their satisfaction with each performance area by circling the number on scales ranging from 1 (worst) to 10 (best) that reflected their level of satisfaction in each area.

Table 4
Customer Satisfaction Items

1. Adequate traffic flow has been maintained through freeway work zones.
2. Crews have done a good job of controlling construction dust.
3. Crews have done a good job of minimizing construction noise.
4. Temporary construction signs and directions are accurate and understandable.
5. I've been adequately informed about this project.

Procedure

The surveys were distributed by a direct marketing company. The surveys were hand delivered to residences and businesses within one-half mile on either side of the construction corridor by a team of distributors. Respondents were asked to mark their response to the survey questions and return the postage paid survey. Responses were then entered into an electronic file for analysis.

Results

The communication and customer satisfaction data collected during the SR 51 project were subjected to a series of analyses to answer the research questions. First, the distribution and percentage of communication sources were calculated. Second, the means and standard deviations of the customer satisfaction items were computed to determine the appropriateness of collapsing the items across each wave. Once collapsed across each wave, the intercorrelations of the unified satisfaction items suggested that a

single measure of customer satisfaction was indicated and a reliability analysis revealed that the single measure was robust. These analyses are described in detail below.

Communication

Table 5 contains the communication channels that customers could have relied upon and the distribution of customers that did rely on each channel. Among direct sources of communication, constructions signs were the most commonly reported source (55.9%). Less than 2% of respondents relied upon e-mail alerts for project communication. Among the indirect sources of communication, television was the most commonly reported source (39.0%) and neighbors and friends were the least commonly reported source (12.7%). Almost 4% of the respondents did not rely on any of the specified sources of project information.

Table 5
Communication Channel Utilization

Source	N	%
Direct		
ADOT Construction Bulletins	3,064	44.8
Construction Signs	3,827	55.9
www.SR51.com	445	6.5
Email Alerts	104	1.5
Indirect		
Radio	2,279	33.3
TV	2,669	39.0
Newspapers	2,460	36.0
Neighbors and Friends	868	12.7
None	261	3.8

Note. Percentages may not sum to 100 because respondents could report more than one source of project information.

More than 96% of respondents relied upon at least one communication channel for construction information. About 20% of respondents did not utilize any of the direct communication channels, and about 30% of respondents did not use any of the indirect

communication channels (see Table 6). Three-quarters of the respondents utilized at least direct communication channel, while two-thirds utilized at least one indirect communication channel. Less than 1% of respondents utilized all four direct communication channels, while about 3% of respondents utilized all four indirect communication channels.

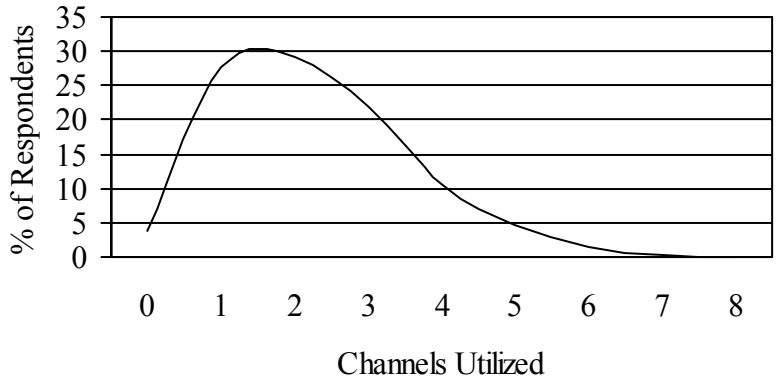
Table 6
Communication Channel Utilization

Channels Utilized	Channel Type	
	Direct	Indirect
0	22.5	31.9
1	48.7	32.4
2	26.7	21.8
3	1.9	10.8
4	.2	3.1

Note. All values are percentages

As indicated in Figure 7, the frequency distribution of channel utilization is skewed. Two communication channels were utilized by more respondents than any other single number of channels, and almost 80% of the respondents reported using between one and three channels.

Figure 7
Channel Distribution



Customer Satisfaction

Table 7 contains the means and standard deviations of the customer satisfaction survey items for each wave. The higher the number, the more satisfied the customers were. The means ranged from 5.94 (item 1, wave C) to 7.90 (item 3, wave B). The standard deviations ranged from 2.06 (item 2, wave A) to 2.92 (item 5, wave C). As can been seen in each row, there is no consistent pattern between the means and standard deviations for each item across each wave. This suggests that analyses of variance and covariance are not indicated and that the satisfaction items can be collapsed across waves.

Table 7
Customer Satisfaction Item Means and Standard Deviations (S.D.)

Item		Wave A	B	C	D	E
1	Mean	6.32	6.71	5.94	6.25	6.64
	S.D.	2.59	2.53	2.66	2.71	2.62
2	Mean	7.86	7.85	7.77	7.69	7.74
	S.D.	2.06	2.16	2.19	2.23	2.34
3	Mean	7.85	7.90	7.83	7.59	7.76
	S.D.	2.13	2.19	2.26	2.36	2.37
4	Mean	7.09	7.19	6.63	6.75	6.98
	S.D.	2.61	2.63	2.85	2.85	2.75
5	Mean	6.93	7.20	6.82	7.42	7.63
	S.D.	2.93	2.89	2.92	2.80	2.70

Table 8 contains the means, standard deviations, and correlation coefficients for the collapsed customer satisfaction items. The relatively strong and highly significant (all $p < .001$) correlations among the average scores of the five customer satisfaction items suggest that the items capture similar but not duplicative variance and can be further collapsed into a single measure of customer satisfaction. Once reduced, a reliability analysis of the five satisfaction items representing a single measure of satisfaction yielded a reliability coefficient of 0.85 and the removal of any of the items would have reduced the reliability coefficient. Thus, this single measure represented customer satisfaction in the following regression analysis.

Table 8
Means, Standard Deviations (S.D.), and Correlation Coefficients

Item	Mean	S.D.	1	2	3	4	5
1	6.36	2.63	-				
2	7.80	2.18	.55	-			
3	7.81	2.24	.50	.75	-		
4	6.95	2.73	.55	.48	.46	-	
5	7.14	2.88	.55	.46	.44	.59	-

Note. All correlation coefficients significant at $p < .001$.

Communication and Customer Satisfaction

Table 9 contains the results of a regression analysis that examined the relationship between communication and customer satisfaction. Construction bulletins contributed the most to customer satisfaction, and about twice as much as the next strongest contributor, the project web site. It should be noted that as sources of project communication, neighbors and friends, had a relatively large and negative effect on customer satisfaction. The effects of e-mail alerts, radio, and television on overall customer satisfaction were not statistically significant and can be presumed to be null. The effect of each statistically significant regression coefficient can be interpreted with the following equation:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \ldots + \beta_{p-1} X_{i,\,p-1} + \varepsilon_i$$

Using this formula, it can be estimated that a customer who relied solely upon direct communication would have a satisfaction score of 8.22, and a customer who relied solely upon indirect communication would have a satisfaction score of 6.42. Likewise, a customer who relied upon all channels of communication would have an estimated satisfaction score of 8.04.

Table 9
Effect of Communication on Customer Satisfaction

Variable	Coefficient	
Constant	6.60	***
Direct		
ADOT Construction Bulletins	.89	***
Construction Signs	.24	***
www.SR51.com	.49	***
E-mail Alerts	.33	
Indirect		
Radio	.02	
TV	-.02	
Newspapers	.21	***
Neighbors and Friends	-.39	***

*** $p < .001$

Conclusions

ADOT attempts to provide sufficient information to its customers. Almost all respondents relied upon at least one channel for construction communication and almost 80% of respondents reported using between one and three channels. The two most utilized communication channels, construction bulletins and construction signs, are both direct channels and were utilized on average by 50% of the respondents. The two least utilized communication channels, the project web site and e-mail alerts, are also both direct channels and were utilized by less than 10% of the respondents. Given the prevalence of Internet technology, it is more likely that the utilization difference is due to the passive nature of the bulletins and signs (no action was required by respondents to receive information on these channels) and the active nature of the web site and e-mail alerts (respondents were required to seek out these information channels).

Among the indirect communication channels, the utilization rates of radio, television, and newspapers averaged about 36%. The relationship between utilization and passive versus active communication channels suggested above is consistent with the findings for radio, television, and newspapers. The activity required to utilize radio, television, and newspapers is more than bulletins and signs but less than web sites and e-mail. Likewise, the utilization of these indirect communication channels was less than bulletins and signs but more than the project web site and e-mail alerts. The exception to this pattern is neighbors and friends as a communication channel. The findings with this channel indicate that even a relatively small number of unhappy customers can significantly damage overall customer satisfaction.

The combined direct and indirect frequency distribution of channel utilization indicates that customers are sufficiently informed. Of the eight communication channels, almost 80% of respondents utilized between one and three channels to obtain construction information. Less than 7% of respondents utilized five or more channels, so the number of channels employed could be reduced with only a minimal effect on construction communication. Given the variety of channels that were employed to communicate construction information, the 3.8% of respondents who reported not utilizing any of the eight channels would seem to be uninterested in receiving any construction information.

Not all channels of communication increase customer satisfaction equally. Overall, direct communication channels were more effective and efficient than indirect channels at increasing customer satisfaction. The most frequently reported source of construction information was construction signage, which significantly contributed to customer satisfaction. Construction bulletins were the second most frequently reported source of construction communication and had the strongest effect on customer satisfaction. Full color construction bulletins cost as little as 15 cents each to design, produce, and hand deliver to area residents and businesses. However, strength was not always in numbers. The project web site was one of the least utilized channels of construction communication but had the second strongest effect on customer satisfaction.

Radio and television did not contribute to customer satisfaction. Given the prevalence of radio and television utilization, the low cost and effort for customers to utilize these channels, and the high level of utilization reported for receiving construction information through these channels, the lack of effect that these channels have on

customer satisfaction should inform future transportation project planning and implementation efforts. Although no paid television communication was included in the SR 51 project, about $10,000 per week was spent on drive-time radio communication. The expensive and ineffectual characteristics of radio contrast with the inexpensive and effective characteristics of neighbors and friends. Unfortunately, the effect of neighbors and friends on customer satisfaction was negative and overwhelmed the customer satisfaction created by newspapers.

Recommendations

ADOT engages in a comprehensive construction communication effort that is generally effective in creating customer satisfaction. In particular, direct communication channels are more effective than indirect communication channels at improving customer satisfaction. The results of this study support the following recommendations for improving communication with and satisfaction of ADOT customers in projects of similar scope.

- Continue to use construction bulletins. Construction bulletins were utilized by 45% of respondents and were the strongest predictor of customer satisfaction.
- Stress the importance of construction signage. Construction signs were the single most utilized source of construction and a significant predictor of customer satisfaction.
- Expand the use and promotion of project web sites. While the SR 51 web site was not heavily utilized, it was a significant predictor of customer satisfaction among those who did use it.

- Expand the use and promotion of project e-mail alerts. The lack of significance found in this study could be reversed with greater promotion and utilization of e-mail alerts. This is an extremely cost effective communication channel and large local employers with Internet access by employees should be aggressively targeted for internal distribution of project e-mail alerts.
- Consider the effect of radio on customer satisfaction. If radio is intended to improve customer satisfaction and if it will be used in future projects, then radio promotions should be improved so that they will increase customer satisfaction.
- Examine the contribution of television to customer satisfaction. Television did not prove to have an effect on customer satisfaction, and consideration should be given to how to make it effective. Because television is an expensive communication channel, paid promotions may not be feasible for most construction projects. However, other creative approaches may be affordable and effective. For example, during U.S. military operations around Iraq, members of the media were embedded in military units and provided generally positive coverage of operations. If this approach were taken by ADOT, then local reporters would follow the progress of a construction project and provide viewers with insight into the construction process.
- Improve the use of newspaper promotions. Newspapers were the weakest significant contributor to customer satisfaction, and future projects should attempt to improve the effectiveness of newspapers on customer satisfaction. One approach to this would be to conduct a focus group of customers who travel

SR 51. During the focus group, the participants would be presented with a portfolio of newspaper notices that were published during the project and solicit their input on how the notices could have been more effective.

- Reduce intermediation by friends and neighbors. As sources of project communication, friends and neighbors had a profoundly negative effect on customer satisfaction, and future projects must address this indirect source of information. Although it may be difficult to prevent an unhappy customer from spreading misinformation and dissatisfaction, it would be possible to reduce the net negative effect with a strategy of accurate and positive information through other communication channels.

Discussion

The constant and heavy use of roads and highways in the United States results in continuous construction and maintenance. These expansion and repair efforts take place in work zones that are hazardous to people and property that pass through them. Work zone deaths have almost doubled in the past six years, and national attention has been focused on the need for construction communication. Without adequate communication, the delay and danger created by work zones can cause customer dissatisfaction. Dissatisfied customers may make unsafe driving decisions and contribute to the dissatisfaction of others. This study is the first to empirically support the relationship between construction communication and customer satisfaction.

Communication establishes a baseline expectation against which experience is measured. Satisfaction results when experience meets or exceeds expectations. In the context of roadway construction and maintenance, the opportunity exists to communicate

information to customers that will create expectations of process and outcome. This information may not necessarily be positive (e.g., closures, detours, etc.) but will result in satisfaction when the project proceeds as it was described. If this information is not communicated then customers could adopt their own expectations that may not be met.

The channel utilized to transmit the information is a critical component of the communication process. There are numerous channels of communication that can be used to deliver construction information. Other reports have documented the use of channels such as direct mail, e-mail, meetings, web sites, radio, and television to communicate construction information but none have examined their effectiveness on satisfaction. This study examined the effectiveness of some of the most common direct and indirect channels of construction communication on customer satisfaction.

The results of this study clearly demonstrated the relationship between construction communication and customer satisfaction. Direct communication has a much stronger effect than indirect communication on customer satisfaction. The results of this study are robust, but additional research is needed to confirm the relationship between communication and customer satisfaction. Additional studies are needed to confirm and improve the reliability of the five-item satisfaction scale. In particular, possible reasons for the variation between the mean scores should be examined. Moreover, these findings are based on a project in an urban area, and future studies should examine data collected during projects in rural areas to confirm how well the results presented here may be generalized to apply to other conditions.

The relatively large value of the regression coefficient suggests that factors other than the five included in the satisfaction scale are responsible for customer satisfaction.

Future studies should examine the effects of e-mail, radio, and television on customer satisfaction to determine whether their lack of statistical significance in this study was due to random error, measurement error, or if they are in fact not related to customer satisfaction. Finally, future research should include additional channels of communication, such as public meetings. Thus, this research has yielded results of practical importance that can be used to increase customer satisfaction and results of statistical importance that can be used to advance research on this important subject.

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