

Driver Understanding of Work-Zone Flagger Signals

NADA D. HUDDLESTON, STEPHEN H. RICHARDS, AND CONRAD L. DUDEK

The results of a human-factors laboratory study conducted in Texas to evaluate driver understanding of 13 work-zone flagger signals are reported. This was an exploratory study in which 123 motorists participated and 23-73 motorists viewed each signal. The signals evaluated included (a) seven standard signals recommended in the 1978 national Manual on Uniform Traffic Control Devices (MUTCD), (b) two signals recommended in the 1973 Texas MUTCD but not included in the 1978 national MUTCD, (c) two signals recommended for use by police, and (d) two nonstandard signals that combined standard signals from the 1978 national MUTCD. A STOP or SLOW sign paddle, a red flag, and/or hand motions were used to perform the various signals. The results indicated that (a) most drivers understood all seven of the 1978 MUTCD signals except signal 2 (Stop Traffic) and signal 9 (Alert Traffic) (both signals required the use of a flag alone), (b) exclusion of the two signals in the 1973 Texas MUTCD from the current Manual was in the best interest of work-zone safety, (c) the two police signals were understood by most drivers but are not recommended for use at this time, and (d) the two nonstandard signals showed no advantage over the 1978 MUTCD signals. The study indicated that most of the signals that involved the use of a STOP-SLOW sign paddle and/or hand motion were understood by the drivers but the signals in which a flag alone was used were less effective.

Flaggers (or flagmen) are used at some highway work zones to guide and direct motorists. They protect the safety of the work crew and encourage safe and efficient traffic operation in the work zone (e.g., continuous traffic flow at reduced speeds).

The Manual on Uniform Traffic Control Devices for Streets and Highways (national MUTCD) presents guidelines for the use of various hand signals and signaling devices for work-zone traffic control. The current (1978) edition of the national MUTCD (1) recommends several standard signals, including three signals used to stop traffic.

Various police agencies have developed guidelines for traffic-control hand signals that could be used for work-zone traffic management. For example, the police training school at the Northwestern University Traffic Institute has recommended standard police hand signals for directing traffic to stop and to turn left (2). Police hand signals, however, are normally not used by work-zone flaggers.

STUDY PURPOSE

A human-factors laboratory study was developed to evaluate drivers' understanding of various flagger signals and signaling devices for work-zone traffic control. The study evaluated 13 signals, including

1. Seven standard signals recommended in the 1978 national MUTCD,
2. Two signals recommended in the original 1973 Texas MUTCD (3) but not included in the 1978 national MUTCD or the 1980 Texas MUTCD (4),
3. Two signals recommended for use by police by the Northwestern University Traffic Institute, and
4. Two nonstandard signals that combine standard signals from the 1978 national MUTCD.

The seven standard signals from the 1978 national MUTCD and the two signals from the 1973 Texas MUTCD involve the use of a red flag or a STOP or SLOW sign paddle. Some of these signals also require hand motions to supplement the flag or paddle. The two police signals evaluated are performed by using only hand motions. The two nonstandard signals studied involve the simultaneous use of both a flag and a STOP or SLOW sign paddle. Figure 1 illustrates and describes the 13 signals evaluated.

STUDY DESCRIPTION

The various signals were performed at a proving-ground facility by a trained flagger, who was situated in a roadside setting but not in an apparent work-zone environment. The flagger wore an orange vest and a hard hat.

Each signal was videotaped in color from inside a stationary vehicle from a distance close enough so that all signals would be clearly visible on the videotape recording. Study participants were shown the taped signals and asked what they would do in response to each signal.

STUDY ADMINISTRATION

The study was administered to licensed drivers in Bryan-College Station, Texas, at a shopping mall and a local driver licensing center. A total of 123 motorists participated in the study, and 23-73 motorists viewed and interpreted each signal. (All but two of the signals were viewed by at least 50 motorists.)

Table 1 summarizes the demographic characteristics of the study sample. The drivers participating in the study, on the average, were younger and better educated than the population of licensed drivers in the United States and Texas.

STUDY RESULTS

Tables 2-4 present the study results for the 13 signals evaluated (Figure 1). The data indicate that the most effective signal evaluated, in terms of driver understanding, was signal 1, which involved the use of a STOP sign paddle and hand motion to stop traffic. This signal implied a "stop" message to 100 percent of the 73 drivers who saw it. The least effective signal was signal 9, which involved the use of a red flag to alert and slow traffic. Only 31 percent of the 23 drivers who viewed this signal understood its intended meaning.

Signals for Stopping Traffic

Five of the 13 signals evaluated in the study were intended to stop traffic (signals 1 through 5 in Figure 1). Table 2 summarizes driver understanding of these signals. The data in Table 2 indicate that four of the five signals (signals 1, 3, 4, and 5) were understood by at least 90 percent of the drivers. These signals involved the use of a STOP sign paddle and/or hand motion.

Signal 2, on the other hand, implied a "stop" message to only 74 percent of the drivers. This signal involved the use of only a red flag and is one of the signals recommended for use in the 1978 national MUTCD.

It is interesting to compare the performance of signals 2 and 3. Both involved the same flagging motion, but in signal 3 this flagging motion was supplemented with a hand motion. This hand motion apparently enhanced driver understanding: The data in Table 2 indicate that 91 percent of the drivers understood signal 3 (flag and hand motion) whereas only 74 percent understood signal 2 (flag only).

Signals for Encouraging Traffic to Proceed

Two signals from the 1978 national MUTCD intended to

Figure 1. Flagger signals evaluated in study.




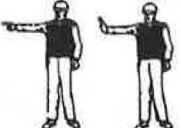







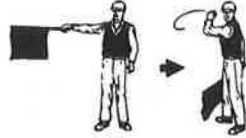
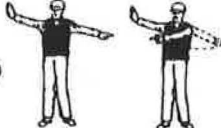
- ①  **Signal Intent:** Stop traffic
Description: The flagger holds the sign paddle in a stationary position with the arm extended horizontally away from the body. The free arm is raised with the palm toward approaching traffic.
Device(s) Used: STOP Sign Paddle and Hand
Source: 1980 Texas MUTCD
- ②  **Signal Intent:** Stop traffic
Description: The flagger faces traffic and extends the flag horizontally across the traffic lane in a stationary position so that the full area of the flag is visible hanging below the staff.
Device(s) Used: Flag
Source: 1980 Texas MUTCD
- ③  **Signal Intent:** Stop traffic
Description: The flagger faces traffic and extends the flag horizontally across the traffic lane in a stationary position so that the full area of the flag is visible hanging below the staff. The free arm is raised with the palm toward approaching traffic.
Device(s) Used: Flag and Hand
Source: 1980 Texas MUTCD
- ④  **Signal Intent:** Stop traffic
Description: The flagger points with his arm and finger and looks straight at the driver. He watches the driver and holds this point until seen. Then, the pointing hand is raised (but not the whole arm) so that the palm is toward the driver.
Device(s) Used: Hand
Source: Police Handbook
- ⑤  **Signal Intent:** Stop traffic
Description: The flagger faces traffic and extends the flag horizontally across the traffic lane in a stationary position so that the full area of the flag is visible hanging below the staff. The left arm is raised with the STOP sign paddle facing approaching traffic.
Device(s) Used: STOP Sign Paddle and Flag
Source: Combination of two signals from the 1980 Texas MUTCD, resulting in a non-standard signal.
- ⑥  **Signal Intent:** Encourage traffic to proceed
Description: The flagger stands parallel to the traffic movement, and with flag and arm lowered from view of the driver, motions traffic ahead with his free arm. The flag is not used to signal traffic to proceed.
Device(s) Used: Hand
Source: 1980 Texas MUTCD
- ⑦  **Signal Intent:** Encourage traffic to proceed
Description: A SLOW sign paddle is held in a stationary position with the arm extended horizontally away from the body. The flagger motions traffic ahead with his free hand.
Device(s) Used: SLOW Sign Paddle and Hand
Source: 1980 Texas MUTCD
- ⑧  **Signal Intent:** Alert and slow traffic
Description: The flagger holds the SLOW sign paddle in a stationary position with the arm extended horizontally away from the body.
Device(s) Used: SLOW Sign Paddle
Source: 1980 Texas MUTCD
- ⑨  **Signal Intent:** Alert and slow traffic
Description: The flagger faces traffic and slowly waves the flag in a sweeping motion with the extended arm from the shoulder level to straight down without raising the arm above a horizontal position.
Device(s) Used: Flag
Source: 1980 Texas MUTCD
- ⑩  **Signal Intent:** Alert and slow traffic
Description: The flagger faces traffic and slowly waves the flag in a sweeping motion with the arm extended from the shoulder level to straight down without raising the arm above a horizontal position. The SLOW sign paddle is held in a stationary position with the arm extended horizontally away from the body.
Device(s) Used: SLOW Sign Paddle and Flag
Source: Combination of two signals from the 1980 Texas MUTCD, resulting in a non-standard signal.
- ⑪  **Signal Intent:** Alert traffic
Description: The flagger faces traffic and waves the flag in a sweeping motion of the arm across the front of the body without raising the arm above a horizontal position.
Device(s) Used: Flag
Source: 1973 Texas MUTCD
(Not included in the 1980 Texas MUTCD)
- ⑫  **Signal Intent:** Slow traffic
Description: The flagger faces traffic and extends the flag horizontally across the traffic lane in a stationary position so that the full area of the flag is visible hanging below the staff. Then the flagger stands parallel to the traffic movement, and with the flag and arm lowered from view of the driver, motions traffic ahead with his free arm.
Device(s) Used: Flag and Hand
Source: 1973 Texas MUTCD
(Not included in the 1980 Texas MUTCD)
- ⑬  **Signal Intent:** Encourage traffic to turn left
Description: The flagger gives the stop signal with his right arm to stop traffic in the opposing lane. Holding this stop signal, he gives a turning gesture with his left arm.
Device(s) Used: Hands
Source: Police Handbook

Table 1. Demographic characteristics of study sample.

Signal	No. of Subjects	Percent Male	Average Age (years)	Average Years of College
1	73	60	33	1.9
2	73	55	34	1.6
3	73	55	34	1.6
4	73	60	33	1.9
5	50	42	29	1.2
6	73	60	33	1.9
7	73	60	33	1.9
8	23	100	41	3.2
9	23	100	41	3.2
10	50	42	29	1.2
11	73	55	34	1.6
12	73	55	34	1.6
13	73	55	34	1.6
All	123	50	32	1.4

Table 2. Driver understanding of signals used to stop traffic.

Signal	Source	Device Used	Sample Size	Drivers Stating Intended Meaning (%)
1	1978 national MUTCD	STOP sign paddle and hand	73	100
4	Police handbook	Hand	73	94
3	1980 national MUTCD	Flag and hand	73	91
5	Combined signals	STOP sign paddle and flag	50	90
2	1978 national MUTCD	Flag	73	74

Table 3. Driver understanding of signals used to encourage traffic to proceed.

Signal	Source	Device Used	Sample Size	Drivers Stating Intended Meaning (%)
6	1978 national MUTCD	Hand	73	100
7	1978 national MUTCD	SLOW sign paddle and hand	73	93

Table 4. Driver understanding of signals used to alert and/or slow traffic.

Signal	Source	Device Used	Sample Size	Drivers Stating Intended Meaning (%)
8	1978 national MUTCD	SLOW sign paddle	23	96
10	Combined signals	SLOW sign paddle and hand	50	62
12	1973 Texas MUTCD	Flag and hand	73	57
11	1973 Texas MUTCD	Flag	73	54
9	1978 national MUTCD	Flag	23	31

encourage traffic to proceed after being stopped were evaluated (signals 6 and 7 in Figure 1). Driver understanding of these two signals is summarized in Table 3. The data indicate that both of these signals were understood by most drivers. The hand-motion signal (signal 6) was most effective; 100 percent of the drivers understood its intended meaning.

Signals for Alerting and Slowing Traffic

Five signals intended to alert and/or slow traffic were evaluated in the study (signals 8 through 12 in Figure 1). Table 4 summarizes driver understanding of these signals. The data indicate that only one of these signals, signal 8, was understood by most drivers. Signal 8, which is recommended for use in

the 1978 national MUTCD, involved the use of a SLOW sign paddle.

Signals 9, 11, and 12 were least effective with respect to driver understanding. All of these signals involved the use of a red flag. The intended meaning of signal 9, which is recommended in the 1978 national MUTCD for alerting and slowing traffic, was understood by only 31 percent of the drivers.

Signal for Encouraging Traffic to Turn Left

A hand signal recommended by the Northwestern University Traffic Institute Police Training School for encouraging traffic to turn left was studied (signal 13 in Figure 1). The data show that 83 percent of the drivers understood the intended meaning of this signal.

CONCLUSIONS AND RECOMMENDATIONS

The study documented in this paper was an exploratory study of general trends in driver understanding of flagger signals. The sample size was relatively small and limited to drivers from one area of Texas, and the study evaluated drivers' understanding of "staged" flagger signals viewed from a stationary vantage point.

Nevertheless, several conclusions regarding the effectiveness of the 13 flagger signals studied can be made based on the study results.

National MUTCD Signals

Five of the seven signals recommended in the 1978 national MUTCD (signals 1, 3, 6, 7, and 8) appear to be understood by most drivers. These five signals involve the use of a STOP or SLOW sign paddle and/or hand motions.

The two signals recommended in the 1978 national MUTCD that were not generally understood by the study participants (signals 2 and 9) involve the use of only a red flag. This finding suggests that a red flag used alone is a relatively ineffective traffic-control device.

Texas MUTCD Signals (Deleted Signals)

The two signals recommended in the original 1973 Texas MUTCD, but not included in the 1980 Texas MUTCD (signals 11 and 12), were not generally understood by the drivers. The exclusion of these signals from the current editions of the national and Texas MUTCDs apparently is in the best interest of work-zone safety.

Stopping Traffic

Signal 1 (STOP sign paddle and hand motion) and signal 3 (flag and hand motion) were understood by most drivers in the study. Both of these signals are included in the 1978 national MUTCD. Based on the study results, their continued use is recommended.

Signal 2 (flag only), on the other hand, is apparently not understood by many motorists even though it is included in the 1978 national MUTCD. Based on this finding, the use of signal 2 is discouraged.

Signal 4 (police hand motion) and signal 5 (STOP sign paddle and flag) performed well in the study in terms of driver understanding. However, these signals would probably not offer any advantages over signal 1 or signal 3; therefore, signals 4 and 5 are not recommended for work-zone traffic control.

Encouraging Traffic to Proceed

Signal 6 (hand motion) and signal 7 (SLOW sign paddle and hand motion) were understood by most motorists. Their use at work zones for encouraging stopped traffic to proceed is supported by the study results. Both signals 6 and 7 are recommended in the 1978 national MUTCD.

Alerting and Slowing Traffic

Signal 8 (SLOW sign paddle) was the only signal for alerting and slowing traffic that was understood by most drivers. This signal is recommended in the 1978 national MUTCD, and its use is supported by the study results.

Four other signals for alerting and slowing traffic were tested (signals 9 through 12), but none of these signals were generally understood by motorists in the study. Their use, therefore, is not recommended. One of these deficient signals, signal 9 (flag only), is included in the 1978 national MUTCD.

Encouraging Traffic to Turn Left

The police hand signal for encouraging traffic to turn left was understood by more than 80 percent of the drivers. This signal and others currently used by police show promise for work-zone traffic control.

Needed Messages

The 1978 national MUTCD addresses only three basic flagging messages: stop, slow, and proceed. Thus, the functions of the work-zone flagger are currently limited. Consideration should be given to developing signals that convey other messages, such as (a) change lanes or merge into one lane, (b) turn left or right, (c) maintain speed, (d) detour or divert, and (e) use shoulder.

Training

The work-zone flagger performs a vital function in promoting traffic safety and operational efficiency. Unfortunately, flagging is viewed by many as a menial, relatively unimportant task. The least experienced or productive worker is often assigned the flagging duty without receiving instruction on proper traffic-control procedures. Flagger morale is usually very low.

It is recommended that the image and effectiveness of the flagger be improved. Proper training and instruction for all flaggers is essential. They should be familiar with proper work-zone traffic-control techniques and devices and should know how to use these tools to protect the safety of the work crew and the motoring public. Flaggers should have a basic knowledge of traffic-flow characteristics (e.g., speed, volume, and capacity) and how these characteristics relate to efficient work-zone traffic operation.

Job Title

It is also suggested that "flaggers" or "flagmen" be referred to by a more descriptive term, one that better reflects their function and importance (e.g., traffic specialists, traffic control specialists, or traffic controllers). In many instances, the flagger is the most important member of the work crew. He or she is responsible for traffic safety

and operations at the work zone and for promoting public understanding and acceptance of the work-zone operation.

Attire

It should be noted that, in addition to driver understanding, other factors influence motorist reaction to a particular flagger signal. Flagger appearance is one of these factors. A flagger should be highly visible in the work-zone environment and command the attention and respect of passing motorists. As a minimum, a flagger should be attired in accordance with MUTCD guidelines (e.g., wear an orange safety vest and optional white hard hat). The development of a special flagger uniform may be the best means, however, of promoting flagger visibility and respect. In fact, special uniforms (white overalls and orange vests) have been worn by flaggers at maintenance work zones on freeways in Houston with reported success (5).

Other Considerations

The work-zone environment (e.g., type of work, presence of a work crew, and sign and barricade layout) may also affect motorist reaction to a particular flagger signal. The length of viewing time and viewing distance are important. In addition, traffic conditions (i.e., speed and volume) may influence drivers' reaction to the signal.

ACKNOWLEDGMENT

We wish to thank Tom Newbern of D-18T for the assistance he provided as contract monitor for the study.

The research documented in this paper was conducted with the guidance of a Technical Advisory Committee. The contributions of the committee members are gratefully acknowledged.

REFERENCES

1. Manual on Uniform Traffic Control Devices for Streets and Highways: Part VI--Traffic Controls for Street and Highway Construction and Maintenance Operations. FHWA, 1978.
2. Directing Traffic: Signals and Gestures. Police Training School, Traffic Institute, Northwestern Univ., Evanston, IL, 1949.
3. Texas Manual on Uniform Traffic Control Devices for Streets and Highways: Part VI--Traffic Controls for Street and Highway Construction and Maintenance Operations. Texas State Department of Highways and Public Transportation, Austin, 1973.
4. Texas Manual on Uniform Traffic Control Devices for Streets and Highways: Part VI--Traffic Controls for Street and Highway Construction and Maintenance Operations. Texas State Department of Highways and Public Transportation, Austin, 1980.
5. R.G. Biggs. Traffic Handling Around Maintenance Activities on Freeways. Transportation Planning Division, Texas State Department of Highways and Public Transportation, Austin, Rept. SS5.3, July 1975.

Publication of this paper sponsored by Committee on Maintenance and Operations Personnel and Committee on Traffic Safety in Maintenance and Construction Operations.