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16. Abstract

The intersection and mandatory movement lane control signs placed on intersection approaches are critical to safe and efficient intersection operations. Ramp, frontage road, and cross-street approaches to interchanges often widen at intersections to accommodate additional through or turn lanes. Currently there is inconsistency in conveying to drivers how they should align themselves upstream of a diamond intersection to maneuver for their desired turning movement as the intersection widens. These inconsistencies can result in drivers making incorrect lane selection, which may result in late lane changes or illegal turns. This project conducted state-of-the-practice surveys, focus groups, and driver surveys to develop test signs used for field deployment and evaluation regarding lane assignment on frontage roads and cross streets. The findings include evaluation of an enhanced R3-8 sign to show roadway widening on a frontage road and evaluation of a guide sign to indicate lane choice when approaching a freeway interchange on a cross street. The research provides recommendations on when to apply non-standard signing to more clearly convey lane assignment to drivers on approach to more atypical intersections.

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LANE ASSIGNMENT TRAFFIC CONTROL DEVICES ON FRONTAGE ROADS AND CONVENTIONAL ROADS AT INTERCHANGES: TECHNICAL REPORT

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Anthony P. Voigt, P.E., Texas Registered Professional Engineer #84845.

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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CHAPTER 1. INTRODUCTION

The intersection and mandatory movement lane control signs placed on intersection approaches are critical to safe and efficient intersection operations. Ramp, frontage road, and cross-street approaches to diamond interchanges often widen at intersections to accommodate additional through or turn lanes. Currently there is inconsistency in conveying to drivers how they should align themselves upstream of an intersection to maneuver for their desired turning movement as the intersection widens. These inconsistencies can result in drivers making incorrect lane selection, which may result in late lane changes or illegal turns. The proper placement of signs and markings may be some distance back from the intersection, prior to where the roadway widens. Conveying lane assignments at sufficient distance for drivers to make lane change decisions is challenging using existing federal or Texas *Manual on Uniform Traffic Control Device* guidance.

This report documents an evaluation of the effectiveness of numerous sign concepts through the use of focus groups and driver surveys, as well as field testing of two sign concepts derived from a series of practitioner surveys of Texas Department of Transportation districts and state departments of transportation (DOTs), driver focus groups, and driver surveys. These signs are intended to assist motorists in the correct selection of a lane on approach to a freeway interchange with a cross street. This report provides the results of the evaluation, as well as guidelines for the potential use of these sign concepts at freeway to cross-street interchanges.

BACKGROUND

In Texas, the frontage road system provides a very important role in providing a link between higher functional class facilities (freeways, highways, and tollways) and the arterial roadway network that provides access to commercial and residential areas. A majority of urban freeways and tollways in Texas have frontage roads, and many rural highways have frontage roads as well. As the Texas Department of Transportation (TxDOT) seeks to maximize interchange operations to reduce delay, often one or more of the intersection approaches is widened to provide additional capacity for through movements and/or left-, right-, and U-turns (or turnaround lanes). Further upstream, however, the number of lanes may be less than at the intersection, which challenges the engineer to convey the proper lane assignment to drivers so that they can make a proper lane choice in advance of the intersection. To date, there has been very little guidance and little research conducted on the signs and markings needed on these types of approaches, specifically on frontage road approaches to an interchange, or cross-street approaches to interchanges.

This issue is of concern because without proper guidance (typically conveyed through the use of signs and pavement markings) at an intersection approach, drivers may be confused or indecisive, make sudden or last minute lane changes, make unnecessary lane changes, and/or be frustrated to the point of making illegal movements. Due to the complications in selecting the correct lane to make left-, right-, and U-turns in close of proximity to the intersection, driver expectancy violations may occur, and frontage and cross-street approaches to interchanges may experience increased crash rates, crash frequency, and/or excessive delay.

In 2003, TxDOT research project 0-4170, Improved Signing for Urban Freeway Conditions, recognized the lack of research in this area and TxDOT incorporated a small section on frontage road and cross-street lane use signing into its *Freeway Signing Handbook (1)*. This section was developed from *Texas Manual on Uniform Traffic Control Devices* (TxMUTCD) intersection principles, although no actual research to assess their use was conducted before or after the recommendations were presented. A review of existing practice revealed that in 2008, there is still very little definitive research on the subject.

OVERVIEW

The TxDOT *Freeway Signing Handbook's* section on frontage road and intersection lane assignment signing provides guidance for the many various geometries and scenarios that exist on the TxDOT system *(1)*. The main focus of the handbook is on the freeways themselves, but positive guidance principles outlined in the manual can be applied to the entire freeway system, including frontage roads and cross streets at interchanges. These positive guidance principles apply to the guidance concerning motorist attention, driver expectancy, and the limitations on quantity of lane assignment information as factors that should to be considered when developing frontage and cross-street signage and pavement markings for lane assignment.

The *Freeway Signing Handbook* provides guidance on frontage road approach signing by presenting drawings from the approach of an intersection on a frontage road, including all signs and pavement markings. Signs typically used include advance black-on-white arrow lane designation signs (R3-8), advance street guide signs, and proper trailblazing signs. Pavement markings may include the use of horizontal lane designation arrows and words (e.g., "ONLY"). The drawings in the manual begin with a simple two-lane frontage road with two lanes at the intersection, and evolve into more complicated scenarios incorporating turnaround lanes and lane widening to the left and/or right with optional turn and turn-only lanes. As the complexity of the roadway approach increases, so does the complexity and the number of recommended signs. The *Freeway Signing Handbook* also focuses on cross-street route signing. A cross-street approach requires proper trailblazer signing so that the driver will know which lane feeds to a particular freeway ramp and freeway direction, and where the driver should turn to enter the intersecting freeway.

The guidance in the *Freeway Signing Handbook* is extremely helpful, but leaves many common configurations, geometries, and situations encountered on Texas roadways unaddressed. It does not explore a majority of the lane assignment traffic control devices currently in use in Texas or the ways in which they can be used. One objective of this project was to provide some quantifiable research on a subset of the recommendations in the *Freeway Signing Handbook* for frontage and cross-street approaches to diamond interchanges.

The final report for TxDOT research project 0-4170 (Report 4170-2) contains a section on Frontage Road Lane-Use Signs *(2)*. Seven focus groups around Texas were conducted to study the project's key urban signing issues. A portion of the session was focused on frontage roads and driver lane decision making at the approach to an intersection before knowing which turning movements are permitted from different lanes (and without knowing how many actual lanes will be available at the intersection). The study technique consisted of showing the participants a base photo along a frontage road, with varying side-mounted lane-use assignment signs (*2*). The participants were asked questions such as "which lane do you need to be in if you want to go straight?", "how many lanes will there be at the intersection?", and "which side of the road do you think a lane will be added?" The study found the main challenge for engineers is communicating to drivers the number of lanes that will be at an intersection, and the turning movements prohibited, in enough time that a driver can safely position his/her vehicle in the correct approach lane.

Along with ensuring that a driver is given adequate information and time to make the proper lane choice, engineers should seek to discourage unnecessary lane movements. In the focus groups mentioned, drivers who were unsure about which lanes would go through at the intersection and which would be turn-only lanes often answered they would move away from the outer lanes (primarily the right lane) in order to make sure they could drive through the intersection. Similarly, when wanting to make a turn, drivers would move to the far left or far right lane because they felt certain they could turn from those lanes, but were unsure about any optional turn lanes. In the scenarios presented, these maneuvers may not have always been needed in order for the driver to make it through the intersection, since the outer lanes may have been optional turn lanes rather than turn only. Proper signs and markings can help to eliminate this confusion so unnecessary weaving is minimized. Intersection safety and operational efficiency should improve when weaving is reduced.

One of the main issues with frontage road and cross-street interchanges, especially in Texas, is the variation in interchange designs which may violate driver expectancies. In this study, researchers examined traffic control devices that may be used to counter this issue, including research on sign and marking applications for several intersection approach geometries:

- *One-Way Frontage Road Approaching a Signalized Intersection.* This scenario is covered in the *Freeway Signing Handbook.* It involves the most common intersection layout occurring in diamond interchanges, but can vary in lane number and allowed movements, with optional and turn-only lanes.

- *Split Diamond Interchange with Four Intersections.* Also known as a three-level box diamond, this intersection geometry is similar to the one mentioned above, but because of the complexity of the two intersecting sets of frontage roads the interchange consists of four total intersections, two on each side of the freeway. Along with the standard signing issues, additional trailblazing and lane designation are needed to help turning drivers know if the turn should be made at the first or second intersection they approach.

- *Two-Way Frontage Road Approaching a Signalized Intersection.* Although becoming rarer overall, two-way frontage roads are common in rural areas of Texas, and attention should be given to these roadways to prevent driving on the wrong side of the road. TxDOT research project 0-4471, Field Evaluations and Driver Comprehension Studies of Horizontal Signing, conducted a before-and-after field study on two-way frontage road treatments to reduce wrong-way movements *(3)*. White, horizontal pavement arrows indicating the correct direction of travel proved very beneficial in reducing wrong-way driving maneuvers during this study.

- *Unsignalized Loop Ramp from a Frontage Road to an Intersecting Roadway.* Common on several freeways in the Houston area and other parts of the state, the cross street crosses over the freeway and frontage road. However, interchanges vary on whether a driver on the frontage road must turn before or after the overpass to access the cross street depending on whether the interchange is a two-way or four-way cloverleaf. Often, the far right lane turns into a turn-only lane before or after the overpass, which can result in last-second maneuvers. Appropriate lane designation and trailblazing signs and markings are needed for these configurations even though a signalized intersection is not involved.

- *Conventional Cross-Street Approach to a Freeway.* Also partially covered in the TxDOT *Freeway Signing Handbook* is the approach of a conventional road, or cross-street, to a freeway interchange. Depending on the type of interchange, the driver's actions to turn to enter the freeway will vary. The approach to the freeway from the cross-street is also included in the scope of this project.

Traffic Control Devices Considered

The most obvious devices to study for lane assignment are signs, including intersection lane control signs, trailblazing and advance street signs. The federal MUTCD prescribes guidance and standards concerning intersection lane assignment signs (R3-8 series signs) *(4)*. The focus groups previously mentioned studied these types of signs, and as mentioned participants believed the number of arrows on the sign represented the number of lanes at the intersection. They also expressed the preference for the short black dividing line on the sign separating the arrows and the lanes. Along with the content of the signs, the number and location of signs were also studied. Researchers addressed the questions about whether the regulatory signs need to be placed on one or both sides of the road, upstream (and at what distance), and also whether the lane designation signs should be placed overhead of the appropriate lane at the intersection.

As mentioned in TxDOT Research Report 0-4471-2, pavement markings can be a beneficial supplement to signing. As with signs, not only the marking content, but also the number and location of the pavement markings are a question of this research. Elongated pavement marking arrows representing the turn movement ahead combined with horizontal text "ONLY" are already used in practice for intersection lane control. Horizontal markings including route designation shields are becoming more common on Texas freeways, and are even being used on a Houston frontage road location on the approach to multiple entrance ramps. Research project 0-4471 found survey participants very responsive to these shields for lane designation.

CHAPTER 2. METHODOLOGY

This chapter briefly summarizes each of the work tasks of this research project. The project sought to provide a literature review of previous studies of signing and pavement marking treatments aimed at lane assignment. The core of this project involved developing and implementing two sign concepts eventually deployed in the field to analyze effectiveness of new sign concepts at desired locations. The general methodologies used in the evaluation of lane assignment signing and pavement markings are highlighted in this chapter.

TASK 1. CONDUCT STATE-OF-THE-PRACTICE AND LITERATURE REVIEW

The researchers conducted a comprehensive literature search to identify publications on existing signing and pavement marking practices for diamond interchange approaches. This search used all available bibliographic resources including the internet and various catalogs and databases such as Texas A&M University's Sterling C. Evans Library local library database, Online Computer Library Center (OCLC) database, National Technical Information System (NTIS), and Transportation Research Information Service (TRIS). Key words and key word combinations selected to conduct a systematic search of the above databases included lane assignment signing, lane assignment pavement markings, guide sign, R3 series sign, lane keeping, and diagrammatic signs, among others.

In addition, the research team conducted a thorough review of current documented practices within Texas, nationally, and worldwide to identify how signs and markings are used to clarify lane assignments on frontage roads and conventional roads approaching a diamond interchange. Additionally, researchers reviewed the current applicable standards given in the TxMUTCD, federal MUTCD, currently proposed amendments to the federal MUTCD, *Older Driver Handbook*, *Standard Highways Signs Manual*, and other U.S. state guidance documents covering interchange signing.

After identifying potential literature sources, researchers acquired abstracts and reviewed those abstracts for applicability to the project. Those documents identified as being of interest were obtained for incorporation into the literature review. Chapter 3 of this report summarizes this effort.

TASK 2. DEVELOP AND CONDUCT STATE-OF-THE-PRACTICE EXPERT INTERVIEWS

Task 2 was subdivided into two subtasks, one addressing existing signing and pavement marking practices relating to lane assignment from TxDOT district staff, and one addressing existing practices from state departments of transportation in the United States.

Subtask 2.1. Identify Texas Interchange Signing and Pavement Marking Methods and Attitudes

This task identified and documented specific methods of selection and installation of signing and pavement marking treatments at diamond interchanges within the state of Texas. TxDOT districts were contacted to determine what guidance, standards, or documents they use to design and place signing and pavement markings at diamond interchanges. District traffic operations engineers and Traffic Operations Division staff were surveyed as part of this effort. An email-based questionnaire was used for this subtask.

Subtask 2.2. Develop a Profile of Existing Practices and Issues from Other States

The research team conducted an email-based survey of state DOT sources regarding existing signing and marking practices at diamond-type, freeway/surface-street interchanges. The traffic engineering or safety divisions of each state transportation agency were contacted to complete the survey. Also completed in the survey was a probe of states for specific signing or marking practices on other interchange types that might parallel or be applicable to the diamond interchange condition.

TASK 3. DEVELOPMENT OF DESIGN AND APPLICATION ALTERNATIVES

Task 3 was subdivided into three subtasks:

1. Developing prototype signing and marking concepts for project advisory committee review
2. Obtaining feedback from the advisory committee on the initial concepts.
3. Finalizing the concepts for testing with focus groups in Task 4.

Based on the findings of Tasks 1 and 2, researchers developed multiple prototype alternatives for the design, configuration, and application of lane assignment signs and markings along frontage and conventional roads at interchanges. This activity considered design factors such as sign and marking placement, the number of signs and markings, and the message and content of the signs and markings. The alternatives were based on perceived best practices found during the state-of-the-practice and survey activities. Concurrently with this subtask, researchers identified the most appropriate evaluation methodology to employ for the different sign and marking configurations being tested. Still photographs to be used in subsequent digital editing and roadway layouts were developed along with the device alternatives.

The Project Monitoring Committee (PMC) was then asked to review, modify, and approve the developed alternatives prior to evaluation. In addition, the proposed evaluation methodology was discussed and finalized with PMC approval. After consultation with the PMC, researchers modified the identified signing and marking alternatives used in the human factors evaluations.

TASK 4. HUMAN FACTORS EVALUATION OF SIGNING AND MARKING ALTERNATIVES

Based on the results from Task 3, two sets of human factors studies were designed to evaluate alternative signing and striping concepts for the lane assignment signs and markings. These studies employed several different methods of evaluation depending on the feature, design, or application aspect being evaluated.

Subtask 4.1. Develop Initial Focus Group Signing and Marking Evaluation Protocol

Once the initial signing and marking alternatives were identified, with concurrence from the PMC, researchers developed a protocol used in the evaluation of the initial alternatives. This protocol was submitted for review by Texas A&M University's Institutional Review Board to assure that the protocol followed accepted and ethical guidelines for conducting studies that use human subjects. Part of this process was to identify and select different technologies or study techniques that were to be used in the evaluation.

Subtask 4.2. Conduct Initial Interchange Signing and Marking Focus Groups

Focus group surveys were conducted in four locations in Texas (College Station, San Antonio, Austin, and Houston) to capture driver opinions on the initial signing and marking concepts. These surveys were used to identify the driving public's concerns and preferences about the existing signing and marking methods and initial alternatives that the research team developed for the lane assignment signing and pavement markings. The focus group results allowed the research team to gather information regarding driver information needs and comprehension that ultimately assisted in narrowing down the alternatives for individual motorist surveys. The signing and marking alternatives were presented to participants as sets of still images as the methodology dictated.

Subtask 4.3. Evaluate Focus Group Results and Conduct Project Advisory Committee Meeting

Following Subtask 4.2, the focus group transcripts were analyzed and presented to the PMC to narrow down the alternatives for the final human factors evaluation. Based on the results from Subtask 4.2 and input from the PMC, the new human factors studies were designed to identify preferred concepts for the lane assignment signs and markings. These preferred alternatives were then evaluated in more detail through individual driver evaluations using visual comprehension testing in a time-limited testing protocol.

Subtask 4.4. Develop Individual Driver Response Evaluation Protocol

Once the most promising signing and marking alternatives were finalized, researchers developed a more dynamic and hands-on individual testing protocol used in the evaluation. This subtask followed the same Institutional Review Board process as Subtask 4.1 to assure that the protocol was acceptable. Part of this process was to identify and select different technologies or study techniques that were used in the evaluation. Alternatives included: driving simulation with active lane decision responses, still images with limited viewing time requiring lane decision responses, and/or passive video viewing with recorded lane decision responses.

Subtask 4.5. Conduct Testing of Individual Driver Response to Signing and Marking Concepts

Driver surveys were conducted in multiple cities in Texas in both urban and rural locations. These interactive surveys were used to determine drivers' expectations and the timeliness and confidence of motorist lane assignment decisions when traveling along a frontage or conventional road. For some of the exercises, participants were given a target destination and were asked to respond with the correct lane choice. For other portions of the testing, the participants were shown an approach to an interchange and were asked what they expected to happen. Finally, driver opinion was assessed when participants were asked their preferences for different signing and marking concepts.

TASK 5. DEVELOPMENT OF GUIDELINES

Based on the results of Task 4, the research team used indications of driver understanding when making lane choice decisions to develop a set of recommended guidelines for lane assignment signs and markings on frontage and conventional roadways. These guidelines may provide the basis for a consistent statewide standard for the design and implementation of signing and marking deployments near interchanges. The guidelines include recommendations on sign and marking content, placement, and quantity. The overall goal of the guidelines is to provide a set of signing and marking guidelines that can be used by the Traffic Operations Division and all districts to consistently sign and mark at-grade interchange approaches.

TASK 6. FIELD TEST OF PREFERRED SIGNING ALTERNATIVE

The research team then identified, in coordination with the PMC and district traffic operations engineers, two candidate sites for deployment of the prototype preferred signing scheme for diamond interchange approaches. Two approaches, one frontage and one cross street, were signed with the preferred signing scheme at each of the two candidate interchanges. Candidate interchanges selected provided atypical geometry configurations where the PMC felt that the prototype signing could potentially mitigate operational issues. Results of the driver surveys indicated that pavement markings may be less effective than signs to provide lane use guidance, so after concurrence from the PMC, the two test sites consisted of signing only.

Before and after deployment of the signs, measures of effectiveness were quantified to include: 1) weaving movements within sight distance of the test signs, 2) lane use violations, and 3) "late" lane changes (or near violations). Other measures were collected, including traffic volumes, turning movements, and signal timings. Data were collected using existing Texas Transportation Institute (TTI) data collection portable trailers equipped with video camera(s), digital video recording capability, and radar volume/speed detection.

CHAPTER 3. LITERATURE REVIEW

This chapter covers Task 1 of the project: State-of-the-Practice and Literature Review. TTI researchers conducted a comprehensive literature search to identify existing sources of information with respect to design guidance for (and usage of) lane assignment traffic control devices at interchange (and intersection) approaches. This search used all available bibliographic resources including the Internet and various catalogs and databases including Texas A&M University's Sterling C. Evans Library local library database, Online Computer Library Center database, National Technical Information System, and Transportation Research Information Service.

The search for existing literature revealed very little research and documentation regarding design guidelines for advance lane assignment traffic control devices at interchanges. There was almost no information with regard to the treatment of bike and pedestrian markings on freeway/cross-street interchanges outside of commonly used documents (MUTCD, etc.). The following sections summarize the findings with respect to the need for advance signs, guidance regarding placement, design characteristics of advance guide and regulatory signs, and the existing state-of-the-practice for lane assignment signs in Texas, the United States, and other countries.

In 2003, TxDOT research project 0-4170, Improved Signing for Urban Freeway Conditions *(2),* recognized the lack of research in this area and TxDOT subsequently incorporated a small section on frontage road and cross-street lane use signing into the *Freeway Signing Handbook (1)*. Chapter Six of the *Freeway Signing Handbook* was developed from *Texas Manual on Uniform Traffic Control Devices (5)* intersection principles, although no actual research to assess their use was conducted before or after the recommendations were presented. A review of existing literature revealed that there is still very little definitive research on the subject.

National Cooperative Highway Research Program (NCHRP) Report 500 suggests that providing lane assignment signs and/or markings on the approach to complex intersections should help alleviate motorist confusion about lane choice *(6)*. The report suggests that if inadequate signs or markings are provided, motorists may experience confusion about proper lane choice. This confusion may lead to increases in crashes, particularly rear-end and sideswipe type crashes, but this confusion can also result in angle-type crashes as drivers perform illegal movements (for example, a left turn from a through-only lane adjacent to another through lane).

When advance signs and/or pavement markings are not used to convey downstream lane use, the odds of violating motorist expectancy may increase. In most cases freeway frontage road intersections are similar enough to allow motorists to develop a sense of familiarity with the intersection design, lane use, and operation. However, Alexander and Lunenfeld found that drivers may make improper movements and take longer to navigate the intersection if expectations are violated. This violation may then lead to crashes and operational issues (lower levels of service and increased delay) at the intersection *(7)*.

The expectancy and confusion issues become even more important for older drivers *(8)*. Older drivers typically have reduced contrast sensitivity and field of vision, which degrades their ability to adequately see and process information from signs and pavement markings. They may have increased decision times and slower reaction times, which may lead to increased overall risk for crashes when determining lane choice and negotiating intersections. A focus group discussion of older drivers conducted by Staplin et al. in 1997 showed that older drivers found themselves in the wrong lane due to:

- Incorrect assumptions about intersection geometry that was different from other intersections along the same roadway.
- No (or inadequate) advanced signage.
- Cars blocking the view of pavement markings.

In those focus group findings, 64 percent of older drivers who participated mentioned the need for more advance notice (warning) for turn-only lanes and suggested the use of multiple advance signs before a right lane becomes a turn-only lane. Focus group participants suggested that distances for advance signs from the turn location should range from 20 to 30 seconds before the approach for the first sign and about 10 seconds before the approach for the second sign *(8)*.

GUIDANCE PROVIDED BY THE TXDOT *FREEWAY SIGNING HANDBOOK*

The *Freeway Signing Handbook's* section on frontage road and intersection lane assignment signing provides initial guidance for basic scenarios that exist on the TxDOT frontage road system *(1)*. While the main focus of the handbook is on the freeways themselves, the positive guidance principles outlined in the manual may be applied to the entire freeway system, including frontage roads and cross streets at interchanges. There are parallels that may made between motorist attention, driver expectancy, and the limitations on quantity of lane assignment information as factors that should to be considered when developing frontage and cross street signage and pavement markings for lane assignment.

Chapter 6, Section 4 of the manual focuses on frontage road approach signing. The chapter generally consists of diagrammatic drawings showing approaches to diamond intersections on a frontage road, with recommended signs shown for various conditions. The signs typically shown are regulatory and warning signs, including advance black-on-white arrow lane designation signs, advance street guide signs, and guide signs. The example figures in the manual begin with a simple two-lane frontage road with two lanes at the intersection, and evolve into more complicated scenarios incorporating three approach lanes, U-turn lanes, and lane widening to the left and/or right with optional turn and turn-only lanes. As the complexity of the roadway approach increases, so do the complexity and the number of recommended signs. The *Freeway Signing Handbook* provides guidance for the placement of the signs.

The examples (and figure numbers) as shown in the *Freeway Signing Handbook* include:

1. Two-lane frontage road approach with stop control:
    a. to an on-system roadway (Figure 6-7)

    b. to an off-system roadway (Figure 6-8)
2. Two-lane on-system frontage road approach:
    a. with signal control (Figure 6-9)
    b. with right-turn lane and signal control (Figure 6-10)
    c. with turnaround lane, right-turn lane, and signal control (Figure 6-11)
    d. with right-turn bay and signal control (Figure 6-12)
    e. with left-turn/turnaround bay, right-turn bay, and signal control (Figure 6-13)
3. Three-lane on-system frontage road approach:
    a. with left-lane drop and signal control (Figure 6-14)
    b. with right-lane drop and signal control (Figure 6-15)
    c. with left-lane drop, right-turn bay, and signal control (Figure 6-16)
    d. with lane control signing on mast arm – turnaround bay, left-lane drop, right-turn bay, and signal control (Figure 6-17).

An example of the *Freeway Signing Handbook* graphics is shown in Figure 1, which is Figure 6-17 of the *Freeway Signing Handbook*.

Chapter 6, Section 5 of the *Freeway Signing Handbook* focuses on cross-street route signing, and does not explicitly address lane assignment signing. Cross-street approaches require proper signing so that the driver will know which lane(s) feed to a particular freeway ramp and freeway direction, and where the driver should turn to enter the intersecting freeway. Figure 2 shows an example of guidance for cross-street route signing (note: no lane assignment guidance is presented).

The guidance in the *Freeway Signing Handbook* is extremely helpful, but leaves many common configurations, geometries and situations encountered on Texas roadways unaddressed. The *Freeway Signing Handbook* does not explore a majority of the lane assignment traffic control devices currently in use in Texas or the ways in which they can be used.

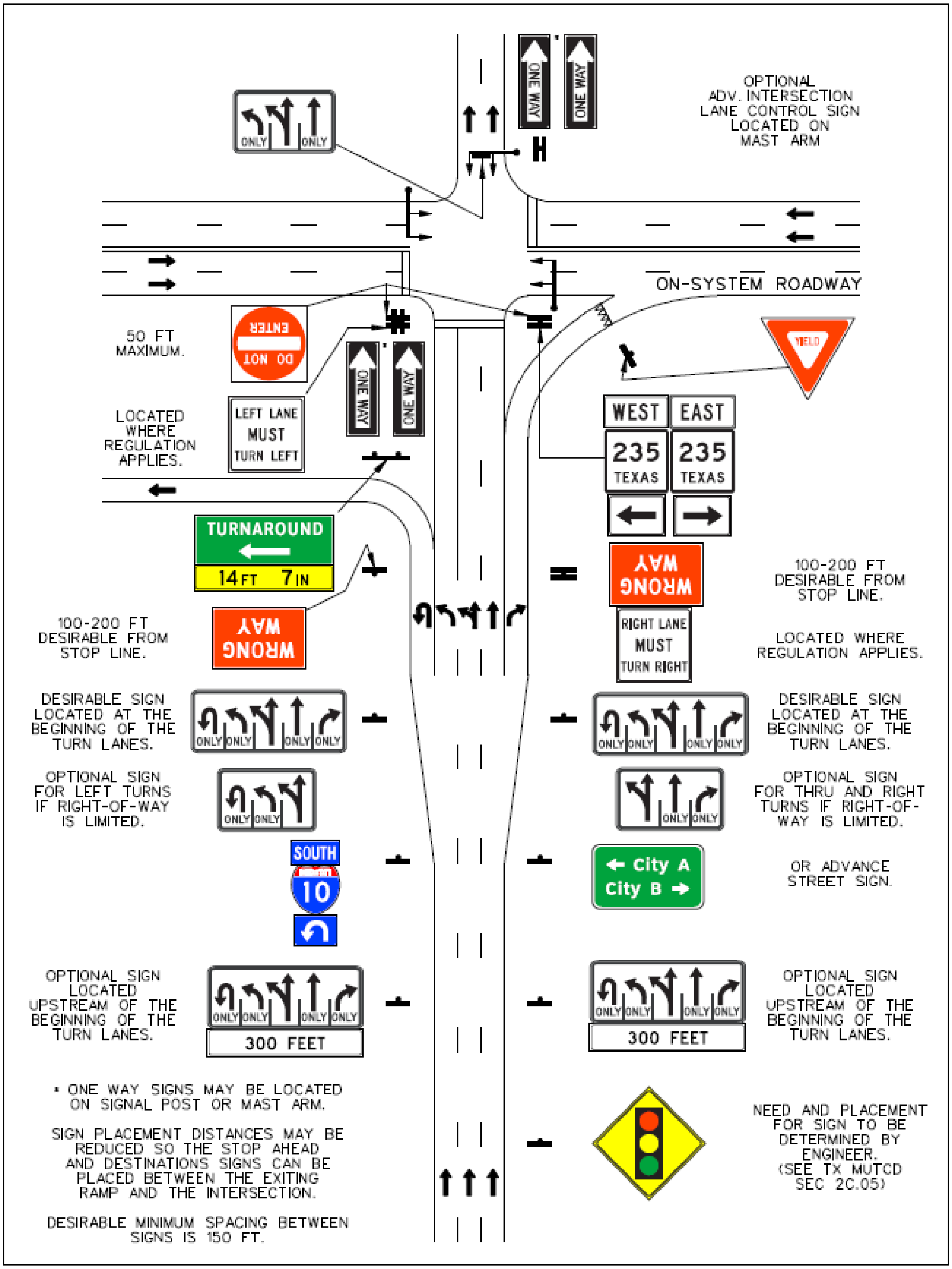


Figure 1. TxDOT Freeway Signing Handbook Figure 6-17 (*1*).

Figure 1 shows the preferred configuration for frontage road approach signing for a three-lane approach to an on-system roadway with lane control signing on mast arm – turnaround bay, left-lane drop, right-turn bay, and signal control *(1)*.

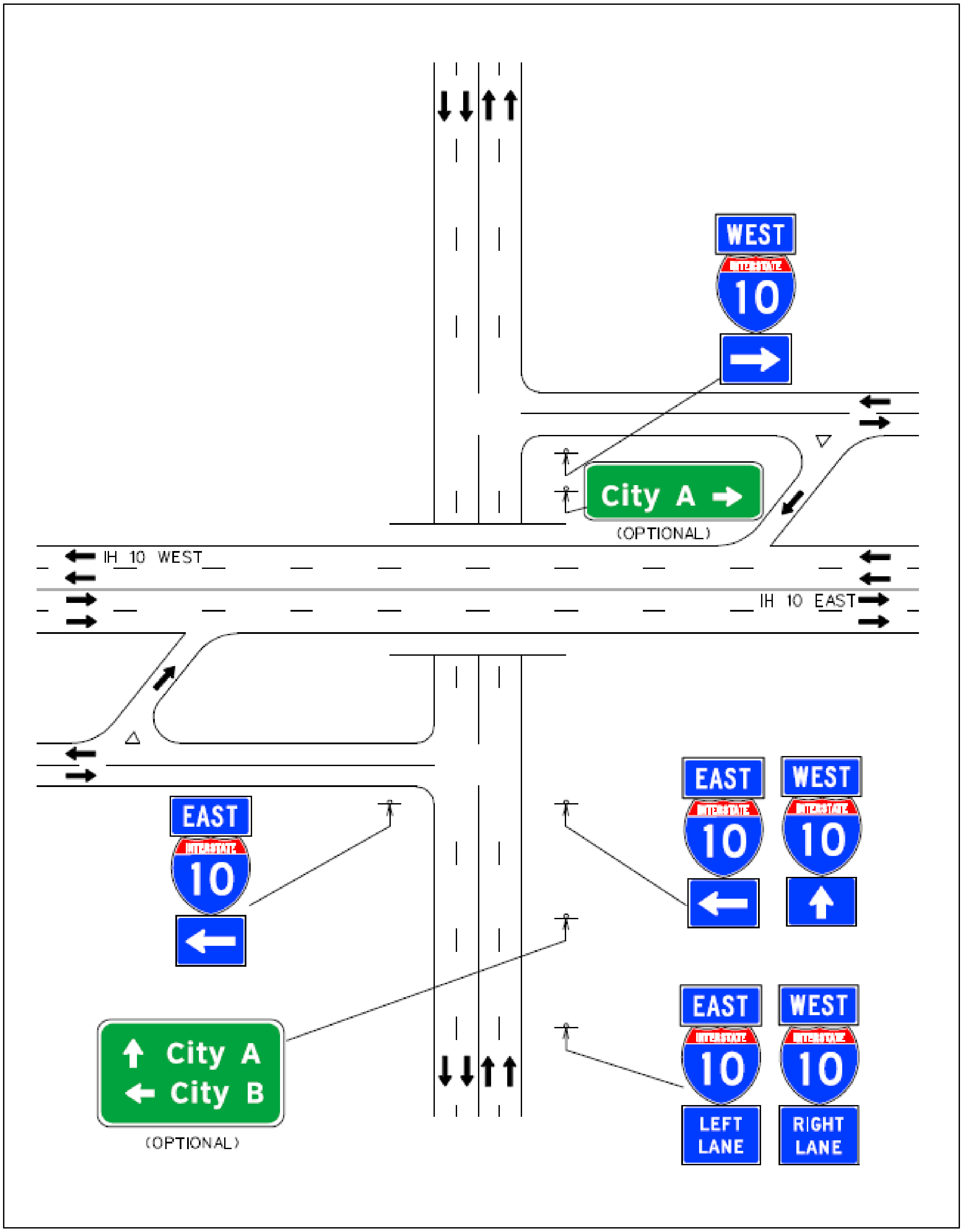


Figure 2. TxDOT Freeway Signing Handbook Figure 6-21 (*1*).

Figure 2 shows the suggested cross-street route signing for left-direction entrance ramp located on the far-right frontage road and right-direction entrance ramp located on near-left frontage road *(1)*.

CURRENT TEXAS PRACTICE

The following sections present the current (as of 2009) guidance for the application of lane assignment signing and pavement markings as specified in the 2006 edition of the TxMUTCD *(5)*.

Intersection Lane Control Signs

The 2006 edition of the TxMUTCD *(5)* specifies the use of intersection lane control signs in the following sections (a brief summary of each of these sections follows – they are not repeated verbatim, but applicable text included as reference):

- 2B.20 – Intersection Lane Control Signs (R3-5 through R3-8)
- 2B.21 – Mandatory Movement Lane Control Signs (R3-5, R3-5a, and R3-7)
- 2B.22 – Optional Movement Lane Control Sign (R3-6)
- 2B.23 – Advance Intersection Lane Control signs (R3-8 Series), and
- 2B.23A – Turnaround Only Sign (R3-8U).

These sections generally address the requirements (and optional placement) of lane control signs near the intersection approach, and not upstream before flaring or widening takes place.

Section 2B.20 – Intersection Lane Control Signs (R3-5 through R3-8)

This section defines Intersection Lane Control as those signs (if used) that:

- Require road users in certain lanes to turn.
- Permit turns from a lane where such turns would otherwise not be permitted.
- Require a road user to stay in the same lane and proceed straight through an intersection.
- Indicate permitted movements from a lane.

The manual states that intersection lane control signs (see Figure 3, TxMUTCD Figure 2B-4) shall have three applications:

1. Mandatory Movement Lane Control (R3-5, R3-5a, and R3-7) signs.
2. Optional Movement Lane Control (R3-6) signs.
3. Advance Intersection Lane Control (R3-8 series) signs.

This section provides guidance that when intersection lane control signs are mounted overhead, each sign should be placed over the lane or a projection of the lane (e.g., on a mast-arm across from the approach) to which it applies. However, it provides that the use of an overhead sign for one approach lane shall not require installation of overhead signs for the other lanes of that approach.

It also provides the option that where the number of through lanes on an approach is two or less, the intersection lane control signs (R3-5, R3-6, or R3-8) may be overhead or ground-mounted.

This section states that Intersection Lane Control signs may be omitted where both the following conditions apply:

- Turning bays have been provided by physical construction or pavement markings.
- Only the road users using such turning bays are permitted to make a similar turn.

2B.21 – Mandatory Movement Lane Control Signs (R3-5, R3-5a, and R3-7)

This section specifies as standard that if used, Mandatory Movement Lane Control (R3-5, R3-5a, and R3-7) signs (see Figure 3 (TxMUTCD Figure 2B-4)) shall indicate only those vehicle movements that are required from each lane and shall be located where the regulation applies. This section addresses signing for lanes exclusively designated for high-occupancy vehicles (HOVs), buses, and/or taxis, through the use of supplemental plaques. The R3-7 word message sign shall be for ground-mounting only.

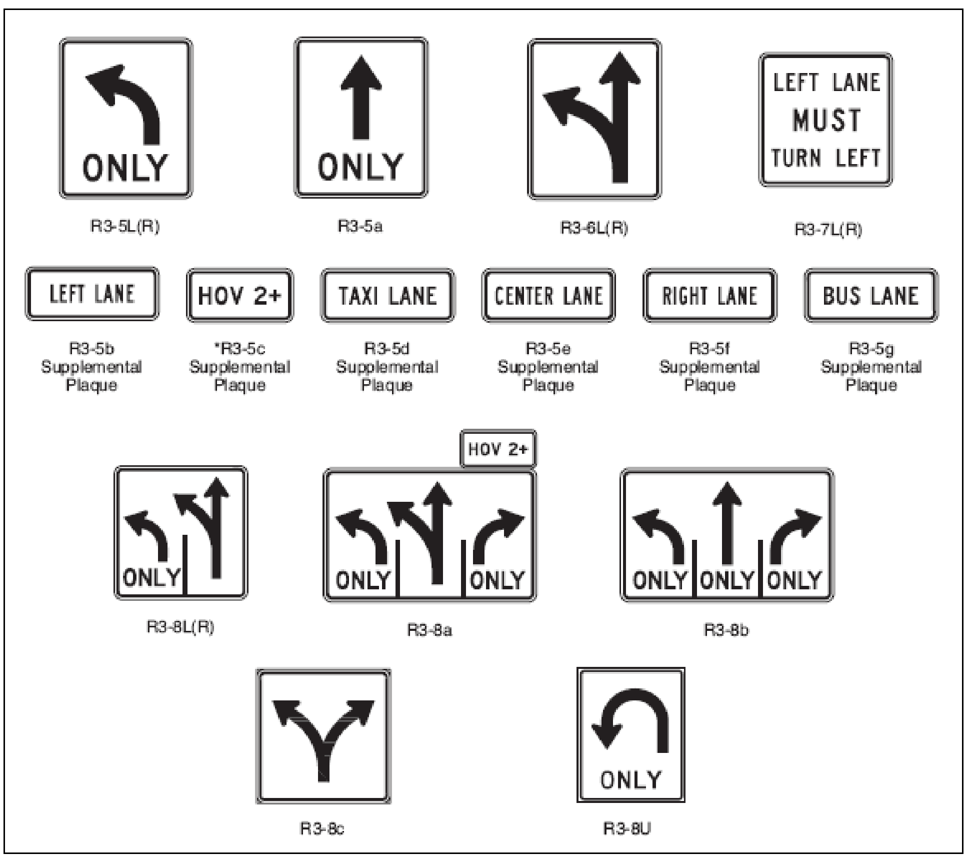


Figure 3. Intersection and Mandatory Movement Lane Control Signs.
(from Figure 2B-4, Texas MUTCD *(5)*)

If the R3-5 sign is ground-mounted on a multi-lane approach, a supplemental plaque shall be added below (see Figure 2B-4), such as LEFT LANE (R3-5b), HOV 2+ (R3-5c), TAXI LANE (R3-5d), CENTER LANE (R3-5e), RIGHT LANE (R3-5f), BUS LANE (R3-5g), or LEFT 2 LANES, indicating the lane with the appropriate movement.

The Mandatory Movement Lane Control (R3-7) sign shall include the legend RIGHT (LEFT) LANE MUST TURN RIGHT (LEFT). The Mandatory Movement Lane Control symbol signs (R3-5 and R3-5a) shall include the legend ONLY.

This section gives guidance on using Mandatory Movement Lane Control signs (R3-5, R3-5a, and R3-7) as they should be accompanied by lane use arrow markings, especially where traffic volumes are high, where there is a high percentage of commercial vehicles, or where other distractions exist. The section also emphasizes as optional the use of the Straight Through Only (R3-5a) sign to require a road user in a particular lane to proceed straight through an intersection. Except for the R3-7 sign, Mandatory Movement Lane Control signs may be overhead or ground-mounted.

2B.22 – Optional Movement Lane Control Sign (R3-6)

This section of the TxMUTCD discusses the use of signs which convey that two (or more) movements can be made from one lane. If used, the Optional Movement Lane Control (R3-6) sign (see Figure 3 (TxMUTCD Figure 2B-4)) shall be used for two or more movements from a specific lane or to emphasize permitted movements. If used, the Optional Movement Lane Control sign shall be located at the intersection and shall indicate all permissible movements from specific lanes.

Optional Movement Lane Control signs shall be used for two or more movements from a specific lane where a movement that is not normally allowed is permitted. The Optional Movement Lane Control sign shall not be used alone to effect a turn prohibition. It is optional to use the word message "OK" within the border in combination with the arrow symbols of the R3-6 sign.

2B.23 – Advance Intersection Lane Control signs (R3-8 Series)

It is optional to use Advance Intersection Lane Control (R3-8, R3-8a, R3-8b and R3-8c) signs (see Figure 3 (TxMUTCD Figure 2B-4)) to indicate the configuration of all lanes ahead. The word messages ONLY, OK, THRU, ALL, or HOV 2+ may be used within the border in combination with the arrow symbols of the R3-8 sign series. The HOV 2+ (R3-5c) supplemental plaque may be installed at the top outside border of the R3-8 sign over the applicable lane. The diamond symbol may be used instead of the word message HOV. The minimum allowable vehicle occupancy requirement may vary based on the level established for a particular facility.

The guidance does not specify with much detail the location of the advance signing, and what engineers should do if the "adequate distance" is before the approach flares out at the intersection. The section states that "If used, an Advance Intersection Lane Control sign should be placed at an adequate distance in advance of the intersection so that road users can select the appropriate lane. If used, the Advance Intersection Lane Control sign should be installed either in advance of the tapers or at the beginning of the turn lane."

2B.23A – Turnaround Only Sign (R3-8U)

Section 2B.23A of the TxMUTCD addresses the optional use of the TURNAROUND ONLY (R3-8U) sign, which may be used indicate the exclusive TURNAROUND movement that is required from a specific traffic lane. It will normally be used on expressways and freeways where a separate traffic lane is provided to connect the frontage roads on either side of the facility without a driver having to go through the adjacent intersection. In Texas, this sign is used frequently on frontage road approaches where turnaround lanes are provided, but in some cases left turns are provided from these lanes as retrofits to increase turn capacity – this practice may not be clearly conveyed with existing standard signing *(5)*.

Advance Street Name Signs

Section 2D.39 of the TxMUTCD addresses Advance Street Name Signs (D3-2) (see Figure 4). These types of signs are used to identify an upcoming intersection.

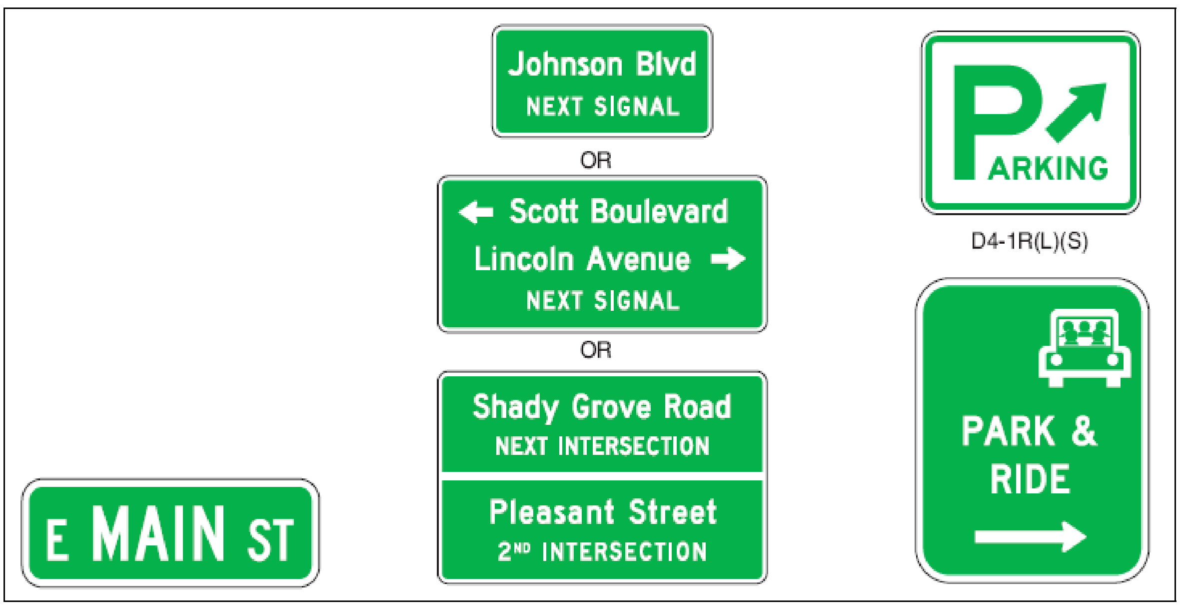


Figure 4. Street Name and Parking Signs (Figure 2D-8 TxMUTCD). *(5)*

Advance Street Name (D3-2) signs, if used; supplement the Street Name (D3-1) signs located at the intersection. The TxMUTCD states that the "Advance Street Name (D3-2) signs may be installed in advance of signalized or unsignalized intersections to provide road users with advance information to identify the name(s) of the next intersecting street to prepare for crossing traffic and to facilitate timely deceleration and/or lane changing in preparation for a turn."

The TxMUTCD gives the following guidance on the use of Advance Street Name signs:

- On arterial highways in rural areas, Advance Street Name signs should be used in advance of all signalized intersections and in advance of all intersections with exclusive turn lanes.

- In urban areas, Advance Street Name signs should be used in advance of all signalized intersections on major arterial streets, except where signalized intersections are so closely spaced that advance placement of the signs is impractical.

Advance Street Name Signs may be used to give drivers visual clues about lane choice before the intersection approach, but not as explicitly (or in a regulatory manner) as lane control signs may convey lane choice information.

Pavement Word and Symbol Markings

The TxMUTCD specifies the use of pavement word and symbol markings in Section 3B.19 – Pavement Word and Symbol Markings *(5)*. In the current practice of providing lane assignment information at intersections, markings are typically limited to arrows and words (typically "ONLY") for turn-only lanes. The manual states that word and symbol markings on the pavement are used for the purpose of guiding, warning, or regulating traffic and that symbol messages are preferable to word messages. Examples of standard word and arrow pavement markings are shown in Figure 5 and Figure 6 (TxMUTCD Figures 3B-20 and 3B-21).

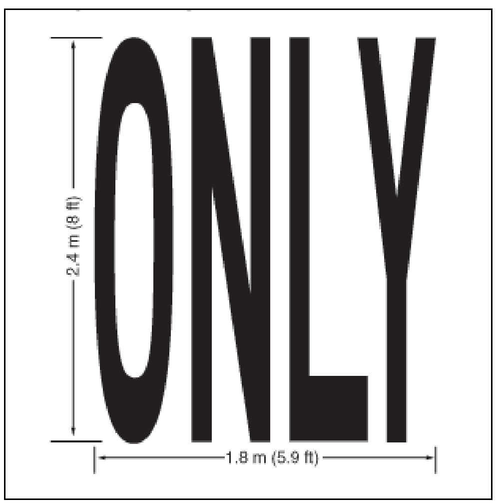


Figure 5. Example of Elongated Letters for Word Pavement Markings.
(TxMUTCD Figure 3B-20) *(5)*

The TxMUTCD specifies as standard that word and symbol markings shall be white unless otherwise noted. Section 3B.19 addresses other specifics of words and markings, such as height, number of lines of information (maximum three lines), and longitudinal spacing. This section also states that the "number of different word and symbol markings used should be minimized to provide effective guidance and avoid misunderstanding."

Section 3B.19 states a standard that where through traffic lanes approaching an intersection become mandatory turn lanes, lane-use arrow markings shall be used and shall be accompanied by standard signs, and that where through lanes become mandatory turn lanes, signs or markings should be repeated as necessary to prevent entrapment and to help the road user select the appropriate lane in advance of reaching a queue of waiting vehicles. As an option, lane-use arrow markings may be used to convey either guidance or mandatory messages, but the ONLY word marking may be used to supplement lane-use arrow markings. Lane-use arrow markings are often used to provide guidance in turn bays, where turns may (or may not) be mandatory. These types of markings are typically used in close proximity to the start of the turn bay or near the intersection, and not typically upstream in advance of roadway widening at the intersection approach *(5)*.

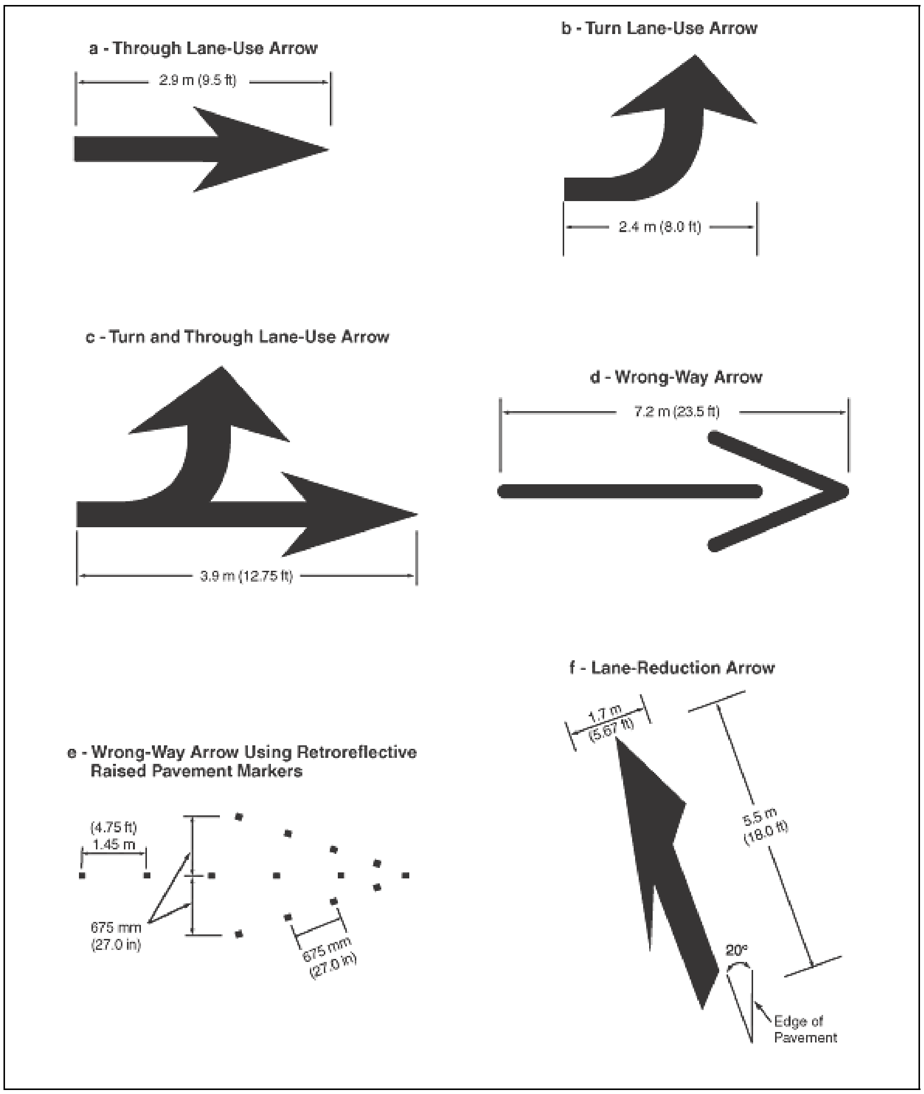


Figure 6. Examples of Standard Arrows for Pavement Markings.
(TxMUTCD Figure 3B-21) (*5*)

RESEARCH RELATED TO LANE USE ASSIGNMENT SIGNING AND MARKINGS

The available literature reiterates the need for advance lane assignment signs and markings ahead of the intersection approach, but there appears to be little practical guidance provided as to the preferred design and recommended locations for applicable signs and markings. The Highway Design Handbook for Older Drivers and Pedestrians recommends the following guidance for devices to convey lane assignment on intersection approach:

1. Consistent overhead placement of lane use control signs (for example, use of R3-5, R3-6, and R3-8 signs – (see Figure 1) at intersections on a signal mast arm or span wire.

2. Consistent posting of lane use control signs and application of lane use arrow pavement markings at a preview distance of at least five seconds (at operating speed) in advance of a signalized intersection is recommended, regardless of the specific lighting, channelization, or delineation treatments implemented at the intersection. Signs should be mounted overhead wherever practical *(9)*.

In the focus group study by Staplin, Harkey, et al., 79% of participants found overhead lane-use signs to be more effective than pole-mounted signs, and multiple participants suggested using both overhead and pole-mounted (roadside) signs *(8)*. While lane use related pavement markings were found to be useful for drivers, 84% stated they should not be used without signs to convey the lane use message. Pavement markings may lose reflectivity, be hidden by traffic, and over time are subject to wear and fading much more so than signs. However, pavement markings have a benefit by providing lane use information without distracting the driver from the roadway.

NCHRP Report 500 suggests using overhead signs as the preferred method of providing lane use information because the lane assignment is located directly above the appropriate lane. But the report also states that post-mounted signs and pavement markings are also acceptable devices for conveying lane assignments. NCHRP Report 500 also suggests that lane assignment signing “should be placed far enough in advance of the intersection so that vehicles can maneuver to the appropriate lane”, but the report provides no guidance on the appropriate distance. The report also notes that while overhead signing may be vastly preferred by most drivers, it is in most cases more costly and takes longer to install in comparison to post-mounted signs and pavement markings *(6)*.

Design Guidance for Lane Assignment Signs and Pavement Markings – Roundabout Experience

With the more recent emphasis on the development of roundabout design and implementation guidance in the U.S., there is a good amount of literature available regarding lane choice signs and pavement markings on approach to roundabouts. This guidance may shed some light on techniques that may be used to guide motorists on traditional intersection approaches.

While roundabouts have been used extensively in European and Asian countries, they are relatively new in their deployment in North America. Before the 2009 Federal MUTCD agencies were largely free to use standard and non-standard signs and markings to convey lane assignment. Weber and Ritchie presented a paper at the 2005 Transportation Research Board's National Roundabout Conference titled Internationally Recognized Roundabout Signs *(10)*. After reviewing lane assignment sign concepts for roundabouts, Weber and Ritchie suggested use of the following principles for creating lane assignment signs for roundabouts:

- Road names, route numbers and/or destinations should always be at the top of their respective lane arrows. A horizontal bar should group two or more lanes leading to the same destination.

- The signs should have a green or blue background with a white border and white letters and arrows as per guide signs in the MUTCD.

- The lane arrows, including any left or right turn arrows, should be centered in their respective lanes and separated by dashed vertical bars. Unlike the map-type signs, arrows with "mushroom caps" should be used.

- Lanes leading to the same destination should be of equal width. The widest lane on the sign should not be greater than twice the width of the narrowest lane. Lanes bypassing the roundabout should be separated from other lanes with a turn arrow or an inclined arrow with chevron pattern.

Weber and Ritchie also suggested that the names of the routes or road names should be at the top of the arrows symbolizing the turn in the roadway and not diagrammatic by putting the names at the end of the arrows (see Figure 7). Weber and Ritchie suggest that by not making the sign diagrammatic, or a representation of the physical intersection, the sign is more compact and "easier to read" *(10)*.

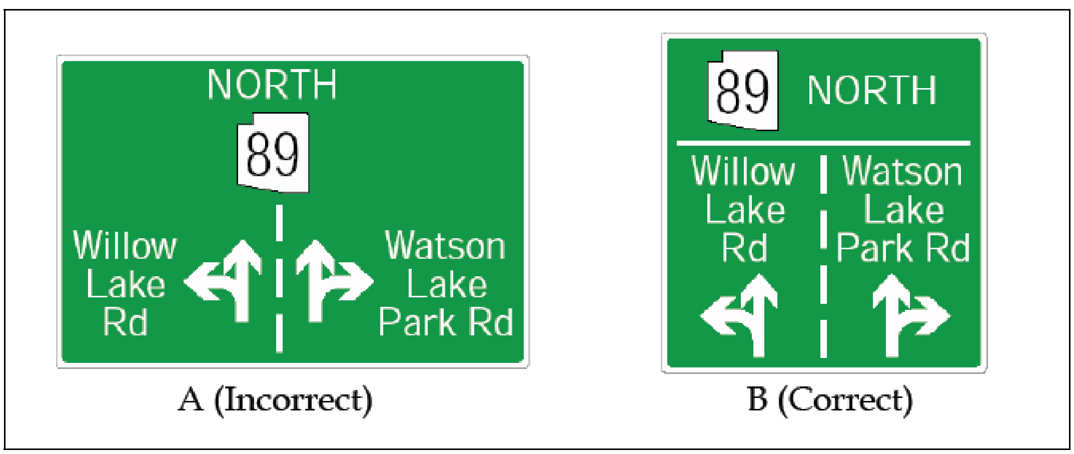


Figure 7. Roundabout Lane Assignment Signage. (*10*)

Weber and Ritchie also suggest that on low speed roundabout approaches (less than 45 mph), only one advanced warning of a roundabout's lane assignments may be needed for the approach. Roundabout approaches with speeds higher than 45 mph should have at least two sets of lane assignment signs. Additionally, at approaches with lanes that "flare to two lanes", a set of signs should be placed at the beginning of the extra lane, or lanes *(10)*.

Signs currently used in the U.S. to show lane assignments on the approach into a roundabout are illustrated in Figure 8. "Fishhook" lane assignment signs (used in both Canada and the U.S.) are similar to existing lane assignment signage used in the US. The UK uses a "guide-type" lane assignment type, which is illustrated in Figure 9.

Weber and Ritchie suggest that the fishhook lane assignment signs are good references for helping motorists making left turns at roundabouts. The illustration of the island shows the motorist not to make the left turn until after passing through the roundabout, not making the turn in front of the island. The guide-type sign may be good in situations where a roundabout has many destinations that lead away from the roundabout. One issue mentioned with respect to using the guide-type sign is that it is not a regulatory sign and cannot be enforced as such.

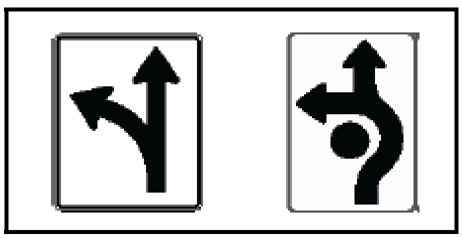


Figure 8. Standard-Type and Fishhook Lane Assignment Signs Used at Roundabouts (North America). *(10)*

Figure 9. Guide-type Lane Assignment Sign (United Kingdom). *(10)*

The fairly new use of roundabouts in British Columbia (BC) prompted the publication of a technical bulletin from the Ministry of Transportation to advise roundabout designers on the use of lane assignment signs and pavement markings *(11)*. This guide prompts designers to implement signs and pavement markings to provide "positive guidance" to motorists entering roundabouts. The concept of positive guidance is to present the motorist with lane assignment expectations before they enter the roundabout, especially when navigating a new or complex roundabout.

Signs from the Ministry of Transportation's R-500 series are used to define the lane assignments (see Figure 10). These signs may be installed overhead or on pole-mounted signs on the side of the road (both sides where a center median exists). The lane use signs are positioned approximately 50 meters (approximately 160 feet) from the Yield Line and confirmatory signs are placed between 60 meters to 120 meters (approximately 195 feet to 400 feet) back from the primary lane use signs *(11)*.

Figure 10. British Columbia Ministry of Transportation R-500 Series Signs. (*11*)

In addition to the lane use signs, the BC Ministry of Transportation specifies that a "tab" sign may be used with the lane use signs to direct motorists to the proper lane. The tab states "GET IN LANE" (see Figure 11). An additional "ROUNDABOUT" tab is used to reinforce the roundabout ahead geometry.

Figure 11. British Columbia Ministry of Transportation R-507 (ROUNDABOUT) & R-508 (GET IN LANE) Name Tabs. *(11)*

In addition to signs, British Columbia's guide states as policy that designers specify lane use pavement markings on roundabout approaches, and when necessary to install "a second set of confirmatory pavement lane use markings." This additional set of markings is intended to confirm to the motorist that they have made the proper lane choice. The pavement markings echo the lane assignments used in the lane use signs (see Figure 12). When the lane ends in a specific maneuver (for example, a left or right turn only), the word "ONLY" is also included in the pavement marking 10 meters (approximately 33 feet) before the lane symbol.

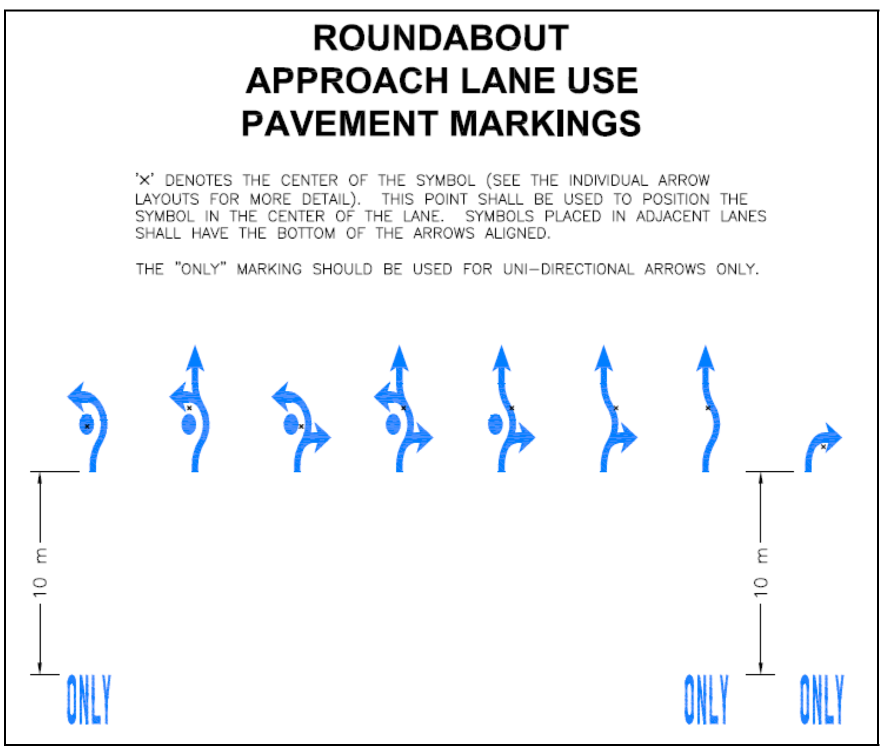


Figure 12. British Columbia Ministry of Transportation Roundabout Approach Pavement Markings. *(11)*

Design Guidance for Lane Assignment Signs and Pavement Markings – Lane Drops

Much of the literature associated with lane drops centers on freeway lane drops at exits and lane drops on the far side of intersections. However, the general consensus of these studies is that lane drops, if not signed and/or marked well, may cause driver expectancy issues. In a 1976 study, Lunenfeld and Alexander found that freeway lane drops lead to accidents, turbulence, erratic maneuvers, lost drivers and delays *(12)*. This study determined that lane drops cause accidents due to unprepared motorists needing to make multiple decisions while traveling at a high speed. Additionally, turn only lanes can lead to drivers taking undesired paths or routes.

Lunenfeld and Alexander also found that inconsistency in application of lane drops (differing treatments from state to state and at different interchanges intrastate) may lead to a "source of driver confusion." They also found that nonstandard signing, inconsistently applied signing, and unique applications of signage is potentially confusing. Lunenfeld and Alexander suggested that consistent and standardized treatments should be applied to assist drivers in making the proper decisions with respect to freeway lane drops *(12),* but there are certainly parallels with respect to driver expectancy on arterial or frontage road lane drops (either before or after the intersection).

Modified vs. Conventional Diagrammatic Signs

The TxMUTCD *(5)* defines *diagrammatic signs* as "guide signs that show a graphic view of the exit arrangement in relationship to the main highway." These graphics can be most useful for atypical interchange configurations. Frontage road configurations at intersections can also be atypical or unexpected and value may be found in studying existing research on the diagrammatic symbols used on freeways.

In 1992, the Texas Transportation Institute (TTI) compared conventional diagrammatic guide signs to modified diagrammatic signs *(13)*. The study found conventional diagrammatic signs did not convey lane assignment information as well as the modified diagrammatic signs did, especially when the sign indicated a forced lane drop as in the far right lane in the figures. Examples of a conventional arrow and a "modified arrow" concept are presented in Figure 13 and Figure 14, respectively. Although in 2007, in another TTI study focusing solely on diagrammatic signing, the results showed limited favorable performance of the modified over the conventional signing *(14)*. Only when there was a single lane drop as opposed to the optional lane drop in the example below, did the modified arrows perform better.

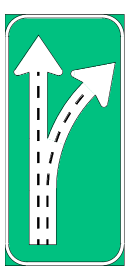


Figure 13. Conventional Diagrammatic Sign.

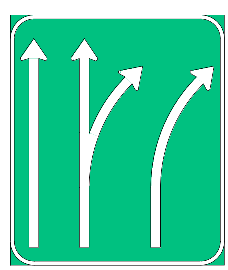


Figure 14. Modified Diagrammatic Sign.

One reason that Chrysler, et al. believed the modified arrow sign performed better for the single lane drop was because of the additional elements added to the modified diagrammatic sign. The federal MUTCD states "Route shields, cardinal directions, and destinations should be clearly related to the arrowhead, and the arrowhead should point toward the route shield for the off movement." Depending on the number of lanes, placing the mentioned information at each arrowhead will add to the complexity of a modified diagrammatic and can become visually complex *(5)*.

When comparing these two guide sign arrow formats to standard intersection lane control signing, the arrows of the modified type better represent what is used in applications of this current research. However, the regulatory lane assignment signs at intersection approaches typically do not display any route or destination information.

DOMESTIC AND FOREIGN STATE-OF-PRACTICE

This section briefly reviews the state-of-the-practice of lane assignment signs and pavement markings in the United States and other countries where lane assignment signs and markings are in use. Lane assignment signs were first introduced into the 1961 Edition of the Federal MUTCD, and very little written or verbal history was found regarding their development and inclusion into the MUTCD.

Lane assignment signs are classified in the Federal and Texas MUTCD as *guide signs* when used on freeways and expressways to direct motorists into the appropriate lanes, consisting of green background, and white arrows and text; and *regulatory signs* when used as lane-use control signs at intersection approaches, consisting of white background, and black arrows and text.

Guide Signs

According to the MUTCD, "guide signs show route designations, destinations, directions, distances, services, points of interest, and other geographical, recreational, or cultural information" (section 2A.05 Classification of Signs). In Section 2A.16, the MUTCD designates a standard for the location of guide signs. The standard says "signs requiring different decisions by the road user shall be spaced sufficiently far apart for the required decisions to be made reasonably safely. One of the factors considered when determining the appropriate spacing shall be the posted speed." Additionally the MUTCD mandates that "signs should be located on the right side of the roadway where they are easily recognized and understood by road users. Signs in other locations should be considered only as supplementary to signs in the normal locations, except as otherwise indicated" *(5)*.

Lane Control Signs

The R3-5 through R3-8 signs are designated as intersection lane control signs (see Figure 3 for the TxMUTCD R3 series signs and Figure 15 for the Federal MUTCD R3 series signs). The Federal MUTCD states that:

"Intersection Lane Control signs, if used, shall require road users in certain lanes to turn, shall permit turns from a lane where such turns would otherwise not be permitted, shall require a road user to stay in the same lane and proceed straight through an intersection, or shall indicate permitted movements from a lane."

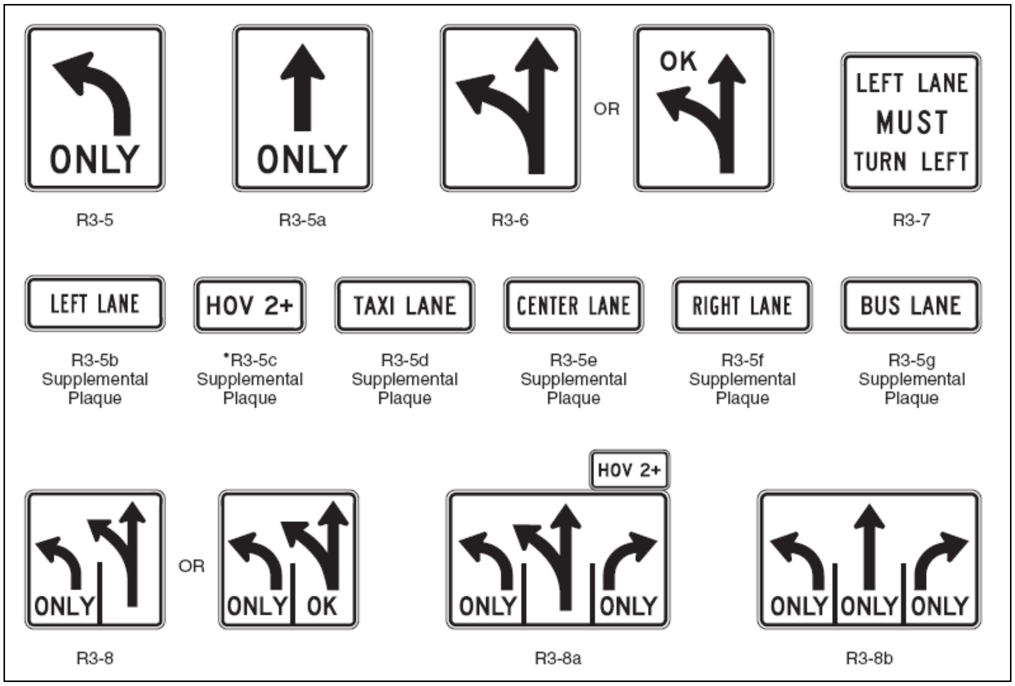


Figure 15. Federal MUTCD Lane Assignment Signs. *(16)*

The 2003 Federal and 2006 Texas MUTCD documents are similar in their applications of lane control (or intersection control) signs, and the discussion on current Texas practice above summarizes the applicable TxMUTCD sections that control lane assignment signing and pavement marking standards and practices. As stated previously, the intersection control signs are divided into three applications:

- mandatory movement lane control (signs R3-5, R3-5a, and R3-7),
- optional movement lane control (R3-6) and
- advance intersection lane control (R3-8 series).

Further guidance on the use of the signs is also provided by both the Federal and Texas versions of the MUTCD. They state a standard: *"when Intersection Lane Control signs are mounted overhead, each sign should be placed over the lane or a projection of the lane to which it applies*." Additionally the MUTCD specifies that the use of one sign does not require all lanes to be signed. In Texas, post-mounted lane assignment signs on the right side of the roadway and projected signs on signal mast arms are more common than upstream overhead gantry signing.

Regarding the use of *advance intersection lane control signs*, the MUTCD suggests that these signs may be used to indicate the configuration of all lanes ahead and that when used, they should be placed at an adequate distance in advance of the intersection so that road users can select the appropriate lane. The MUTCD further suggests that advance intersection lane control signs should be installed either in advance of the tapers or at the beginning of the turn lane.

The 2007 Federal MUTCD Notice of Proposed Amendments included a few lane use sign concepts not in the 2003 Federal or the 2006 Texas MUTCD, particularly with respect to jughandle intersections (including the proposed R3-23, R3-24, R3-25, and R3-26 series (shown in Figure 16)) *(15)*. These signs are generally text signs which might be modified to indicate from which lanes turns may be made and could be supplemented with "AHEAD" or "AT INTERSECTION" plaques as necessary.

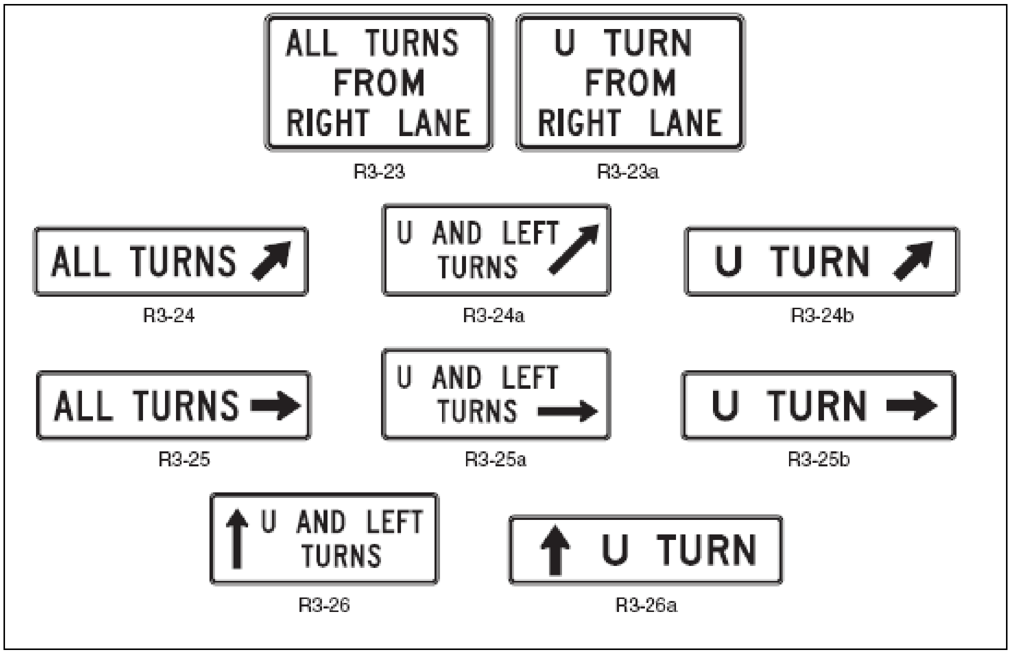


Figure 16. Proposed R3 Series Signs in 2007 Notice of Proposed Amendments for Federal MUTCD (Proposed Figure 2B-11). *(15)*

Pavement Markings

Although no specific guidance regarding distance is available for frontage road lane drop pavement markings, the MUTCD for lane drops in general states "where pavement markings are used, lane reduction transition markings shall be used to guide traffic through transition areas where the number of through lanes is reduced." This refers to the longitudinal markings where the number of lanes is reduced prior to the intersection. On a frequently asked questions webpage *(16)*, the MUTCD suggests the use of engineering judgment to determine the distance for lane drop markings when used for advance warning of lane drops on conventional roads.

Regarding horizontal pavement words and symbols, both the Federal and Texas MUTCD states that symbol messages are preferable to word messages. Examples shown in both manuals can be seen in Figures 5 and 6. The manual states that sizes may be reduced approximately one-third for low-speed urban conditions and refers to the Standard Highways Signs Handbook for further information on the proper proportion for road speed *(17)*.

The MUTCD also states as standard practice that "where through traffic lanes approaching an intersection become mandatory turn lanes, lane-use arrow markings shall be used and accompanied by standard signs." The manual also states the arrow markings for lane use, lane reduction, and wrong-way shall be designed as shown in Figure 6.

Although they are becoming rarer, two-way frontage roads still exist in Texas. TxDOT research project 0-4471-2, Field Evaluations and Driver Comprehension Studies of Horizontal Signing conducted a before and after field study on two-way frontage road treatments to reduce wrong-way movements *(3)*. White, horizontal, pavement arrows indicating the correct direction of travel proved very beneficial in reducing wrong-way driving maneuvers during this study (see Figure 17 for an example of this application).

Figure 17. View of Frontage Road Lane Use Guidance after Arrow Pavement Marking Installation. *(3)*

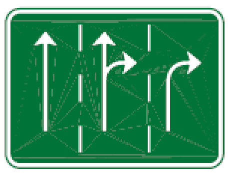
As mentioned previously, TxDOT Research Report 0-4471-2 showed that pavement markings were found to be a beneficial supplement to signing. As with signs, the number and location of the pavement markings should be studied in addition to the marking content. Elongated pavement marking arrows representing the allowed turn movement of the lane and horizontal text of the word "ONLY" are already used in practice for intersection lane control. Horizontal markings including route designation shields are becoming more common on Texas freeways and are even being used on a Houston frontage road location on the approach to multiple entrance ramps. Research project 0-4471 found survey participants very responsive to these shields for lane designation.

International Practice

Several examples of guide and regulatory signing and pavement markings that address lane assignment upstream of intersection widening were found in review of international guidelines. Presented below are findings of the review of signing and marking guidance from Australia, New Zealand, the United Kingdom and Scotland, and Germany.

Australia

Australia employs a few guide sign designs that are intended to indicate lane assignment configuration at an intersection in advance of the widening. The "Advanced Lane Designation – Multiple Panel" sign is shown in Section Four of Australia's Manual of Uniform Traffic Control Devices (Australian Standard 1742.1), in a section which pertains to guide signs. The use of these signs is specified by Australian Standard 1742.2: Traffic Control Devices for General Use *(18)*. Signs in the G9-43 series may typically be used on arterial type roads. They may be used with or without destinations or road names associated with the arrows. Signs in the series can be designed with or without destinations, see Figure 18.



Advance lane designation—multiple panel G9-43-1

Advance lane designation—multiple panel G9-43-3

Figure 18. Australian Lane Assignment Signs With and Without Destinations. *(18)*

Another sign shown in the Australian manual shows the lane assignment for each lane approaching the intersection with an optional "at signals" banner at the bottom of the sign. Figure 19 shows an example with two lanes approaching the intersection and widening to three lanes at the intersection by adding a left turn lane. A solid white quadrilateral is used to show where the lane is added in reference to the existing lanes.

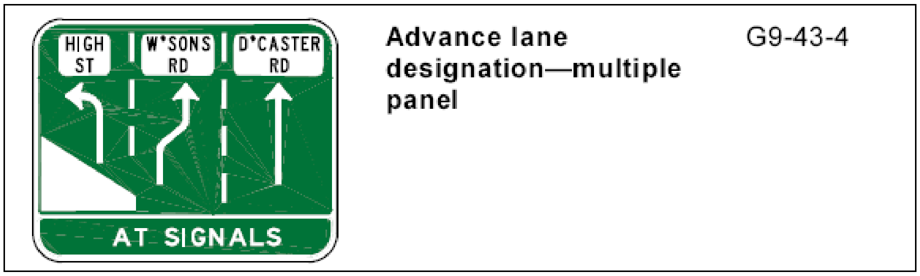


Figure 19. Australian Lane Designation Sign with Additional Lane Shown at Intersection. *(18)*

New Zealand

New Zealand's *Manual of Traffic Signs and Markings (19)* provides general reference to the use and placement of advanced lane designation signs. The manual says "advanced lane designation signs are normally only necessary on the approaches to intersections on high volume multilane roads." The New Zealand manual also notes that overhead signs are costly and that other alternatives should be used that may perform the same function. These are very similar to guide signs in the U.S.

The New Zealand manual states that advanced lane designation signs should be mounted "beside or over one or more of the intersection approach lanes." The "AL-1" series signs (see Figure 20) are mounted above the lane(s) it refers to and include an arrow that points down to the referenced lane. However, AL-1 signs are located where the designated lane is "fully developed". Additional guidance says "to be effective, these signs must be readable from a point where drivers can safely maneuver into the correct lane(s) before reaching the intersection." It appears that the New Zealand method is to provide signs that are large enough to be seen far away such that drivers may realize into what lane they need to correctly maneuver, regardless of whether the transition to a "flared" cross-section has taken place. The New Zealand manual provides no recommended placement distance for the AL-1 signs.

Figure 20. AL-1 Series Sign (Overhead), New Zealand. *(19)*

New Zealand's AL-2 series signs are placed next to (or positioned above) the lane but do not project completely over the designated lane. AL-2 signs are typically mounted just before the start of the lane and use a legend (left or right lane). An example of these signs can be seen in Figure 21. If a direction or distance is used on the sign, it is placed further in advance before the intersection.

Figure 21. AL-2 Series Sign (Roadside), New Zealand. *(19)*

New Zealand also specifies signs that are similar to the Federal MUTCD R-3 Series signs, the RG-29 Series. New Zealand RG-29 series signs "should be erected overhead in advance of an intersection having a multi-lane approach on which lane arrows are marked and where, due to high traffic volume or special lane marshalling requirements, these lane arrows are not easily seen soon enough to promote correct lane usage. A separate sign is required for each lane and the arrow(s) on the sign should indicate the same directions as the respective lane arrow(s) marked on the roadway. No other signs may be attached to the supports or the suspension members. Location: Each sign should be located approximately 15 m in advance of the intersection" *(19)*.

New Zealand allows pavement markings to be used with advanced lane designations in a similar manner as the Federal MUTCD. The following legislation shows when pavement markings need to be used:

- A road controlling authority may mark lane arrows before any intersection or entrance where traffic approaches in more than one-lane, to restrict the movements which drivers in those lanes may make at the intersection or entrance,
- Any two lane arrows may be combined to show the movements required or permitted from that lane,
- Lane arrows must be marked far enough in advance of the intersection or entrance to which they apply to give drivers adequate warning of the movements permitted from that lane, and
- Signs showing the movements required or permitted by lane arrows marked on the road may be erected above the lane.

The manual specifies that these arrows be used to direct motorists to the correct lane to make specific turns and should not be used when no restriction on movements exists. No pavement markings were provided in the New Zealand guidance for advance lane assignment *(20)*.

United Kingdom and Scotland

The United Kingdom's Traffic Signs Manual specifies signing and marking concepts used in the U.K. and Scotland. Chapters 5 (Road Markings) and 7 (The Design of Traffic Signs) contain applicable concepts that are used for advance lane assignment guidance and regulation. *United Kingdom Traffic Signs Manual Chapter 5 – Road Markings*.

Chapter 5 of the U.K. guideline addresses pavement markings, and contains detailed sections on lane destination markings *(21)*. Section 9 of this chapter, Signal Controlled Junctions, is clear for the intent of the use of markings for lane assignments:

> *"LANE DESTINATION MARKINGS 9.9 It is essential that drivers are made aware in good time of the correct lane to use at signaled junctions. Where lanes are indicated for left or right turn movements only, it is particularly important that early notice is given by the use of the appropriate lane arrow, repeated as necessary. If this is neglected, drivers are likely to become trapped in the wrong lane. A lane arrow should be used at the start of a newly formed lane, and at heavily-trafficked junctions the lane markings should be extended sufficiently far upstream to cope with peak flows. The use of lane arrows and lane destination markings is described in paras 13.1 to 13.5, and para 13.6 indicates where traffic regulation orders are required (21)."*

Highlights of Section 13 of Chapter 5 include guidance in relation to:

- Direction Arrows (see Figure 22)
  - The use of lane arrows (called "direction arrows") to give drivers advance indication of the correct lane. Where provided, use two direction arrows, but three may be used where necessary. Guidance states to place these direction arrows far enough back to where the longest peak hour queue does not block their view, but not in advance of a previous intersection so to cause confusion.
  - Only two arrow heads may be on each direction arrow.
  - Arrow size and minimum distances from the stop line are given, and they are based on speed limit.

- Worded Lane Destination (see Figure 23)
  - These markings reinforce information shown in advance direction guide signs placed on the approach to intersections.
  - They are typically words used in combination with arrows.
  - Intended as an alternative indication in case the advance signs were obscured.
  - Two sizes of words are used, 1600 mm (63 in.) for 40 mph and less speed limit, and 2800 mm (110 in.), used with speed limits greater than 40 mph.

- Mandatory Turn Arrows (see Figure 24). These lane arrows that are supplemented with the legends "TURN LEFT", "TURN RIGHT", and "AHEAD ONLY" are used only where regulated lane movements exist. These markings are used to reinforce protected turns and traffic signals (similar to "ONLY" in the U.S.).

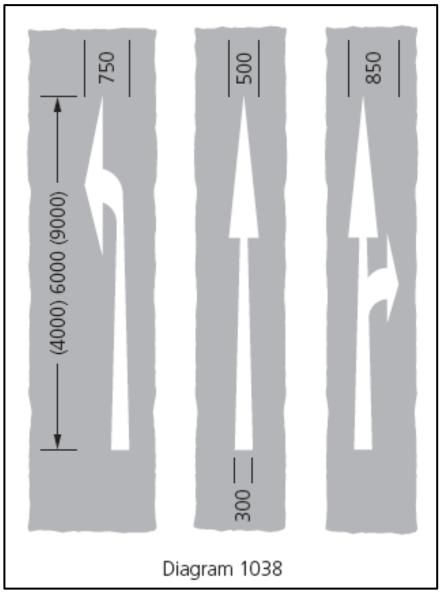


Figure 22. Direction Arrows, United Kingdom. *(21)*

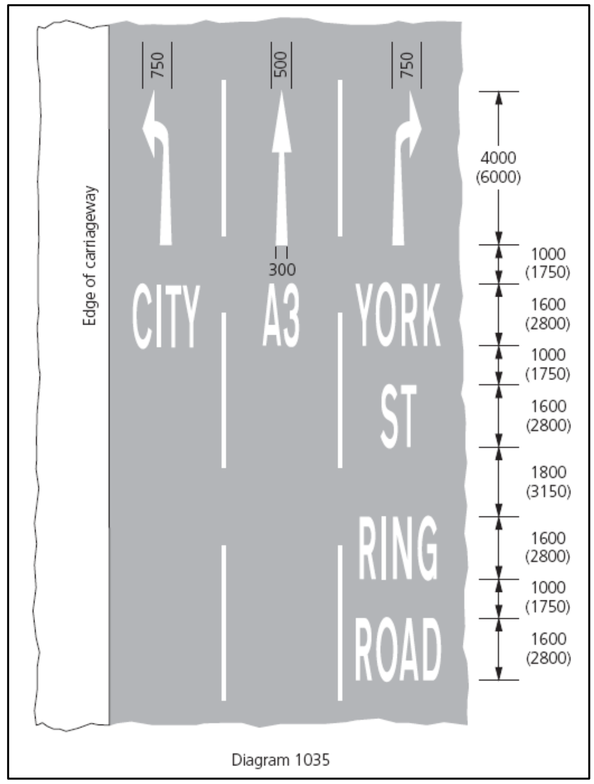


Figure 23. Worded Lane Destinations. *(21)*

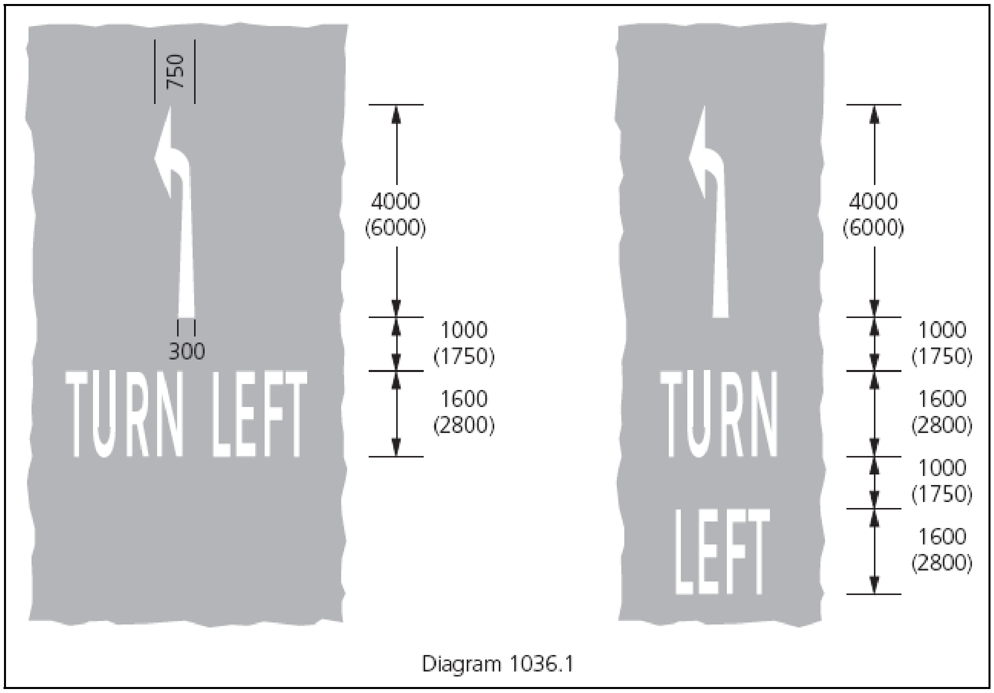


Figure 24. Mandatory Turn Arrows, United Kingdom. ***(21)***

Traffic signs in the United Kingdom seem to use guidance and regulation hand-in-hand when applied to advanced lane assignment signing. Color is used differently than in the U.S., with green, light blue, and white background signs being used as guide signs for different classes of roadways (light blue – motorways/highways, green – primary routes, and white – non-primary routes). Section 6 of the *United Kingdom Traffic Signs Manual Chapter 7: Design of Traffic Signs* deals with Dedicated Lane Advance Direction Signs, which designate lane use by destination *(22)*. These signs are used at intersections or at ramps for highways. Figure 25 shows an example of such signs.

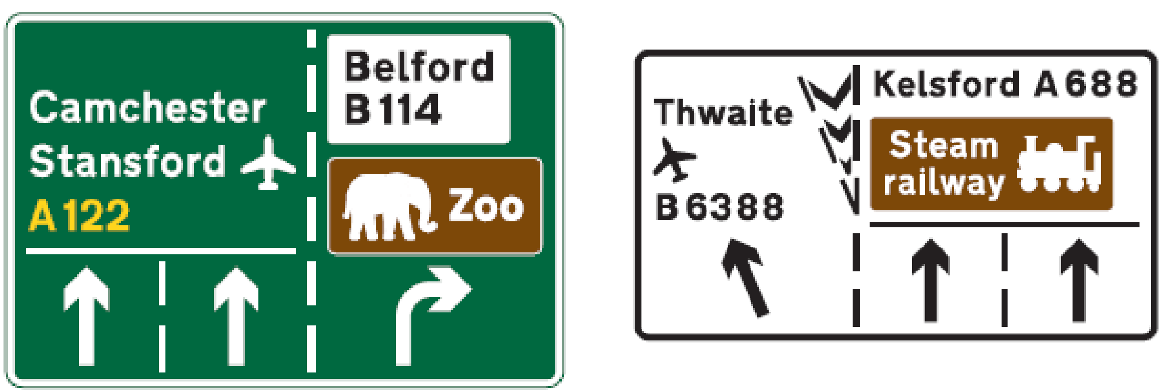


Figure 25. Examples of Dedicated Lane Advance Direction Signs, United Kingdom. ***(22)***

Signs in Figure 26 are used in both the United Kingdom and Scotland to show lane assignments on roadways and at intersections *(23)*. When overhead signs are used, an arrow points directly over the lane and is coupled with a destination sign. When multiple lanes go to the same destination, the destination is grouped together on one sign. On signs that are mounted on the side of the road, the lanes are grouped together on one sign. Each lane is designated by a vertical dashed line and has an arrow to show the movement ahead. Additionally, lane assignment signs can be made without destinations. These signs designate the permitted movement that will be allowed in the lane ahead with an arrow in each lane.

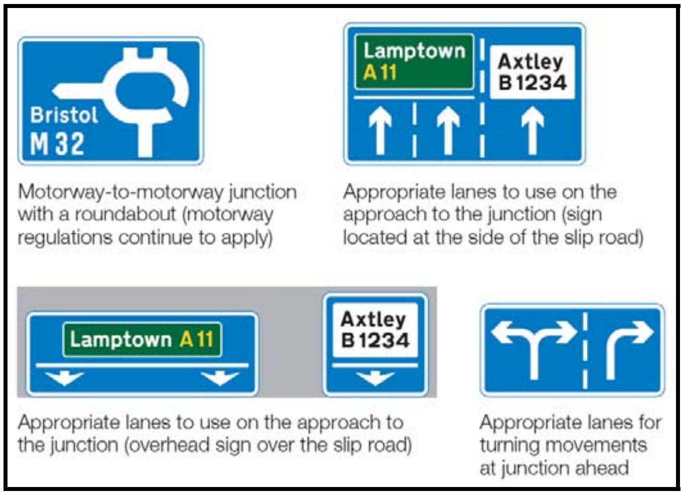


Figure 26. United Kingdom/Scotland Lane Assignment/Guide Signs. *(23)*

Other U.K. signs, shown in Figure 27, are provided to show the motorist the appropriate lane to use for specific movements.

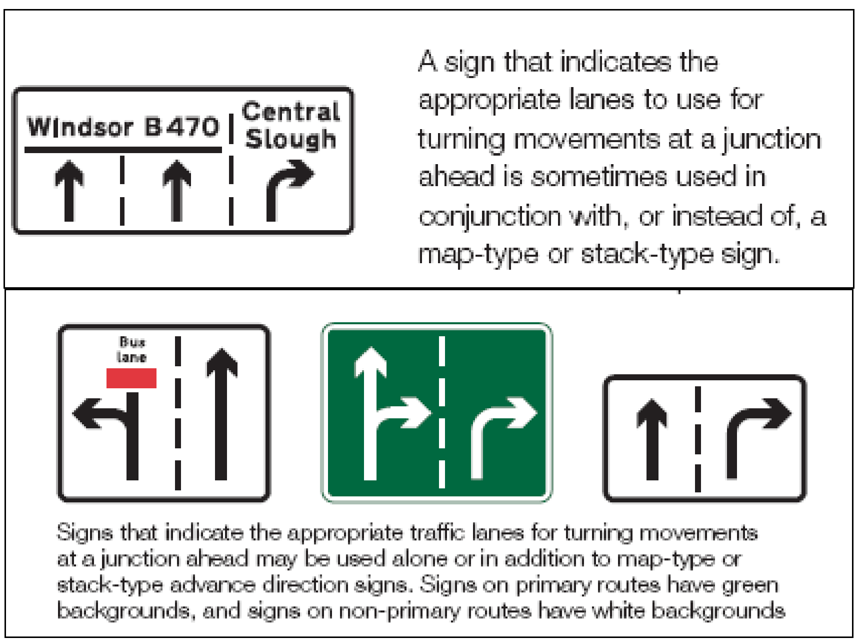


Figure 27. Lane Assignment Signs, United Kingdom. *(23)*

Additional signs shown in the Department of Transport's guide use the filled-in quadrilateral to show lane use signs for both lane reduction and lane addition ahead signs. Examples of both types of signs are shown in Figure 28.

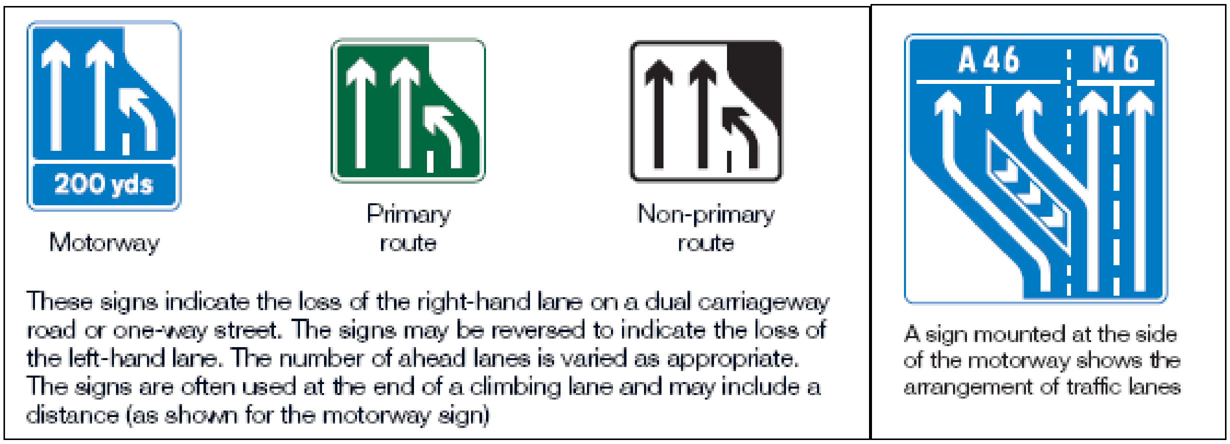


Figure 28. Trap Lane and Additional Lane Use Ahead Signs, United Kingdom. *(23)*

Germany

The German Road Traffic Code (*Straßenverkehrs-Ordnung*) *(24)* provides examples of signs and pavement markings applied in Germany in advance of lane drops and additions, and on approach to intersections. A website provided to help tourists in Germany, *Brian's Guide to Getting Around Germany (25)* presents good examples of several signs used in Germany to convey lane additions and drops (see Figure 29). As illustrated, the lane assignment signs in Germany use arrows to represent each lane of traffic. These signs are used to show when lanes are reduced or added. The straight arrows represent lanes that provide a continuing through movement. When a lane ends, the arrow curves toward the lane that the motorist should merge into from the lane that is ending. Similar signs show mandatory movements (see Figure 30). The German Road Traffic Code also shows the use of pavement markings to denote advance lane assignments, but does not provide substantive guidance as to their application.

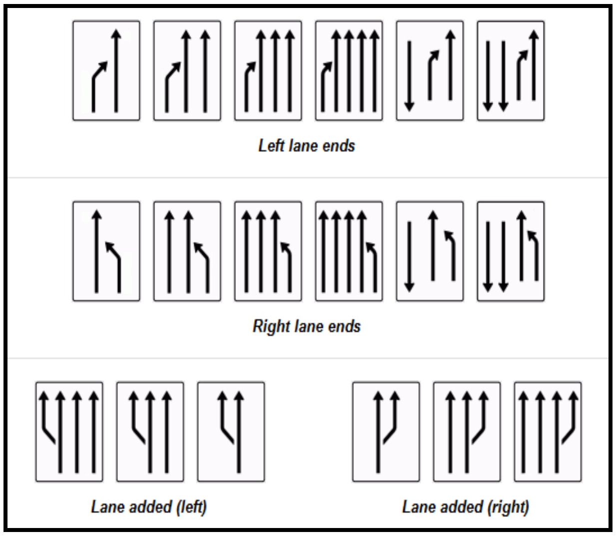


Figure 29. German Lane End and Lane Add Signs. ***(25)***

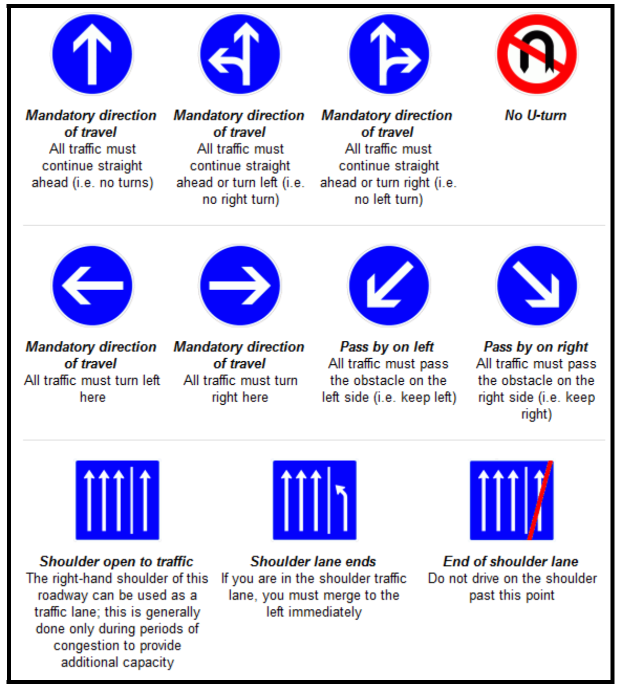


Figure 30. Mandatory Lane Use Signs, Germany. ***(25)***

CHAPTER 4: PRACTITIONER SURVEYS

This chapter summarizes the objectives and results of surveys of practitioners both in Texas and in United States state and territories. The intent of the survey was to glean whether districts in Texas or other states had flared approach interchanges with atypical or problematic lane assignments and what countermeasures are used to address them. In addition, information was sought regarding the current practices for design and placement of signs and markings being implemented to address atypical lane assignments. Both Texas and national surveys are summarized in this chapter, and detailed responses are provided in Appendix A for reference.

Both Texas and National surveys were developed with the intent of determining if Texas districts and states had flared approach interchanges with atypical or problematic lane assignments and how those issues are addressed (what countermeasures are used, etc.). In addition, information was sought regarding current practices for design and placement of signs and markings that are being implemented as countermeasures to address atypical lane assignment issues within Texas. The survey was structured in five sections so as to:

1. Identify agency experience related to the presence of flared approach interchanges that have atypical (something most drivers would not expect) lane assignments and any adverse impacts of such lane assignments (e.g., an increased number of crashes, public or law enforcement concerns) and determine countermeasures employed to address any issues related to atypical lane assignments and the impact of these countermeasures.

2. Gather general information regarding the use of advance intersection lane control signs (LCS), standards, or specifications used for design and placement of signing and pavement markings meant to address atypical lane assignments, obstacles encountered in the field during installation, and criteria for implementing advance lane assignment signs and pavement markings at an approach.

3. Identify current practice regarding sign placement including the type of sign placement employed by the districts and states (i.e., overhead, roadside mounted), the criteria for using and not using overhead signs, and the location of advance LCS both for overhead and roadside-mounted signs.

4. Identify current practice regarding sign design concepts including how to convey location of an additional lane (whether lane is being added on left or right side), use of advance LCS for trap lanes (or lanes that drop beyond an intersection point), inclusion of supplemental information, and signing and markings at cloverleaf-type interchanges.

5. Identify current practice regarding location and use of pavement markings for lane assignments and other supplemental information.

SURVEY OF TXDOT DISTRICT STAFF

The survey (in both Microsoft Word® and a Portable Document Format (PDF) formats) were emailed to all TxDOT district transportation operations engineers in August 2009. Of the 25 districts surveyed, detailed responses were obtained from 19 districts (76 percent). One district responded that they did not have any atypical interchanges within its jurisdiction and therefore did not complete the survey, and five districts (20 percent) did not respond to the survey. Therefore, an overall 80 percent response rate was realized for this survey. Table 1 shows the TxDOT districts and corresponding responses to the overall survey.

Table 1. TxDOT District Survey Response.

TxDOT District	Survey Response	TxDOT District	Survey Response
Abilene	Completed	Laredo	No response
Amarillo	Completed	Lubbock	Completed
Atlanta	Completed	Lufkin	Completed
Austin	Completed	Odessa	Completed
Beaumont	Completed	Paris	No response
Brownwood	Did not complete	Pharr	Completed
Bryan	Completed	San Angelo	Completed
Childress	Completed	San Antonio	No response
Corpus Christi	Completed	Tyler	No response
Dallas	Completed	Waco	Completed
El Paso	Completed	Wichita Fall	Completed
Fort Worth	No response	Yoakum	Completed
Houston	Completed		

Findings

Both the individual survey questions and their results are presented in Appendix A. All results are shown as a percentage of the total TxDOT districts (19) responding to the survey. Results for some questions are also shown as a percentage of the number of respondents for each of those questions when number of respondents for the question was less than the number of total respondents to the survey.

Interchanges that have flared approaches and atypical lane assignments are quite common in Texas. Thirty-seven percent (37%) of TxDOT districts that responded to the survey reported problematic lane assignments at interchanges that cause operational and safety issues. TxDOT staff reported that the atypical lane assignments at interchanges may cause public motorist concern and law enforcement concerns and can also be a contributing factor for increased crashes. The countermeasures being used by TxDOT districts to address operational and safety issues at flared interchanges include both standard lane control signs (mandatory, optional, and advance) and some non-standard techniques, including modified lane control signs, pavement markings, interstate route shields, guide signs, divided highway signs, and multiple sets of pavement markings. Some of the common reasons for employing countermeasures include drivers illegally turning from through lanes, drivers making indecisive and late lane changes, and drivers making illegal through movements from turn-only lanes. The countermeasures were found effective in addressing operational and safety issues as observed by TxDOT personnel, however, no studies were either completed or available to document the effectiveness of these measures.

Advance intersection lane control signs are commonly used at approaches that have turn-only lanes, trap lanes, and more lanes at the intersection than upstream. Some districts also use advance intersection lane control signs when there are long queues and drivers cannot see the mandatory lane control signs until they are near the intersection. The TxMUTCD (*5*), along with *Texas Sign Crew Field Book* (*26*) and *Texas Freeway Signing Handbook* (*1*) are the most commonly used standards and guidelines for design and placement of lane assignment related traffic control devices. District-developed policies and engineering judgment are also used for design and placement of lane assignment traffic control devices at interchanges with flared approaches.

The most commonly encountered obstacles during placement of lane control signs in the field include other existing signs, upstream geometric features (e.g., exit ramps), obstruction of sight distance, and trees. Private driveways and utility poles also sometimes pose challenges to placement of lane control signs.

Turn-only lanes are the most commonly used criteria for implementation of advance lane assignment signs and pavement markings, followed by public complaints about confusing geometry and more lanes at the intersection than upstream. Different lane arrangement compared to all other intersections along the roadway, agency policy, and crash patterns are also used as criteria for implementing advance lane assignment signs and pavement markings.

From an agency perspective, type of sign placement plays a role in terms of initial cost and ongoing maintenance, as well as right-of-way requirements. Roadside-mounted signs for lane assignments are more common as compared to overhead-mounted signs. The decision to mount advance intersection lane control signs overhead is generally based on field conditions, including high traffic volumes, limited sight distance, other visual obstructions, intersections with dual turn lanes, and proximity to freeway exit ramps. District policy is also a factor for use (or non-use) of overhead-mounted advance lane control signs. Districts stated that reasons for not using overhead-mounted signs include initial cost, ongoing maintenance requirements, and availability of right-of-way.

When using roadside-mounted advance lane control signs, more TxDOT districts prefer to use a complete sign (showing assignment for all lanes at the intersections) compared to a split sign on either side of the roadway showing optional lane assignment. Roadside-mounted advance lane control signs are typically installed at the taper of the additional lane. However, when roadside signs are mounted at multiple locations, they may be located upstream of the beginning of the additional lane and at the intersection. The number and spacing of signs is determined based on both field conditions and engineering judgment. No consistent guidelines or standards appear to be available for deciding how far ahead of the intersection these signs should be placed.

Overhead advance lane control signs are most commonly mounted on the signal mast arm or span wire. When placed upstream of the beginning of an additional lane or a certain distance ahead of the intersection, the decision regarding distance is based on field conditions and engineering judgment and not on any stated or standard criteria.

There are some differences among districts on the application of advance lane control signs. The Austin District splits the advance lane control signs such that left-turn and through signs are used on the left side and right-turn-only signs are on the right side in order to inform motorists as to which side of the roadway the lane would be added. The Pharr District installs advance lane control signs on the same side of the roadway that the lane is being added. However, all other districts indicated they do not have any standard way to inform motorists as to which side of the roadway a lane is being added. Some districts implied that a more uniform and standard practice for advance intersection lane control signs may help motorists understand better which side of the road the lane will get added. Using advance intersection lane control signs for through lanes that become either turn-only lanes at the intersection or trap lanes is a common practice. However, the number of signs used and the spacing between signs varies among TxDOT districts, and they are typically based on site conditions and engineering judgment. While the TxMUTCD, *Texas Sign Crew Field Book*, and *Texas Freeway Signing Handbook* are the most commonly used references for design and placement of lane assignment related traffic control devices on cloverleaf-type interchanges specifically, some TxDOT districts feel there is a need for additional guidance for signing and marking on these interchanges.

Finally, district staff generally indicated that advance lane control pavement markings are used to supplement lane control signs and are usually located at the beginning of the additional lane or near the intersection. There are no standard criteria being used for deciding the distance of pavement markings from the intersection, with the decision typically based on field conditions and engineering judgment.

Overall the TxDOT district survey results suggest engineering judgment is extensively and/or exclusively used in making decisions for design and implementation of lane assignment control signs and markings. There are no standard guidelines regarding spacing between signs, distance from the intersection for sign placement, or the number of signs that should be used. Some districts have developed district-level policies, standards, and typical applications for use within that district; however, these practices vary widely from district to district.

SURVEY OF U.S. STATE DEPARTMENTS OF TRANSPORTATION

The surveys (in Word and PDF formats) were emailed to each of the 50 state chief traffic engineers, the chief traffic engineer of Puerto Rico, and the chief traffic engineer of Washington, D.C. in August 2009. Of the 52 surveys, detailed responses were obtained from 17 states as shown (shaded) in Figure 31. Therefore, an overall 37 percent response rate was realized for this survey.

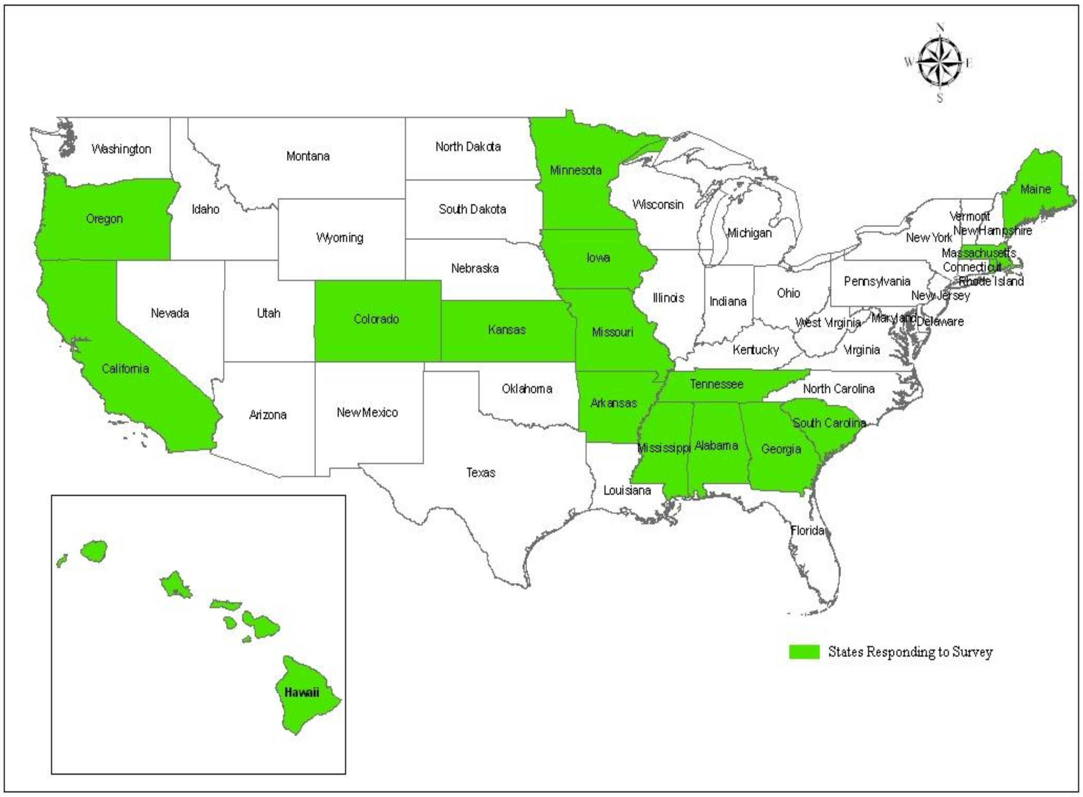


Figure 31. States Responding to the National Survey.

Findings

Both the individual survey questions and their results are displayed in Appendix B. All results are shown both as a percentage of the total respondents for the survey (17) and as a percentage of the total respondents for each individual question where number of respondents for a question is less than the number of respondents for the overall survey.

Interchanges that have flared approaches and atypical lane assignments are common in the states that responded to the survey. Fifty-nine percent of states that responded to the survey reported problematic lane assignments at these interchanges that result in operational and safety issues. The atypical lane assignments at these interchanges cause public and law enforcement concerns and can also be a contributing factor for increased crashes.

The countermeasures being used by states to address operational and safety issues at flared interchanges include both standard lane control signs (mandatory, optional, and advance) and some non-standard techniques such as modified lane control signs (shared U-turn and left-turn or a shared left/through/right sign), pavement markings (lane drop markings), and special signage for multi-lane roundabouts, bus-on-shoulder operations, etc. Some of the common reasons for employing countermeasures include: illegal turns from through lanes, indecisive and late lane changes, illegal through movements from turn-only lanes, operational and crash issues, and standard practice. The countermeasures are generally effective in addressing operational and safety issues; however, no study is available to document the effectiveness of these measures, and the effectiveness varies from location to location.

Advance intersection lane control signs are used at approaches that have turn-only lanes, trap lanes, and more lanes at the intersection than upstream. The decision to implement advance lane control signs is based on need, engineering judgment, traffic conditions, and intersection geometry. Federal MUTCD or state MUTCDs and/or engineering judgment are commonly used for design and placement of traffic control devices providing guidance for lane assignment at interchanges with flared approaches.

Commonly encountered obstacles during placement of lane control signs in the field include other signs and upstream geometric features such as exit ramps, utility poles, and trees. Private driveways and sight distance triangle also create challenges to placement of lane control signs.

Public complaints about confusing geometry are the most common criteria used for implementation of advance lane assignment signs, followed by turn-only lanes and more lanes at the intersection than upstream. Different lane arrangement compared to all other intersections along the roadway and crash patterns are also used as criteria for implementing advance lane assignment signs.

Crash patterns are the most commonly used criteria for implementation of advance lane assignment pavement markings followed by public complaints about confusing geometry and more lanes at the intersection than upstream. Agency policy, more lanes at the intersection than upstream, and turn-only lanes at the intersection are also used as criteria for implementing advance lane assignment pavement markings.

Roadside-mounted signs for lane assignments are more common as compared to overhead mounted signs. The decision to mount advance intersection lane control signs overhead is generally based on engineering judgment and observed operational issues. Reasons for not using overhead-mounted signs include initial cost, maintenance cost, lack of need for overhead mounting, and availability of right-of-way.

When using roadside-mounted advance lane control signs most states use the complete sign showing assignments for all lanes at the intersections. Roadside advance lane control signs are usually mounted at the beginning of the additional lane, and sometimes are also located upstream of the beginning of the additional lane and at the intersection. The signs installed at the beginning of the additional lane are placed as close to the beginning of additional lane as practical in the field.

Overhead advance lane control signs are most commonly located at the beginning of additional lanes. These are also sometimes placed upstream of the beginning of additional lanes or on a signal mast arm/span wire. The decision regarding distance is based on field conditions, engineering judgment, and availability of overhead structures, but it is not based on standard criteria.

There is no standard way to inform motorists as to which side of the roadway a lane will be added. A standard practice needs to be developed for advance intersection lane control signs. Using advance intersection lane control signs for through lanes that become turn-only lanes at the intersection is a common practice. Usually one sign at the beginning of the taper of the additional lane is used. Some states use two signs, one at beginning of taper and a second at the intersection. Additionally, some states have distance criteria, but others use engineering judgment for spacing of these signs.

Most states that responded to the survey do not include cross-street names on the advance lane assignment signs or any other supplemental information as pavement markings. However, information regarding cross-street names, distance to intersection, and distance to turn lanes are considered important for inclusion on advance lane assignment signs, and information regarding cross-street names, yield to bikes, and distance to turn lanes are considered important for display as advance pavement markings.

The federal MUTCD or state MUTCDs are commonly used for design and placement of lane assignment traffic control devices on cloverleaf-type interchanges. A few states feel there is need for additional guidance for signing and marking of cloverleaf-type interchanges, though most states feel sufficient guidance is available.

Finally, advance lane control pavement markings are used to supplement lane control signs and are usually located at the beginning of the additional lane or near the intersection. Most states use field conditions and engineering judgment to decide the distance of pavement markings from the intersection.

CHAPTER 5: DEVELOPMENT OF ALTERNATIVES

TTI researchers developed two human factors studies to assess drivers' understanding of standard and alternative signs and markings for lane assignment at frontage roads and conventional roads. However, before designing the studies, researchers used the information found in the literature review and practitioner surveys to develop a set of alternatives and concepts to test. These concepts and some of the resulting signs and markings are explained in this chapter.

SIGN SPLITTING

Because six of the responding 19 TxDOT districts said they would consider splitting advance lane assignment signs (putting part of the information on the left side and part on the right side of the road as shown in Figure 32) researchers wanted to test this concept with drivers. Researchers suspected that dual posting of a lane assignment sign with five or more lanes shown could become information overload; although they recognized that placing the sign on only one side of the road may not be adequate if the sign was blocked from view by another vehicle. This is where the concept of sign splitting can be applied.

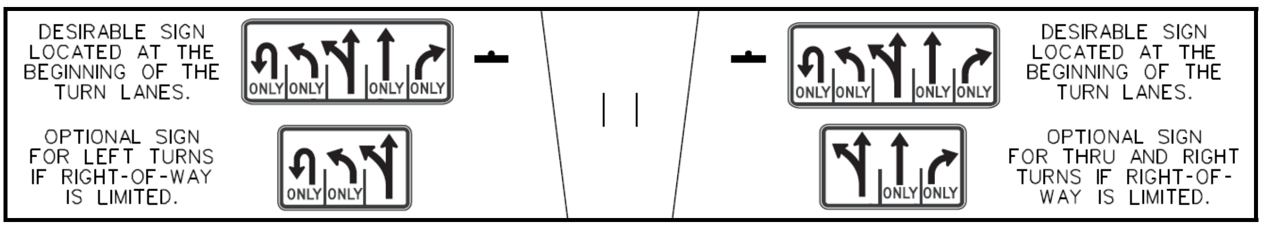


Figure 32. Example of Sign Splitting (*1*).

There are several ways that the sign information can be split:

- If there is an even number of lanes, half of the total lanes are represented by a sign on the left sign, and half on the right;
- If there is an odd number of lanes, the information is split with the center lane represented on both sides (as in Figure 32);
- Only lanes with an exclusive or optional turn movement are represented on the signs (split appropriately on either side of the road); or
- Only lanes with an exclusive turn movement are represented on the signs (split appropriately on either side of the road).

OVERHEAD LANE ARROWS

Of the responding TxDOT districts in the practitioner survey, 42 percent responded that they use overhead and roadside-mounted signs for advance intersection lane control.

Section 2B.20 of the TxMUTCD *(5)* provides guidance that when intersection lane control signs are mounted overhead, each sign should be placed over the lane or a projection of the lane (e.g., on a mast-arm across from the approach) to which it applies. However, it provides that the use of an overhead sign for one approach lane shall not require installation of overhead signs for the other lanes of that approach. It also provides the option that where the number of through lanes on an approach is two or less, the intersection lane control signs may be overhead or ground-mounted.

Researchers wanted to explore overhead sign options in the human factors evaluations. In practice, overhead lane assignment arrows have varied in placement and also in color. The lane arrows have been represented on a single sign like on typical ground-mounted signs but are also often placed individually over the corresponding lanes. Sometimes, the individual signs are placed on a mast arm, while they can also be mounted on an overpass. The individual signs have been seen as black-on-white and also white-on-green signs.

COMBINATION SIGNS

Researchers also wanted to explore the concept of combination signs that contained both lane assignment and street/directional information. Figure 33 shows two examples of signs found in New Mexico (shown on left), as well as two examples developed by the research team (shown on the right).

Figure 33. Example Concepts of Regulatory/Guide Combo Signs.

GUIDE SIGN ARROW FORMAT AND PLACEMENT

Arrows are used extensively on guide signs marking turns at unsignalized intersections of freeway frontage roads and cross streets. Typically, when seen on the same sign, horizontal arrows are used for the most immediate turn, with a vertical or through arrow for the second turn. The turn arrow is placed on the side of the sign that matches the side of the road from which the turn is made. The through arrow typically is placed on the side of the sign adjacent to the roadway.

Researches wanted to look at how the appearance and placement of the arrows would alter drivers' impressions on where the turn was and what side of the road it was on. Several concepts would be tested:

- Do right-angled arrows give the perception that the driver must pass the first turn before coming to his or her desired turn?

- Do any of the arrow types imply a sense of urgency to where the turn is?
- Does the placement of an arrow on the left or right side of the sign change the driver's perception of the side of the road from which the turn is made?
- Do arrows that more closely represent the shape of the roadway help drivers to understand where a turn is?

Figure 34 and Figure 35 show arrow concepts that would be tested in the driver studies.

Figure 34. Examples of Arrow Concepts for Frontage Road Approach to an Unsignalized Intersection or Interchange.

Figure 35. Examples of Arrow Concepts for Cross-Street Approach Signing to an Unsignalized Intersection or Interchange.

SUPPLEMENTAL PLAQUES AND PHRASES

The federal *(4)* and Texas MUTCDs *(5)* use many words and phrases to assist in lane assignment comprehension. Guide signs may use phrases such as "KEEP RIGHT," "NEXT SIGNAL," or "2nd RIGHT" where regulatory signs may use "AHEAD," "ONLY," or "OK." Researchers wanted to test and compare some of these phrases and words to determine if any were better understood by drivers and/or if any were so poorly comprehended that they should not be used at all.

ADVANCED PAVEMENT MARKING CONCEPTS FOR LANE DROPS

Although supplemental to signs, pavement markings can be very beneficial in informing a driver of what is to come, especially when there is a lane drop. Researchers wanted to test four concepts as seen left to right in Figure 36: the "ONLY" text and arrow traditionally used at the intersection, the "ONLY" text and arrow followed by the text "AHEAD." text reading "TURN ONLY AHEAD," and the "ONLY" text and arrow with longitudinal lane drop markings.

Figure 36. Advanced Pavement Marking Concepts for Lane Assignment.

LANE ASSIGNMENT SIGN GEOMETRY

Finally, researchers wanted to develop and test new lane assignment concepts based on what was found in the literature review. Signs such as those shown in Figure 37 and Figure 38 from Australia and the United Kingdom, respectively, introduce ideas such as a geometric taper to indicate a lane addition or reduction. Figure 39 from Germany shows how an arrow can be reconfigured to indicate that a lane is being added to existing lanes.

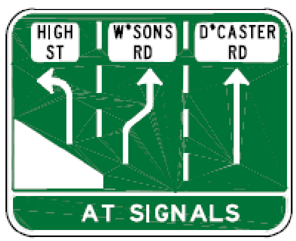


Figure 37. Australian Lane Designation Sign with Lane Addition Taper. *(18)*

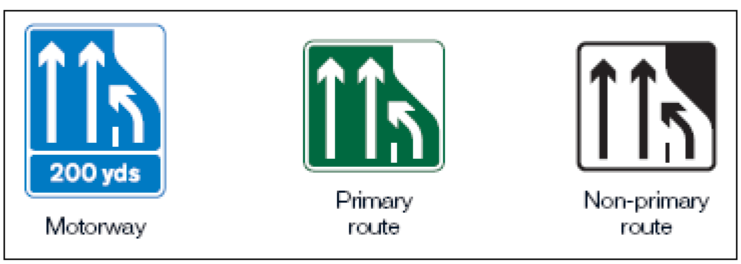


Figure 38. United Kingdom Trap Lane and Additional Lane Use Ahead Signs with a Lane Reduction Taper. *(22)*

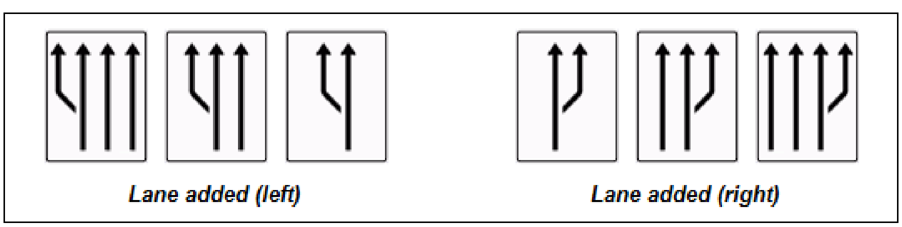


Figure 39. German Lane Addition Signs. *(24)*

The project team wanted to explore the international lane assignment signing concepts as shown in Figure 37, Figure 38, and Figure 39 in driver surveys and focus groups, but with the look and feel of current MUTCD standards for lane assignment signs. Figure 40 shows three example concepts the researchers developed based on the foreign sign designs. The first sign on the left uses what will be referred to as a "lane addition arrow," the second a "lane addition taper," and the third a "lane drop block." Various combinations of these concepts would be tested in the driver surveys. The research goal was to develop signs with arrows that best created a visual for the driver of what the lanes ahead would do.

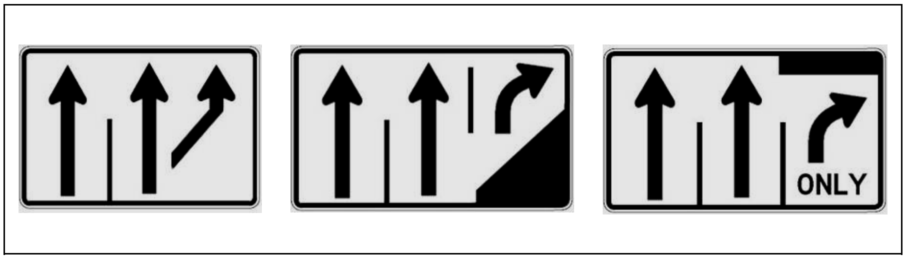


Figure 40. Lane Assignment Geometric Concepts.

CHAPTER 6: FOCUS GROUPS

In order to assess driver assumptions about lane assignments on frontage roads approaching interchanges and complex intersections, TTI researchers conducted focus groups with Texas drivers. The focus group discussions were primarily open-ended discussions about frontage road and arterial intersections and what drivers believe will happen to each of the lanes at the intersections. Discussion included driver thoughts on what signs and markings are needed to mark these intersections and what they believe signs and markings should look like. In development of the discussion guide, the researchers created the following list of questions to address the following topics:

- Driver concerns about frontage road signing;
- Driver assumptions made as they approach an intersection, specifically as to how lanes will be added and dropped at the intersection;
- Driver cues, beyond signs and markings, used when approaching an intersection to make decisions;
- Types of intersection approach configurations that violate driver assumptions;
- Whether drivers believe it is necessary to place signs that convey cross-street information, and how they think signs should be used;
- How drivers use pavement markings in making a lane choice decision;
- When drivers believe that markings or signs only are sufficient;
- Driver impressions on overhead signing; and
- Driver expectations regarding a U-turn lane.

This section provides a description of the visuals for the focus group, a short summary of the discussion, and recommendations which were taken forward for further evaluation in the driver survey task. Although the focus group participant responses have been summarized in the body of this report, readers are encouraged to read the full transcripts of the focus groups, found in Appendix C, to gain the full understanding of participants' thoughts.

PROCEDURE

A total of 39 Texas drivers participated in the focus groups: 16 men and 23 women. They ranged in age from 20 to 75, with an average age of 49 and an average of 32 years of driving experience. Researchers conducted the focus groups in TTI offices in College Station, San Antonio, Austin, and Houston. Table 2 shows a breakdown of age and gender demographics of the drivers.

Table 2. Demographics of Focus Group Participants.

City	Total Number	Number of Men	Number of Women	Age Range
College Station	10	5	5	34-75
San Antonio	10	4	6	20-67
Austin	9	4	5	38-70
Houston	10	3	7	39-67
Totals	**39**	**16**	**23**	**20-75**

The focus group relied on a PowerPoint® presentation that consisted of unaltered roadway photographs as well as photographs that had been digitally edited to include sign designs. The facilitator worked from the same script for each group. The focus group facilitator presented images of signs and roadways to the groups to prompt discussion on lane assignment on the approach to various intersections. A digital projector displayed the images via computer on a screen in the conference rooms where the focus groups took place. The majority of the visuals were photographs taken by the researchers or obtained from the Google™ Earth software program. In some cases, researchers digitally edited photographs in order to present signs in a roadway context and to present different versions of the same sign. One portion of the discussion involved participants individually providing answers about roadway signing and configurations. Before beginning the study, the participants were asked to read a Study Consent Form, providing their consent to participate in the study (as presented in Appendix D).

DISCUSSION TOPICS AND COMMENT SUMMARY

The focus group topics and slides used in the discussion are presented in this summary section. The first few slides showed welcome messages and procedural details. After personal introductions, the facilitator introduced the topic and said the discussion would focus on what assumptions are made while driving as you approach an intersection. The facilitator began by asking the participants if they had ever been on a frontage road approaching an intersection and found themselves in the incorrect lane. Although they gave different reasons, there was consensus that everyone has found themselves in this situation. It was expressed that the common issue was unfamiliarity; either with what the lanes do at the intersection or with the cross street itself.

Drivers appeared to largely rely on signs and arrow pavement markings as visual cues to determine which lane they should be in on approach to an intersection. They also reported watching how other traffic behaved downstream to identify if a particular lane allowed through and/or turn movements. When asked, participants stated that slowing down, stopping in the lane, and veering were safety problems that arose from finding yourself in the wrong lane.

Figure 41 was shown to participants as an example of a two-lane frontage road with the downstream intersection out of view. Participants were asked whether they thought there would be a stop sign or traffic signal at the intersection ahead. Although the entire San Antonio group initially said a traffic signal, there was much discussion among all the groups about how rural and undeveloped the picture looked, and what the chances were that there may only be a stop sign. When asked which lanes could go straight, many participants said both A and B, but there was a lot of discussion about what lane assignment may happen to lane A. There were opinions stated that the left lane would be forced to enter the freeway, would end to make way for a lane exiting the freeway, or would become a turn lane at the intersection. The participants were a bit more certain about lane B, believing that they would be able to go straight or make a right turn. When asked, participants did not believe this was too early to place a sign indicating what would happen with respect to lane use at the intersection, although many of the College Station participants did not think that a sign was necessary for this type of two lane, rural frontage road (especially if lane A could travel left or straight and B could travel right or straight).

Figure 41. Focus Group Visual: Two-Lane Frontage Road.

The focus groups were then shown the photo in Figure 42, a picture of a more urban, three-lane frontage road with the downstream intersection out of view. Participants were told that there would be five lanes at the point of the intersection, and they were given a roadway sketch representing the picture (Figure 43) and asked to complete the following three tasks:

- Task 1: indicate how you believe the three lanes will transition to five lanes, either by drawing arrows or drawing the lanes.
- Task 2: indicate with arrows which directions the five lanes at the intersection can turn or go through.
- Task 3: draw signs or pavement markings that could relay lane choice information to the driver.

The results of this exercise are presented in Table 3 (Task 1) and Table 4 (Task 2), and Figure 43 shows one sample of the signs and markings participants drew for Task 3.

Figure 42. Focus Group Visual: Three-Lane Frontage Road.

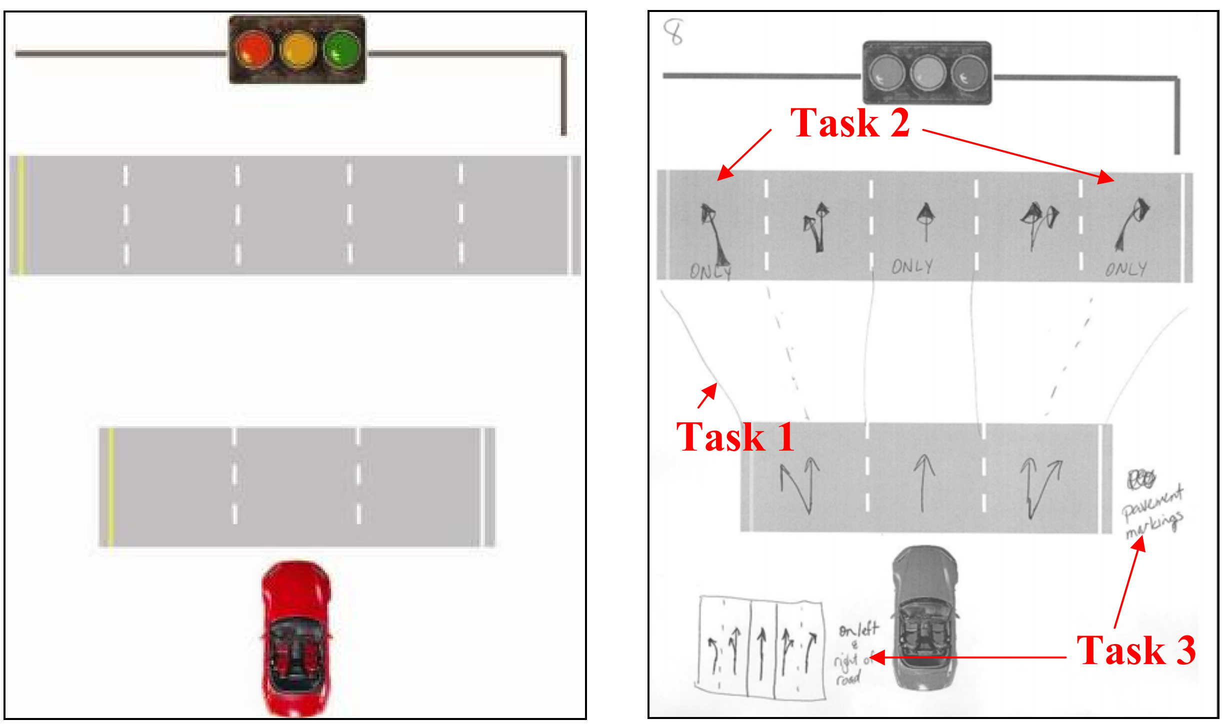


Figure 43. Focus Group Visual and Answer Sheet: Three-Lane Frontage Road that Widens to Five Lanes at Intersection.

Of the 39 participants, 28 provided an answer to Task 1 that researchers were able to decipher and code, with results shown in Table 3. Of those 28 responses, all but two of the subjects indicated they believed the left and right lanes would lead to other lanes while the center lane would not.

Table 4 shows what participants believed would happen to the lanes at the intersection as required in Task 2, with the results indicating that there was much more variation in expectations than with Task 1. The complete set of driver expectations drawings can be found in Appendix E.

A majority of focus group participants expected that an added right-lane would function as a right-turn-only lane and the center lane would be a through movement. Comments during the discussion of these drawings indicated that when uncertain, many drivers may choose the center lane to maximize their opportunity to make their desired movement. These results showed a general expectation that with this roadway configuration there would be more available lane movements in the left direction than to the right. The results shown in Table 4 can be used by engineers to gauge which lane assignments may be more problematic for drivers and which lane assignments need additional guidance if they violate driver expectancy. For example, if the right lane on a five-lane approach is not a right-turn-only lane, additional emphasis may be necessary so that right turns from the right-inside lanes are discouraged (with about 44 percent expecting that a right turn from that lane could be made legally).

Task 3 of this exercise was for the participants to draw signs and markings that they thought would best represent how the three lanes were widening to five lanes. Details of the signs varied, but overwhelmingly participants drew signs with some form of lane assignment arrows similar to current regulatory standards such as Example #1 or #2 in Figure 44. Although similar, some of these signs (for instance, Example #6, #10, or #11) varied the way the line markings were shown, or varied the way the arrows were drawn. Some participants envisioned overhead signs (see Examples #3, #8 and #12). The majority of drawings showed a sign with an arrow representing all five lanes, but as seen in Example #9, the center lane was not always marked. Participants who drew Examples #1 and #5 wanted to see the name of the cross street on a sign. And finally, some participants believed there should be some sort of markings on the pavement, like the street information in Example #2.

**Table 3. Focus Group Results: Task 1, Driver Expectations,
How Three Lanes Widen to Five Lanes.**

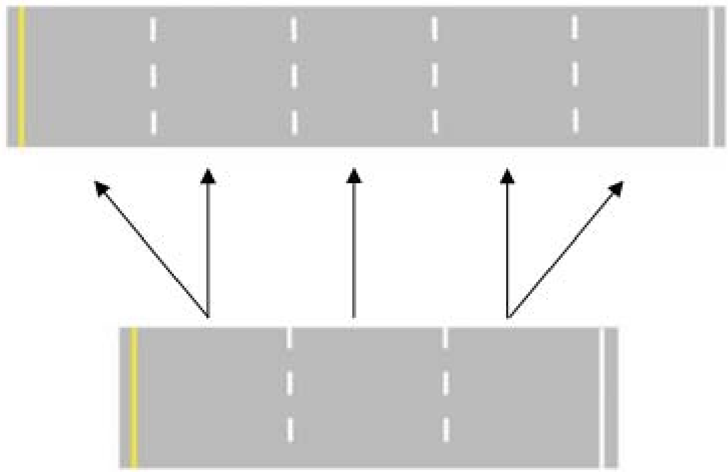
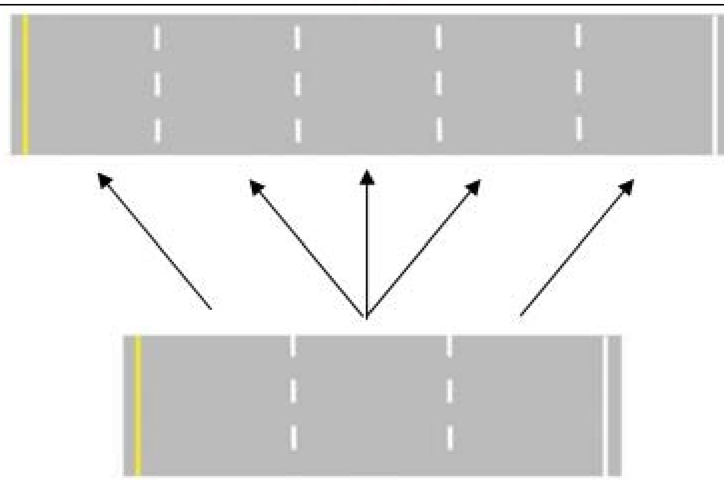
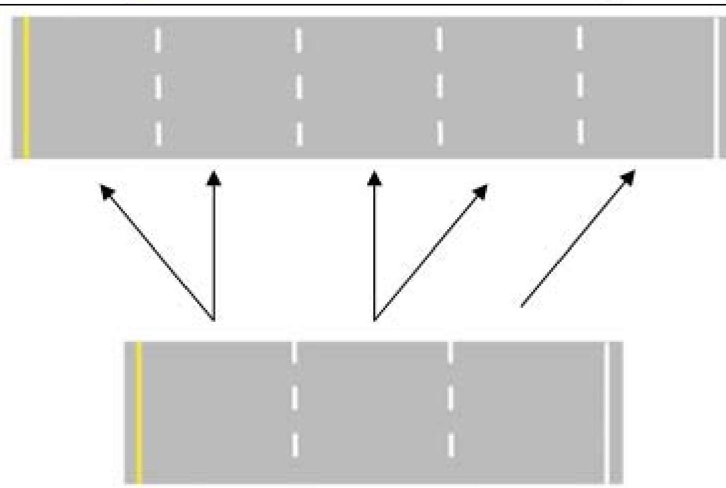
# of Participants (Percentage)	Lane Transition Variations
26 (92.86%)	
1 (3.57%)	
1 (3.57%)	

Table 4. Focus Group Results: Task 2, Driver Expectations,
Which Turning Movements Will Be Allowed at the Five Lanes at the Intersection?

Lane 1	Lane 2	Lane 3	Lane 4	Lane 5
ONLY **48.72%**				
2.56%				
ONLY **48.72%**	ONLY 41.03%			
	48.72%	17.95%	2.56%	
	ONLY 10.26%	ONLY **82.05%**	ONLY **51.28%**	
			43.59%	
			ONLY 2.56%	ONLY **100.00%**

Note: Most expected turning movement by survey participants denoted by boxed text.

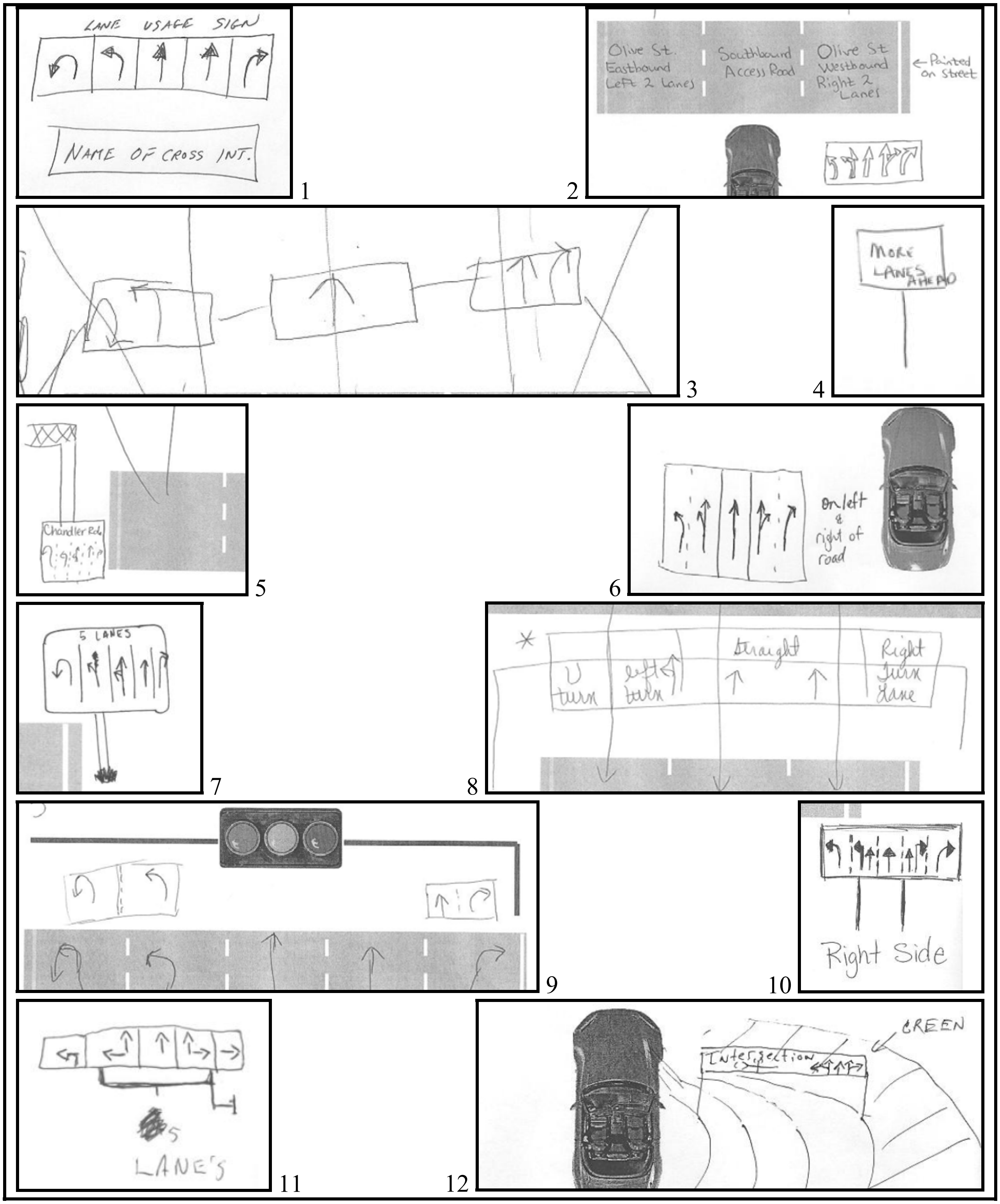


Figure 44. Focus Group Results: Task 3, Driver Expectations: Sample Results, Signs and Pavement Markings Representing Five Lanes at the Intersection.

The next portion of the focus group sessions focused on the practice used by some agencies of dual-posting (or splitting) lane assignment signs. Two sample pictures were created through digital editing. The first showed all five lane assignments for the upcoming intersection on signs mounted on both sides of the road (see Figure 45). Several people in each focus group location had drawn their signs on both sides of the road, although when prompted with Figure 45, participants had mixed responses. Some believed the two signs could be confusing, hard to read, or were unnecessary, but all focus group participants commented on how a single sign could be blocked from view by a larger vehicle.

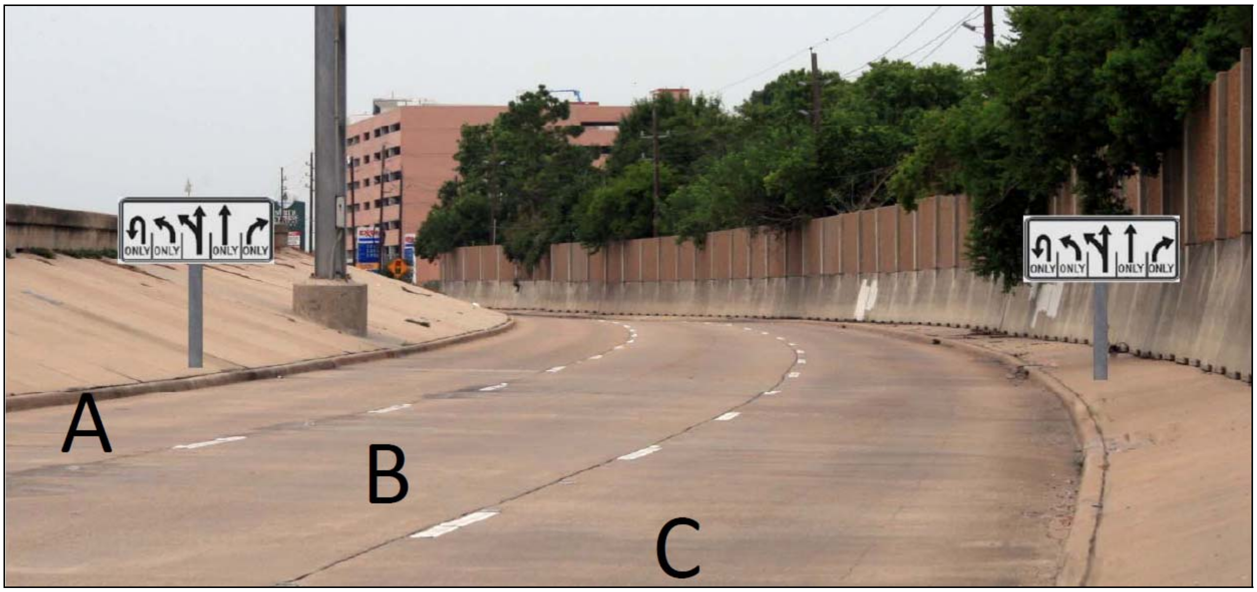


Figure 45. Focus Group Visual: Duplicate Signs Used to Show Allowable Lane Assignments at a Downstream Intersection.

The next picture illustrated an option developed by TTI researchers based on practices found in the state-of-the-practice review. One issue associated with the need to split a lane assignment sign is that for large intersections the lane assignment sign can be excessive in width. Indeed, if the signs inserted in Figure 45 had actually been there, they would have protruded into the traveled way. Figure 46 illustrates one way of splitting the lane assignments into two signs where each sign simply shows the lanes on that side of the road. Participants in all cities were not very receptive to this idea. They believed that they would be required to look in two places to get all the information they needed, leading to confusion, and that they were not sure how many lanes were ahead with the split signs. However, as the discussions continued, the researchers realized that many of the negative reactions were due to the perception that the two signs, when combined, can be understood to illustrate six lanes total, rather than the five that are actually there. In retrospect, it would have been better to have this picture illustrate two lanes on one sign and three lanes on the other. Even with this change, the concerns expressed about not being able to understand which lane on the sign matched which lane on the road would still be valid. The posting of turn-only messages alone, however, is fairly widespread in Texas cities and will continue to be a topic of later research tasks.

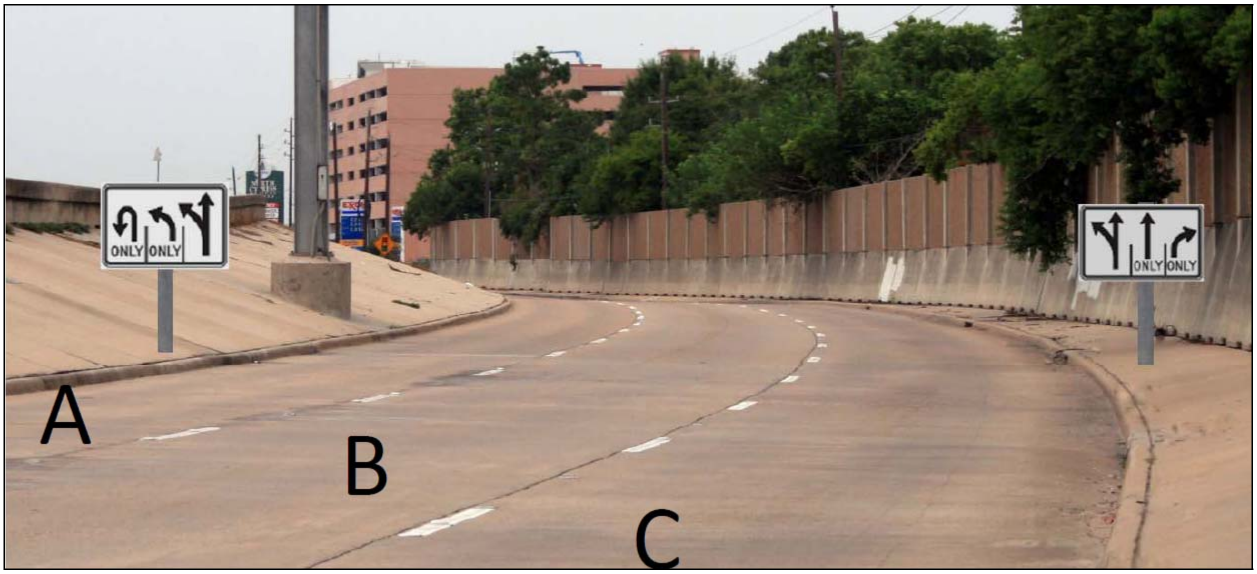


Figure 46. Focus Group Visual: Split Signs Used to Show Allowable Lane Assignments at a Downstream Intersection.

The discussion of the focus group shifted to views of unsignalized intersections along a freeway and frontage road system, and how their geometry (and therefore the driver expectations) can change. Figure 47 is a view from the driver viewpoint on a frontage road approaching a cross street.

The focus group participants were asked where they thought they should turn to go in the left direction at the cross street. Typical responses included: going to the next intersection and making a U-turn, turning right before the overpass, or going under the bridge and turning right and looping around to the cross street.

Participants were then asked if they thought if their expected turn locations would always be consistent. Upon further discussion, it was conveyed to the participant that some diamond-type freeway/frontage road intersections require a turn before the overpass regardless of the direction you want to go on the cross street. The participants were also asked what kind of signs would be helpful at this location. Ideas included using cardinal directions, side-by-side signs marking the turn in front of the overpass as well as the second turn past the overpass, and directional arrows.

Figure 47. Focus Group Visual: Frontage Road Approach to an Unsignalized Intersection.

Figure 48 and Figure 49 show unsignalized interchanges with varying geometries. The blue star in each figure marks a location where the driver's view could be that seen in Figure 47, yet drivers must make different maneuvers if they would like to drive in the left (to the west) direction in the two scenarios. Interestingly, participants seemed to have preconceived notions about the geometries of interchanges that depended on participant age, or whether they were from a rural or urban area, but among participants there was not a clear pattern as to why they made these leading assumptions.

Figure 48. Focus Group Visual: Diamond Interchange with a Frontage Road.

Figure 49. Focus Group Visual: Unsignalized Intersection in Half-Cloverleaf Geometry.

Continuing the discussion of unsignalized interchanges, Figure 50 shows the approach to a freeway from the cross street. As with the frontage road approach, it was discussed how on the cross street approach there also could be various locations you would turn to head in the same direction on the freeway, depending on the geometry of the interchange. Participants indicated they want signing no matter what the geometry of the interchange. Several also mentioned the addition of pavement markings.

Figure 50. Focus Group Visual: Arterial Approach to an Unsignalized Freeway Interchange.

Next, the focus group discussion returned to detail about signage located where frontage roads intersect cross streets near freeways with a signalized interchange. Participants were asked how they know what the name of the cross street is, and even whether or not they need to know the name of the street. Figure 52 presents two examples of how to sign an upcoming intersection. Participants preferred the first alternative showing a signal and the cross street name. Only a few participants believed drivers could confuse the name on the sign with the name of the road they were on. The participants did not prefer the second alternative with the cross graphic as much as they did the signal graphic. In further discussion about how to sign for the cross street, focus group participants did prefer the idea of using pavement markings to display the name of the cross street on the frontage road.

Figure 51. Focus Group Visual: Unsignalized Intersection in Cloverleaf Geometry.

Figure 52. Focus Group Visual: Sign Alternatives for Indicating an Upcoming Cross Street on a Frontage Road.

Figure 53 through Figure 55 are unaltered photographs of existing methods used to provide cross-street name signs. All focus group participants preferred the street name sign being placed overhead, although some mentioned that this should be for confirmation with an initial sign placed at some distance upstream of the intersection. Although there was some confusion looking at the mismatched street names in Figure 54, participants still preferred the street name sign overhead and showed interest in having lane use arrows on signs overhead as well.

Figure 53. Focus Group Visual: Houston Alternative for Signing a Cross Street.

Figure 54. Focus Group Visual: Albuquerque Alternative for Signing a Cross Street.

Figure 55, taken in San Antonio, Texas, shows a larger set of overhead signs portraying more elements of information than the previous cross-street signs the focus group participants had viewed. Participants liked the usage and look of the arrows on the sign. They also liked the color green used for the sign backgrounds, although some mentioned they usually associated green signs with a freeway.

When focusing on the pavement markings shown in the figure, participants seemed to have a good understanding of the word "ONLY" and thought it was okay that the center lane did not have lane use pavement markings. Researchers believe further research could be done to test driver perceptions of an unmarked lane and if using pavement markings and/or signing for only the lane drop lanes is a valid approach. Focus group participants were asked about using pavement markings to convey street names in a situation like is the one shown in Figure 55, but they did not think the street names should be painted on the pavement.

Figure 55. Focus Group Visual: San Antonio Alternative for Signing a Cross Street.

A lane drop can be difficult to sign, and difficult for drivers to understand, when it occurs immediately downstream of a signalized intersection, as shown in Figure 56. Warning signs that are located after the traffic signal, but visible before the traffic signal, could be interpreted incorrectly if read before passing beyond the intersection. One question asked to focus group participants was whether they needed to know what would happen downstream of an intersection to be able to position themselves in an appropriate lane as they approached the intersection. Participants overwhelmingly believed that in order to eliminate confusion and possible weaving issues downstream that the lane should not be allowed to continue through the light if it was going to end "soon" after the intersection. Suggestions included extending the curb to block the through lane, or using pylons to prevent the traffic from driving straight through in the left lane.

Figure 56. Focus Group Visual: Example of a Lane Drop on Far Side of the Intersection.

Figure 57, showing a roadway in Dallas, Texas, presents the approach to a signalized interchange from the cross street. Participants were asked what they thought about the lane designation arrows as signed overhead and also what they thought about the colors used in the signs. Figure 58 and Figure 59 show white-on-green overhead lane designation arrow signing. The main concern subjects had with these figures was that the signs were too small and difficult to see. Some participants mentioned moving them to the traffic signal mast-arms so that they were not too high and would be more visible. There was some concern among the focus group participants that if you moved the signs too far upstream on the cross-street approach, that people may try to turn left on the frontage road, but this seemed to be a minor concern. Looking at Figure 59, participants suggested that moving the I-35 South sign to the traffic signal mast arm could help mitigate this concern. Overall, there were no strong opinions concerning the color of the signs being black-on-white or white-on-green.

Figure 57. Focus Group Visual: Dallas, Texas, Overhead Lane Assignment Arrows.

Figure 58. Focus Group Visual: San Antonio, Texas, Signalized Cross-Street Approach.

Figure 59. Focus Group Visual: San Antonio, Texas, Lane Assignment Signing.

Figure 60 shows a combination lane assignment and guide sign used in Albuquerque, New Mexico, that uses traditional lane assignment arrows within a green guide sign. The Houston group's initial impression was that this was too much information, but participants tended to like the combination sign. These combination signs were found to be candidates for further study in the driver survey task. When asked if there was only one of the two guide signs shown in the picture used, all participants wanted the first one hung on the overpass rather than the one shown downstream at the second signal.

Figure 60. Focus Group Visual: Albuquerque, New Mexico, Lane Assignment Arrows.

FOCUS GROUP QUESTIONS TAKEN FORWARD TO DRIVER SURVEYS

Taken from the results of the focus groups and discussions with the project panel members, a new set of questions was developed to guide further driver survey research as documented in Chapter 7:

- When does a driver need (or not need) signs and markings for lane assignment?
- What types of intersection approach situations violate driver assumptions?
- When do drivers need to see lane assignment information (and where)?
- How do the look and placement of arrows change driver perceptions of lane assignment?
- How does sign color change driver perceptions of lane assignment signing?
- What terminology or phrases related to lane assignment do drivers best understand or prefer?
- What is the driver's perception of the best method to convey cross-street information?
- Are signs needed on freeway exit ramps for the upcoming intersection?

As well as attempting to answer these questions, additionally the next phase of human factors research evaluated the comprehension of new sign concepts developed by the research team.

CHAPTER 7: DRIVER SURVEYS

To further assess driver assumptions about lane assignments at interchanges, the research team used the information gathered in the focus groups to develop computer-based driver surveys. In development of the survey questions, the researchers created the following list of questions or objectives:

1. When do you need or not need signs and markings to convey information about an upcoming intersection?
    a. In a rural setting, is any warning needed of an upcoming intersection?
    b. At an intersection, what pavement markings are needed?
    c. At an intersection, what detail is needed on the lane assignment signs?
2. What types of intersection characteristics related to lane assignment violate driver assumptions?
    a. What does a driver think will happen to the frontage road lanes at a signalized intersection?
    b. What does a driver think will happen at an unsignalized interchange on a frontage road?
    c. What does a driver think will happen on an unsignalized intersection from the cross-street approach?
3. How do the look and placement of arrows on a sign change driver perceptions?
4. How does sign color influence driver perceptions?
5. What terminology or phrases do drivers best understand or prefer?
6. What is the driver's perception of the best method to convey cross-street information?
7. What is driver comprehension of proposed signs and pavement marking concepts?

The complete question set for the surveys was numbered based on the numbered objectives above. Originally researchers had an eighth objective: Where (and at what spacing) should lane assignment signs and markings be placed? However, it was determined that it would be difficult to address these issues with a computer survey showing still pictures and that this would be included in the objectives of the field study documented in Chapter 8.

This section provides a description of the questions asked in the survey, their results, and recommendations for further evaluation in the field study.

PROCEDURE

Researchers surveyed 204 participants at TTI offices in four Texas cities: San Antonio, Austin, Dallas, and College Station. Recruitment consisted of contacting potential participants in TTI's previous survey participant database and by distributing flyers containing information about the survey within the office buildings. Each survey session lasted approximately 20 to 30 minutes.

The gender distribution of the participants is shown in Table 5. A total of 116 females and 88 males participated in the surveys. The participants' age distribution is shown in Table 6.

Table 5. Driver Survey Participants: Gender Distribution by City.

Participants	San Antonio	Austin	Dallas	College Station	Total
Male	40%	40%	49%	43%	43%
Female	60%	60%	51%	57%	57%
Total	50	50	53	51	204

Table 6. Driver Survey Participants: Age Distribution by City.

Age Range	San Antonio	Austin	Dallas	College Station	Total
18-29	34%	28%	23%	27%	28%
30-39	20%	26%	25%	2%	18%
40-49	22%	14%	30%	8%	19%
50-59	22%	26%	6%	22%	19%
60-69	2%	6%	17%	25%	13%
70-79	0%	0%	0%	14%	3%
80+	0%	0%	0%	2%	0%
Sample Size	50	50	53	51	204

SURVEY DESIGN

Each participant completed one of five versions of the survey. In this report, the participants completing each version will be referred to as being in Group A, B, C, D, or E, as seen in Table 7.

Table 7. Participant Group Distribution by City.

Group	San Antonio	Austin	Dallas	College Station	Total
A	11	9	11	11	42
B	10	10	11	10	41
C	10	10	11	10	41
D	10	10	10	10	40
E	9	11	10	10	40
Sample Size	50	50	53	51	204

As an attempt to prevent the survey from taking too long, some of the questions were divided out among members of the five groups. The specific questions contained in each version are shown in Table 8; however, the order of the survey questions was different for each group to prevent learning effects. The questions that vary from group to group have been lightly shaded.

Table 8. Question Distribution by Group.

Group A	Group B	Group C	Group D	Group E
1.1	1.1	1.1	1.1	1.1
1.2	1.2	1.2	1.2	1.2
1.3	1.3	1.3	1.3	1.3
2.1A	2.1A	2.1A	2.1A	2.1A
2.1B	2.1B	2.1B	2.1B	2.1B
2.1C	2.1C	2.1C	2.1C	2.1C
2.2	2.2	2.2	2.2	2.2
2.3	2.3	2.3	2.3	2.3
3.1	3.2	3.3	3.3C	3.5
3.3B	3.3B	3.4	3.6	3.4
3.8	3.9	3.1	3.11	3.12
4.1	4.1	4.1	4.1	4.1
4.2	4.2	4.2	4.2	4.2
5.1	5.1	5.2	5.3	5.3
5.4	5.4	5.4	5.4	5.4
5.5A	5.5A	5.5A	5.5A	5.5A
5.5B	5.5B	5.5B	5.5B	5.5B
5.6A	5.6A	5.6A	5.6A	5.6A
5.7	5.7	5.7	5.7	5.7
5.6B	5.6B	5.6B	5.6B	5.6B
5.8A	5.8B	5.9	5.1	5.11
6.1	6.1	6.1	6.1	6.1
7.1	7.1B	7.2	7.2C	7.1C
7.2B	7.3D	7.3C	7.3B	7.3
7.4	7.4	7.4	7.4	7.4
7.5	7.5	7.5	7.5	7.5
7.6	7.6	7.6	7.6	7.6
7.6B	7.6E	7.6F	7.6D	7.6C
5.2	7.7B	7.7C	7.7A	7.7D
7.8	7.8	7.8	7.8	7.8
7.9B	7.9B	7.9	7.9	7.10D
7.10	7.10	7.10	7.10	7.10
7.10B	7.10C	3.7	3.7	3.6
7.11	7.11	7.11	7.11	7.11
7.11B	7.11B	7.11C	7.10E	7.11C

Note: The blackened cells' responses will be omitted in analyses due to survey error
but their questions will still be discussed in this report. Shaded cells distinguish those questions sets that varied by participant – each participant was shown a subset of possible questions to produce a more appropriate length survey.

Each of the five survey versions was developed using the survey software SuperLab™. The software allows measurement of response time (in milliseconds), keystroke logging, and controlled presentation of photographs, text, and video. The software can create a unique random order of presentation of test items, or can be programmed to follow a prescribed order (as was done for this study). For this study, the controlled and timed presentation of photographs was used, but response time measurements and video stimuli were not utilized. A binder containing pictures was also used for sections of the survey. For some questions the researchers wanted the subjects to be able to browse among several pictures before making answer choices, and the binder method facilitated this functionality.

Driver survey participants were tested individually in a conference room with the ability to accommodate five individuals at the same time, as shown in Figure 61. Each participant viewed the survey on a 19 inch monitor connected to a laptop computer running the SuperLab™ software. A button box, as shown in Figure 62, was used instead of the keyboard for the subjects to enter their responses. The use of the box helps prevent operator error, especially with older participants who may be unfamiliar and/or uncomfortable using a computer keyboard. With the use of a button box, the survey is limited to multiple choices, with no open-ended answer opportunities.

Figure 61. Driver Survey Workstation Configuration.

Figure 62. Button Box Used for Driver Survey Participant Response Entry.

Getting Started

After reading the information form shown in Appendix F and giving consent to participate, participants began the survey with a brief explanation by the researcher of the button box and the binder. The following introductory information was shown on the computer screen:

> [First slide] *Thank you for participating in this research study conducted by the Texas Transportation Institute. Please turn off all cell phones before beginning. You will not need to use the computer's keyboard for this study. You will only need to use the buttons on the box in front of you labeled 1 through 7. Press any button when you are ready to begin.*
>
> [Next slide] *Please read each question carefully. When reading each question, please read ALL answer choices before selecting an answer. At times you will be asked to look at images in the binder at your computer station. Today you will be looking at signs and markings that you may find on frontage roads and intersections alongside a freeway. Please let the researcher know if you have any questions at any time. Press any button to continue.*

The survey then asked each participant to enter information about themselves. Along with providing valuable information, this portion of the survey allowed the participants to become more familiar and comfortable with the button box and the interaction the survey would require. As the participants completed the survey, the researcher remained present in the survey room to answer any questions and to monitor progress.

SURVEY QUESTIONS AND RESULTS

This section shows both the individual survey questions and summaries of their results, organized by survey objective. The complete data set can be found in Appendix G. The question format varied from question to question. Some questions required the use of the binder, some provided an introduction to a scenario before a picture was shown with limited viewing time, while others showed still stimuli where the participants could take as long as they needed to study the picture. The type of question used for each of the objectives is described in more detail below.

All survey results are shown as a percentage of the participants, by city, who responded per answer choice. Because not every group was given every question (as shown in Table 8) the sample size is also provided in each table. In each data table, the highest percentage of respondents is bolded. If the question has a correct answer choice, those response fields are shaded.

Objective 1: When Do You Need (or Not Need) Signs and Markings?

The questions for this objective use a subjective scale (1 to 5) to determine how much information is too little, or too much, in marking an upcoming intersection.

Question 1.1

Question 1.1 was divided into three parts, 1.1A, 1.1B and 1.1C (shown in Figure 63). The pictures provide a view of a rural two-lane frontage road with sign and pavement marking options to indicate a signal is coming up. The base picture is the same while the signs and/or markings change. Question 1.1B adds the cross-street name plaque under the sign, and Question 1.1C adds lane assignment pavement marking arrows. An example of the instructions for these three questions is as follows:

> *Look at pictures X-XC in the binder you have been provided. We want your opinion about the changes we made to the signs and markings. Picture X is a base picture and the others have had changes made. You will be asked how much information has been provided to you about the intersection ahead by giving a number from 1 to 5, with 1 being Not Enough, and 5 being Too Much.*

The numbering system in the binder that is mentioned in the instructions was unique to the number system of the question set.

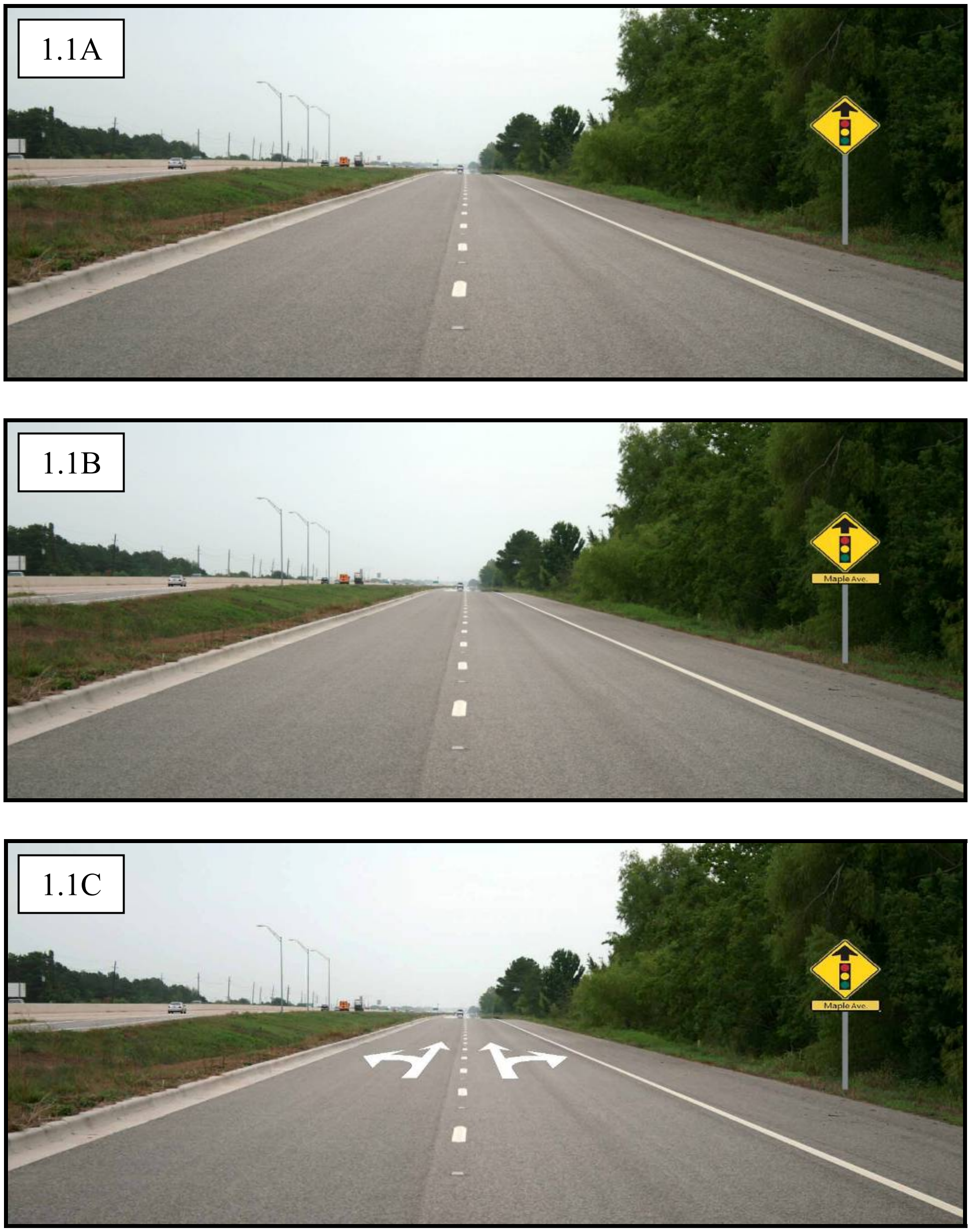


Figure 63. Driver Survey: Question 1.1 Stimuli.

The participant was able to flip through the three images in the binder before being asked about each picture (1.1A, 1.1B, and 1.1C): On a scale of 1-5, how much information has been provided about the intersection?

Results for each stimulus picture can be found in Appendix G. Table 9 compares the results of Questions 1.1A-1.1C. With only a sign indicating a signal ahead, most participants did not think enough information was given about the intersection ahead, but with the street name plaque added, most participants found the information to be just enough (or more than enough). When the pavement markings were added to this rural scenario, half of the participants thought there was more than enough information about the upcoming intersection.

Table 9. Driver Survey: Question 1.1 Results.

Question 1.1: On a scale of 1-5, how much information has been provided about the intersection?			
Response	**1.1A**	**1.1B**	**1.1C**
1-Not Enough	25%	6%	2%
2	**39%**	20%	3%
3-Just Enough	34%	**59%**	**45%**
4	1%	15%	39%
5-Too Much	0%	0%	11%
Sample Size	204	204	204
NOTE: Bold percentages indicate highest percentage of respondents making that choice.			

Question 1.2

Question 1.2 was divided into four parts, 1.2A, 1.2B, 1.2C, and 1.2D (shown in Figure 64). The pictures show a frontage road approach to a signalized intersection with five lanes. The far left lane is a U-turn lane, and the far right lane is a right-turn-only lane. In the pictures the lane assignment pavement markings are being altered. An example of the instructions for these four questions is:

> *Look at pictures X-XD in the binder you have been provided. We want your opinion about the changes we made to the markings on the road only. Picture X is a base picture and the others have had changes made. You will be asked how much information has been provided to you about the intersection ahead by giving a number from 1 to 5, with 1 being Not Enough, and 5 being Too Much.*

The participant was able to flip through the four images in the binder before being asked for each picture: On a scale of 1-5, how much information has been provided about the intersection?

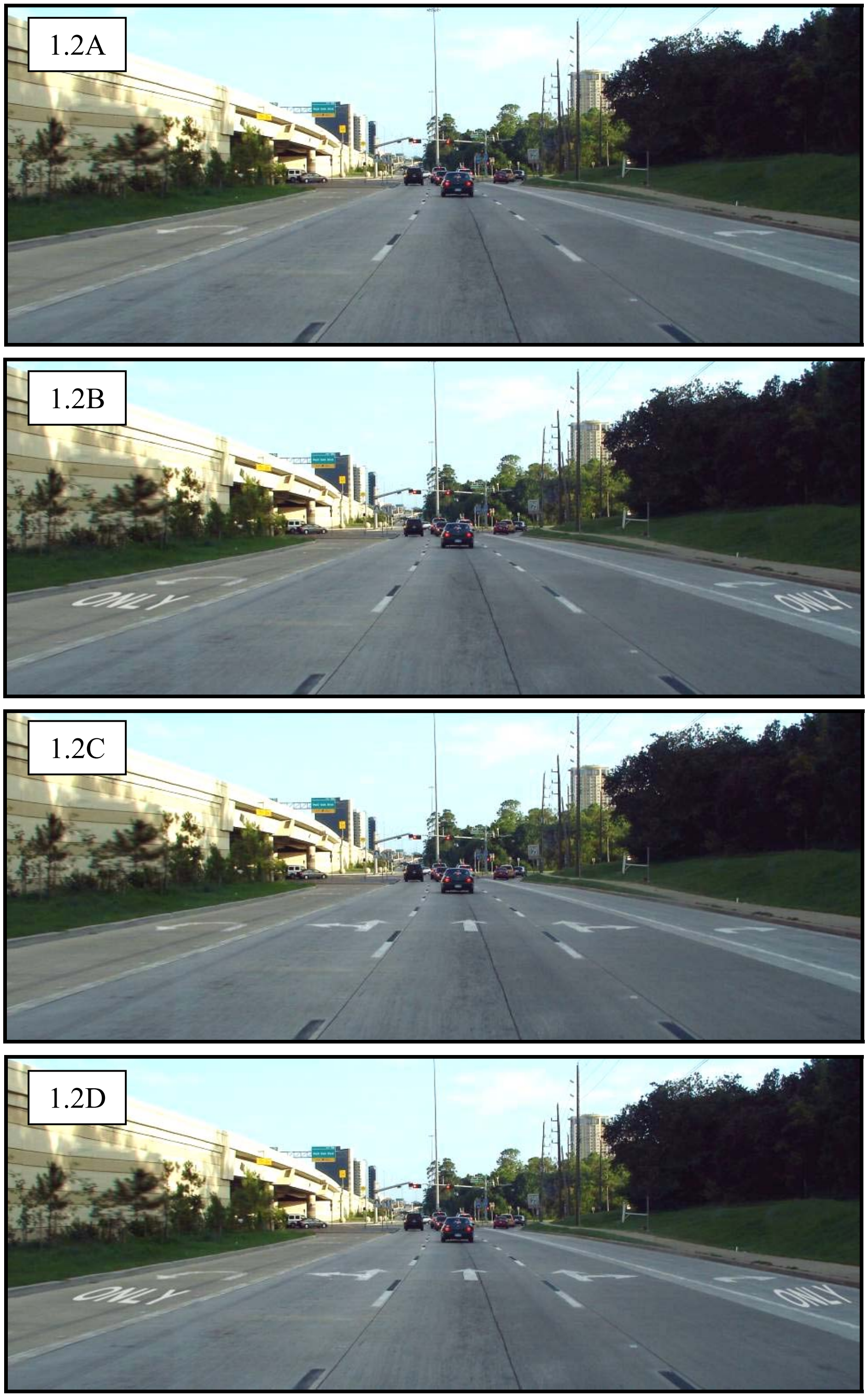


Figure 64. Driver Survey: Question 1.2 Stimuli.

Table 10 compares the results for the four pictures. For the markings shown in 1.2A and 1.2B, with only the outer exclusion lanes marked, almost all participants believed the markings provide less than enough to just enough information. When the arrows are spread across all lanes of travel, the participants begin to believe enough information has been provided, and when the "ONLY" text was added to the turn only lanes in 1.2D, participants started to believe there was just enough to too much information.

Table 10. Driver Survey: Question 1.2 Results.

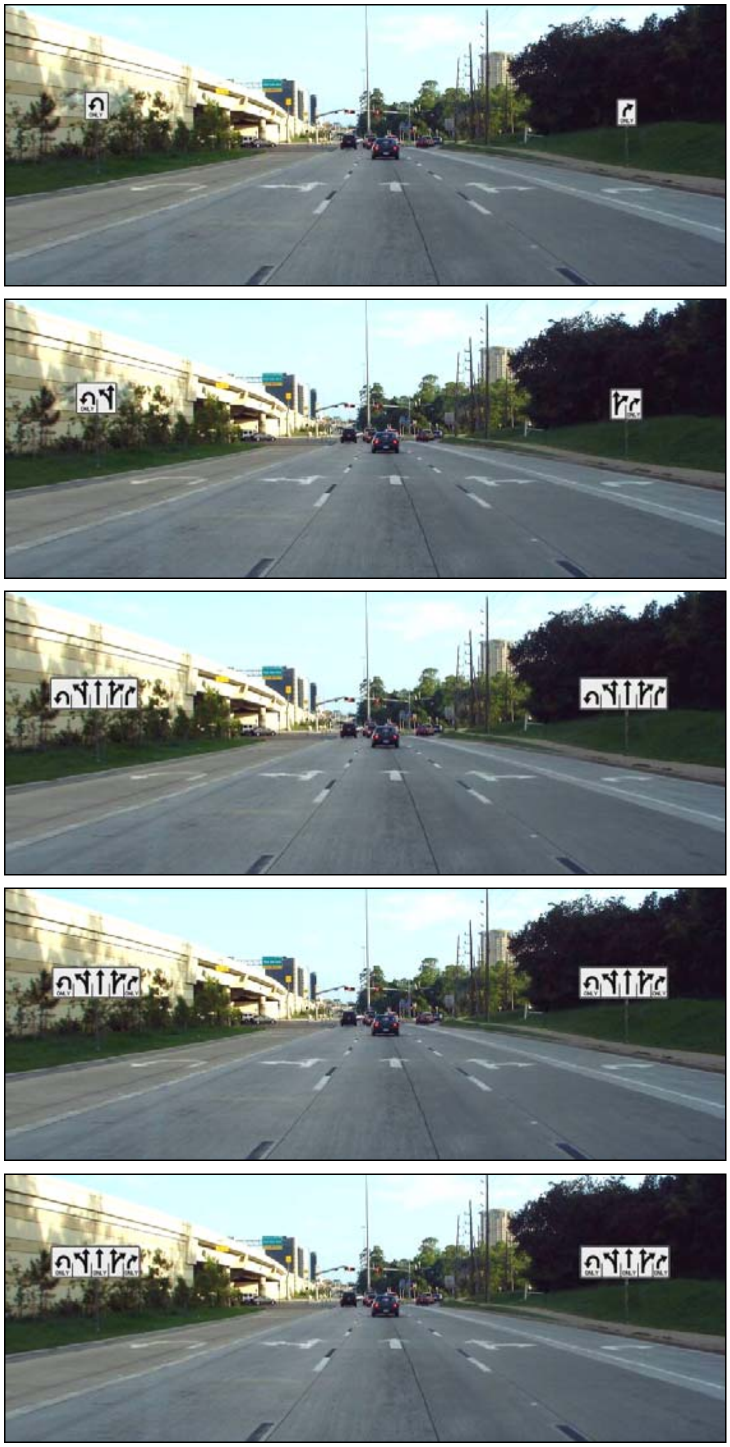
Question 1.2: On a scale of 1-5, how much information has been provided about the intersection?				
Response	**1.2A**	**1.2B**	**1.2C**	**1.2D**
1-Not Enough	**50%**	25%	2%	0%
2	29%	**39%**	5%	0%
3-Just Enough	18%	27%	**59%**	**40%**
4	2%	8%	28%	**40%**
5-Too Much	0%	1%	6%	19%
Sample Size	204	204	204	204
NOTE: Bold percentages indicate highest percentage of respondents making that choice.				

Question 1.3

Question 1.3 was divided into six parts, 1.3A through 1.3F (shown in Figure 65). Like Question 1.2, the parts show a frontage road approach to a signalized intersection with five lanes, although now the lane assignment (lane control) signs have been altered. These signs are based on those specified in Section 2B.20 of the TxMUTCD *(5)*. An example of the instructions for these six questions is:

> *Look at pictures X-XF in the binder you have been provided. We want your opinion about the changes we made to the signs only. Picture X is a base picture and the others have had changes made. You will be asked how much information has been provided to you about the intersection ahead by giving a number from 1 to 5, with 1 being Not Enough, and 5 being Too Much.*

The participant was able to flip through the six images in the binder before being asked for each picture: On a scale of 1-5, how much information has been provided about the intersection?



1.3A

1.3B

1.3C

1.3D

1.3E

Figure 65. Driver Survey: Question 1.3 Stimuli.

For Questions 1.3A and 1.3B, the greatest percentage of respondents believed signing for just the outer exclusion lanes or for all turn lanes was sufficient, as seen in Table 11. For signs that marked all five lanes of the roadway and were posted on both sides of the road (1.3D, 1.3E, and 1.3F), the greatest percentage of respondents thought the information was too much. For version 1.3F, where the sign was placed only on one side of the road, the majority of participants still believed the information was more than enough, although 30 percent fewer participants thought it was too much information compared to version 1.3E with the same sign on both sides of the road.

Table 11. Driver Survey: Question 1.3 Results.

Question 1.3: On a scale of 1-5, how much information has been provided about the intersection?							
Response	**1.3A**	**1.3B**	**1.3C**	**1.3D**	**1.3E**	**1.3F**	**Total**
1-Not Enough	14%	2%	0%	0%	4%	7%	5%
2	29%	13%	2%	0%	5%	12%	10%
3-Just Enough	**42%**	**47%**	18%	18%	26%	29%	30%
4	12%	30%	21%	22%	14%	**32%**	22%
5-Too Much	2%	8%	**59%**	**61%**	**50%**	20%	33%
Sample Size	204	204	204	204	204	204	1224
NOTE: Bold percentages indicate highest percentage of respondents making that choice.							

Objective 2: What types of things violate drivers' assumptions?

This line of survey questions examined unsigned and unmarked pictures approaching intersections and asked participants where they thought the lanes would turn. The research objective was to determine what possible movements would violate driver assumptions and would highlight where additional sign guidance would be beneficial.

Question 2.1

Question 2.1 was divided up into three parts, 2.1A, 2.1B, and 2.1C, as shown in Figure 66. The pictures showed a three-lane frontage road where the next intersection is out of view. Each picture was taken from the perspective of a different lane. Each question first displayed the following instructions:

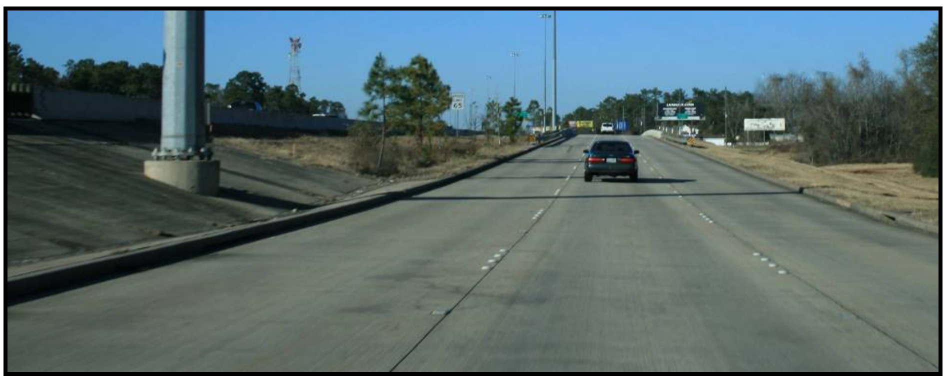
> *Mike is driving along a frontage road and will be approaching a cross street intersection with a signal. The cross street is a little further down the road and he cannot see it yet. The picture shown is from Mike's perspective as he drives. Please hit any button to continue.*

The next screen stressed which lane Mike was in (the left lane in image 2.1A, the center lane for image 2.1B and the right lane for image 2.1C) and asked the participant to indicate the arrow that best represented what would most often happen to the lane Mike was in at the intersection ahead.

For picture 2.1A, the researchers have some concern that participants may have gotten confused thinking Mike was the car in the picture in the center lane, even though the screen stated Mike is in the **RIGHT** Lane. There is no way to know if this affected the results.

2.1A

2.1B



2.1C

Figure 66. Driver Survey: Question 2.1 Stimuli.

Table 12 shows the comparison of the results for each of the three lanes. The greatest percentage of respondents believed that for a three-lane frontage road, the left lane will be a turn-only lane, the center lane will only go straight, and the right lane will be an optional right turn. Without proper signing, drivers may make unnecessary lane changes because of these assumptions they make about an upcoming intersection. For example, many drivers in the left lane may change lanes because they believe they will be forced to turn at the light, when in fact that may not be true.

Table 12. Driver Survey: Question 2.1 Results

Question 2.1: Which arrow represents what will happen the most often to the lane that Mike is in at the upcoming intersection? (Answer Comparison for all 3 lanes)			
Response	**Left Lane**	**Center Lane**	**Right Lane**
	**71%**	1%	n/a
	26%	28%	n/a
	3%	**68%**	14%
	n/a	2%	**50%**
	n/a	0%	36%
NOTE: Bold percentages indicate highest percentage of respondents making that choice.			

Question 2.2

Question 2.2's picture showed a three-lane frontage road approaching a unsignalized intersection, as shown in Figure 67. From the perspective of the picture, the interchange looks like it could be either a diamond or a cloverleaf configuration. The participants first read the following instructions:

> *Mike is driving along a frontage road about to go under a bridge. The bridge is a cross street that passes over the frontage road and the freeway. The picture is shown from Mike's perspective as he drives. Please press any button to continue.*

The next screen showed the picture stimulus and asked what Mike would need to do the most often in order to travel in the **LEFT** direction (over the freeway) on the cross street.

Figure 67. Driver Survey: Question 2.2 Stimulus.

Results in Table 13 show equal assumptions of where drivers believe Mike will turn to cross over to the opposite side of the freeway. This can be interpreted as one-half of drivers not clearly understanding the expected conditions ahead.

Table 13. Driver Survey: Question 2.2 Results.

Question 2.2: What will Mike need to do the most often in order to travel in the LEFT direction (over the freeway) on the cross street?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Turn right before the overpass and turn left onto the cross street at a stop sign or signal	38%	68%	42%	55%	**50%**
B. Turn right after the overpass and loop around to join the cross street	62%	32%	58%	45%	**50%**
Sample Size	50	50	53	51	204
NOTE: Bold percentages indicate highest percentage of respondents making that choice.					

Question 2.3

Question 2.3's picture showed a cross-street approach to a freeway. From the perspective of the picture, the interchange looked like it could be either a diamond or a cloverleaf configuration (see Figure 68). The participants first read the following instructions:

> *Mike is driving on a street that crosses over a freeway. The picture shown is from Mike's perspective as he approaches the freeway from the cross street. Please press any button to continue.*

The next screen shows the picture and asks what will Mike need to do the most often in order to travel in the **LEFT** direction on the freeway.

Figure 68. Driver Survey: Question 2.3 Stimulus.

Results in Table 14 show almost equal assumptions about which lane Mike should select to travel left at the freeway. This can be interpreted as one-half of drivers not clearly understanding the expected conditions ahead and an indication that further guidance may be necessary.

Table 14. Driver Survey: Question 2.3 Results.

Question 2.3: What will Mike need to do the most often in order to travel in the LEFT direction on the freeway?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Turn left on the other side of the overpass	54%	50%	42%	61%	51%
B. Turn right on the other side of the overpass and loop around	46%	50%	58%	39%	49%
Sample Size	50	50	53	51	204

Objective 3: How do the look and placement of arrows on a sign impact drivers' perceptions?

After discussion with the Project Monitoring Committee, it was decided to ask drivers how arrows on guide signs impact where they believe a lane or lanes will accommodate the corresponding turn movement. For example, if an arrow is on the left side of the sign, do drivers believe the turn is from the left lane(s)? If an arrow has a "tail" before pointing to the left or right (referred to as a right-angled arrow), would that graphic configuration lead the driver to believe the turn is not immediate, but up ahead a short distance? Alternatively, does a right-angled arrow encourage a sense of urgency for the turn?

Questions 3.1-3.7

Questions 3.1-3.7 showed a base picture of a three-lane frontage road approaching a unsignalized intersection (as shown in Figure 69). In each picture, the guide sign in advance of the interchange was altered. The sign variations were created with guidance from the TxMUTCD section on Advance Route Turn Assemblies, Section 2D.29 *(5)*. Although the perspective of the picture looked like it could be either a diamond or a cloverleaf configuration, the sign alternatives generally represented a cloverleaf interchange. For Questions 3.1-3.7, excluding 3.3B and 3.3C, the participants first read the following instructions for each question:

> *The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is taken from Mike's perspective as he drives along a frontage road approaching a cross street. Mike wants to drive on* [Pinemill St. West]. *When you are ready to view the picture, please hit any button.*

The street destination in brackets varied from question to question, but it always referred to the line on the sign indicating the second turn of the cloverleaf interchange. The next screen displayed the stimulus picture alone for 3.5 seconds before disappearing and asking the question: Mike wants to drive on [Pinemill St West], where will he turn?

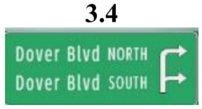
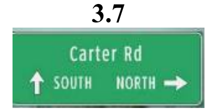
For Questions 3.3B and 3.3C, the drivers were asked the question variation: Which lanes can Mike be in to turn on [White Oaks Dr East]?

Figure 69. Driver Survey: Questions 3.1-3.7 Example Stimulus.

Table 15 shows a comparison of the results for Questions 3.1-3.7. All sign versions except for 3.3 had a high percentage of respondents choosing the correct answer, with sign option 3.7 performing the best at 90 percent and 3.3 performing the worst with 51 percent correct. Moving the straight arrow between the position adjacent to the travel lanes to the side the turn is on did not make a difference as shown in 3.1 and 3.2. Also, the right-angled arrow in version 3.3 did not portray better than 3.1 that you must first drive straight and then take a right to get to White Oak Dr East.

Table 15. Driver Survey: Questions 3.1-3.7 Results.

Response	3.1 	3.2 	3.3 
A. Right, before the overpass	17%	17%	49%
B. Right, after the overpass	**83%**	**83%**	**51%**
Sample Size	42	41	41

Response	3.4 	3.5 	3.6 	3.7 
A. Right, before the overpass	15%	23%	18%	10%
B. Right, after the overpass	**85%**	**78%**	**83%**	**90%**
Sample Size	81	40	80	81

Note: Shaded cells indicate correct response.

Often at a cloverleaf interchange, the first turn in front of the overpass is a lane drop to the right. The sign versions 3.3B and 3.3C aimed at finding the best arrow configuration to portray this geometry. Shown in Table 16, 3.3C with the diagrammatic-type arrows more closely representing what the lanes are doing performed better than 3.3B, but still did not show high comprehension. With additional standard lane drop signs and markings, participant comprehension of both of these signs may have been significantly better.

Table 16. Driver Survey: Questions 3.3B and 3.3C Results.

Questions 3.3B and 3.3C Which lanes can Mike be in to turn on White Oaks Dr East (Greene Rd North)?		
Response	**3.3B** 	**3.3C** 
A. Left Only	4%	0%
B. Center Only	1%	20%
C. Right Only	**77%**	**48%**
D. Left or Center	1%	3%
E. Right or Center	17%	30%
Sample Size	83	40
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded row indicates correct answer.		

Questions 3.8 - 3.12

Questions 3.8 through 3.11 used images showing a cross-street approach to a freeway. From the perspective of the picture, the interchange looked like it could be either a diamond or a cloverleaf configuration (see Figure 70), although the signs for 3.8 and 3.9 were designed to represent a diamond interchange, and 3.10 and 3.11 a cloverleaf. The participants first read the following instructions on the monitor:

> *The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is taken from Mike's perspective as he is approaching a freeway. Mike wants to drive towards the city of* [Morganville]. *When you are ready to view the picture, please hit any button.*

The city in brackets varied from question to question, but it always referred to the line on the sign indicating the second turn. The next screen displayed the stimulus picture alone for 3.5 seconds before disappearing and asking the question: Mike wants to drive towards [Morganville], where will he turn?

Figure 70. Driver Survey: Questions 3.8-3.11 Example Stimulus.

As with the right-angled arrows shown on the frontage road signs, the arrows on the cross-street signs produced a more immediate desire to turn, primarily with the right-tailed arrow in sign 3.10 (see Table 17). In general practice, the through arrow (as in sign 3.8) is placed adjacent to the travel lane on the sign. If this placement was used to indicate which side of the road the turn would be on, the right arrow placement in 3.11 performed much more effectively than the left arrow placement in 3.8. The best scoring sign version for a right-hand turn was the straight through arrow placed on the right side of the sign, with 63 percent answer correctly, and the best scoring for a left turn was a left right-angled arrow placed on the left side of the sign, with 49 percent answering correctly.

Table 17. Driver Survey: Questions 3.8-3.11 Comparison.

Questions 3.8-3.11 Compared: Mike wants to drive towards (Fill in the blank), where will he turn?				
Response	**3.8** 	**3.9** 	**3.10** 	**3.11** 
A. Right, before the overpass	12%	17%	63%	8%
B. Left, before the overpass	5%	20%	2%	3%
C. Right, after the overpass	67%	15%	34%	63%
D. Left, after the overpass	17%	49%	0%	28%
Sample Size	42	41	41	40

NOTE: Shaded row indicates correct answer.

For Question 3.12, the same base picture was used as in Questions 3.8-3.11 (see Figure 71), but the drivers were told Mike wants to enter the freeway and were asked where he would turn. Table 18 shows 65 percent of the subjects correctly chose that Mike would take the second turn.

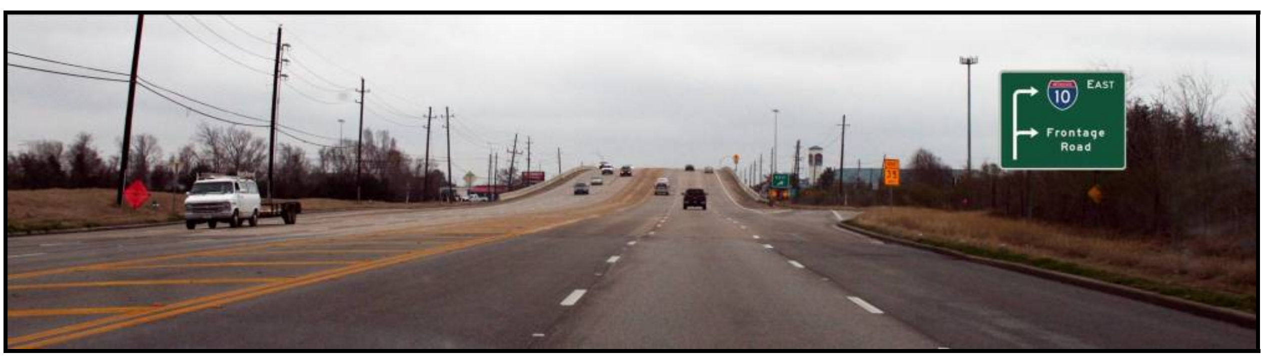


Figure 71. Driver Survey: Question 3.12 Example Stimulus.

Table 18. Driver Survey: Question 3.12 Results.

Question 3.12: Mike wants to enter the freeway, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. First turn to the right	44%	36%	30%	30%	35%
B. Second turn to the right	56%	64%	70%	70%	65%
Sample Size	9	11	10	10	40

NOTE: Shaded row indicates correct answer.

Objective 4: How Does Sign Color Impact Driver Perceptions?

Knowing that color standards are firmly entrenched into existing guidance, the research team decided to inquire with drivers only about their perceptions of enforcement for white versus green for lane assignment signs, particularly with examples of both schemes in practice.

Questions 4.1 and 4.2

Questions 4.1 and 4.2 show a base picture of vehicles stopped at a cross-street intersection with a freeway's frontage road. The stimulus perspective is from the left-turn-only lane (see Figure 72 and Figure 73). In the two pictures, the color of the overhead lane assignment signs varied from black-on-white to white-on-green. For each version participants were asked: Is the black sports car in the lane on your right allowed to turn left at the light?

As seen in Table 19 and Table 20, 99 percent correct for both questions indicated that neither color encouraged the perception that a turn from the second lane was allowed.

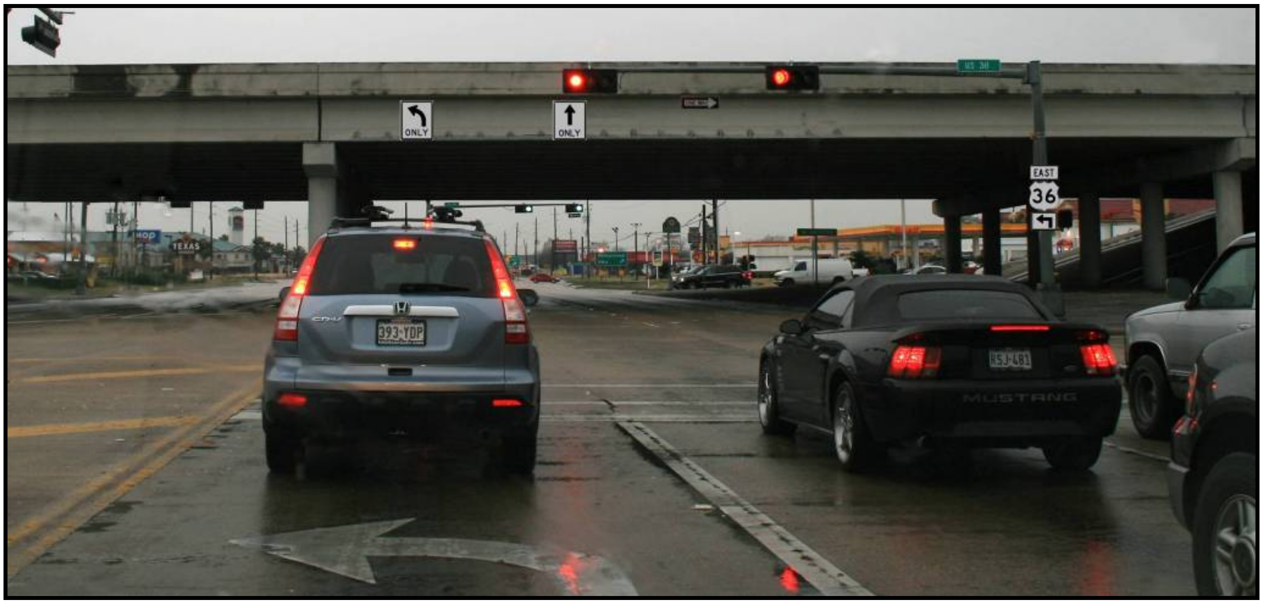


Figure 72. Driver Survey: Question 4.1 Stimuli.

Table 19. Driver Survey: Question 4.1 Results.

Question 4.1 Is the black sports car in the lane on your right allowed to turn left at the light?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Yes	2%	2%	2%	0%	1%
B. No	98%	98%	98%	100%	99%
Sample Size	50	50	53	51	204

NOTE: Shaded row indicates correct answer.

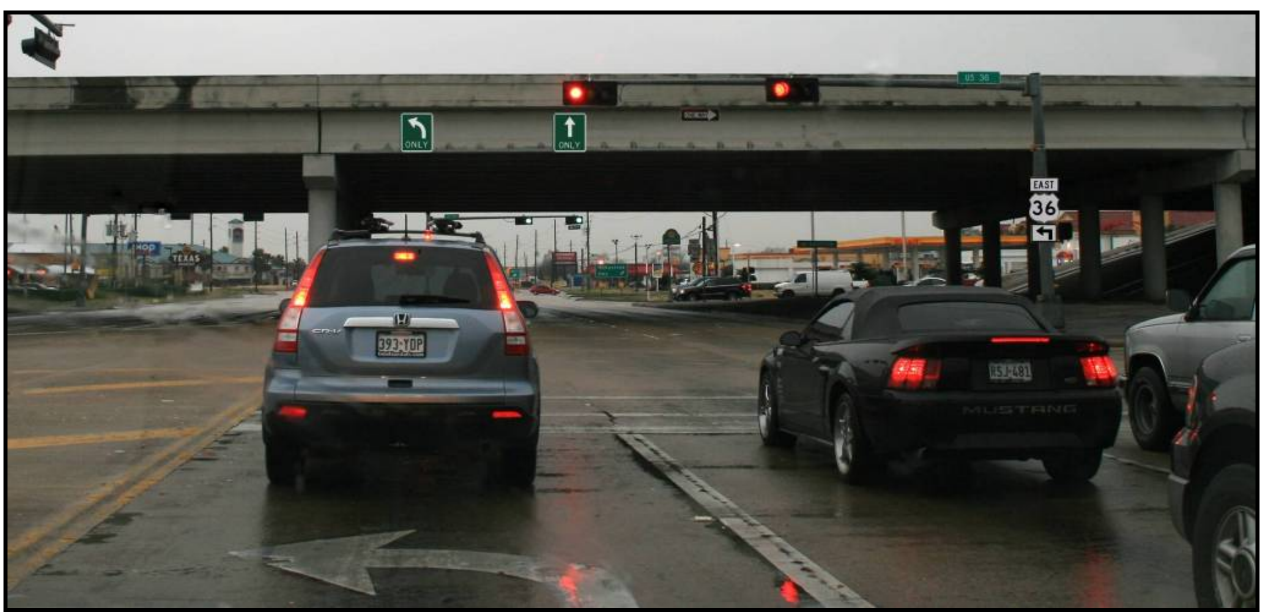


Figure 73. Driver Survey: Question 4.2 Stimuli.

Table 20. Driver Survey: Question 4.2 Results.

Question 4.2 Is the black sports car in the lane on your right allowed to turn left at the light?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Yes	4%	0%	2%	0%	1%
B. No	96%	100%	98%	100%	99%
Sample Size	50	50	53	51	204

NOTE: Shaded row indicates correct answer.

Objective 5: What Lane Assignment Terminology and/or Phrases Do Drivers Best Understand or Prefer?

In practice and in standards there are many terms and phrases used for lane assignment applications. This objective looked at some of these examples hoping to determine if some are better understood by drivers than others, and if some should be eliminated all together.

Question 5.1

Question 5.1 showed the previously used base picture of the cross-street approach to an intersection, with a sign generally used for jughandle turns (see Figure 74). The participants first were shown a screen with the following explanation:

The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is taken from Mike's perspective as he is approaching a freeway. Please read the signs Mike sees along the roadway. When you are ready to view the picture, please hit any button.

The next screen displayed the stimulus picture alone for 3.5 seconds before disappearing and asking the question: Mike wants to drive in the LEFT direction when he gets to the freeway, which lane should he be in?

Figure 74. Driver Survey: Question 5.1 Stimuli.

Table 21 presents the results of Question 5.1. With only 64 percent of the participants responding correctly, the sign in question 5.1 "ALL TURNS FROM RIGHT LANE" showed moderate comprehension for a cloverleaf approach application.

Table 21. Driver Survey: Question 5.1 Results.

Question 5.1: Mike wants to drive in the LEFT direction when he gets to the freeway, which lane should he be in?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right	57%	63%	64%	71%	64%
B. Left	43%	37%	36%	29%	36%
Sample Size	21	19	22	21	83

NOTE: Shaded row indicates correct answer.

Questions 5.2 and 5.3

Questions 5.2 and 5.3 showed a three-lane frontage road with two different sign variations for a right-turn-only lane (see Figure 75 and Figure 76). The image associated with Question 5.2 displayed a R3-7R sign from the TxMUTCD and the image for Question 5.3 showed a R3-5R sign *(5)*. The participants first were shown a screen with the following explanation:

> *The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is taken from Mike's perspective as drives along a frontage road in the* ***right*** *lane. Please read the signs Mike sees along the roadway. When you are ready to view the picture, please hit any button.*

The next screen displayed the stimulus picture alone for 3.5 seconds before disappearing and asking the question: If Mike stays in this lane, what options does he have at the intersection?

For both Questions 5.2 and 5.3 there is concern that subjects may have been somewhat confused, thinking Mike was the car in the center lane, even though the instructions said the picture was taken from Mike's perspective in the ***right*** lane. If this occurred it could account for some of the responses of choices C or D for either of the questions.

Results for Questions 5.2 and 5.3 indicated that the all-text version of the sign performed slightly higher at 81 percent correct responses compared to the graphical (arrow) version at 76 percent.

Figure 75. Driver Survey: Question 5.2 Stimuli

Table 22. Driver Survey: Question 5.2 Results.

Question 5.2: If Mike stays in this lane what options does he have at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Can turn left only	5%	0%	0%	0%	1%
B. Can turn left or go straight	10%	0%	5%	0%	4%
C. Can go straight only	5%	11%	9%	5%	7%
D. Can turn right or go straight	10%	5%	5%	10%	7%
E. Can turn right only	71%	84%	82%	86%	81%
Sample Size	21	19	22	21	83

NOTE: Shaded row indicates correct answer.

Figure 76. Driver Survey: Question 5.3 Stimuli.

Table 23. Driver Survey: Question 5.3 Results.

Question 5.3: If Mike stays in this lane what options does he have at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Can turn left only	0%	0%	0%	10%	3%
B. Can turn left or go straight	5%	0%	0%	0%	1%
C. Can go straight only	21%	10%	10%	10%	13%
D. Can turn right or go straight	16%	5%	5%	5%	8%
E. Can turn right only	58%	86%	85%	75%	76%
Sample Size	19	21	20	20	80

NOTE: Shaded row indicates correct answer.

Question 5.4

Question 5.4 showed a picture of a frontage road intersection (Figure 77) where the right lane becomes a turn-only lane. This question was intended to determine driver preference for supplemental plaques indicating where the lane drop may occur. The participants viewed three versions of the signs shown in Table 24. The participants were asked to:

> *Look at pictures XA-XC in the binder. Which addition to the sign on the right side of the picture do you prefer for making lane change decisions for an upcoming intersection?*

Figure 77. Driver Survey: Question 5.4 Stimuli.

Table 24 shows the results of Question 5.4, and shows a preference for the "AT SIGNAL" plaque over "500 FEET" and "AHEAD" messages. At 63 percent response, participants preferred the addition of the "AT SIGNAL" plaque to the "RIGHT LANE MUST TURN RIGHT" sign.

Table 24. Driver Survey: Question 5.4 Results.

Question 5.4: Which addition to the sign on the right side of the picture do you prefer for making lane change decisions for an upcoming intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. **500 FT** 	24%	18%	25%	18%	21%
B. **AT SIGNAL** 	50%	66%	60%	76%	63%
C. **AHEAD** 	26%	16%	15%	6%	16%
Sample Size	50	50	53	51	204

Questions 5.5 - 5.7

Figure 78 shows the image used in Questions 5.5A and 5.5B. These two questions address driver understanding of the text "ONLY" when placed below an arrow on a lane assignment sign. There has been previous research showing confusion if the term is interpreted to mean *this is the only lane that will turn* or *if you are in this lane, you can only turn and not go straight*. The participants had unlimited viewing time to answer these questions. The results of these true/false questions are shown in Table 25 and NOTE: Shaded row indicates correct answer.
Table 26.

Figure 78. Driver Survey: Question 5.5A and 5.5B Stimuli.

Table 25. Driver Survey: Question 5.5A Results.

Question 5.5A: Imagine there is a signal coming up just out of view. If I am in Lane A, I will be forced to turn left at the signal.					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	94%	98%	98%	98%	97%
B. False	6%	2%	2%	2%	3%
Sample Size	50	50	53	51	204

NOTE: Shaded row indicates correct answer.

Table 26. Driver Survey: Question 5.5B Results.

Question 5.5B: Imagine there is a signal coming up just out of view. If I want to turn left, I must be in Lane A.					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	90%	74%	91%	78%	83%
B. False	10%	26%	9%	22%	17%
Sample Size	50	50	53	51	204

NOTE: Shaded row indicates correct answer.

The results indicate that there is strong driver expectation that the R3-5L(R) type signs with the word "ONLY" lead to a lane ahead that is a forced turn. Drivers also expect that the turn-only lane drops at the intersection ahead, regardless if a turn bay is provided. The next two questions, Questions 5.6A and 5.6B, were used to test driver comprehension of combination turn-only and shared lane assignment signing. The image used for these two questions is shown in Figure 79.

Figure 79. Driver Survey: Question 5.6A & 5.6B Stimuli.

There appears to be strong comprehension among survey participants that the sign shown in Figure 79 indicates that the center lane, Lane B, can be used for left turns and straight through movements as well. There does not appear to be any confusion as to the meaning of these signs.

Table 27. Driver Survey: Question 5.6A Results.

Question 5.6A: Imagine there is a signal coming up just out of view. If I am in Lane B, I will be forced to turn left at the signal.					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	2%	2%	0%	0%	1%
B. False	98%	98%	100%	100%	99%
Sample Size	50	50	53	51	204
NOTE: Shaded row indicates correct answer.					

Table 28. Driver Survey: Question 5.6B Results.

Question 5.6B: Imagine there is a signal coming up just out of view. If I want to turn left, I must be in Lane A.					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	28%	6%	23%	8%	16%
B. False	72%	94%	77%	92%	84%
Sample Size	50	50	53	51	204
NOTE: Shaded row indicates correct answer.					

The next question, Question 5.7, used Figure 80 to ask drivers about the use of the word "OK" supplementing the shared turn/through arrow. This usage is currently optional per the TxMUTCD and federal MUTCD.

Figure 80. Driver Survey: Question 5.7 Stimuli.

Table 29 summarizes the results of Question 5.7. It appears overwhelmingly that drivers understand the meaning of the shared turn arrow, regardless of the presence of the "OK" text. Question 5.7 and Question 5.6A confirm that the same level of comprehension results from the shared movement graphic, with or without the "OK" text present.

Table 29. Driver Survey: Question 5.7 Results.

Question 5.7: Imagine there is a signal coming up just out of view. If I am in Lane B, I will be forced to turn left at the signal.					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	6%	0%	0%	0%	1%
B. False	94%	100%	100%	100%	99%
Sample Size	50	50	53	51	204
NOTE: Shaded row indicates correct answer.					

Table 30 demonstrates that most drivers best understand an optional turn lane when there is signage for it. When only shown a turn only sign for the left lane, only 17% believed they could possibly turn from the center lane (Lane B).

Table 30. Driver Survey: Questions 5.6A and 5.6B Comparison.

Questions 5.5B and 5.6B: Imagine there is a signal coming up just out of view. If I want to turn left, I must be in Lane A.		
Response	**5.5B** 	**5.6B** 
A. True	**83%**	16%
B. False	17%	**84%**
Sample Size	204	204
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded row indicates correct answer.		

Question 5.7 looked at drivers' understanding of the word "OK" on a lane assignment sign like sign R3-8 in the federal MUTCD *(4)*. Shown in Table 31, both the signs with and without the "OK" in the optional turn lane showed equal comprehension that the lane could turn left or go straight.

Table 31. Driver Survey: Questions 5.6A and 5.7 Comparison.

Questions 5.6A and 5.7 Compared: Imagine there is a signal coming up just out of view. If I am in Lane B, I will be forced to turn left at the signal		
Response	5.6A 	5.7 
A. True	1%	1%
B. False	99%	99%
Sample Size	204	204
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded row indicates correct answer.		

Questions 5.8A and 5.8B

These two questions asked drivers about example signs from the TxMUTCD's Section 2D.38 *(5)* which use the expressions "Next Intersection," "2nd Intersection," and "Next Signal" (see Figure 81 and Figure 82). Before viewing the stimulus, the participants were given the following instructions:

The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed.

The stimulus was shown for five seconds in order for participants an opportunity to notice the next intersection ahead. They were then asked: If you turned left at the next intersection, what road would you turn on?

Figure 81. Driver Survey: Question 5.8A Stimuli.

The results for Question 5.8A are shown in Table 32. About two-thirds of the drivers responded correctly that the next left turn would be at the nearest intersection (Shady Grove Rd).

Table 32. Driver Survey: Question 5.8A Results.

Question 5.8A: If you turned left at the next intersection, what road would you turn onto?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Shady Grove Rd	64%	56%	73%	73%	67%
B. Pleasant St	36%	44%	27%	27%	33%
Sample Size	11	9	11	11	42
NOTE: Shaded row indicates correct answer.					

Figure 82. Driver Survey: Question 5.8B Stimuli.

Table 33 presents the results for Question 5.8B (combination arrow graphic and Next Signal text). The percent correctly answering this question is similar to the results from Question 5.8A (Next Intersection/2nd Intersection text), indicating no preference of the two concepts. Signs 5.8A and 5.8B showed equal comprehension of their terms and sign layout.

Table 33. Driver Survey: Question 5.8B Results.

Question 5.8B: If you turned left at the next intersection, what road would you turn onto?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Scott Blvd	70%	80%	64%	60%	68%
B. Lincoln Ave	30%	20%	36%	40%	32%
Sample Size	10	10	11	10	41
NOTE: Shaded row indicates correct answer.					

Questions 5.9 - 5.11

Questions 5.9, 5.10, and 5.11 were asked to gauge understanding of the phrases "2nd Right," "Keep Right," and "Keep Left" using signing examples given in Section 2E.49 of the TxMUTCD *(5)*. The participants first read the following instructions:

> *The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is taken from Mike's perspective as he is approaching a freeway. Mike wants to drive* [East on I-10]. *When you are ready to view the picture, please hit any button.*

The destination in brackets varied from question to question. The next screen displayed the stimulus picture alone for 3.5 seconds before asking the question: Mike wants to drive [East on I-10], where will he turn?

The results for Question 5.9 are shown in Table 34. There is high comprehension for the use of "2ND RIGHT" for guidance (see Figure 83) approaching an interchange at 83 percent positive response. For Questions 5.10 and 5.11, which used the terminology "Keep Right," the percentages of correct answers were 68 percent and 63 percent respectively (see Table 35 and Table 36), with both signs showing a high response on answer C: Right, after the overpass. However, there appears to be over one-third of drivers who remain confused about the proper turn location with these sign concepts.

Figure 83. Driver Survey: Question 5.9 Stimuli.

Table 34. Driver Survey: Question 5.9 Results.

Question 5.9: Mike wants to drive East on I-10, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	20%	20%	0%	10%	12%
B. Left, before the overpass	10%	10%	0%	0%	5%
C. Right, after the overpass	70%	70%	100%	90%	83%
D. Left, after the overpass	0%	0%	0%	0%	0%
Sample Size	10	10	11	10	41
NOTE: Shaded row indicates correct answer.					

Figure 84. Driver Survey: Question 5.10 Stimuli.

Table 35. Driver Survey: Question 5.10 Results.

Question 5.10: Mike wants to drive towards Eatontown, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	60%	70%	80%	60%	68%
B. Left, before the overpass	10%	0%	0%	0%	3%
C. Right, after the overpass	30%	30%	20%	40%	30%
D. Left, after the overpass	0%	0%	0%	0%	0%
Sample Size	10	10	10	10	40
NOTE: Shaded row indicates correct answer.					

Figure 85. Driver Survey: Question 5.11 Stimuli.

Table 36. Driver Survey: Question 5.11 Results.

Question 5.11: Mike wants to drive East on I-18, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	67%	64%	60%	60%	63%
B. Left, before the overpass	0%	0%	10%	10%	5%
C. Right, after the overpass	33%	36%	30%	30%	33%
D. Left, after the overpass	0%	0%	0%	0%	0%
Sample Size	9	11	10	10	40
NOTE: Shaded row indicates correct answer.					

Objective 6: How To Best Sign Cross-Street Information?

In the United States and internationally, there are many variations in practice for signing cross-street names. Question 6.1 asked about driver preference for three of these options (as shown in Figure 86).

Question 6.1

Question 6.1 was broken up into two parts to ask the participants' preference of the best and worst cross-street sign. The first two signs were taken from examples in the TxMUTCD's Section 2D.38 *(5),* and the third sign was developed by researchers. The participants were first asked:

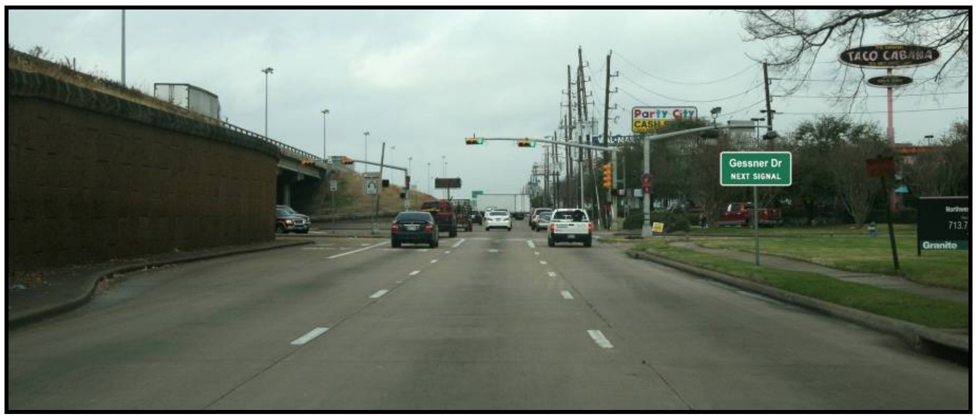
> *Look at pictures XA-XC in the binder you have been provided. The pictures show various ways that the cross street name can be shown on a sign at an intersection. You will be asked to indicate the best and worst placement of the information.*

Table 37. Driver Survey: Question 6.1, Part A, Results.

Question 6.1A, Part A: Which picture shows the cross-street name in a location that does the BEST job of portraying the information?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. 6A (Overhead)	48%	32%	26%	33%	35%
B. 6B (Roadside)	30%	48%	45%	31%	39%
C. 6C (R3-8 Mod. w/plaque)	22%	20%	28%	35%	26%
Sample Size	50	50	53	51	204

Binder
Picture 6A

Binder
Picture 6B



Binder
Picture 6C

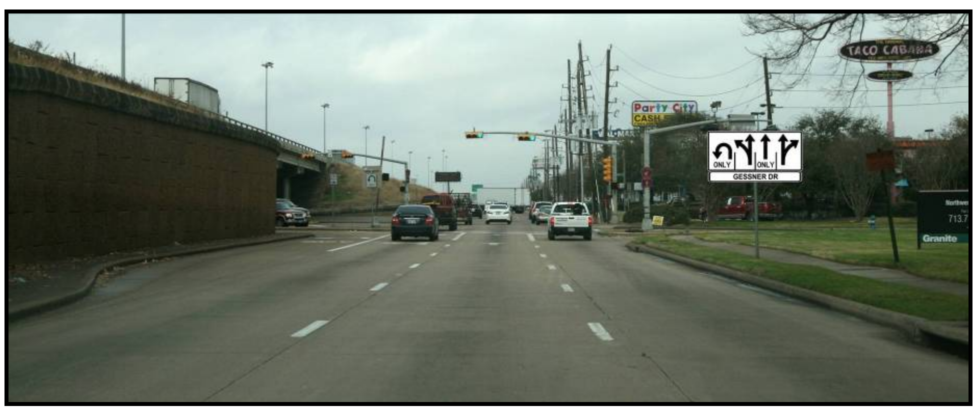


Figure 86. Driver Survey: Questions 6.1A and 6.1B Stimuli.

Table 38. Driver Survey: Question 6.1, Part B, Results.

Question 6.1, Part B: Which picture shows the cross street name in a location that does the WORST job of portraying the information?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. 6A (Overhead)	24%	32%	43%	31%	33%
B. 6B (Roadside)	18%	14%	6%	22%	15%
C. 6C (R3-8 Mod. w/plaque)	58%	54%	51%	47%	52%
Sample Size	50	50	53	51	204

The highest response for the best option, at 39 percent, was Picture B with an advance guide sign mounted to the right of the road. Picture A (overhead mounted street name sign) received only a slightly lower score at 35 percent. For the worst sign, the greatest percentage of participant responses (over half) chose the lane assignment sign with the added street name plaque shown in Picture C.

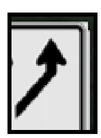
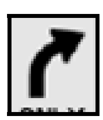
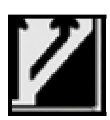
Objective 7: What is Driver Comprehension of New Signs and Marking Design Ideas?

In Task 1's literature review, researchers gathered concepts for signing and marking lane assignments. This set of questions aimed at determining what participants thought some of these concepts meant and which ones they preferred.

Questions 7.1 - 7.3D

Questions 7.1-7.3D aimed at determining driver perceptions of existing, adapted, and new concepts all applied to the same lane on a lane assignment sign. These concepts will be referred to as:

- "ONLY" text: 

- Lane addition arrow: 
- Turn-only arrow: 
- Lane addition taper: 
- Lane drop block: 

The questions displayed the following instructions before their stimulus was viewed:

The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is a sign that you would see along a frontage road when approaching an intersection. Please read the signs you see along the roadway. When you are ready to view the picture, please hit any button.

The stimulus slide was shown for 3.5 seconds before the participant was asked what he or she thought would happen to the right lane based on the sign (see Figure 87).

Figure 87. Driver Survey: Questions 7.1-7.3D Example Stimulus.

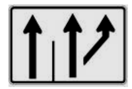
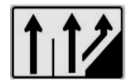
Question 7.1B's data are not included due to survey error. The stimulus that was supposed to be presented is shown in Figure 88. Although not tested, researchers still proposed swapping the lane drop arrow and the "ONLY" text as an option. The rearrangement lines the arrows up at the bottom of the sign, and more clearly illustrates with the placement of the arrowheads what the lanes will be doing ahead. This rearrangement may be necessary if sign space saving is needed to add a lane addition taper such as the one seen in Question 7.3.

Figure 88. Driver Survey: Omitted Question 7.1B Stimuli.

The data for Questions 7.1-7.3D are compared in Table 39. The individual data for each question can be found in Appendix G. The lane drop block did not perform favorably in conjunction with the lane addition arrow as shown by the image for 7.2C, but was better understood in conjunction with the turn-only arrow in the image for 7.1C, with 78 percent of the participants correctly understanding its meaning.

Adding a lane line mark to image 7.3 to create image 7.3B did not result in a greater understanding of the sign, although adding an "AT SIGNAL" plaque in 7.3C did, with 76 percent correctly interpreting the sign.

Table 39. Driver Survey: Question 7.1-7.3D Results.

Questions 7.1-7.3D Compared: What will happen to the far right lane at the intersection?									
Response	7.1 	7.1C 	7.2 	7.2B 	7.2C 	7.3 	7.3B 	7.3C 	7.3D 
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	7%	0%	**68%**	**43%**	**45%**	5%	10%	2%	22%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	**52%**	**78%**	2%	17%	25%	33%	38%	22%	27%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	40%	23%	29%	40%	30%	**63%**	**53%**	**76%**	**51%**
Sample Size	42	40	41	42	40	40	40	41	41
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded cells indicate correct answers.									

Questions 7.4 and 7.5

Participants did not view Questions 7.4 and 7.5 until after they had viewed all of their group's questions from the Question set 7.1-7.3D. For questions 7.4 and 7.5, participants were asked which sign best indicated the following two lane geometries:

1) The road is widening ahead and there is a lane being added on the right.
2) At the intersection ahead the far right lane MUST turn.

Looking at the geometry of the lane being added, Table 40 indicates a total preference of 46 percent for a sign with a lane addition taper and a lane addition arrow (7.2B), even though the same sign without the taper (7.2) scored a 25 percent greater understanding in the previous comparison table (Table 39).

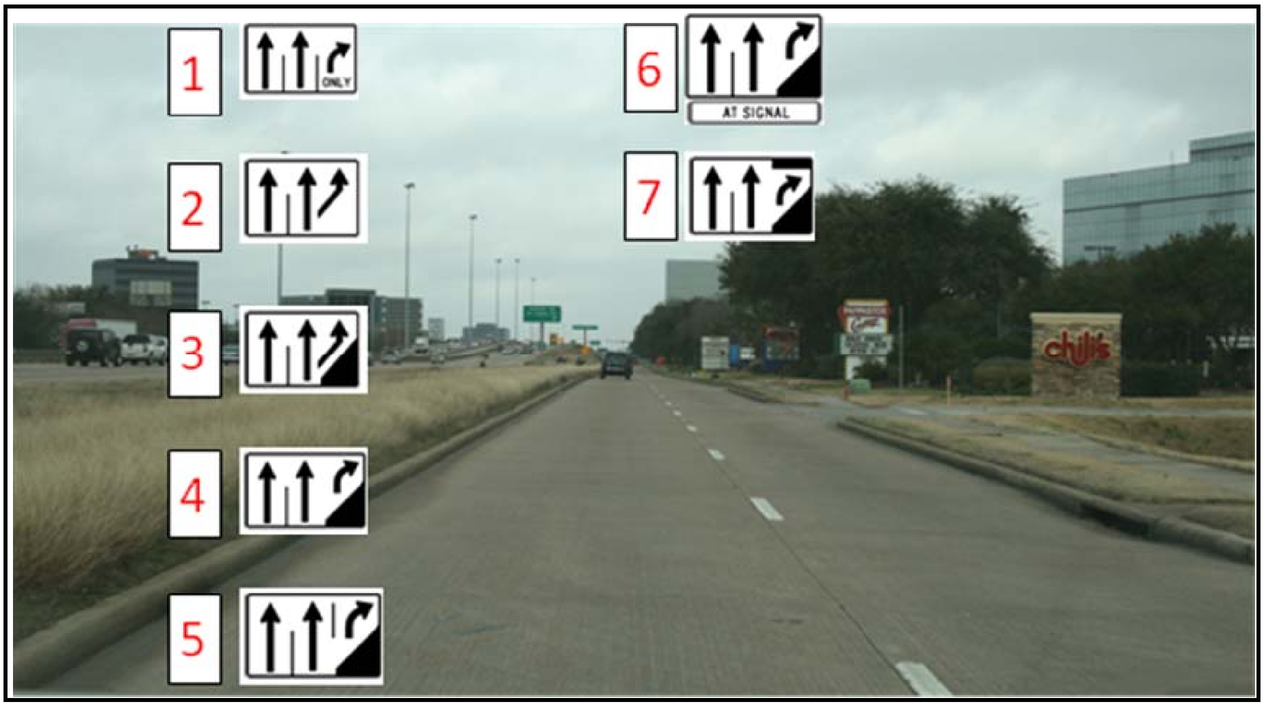


Figure 89. Driver Survey: Question 7.4 Stimuli.

Table 40. Driver Survey: Question 7.4 Results.

Question 7.4: Which of these signs do you think best indicates that the road is widening ahead and there is a lane being added on the right?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1 - (Sign 7.1)	8%	4%	6%	6%	6%
2 - (Sign 7.2)	12%	4%	13%	14%	11%
3 - (Sign 7.2B)	40%	46%	47%	51%	46%
4 - (Sign 7.3)	0%	4%	2%	0%	1%
5 - (Sign 7.3B)	30%	20%	11%	10%	18%
6 - (Sign 7.3C)	6%	18%	15%	16%	14%
7 - (Sign 7.3D)	4%	4%	6%	4%	4%
Sample Size	50	50	53	51	204

Looking at the geometry for a turn-only lane, the standard existing sign (7.1) was favored by 49 percent of the participants, as seen in Table 41. The second favorite (7.1C) at 28 percent was the same sign with the addition of a lane drop block (Sign 5 in Figure 90).

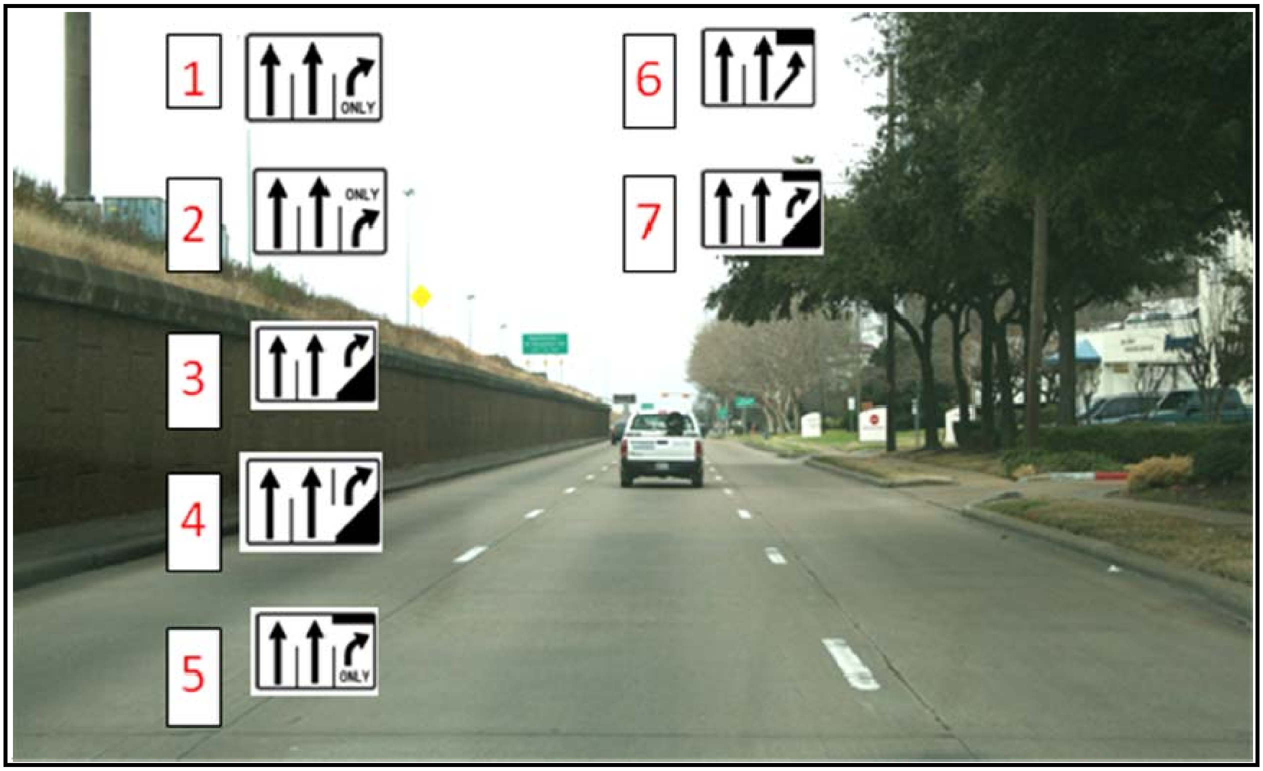


Figure 90. Driver Survey: Question 7.5 Stimuli.

Table 41. Driver Survey: Question 7.5 Results.

7.5 Which of these signs do you think best indicates that at the intersection ahead the far right lane MUST turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1- (Sign 7.1)	42%	58%	42%	55%	**49%**
2- (Sign 7.1B)	28%	8%	17%	14%	17%
3 - (Sign 7.3)	4%	4%	2%	0%	2%
4 - (Sing 7.3B)	0%	0%	0%	4%	1%
5 - (Sign 7.1C)	22%	26%	40%	24%	28%
6 - (Sign 7.2C)	0%	0%	0%	0%	0%
7 - (Sign 7.3D)	4%	4%	0%	4%	3%
Sample Size	50	50	53	51	204
NOTE: Bold percentages indicate highest percentage of respondents making that choice.					

Questions 7.6A - 7.6F

Questions 7.6A-7.6F focused on the signalized intersection of a cross street and frontage road from the view of the cross street (see Figure 91). The perspective of the base picture was from a left-turn-only lane. For each stimulus picture, the route numbers and directions were altered. The following instructions were displayed before each stimuli was viewed:

> *The next picture will only be shown for several seconds before you will be asked a question about the signs you viewed. The picture is taken from the perspective of Mike at an intersection with the frontage road of a freeway. When you are ready to view the picture, please hit any button.*

The stimulus slide was shown for 3.5 seconds before asking the participant to choose what they thought would happen at the light to the lane Mike was traveling. The data for Question 7.6C were omitted due to survey error, although researchers still propose this route assembly placement as an option to be considered.

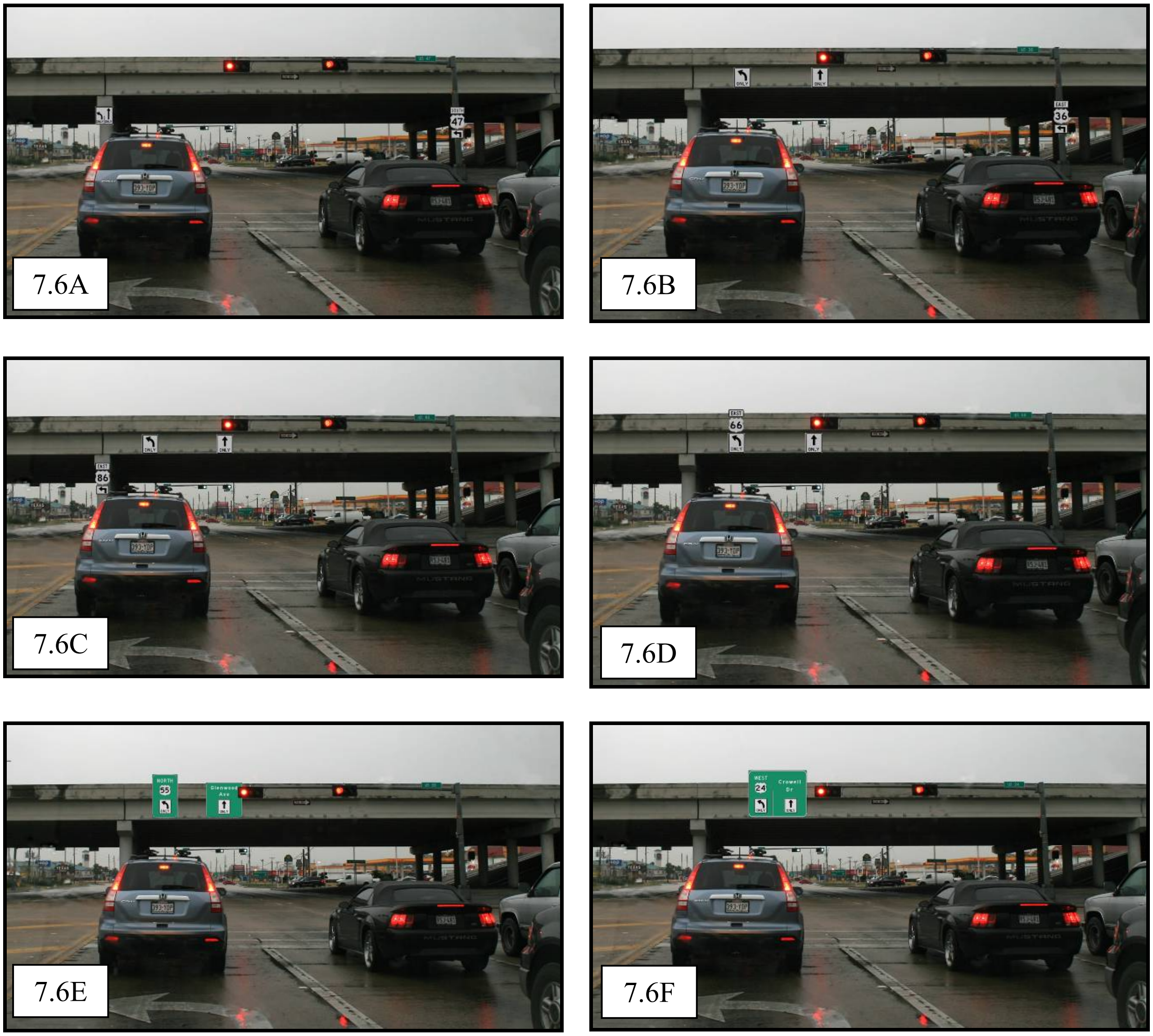


Figure 91. Driver Survey: Questions 7.6-7.6F Stimuli.

Table 42 shows a comparison of the data for Questions 7.6A-7.7F. Each question resulted in the greatest percentage of the correct response, with 7.6B performing the best at a 55 percent level of correct response. The combination signs in Question 7.6E (taken from the federal MUTCD's sign D15-1 in Section 2D.33 *(4)*) and Question 7.7F had the second-best scores at 49 percent correct. The majority of responses for all stimuli indicated drivers understood they would be turning left from this lane, although there was some confusion on whether they were turning on a frontage road or the actual freeway itself.

Table 42. Driver Survey: Questions 7.6A-7.6F Comparison.

Questions 7.6A-7.6F Compared: What will happen to the lane Mike is in at the intersection?					
Response	**7.6A**	**7.6B**	**7.6D**	**7.6E**	**7.7F**
A. Will turn left on unknown frontage road	24%	10%	30%	0%	15%
B. Will turn left on [36 East] frontage road	**44%**	**55%**	**45%**	**49%**	**49%**
C. Will turn left on [36 East]	25%	36%	18%	37%	29%
D. Will go straight on unknown road	4%	0%	3%	2%	2%
E. Will go straight on [36 East]	2%	0%	3%	5%	0%
F. Will go straight on [Palmer Rd]	0%	0%	3%	7%	5%
Sample Size	204	42	40	41	41
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded row indicates correct answer.					

Questions 7.7A - 7.7D

Questions 7.7A-7.7D looked at various methods to indicate a lane drop with pavement markings, as seen in Figure 92. The base picture showed a three-lane frontage road from the perspective of the right lane. For each question, the following instructions were displayed before the stimulus was viewed:

> *The next picture will only be shown for several seconds before you will be asked a question about the signs you viewed. The picture is taken from Mike's perspective as he drives along a frontage road in the right lane. When you are ready to view the picture, please hit any button.*

The stimulus slide was shown for 3.5 seconds before participants were asked what they thought would happen ahead to the lane Mike was traveling.

Questions 7.7A-7.7D results are compared in Table 43. All four pictures resulted in high comprehension. Stimulus 7.7B and 7.7C, both using the word "AHEAD," each scored a 90 percent comprehension. Questions 7.7A and 7.7D also scored high comprehension, with 78 percent each.

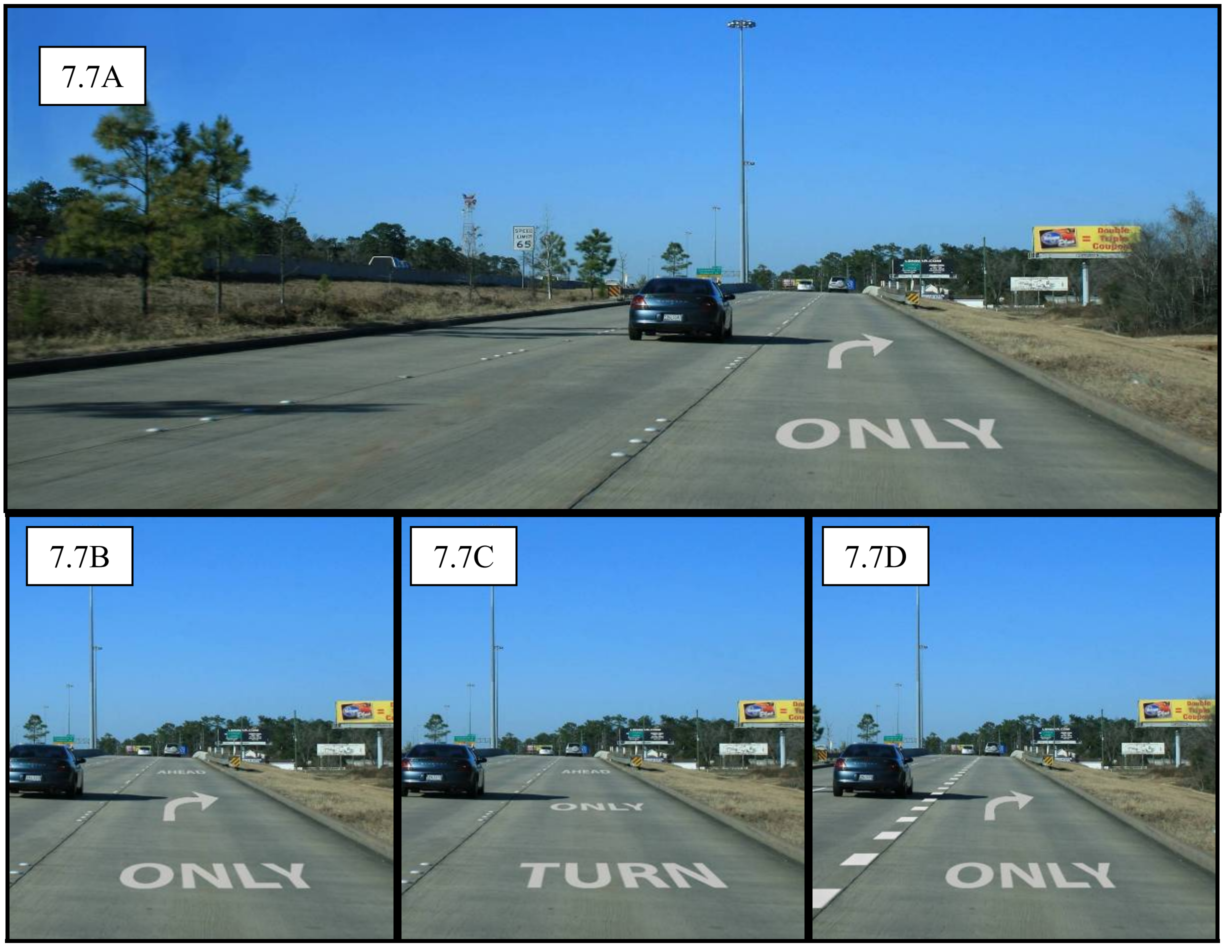


Figure 92. Driver Survey: Questions 7.7A-7.7D Stimuli.
(Note: All four stimuli showed the full road as seen in Question 7.7A's stimulus)

Table 43. Driver Survey: Questions 7.7A-7.7D Comparisons.

Questions 7.7A-7.7D Compared: What will happen up ahead to the lane Mike is in?				
Response	**7.7A** 	**7.7B** 	**7.7C** 	**7.7D** 
A. It will go straight only	18%	2%	5%	13%
B. It can go straight or right	5%	7%	5%	10%
C. It will turn right only	**78%**	**90%**	**90%**	**78%**
Sample Size	40	41	41	40
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded row indicates correct answer.				

Question 7.8

Question 7.8 asked the survey participants which of the previously shown pavement markings best tells the driver what will happen to the lane at the intersection. When the thicker longitudinal markings representing a lane drop (Figure 3B-10 in the TxMUTCD *(5)*) were added to version 7.7A, creating 7.7D, the comprehension results did not produce a greater percentage of correct responses. Although when asked which type of markings best indicated what was happening to the lane ahead, 7.7D was the preference at 50 percent (see Table 44). At 35 percent, the second preference was 7.7B.

Figure 93. Driver Survey: Question 7.8 Stimulus.

Table 44. Driver Survey: Question 7.8 Results.

Question 7.8: Which of these markings do you think best tells you what will happen to the lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1- (7.7A)	4%	8%	9%	4%	6%
2- (7.7B)	38%	30%	34%	37%	35%
3 - (7.7C)	20%	4%	9%	4%	9%
4 - (7.7D)	38%	58%	47%	55%	50%
Sample Size	50	50	53	51	204

Questions 7.9A and 7.9B

Questions 7.9A and 7.9B (Figure 94 and Figure 95) show a base picture of a two-lane frontage road with a lane assignment sign indicating four lanes of travel. Question 7.9A showed a standard lane assignment sign, whereas 7.9B showed a sign utilizing lane assignment tapers. For each question, the following instructions were first displayed:

> *The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is from Mike's perspective as he drives in the left lane of a frontage road approaching an intersection. Please*

read the signs Mike sees along the roadway. When you are ready to view the picture, please hit any button.

The stimulus slides in Figure 94 and Figure 95 were then shown for 3.5 seconds before the participant was asked to choose what would happen to the lane Mike was traveling in at the upcoming intersection.

The standard sign shown in Question 7.9 does not graphically illustrate where the extra two lanes will be added to the frontage road, although 7.9B used lane addition tapers to do so. Without the tapers, 62 percent of the participants believed the left lane would be forced to turn left at the intersection, but this would only be correct if both lanes were added to the right side of the road, which would be a rare configuration. With Question 7.9B, 65 percent of the participants responded correctly that the left lane would have the option to turn or go straight.

Figure 94. Driver Survey: Question 7.9 Stimuli.

Table 45. Driver Survey: Question 7.9 Stimulus and Result.

Question 7.9A: What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike will be forced to turn left at the intersection	50%	55%	76%	65%	62%
B. Mike can turn left or drive straight at the intersection	50%	45%	24%	35%	38%
C. Mike can only drive straight at the intersection	0%	0%	0%	0%	0%
Sample Size	20	20	21	20	81

Figure 95. Driver Survey: Question 7.9B Stimuli.

Table 46. Driver Survey: Question 7.9B Results.

Question 7.9B: What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike will be forced to turn left at the intersection	33%	26%	41%	29%	33%
B. Mike can turn left or drive straight at the intersection	62%	68%	59%	71%	65%
C. Mike can only drive straight at the intersection	5%	5%	0%	0%	2%
Sample Size	21	19	22	21	83

Questions 7.10A - 7.10E

Questions 7.10A-7.10E showed a base picture of a three-lane frontage road with a lane assignment sign indicating five lanes of travel (see example shown in Figure 96). The initial image shown as part of Question 7.10A-7.10E showed a standard version of the sign, while 7.10A-7.10E showed versions utilizing lane addition tapers and lane drop blocks. For each question, the following instructions were first displayed:

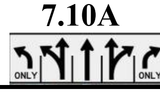
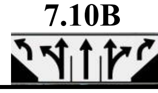
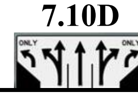
> *The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is from Mike's perspective as he drives in the right lane of a frontage road approaching an intersection. Please read the signs Mike sees along the roadway. When you are ready to view the picture, please hit any button.*

The stimulus slide was then shown for 3.5 seconds before the participant was asked to choose what would happen to the lane Mike was traveling in at the upcoming intersection.

Figure 96. Driver Survey: Questions 7.10A-7.10E Example Stimulus.

Table 47 shows the results compared for Questions 7.10A-7.10E. The stimulus for 7.10 is a standard sign without lane addition tapers. The other four signs use lane addition taper graphics to indicate that a lane will be added on either side of the road. For the signs with the lane addition tapers it was more clear to the participants than the standard sign that the right lane could travel straight or turn right. Sign 7.10B performed the best at 74 percent. The difference between signs 7.10C and 7.10D was an increase in the lane addition taper length from the bottom of the sign. This adjustment showed an increase of 12 percent comprehension for sign 7.10D. Adding “ONLY” text (7.10C) or lane drop blocks (7.10E) did not result in as high comprehension as the less complicated sign 7.10B.

Table 47. Driver Survey: Questions 7.10-7.10E Comparisons.

Questions 7.10A-7.10E Compared: What will happen to the lane Mike is in at the intersection?					
Response	**7.10A** 	**7.10B** 	**7.10C** 	**7.10D** 	**7.10E** 
A. Mike can only drive straight at the intersection	3%	7%	0%	8%	15%
B. Mike can turn right or drive straight at the intersection	47%	**74%**	**54%**	**68%**	**63%**
C. Mike will be forced to turn right at the intersection	**50%**	19%	46%	25%	23%
Sample Size	204	42	41	40	40
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded cells indicate correct answers.					

Questions 7.11A - 7.11C

Questions 7.11A-7.11C showed an initial base picture of a three-lane frontage road with a lane assignment sign indicating five lanes of travel (Figure 97). Questions 7.11A-7.11C displayed a standard sign, while the other versions showed alternatives using lane addition tapers and lane drop blocks. For each question, the following instructions were first displayed:

> *The next picture will only be shown for several seconds before you will be asked a question about the sign you viewed. The picture is from Mike's perspective as he drives in the left lane of a frontage road approaching an intersection. Please read the signs Mike sees along the roadway. When you are ready to view the picture, please hit any button.*

The stimulus slide was then shown for 3.5 seconds. The participant was asked to choose what would happen to the lane Mike was traveling in at the upcoming intersection.

Figure 97. Driver Survey: Questions 7.11-7.11C Example Stimulus.

The responses to Question 7.11 and the alternatives 7.11B and 7.11C are compared in Table 48. The sign in 7.11 does not graphically indicate where the two new lanes of travel represented on the sign will be added. Of the respondents, 75 percent assumed that the left lane in the picture would turn left at the intersection. Questions 7.11B and 7.11C used lane addition tapers to represent two different ways that the two new lanes could be added to the roadway. Question 7.11B resulted in 61 percent correctly responding that Mike would be forced to turn left at the intersection, 6 percent less than the amount who responded the same way for the standard sign. Although only 22 percent of respondents correctly chose that Mike could only drive straight with version 7.11C, that was 16 percent more than those who responded the same for the standard sign, 7.11.

Table 48. Driver Survey: Questions 7.11-7.11C Comparison.

Questions 7.11-7.11C Compared: What will happen to the lane Mike is in (the left of three lanes) at the intersection?			
Response	**7.11** 	**7.11B** 	**7.11C** 
A. Mike will be forced to turn left at the intersection	**75%**	**61%**	38%
B. Mike can turn left or drive straight at the intersection	20%	35%	**40%**
C. Mike can only drive straight at the intersection	6%	4%	22%
Sample Size	204	83	81
NOTE: Bold percentages indicate highest percentage of respondents making that choice. Shaded cells indicate correct answers.			

DRIVER SURVEY CONCLUSIONS

From the data collected from the computer survey, researchers formulated the following conclusions:

- As shown by the data in Table 10, most subjects do not feel advanced pavement markings are necessary to mark an upcoming intersection on simple two-lane frontage roads, although advance signing is still desired.

- Questions 1.2A-1.2D (see Table 10) compared various pavement marking options for lane assignment at a frontage road/cross street intersection. From the results of Questions 1.2C and 1.2D, it can be implied that if budget or maintenance concerns are an issue, the use of *lane assignment pavement marking <u>arrows</u>* across all lanes of travel may convey an appropriate amount of information to drivers, leaving the "ONLY" text for the turn-only lanes as optional guidance that could be omitted as necessary.

- Contrary to the general opinions heard in the focus groups, drivers in the surveys mainly thought that a lane assignment sign depicting five lanes of travel on both sides of the road was too much information (see Figure 65 and Table 11). The survey participants appear to be more satisfied with the signs divided and depicting turn movements on the respective sides of the road. Signs installed on either side of the road could represent only the exclusive turn lanes, or could include all turn-only lanes and shared or optional turn lanes. The through-only lanes do not appear to be critical information to drivers with respect to their comprehension of "split" signing versus signing depicting all lanes.

- The results of Question 2.1, summarized in Table 12, imply that the majority of drivers assume that when driving on a three-lane frontage road the far left lane will be forced to turn left at the upcoming intersection. These results may also be used to imply that drivers in the left lane may tend to make unnecessary lane changes upstream of the intersection if they do not want to turn. Since there appear to be fairly clear driver expectations for lane use on approach to an intersection, it can be assumed that where driver expectations may be violated additional signing may be necessary to clarify lane assignments further upstream.

- Questions 2.2 and 2.3 clearly show that when approaching an unsignalized intersection of a freeway frontage road and a cross street drivers are equally split on their assumptions of the interchange geometry and where they should turn, indicating that advance guide signing and/or lane assignment signing is warranted in these situations (see Table 13 and Table 14).

- Right-angled arrows used on guide signs (rather than the straight through movement arrow) tended to lead survey participants to believe the turn was immediate and not farther down the road (see Table 15 and Table 16).

- Referring to the data shown in Table 30, if an intersection approach has an optional turn lane next to an exclusive turn lane, but there is only a sign for the turn-only lane, drivers tend to believe that the far lane (either left or right) is the only lane from which they can turn. These results indicate that the optional turn lane should always be signed.

- Referring to the data gathered for Questions 5.10 and 5.11, the use of "KEEP RIGHT" does not appear to give drivers enough information to judge where a particular movement may be made. The use of this language may cause misconceptions on the distance and/or immediacy of the turn (see Table 35 and Table 36). While it was not explicitly tested in the survey, the use of "RIGHT LANE" or a distance (e.g., "500 FEET") may provide more clarity.

- Question 5.4 (see Table 24) indicates that driver wording preferences for a plaque added to the bottom of a lane assignment sign is "AT SIGNAL." In Table 39, a lane assignment sign with the same plaque (7.3C) showed higher comprehension than one without the plaque.

- Responses to Question 7.7 (see Table 43) indicated that when using advance pavement markings for a lane drop where the intersection approach is out of sight, drivers best respond to a pavement marking configuration that used the word "AHEAD" on the pavement (either a "ONLY" + arrow + "AHEAD or "TURN" + "ONLY" + "AHEAD" configuration).

- The lane addition taper graphic can be utilized on lane assignment signs to show where lane additions will occur. Increasing the taper length on the rectangular shape used to denote the taper geometry increased comprehension as shown in the comparison of 7.10D to 7.10C in Table 47. However, answers to Question 7.11 (see Table 48) may imply that lane assignment signs that incorporate the taper geometry graphically are the most effective for cases where the downstream geometry varies from driver expectations (which was addressed by Objective 2 of the driver survey). For cases where the geometry and lane use does not generally violate driver expectation, the use of the taper graphic on the R3-8 modified sign may be less effective.

CHAPTER 8: FIELD DEPLOYMENT AND EVALUATION

Following the results of the focus groups and driver surveys, sign types for two different applications were chosen for field installation and observational testing. The first sign type was selected for use on an arterial cross-street approach to a cloverleaf-type freeway interchange. The second sign type was selected for use on a frontage road approach to a signalized intersection where the frontage road flares out to include additional lanes at the intersection. For each of the two sign types, the research team selected multiple potential field test sites in the Houston District. The number of sites was narrowed down and presented to the PMC, and one site was chosen for each of the two types of sign applications.

EVALUATION SITE #1: ARTERIAL CROSS-STREET APPROACH TO A CLOVERLEAF-TYPE FREEWAY INTERCHANGE

The first selected site was the eastbound approach of West Little York Road to US 290 in the TxDOT Houston District. West Little York Road is a four-lane arterial roadway that intersects US 290 at a modified cloverleaf interchange. The cloverleaf ramps connect to and from the US 290 frontage road, and they allow for all eight movements at the interchange. The posted speed limit on West Little York Road is 45 mph, and the directional ADT for the eastbound direction of this roadway is 14,400 vehicles per day.

Eastbound traffic on West Little York Road must take a right prior to the overpass to access US 290 eastbound. In order to access US 290 westbound, eastbound West Little York traffic must cross the overpass and take a right, entering the loop that connects to the US 290 westbound frontage road. West Little York Road has two continuous lanes in the eastbound direction, and the exits to US 290 are optional exits from the right lane. Figure 98 shows a map of this site with arrows showing the eastbound path of West Little York Road.

Study Methodology

A before-and-after study approach was selected to evaluate the operational effects of the selected sign. Specifically, the site was to be observed during three data recording study periods: 1) Before, 2) After #1, and 3) After #2. In the Before period, no changes were made to the site. The existing signage remained, and no additional signage was added. In the After #1 period, the first proposed sign was added on the right side of the eastbound approach to the interchange, approximately 200 feet prior to the right turn to US 290 eastbound. In the After #2 period, the sign was revised, and the new sign display replaced the sign installed for After #1. Appendix H shows the sign tested in measured detail.

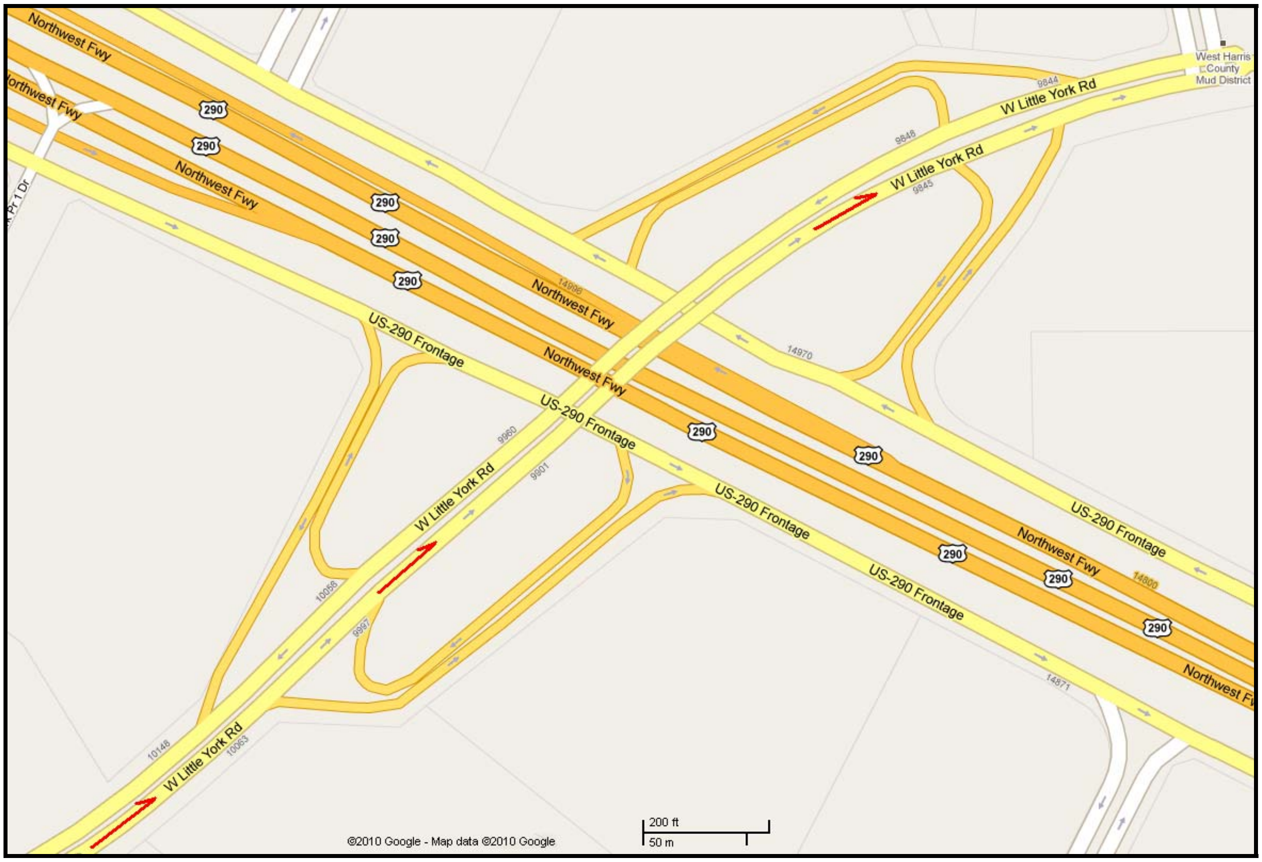


Figure 98. Site 1: Map of West Little York Road at US 290, Houston, Texas.

The sign being tested was a guide sign with an up arrow and emblem for US 290 west on the top and a right-facing arrow with an emblem for US 290 east on the bottom. The top of the sign was intended to direct drivers across the overpass to access US 290 westbound. The bottom portion of the sign was intended to direct drivers to take a right before the overpass to access US 290 eastbound. In order to test two types of sign display, an interchangeable sign was installed with two up arrows on the top portion of the sign (one on each side of the US 290 emblem).

In the After #1 period, the arrow on the right side was covered so that it was not visible or noticeable to approaching drivers. This means that the After #1 period tested a sign that had the up arrow on the left side of the top portion of the sign. For the After #2 period, the up arrow on the top right of the sign was uncovered, and the up arrow on the top left was covered so that it was not visible or noticeable to approaching drivers. Therefore, the After #2 period tested a sign that had the up arrow on the right side of the top portion of the sign. The bottom portion of the sign remained the same for the After #1 and After #2 periods. Figure 99 and Figure 100 show the signs used for After #1 and After #2, respectively.

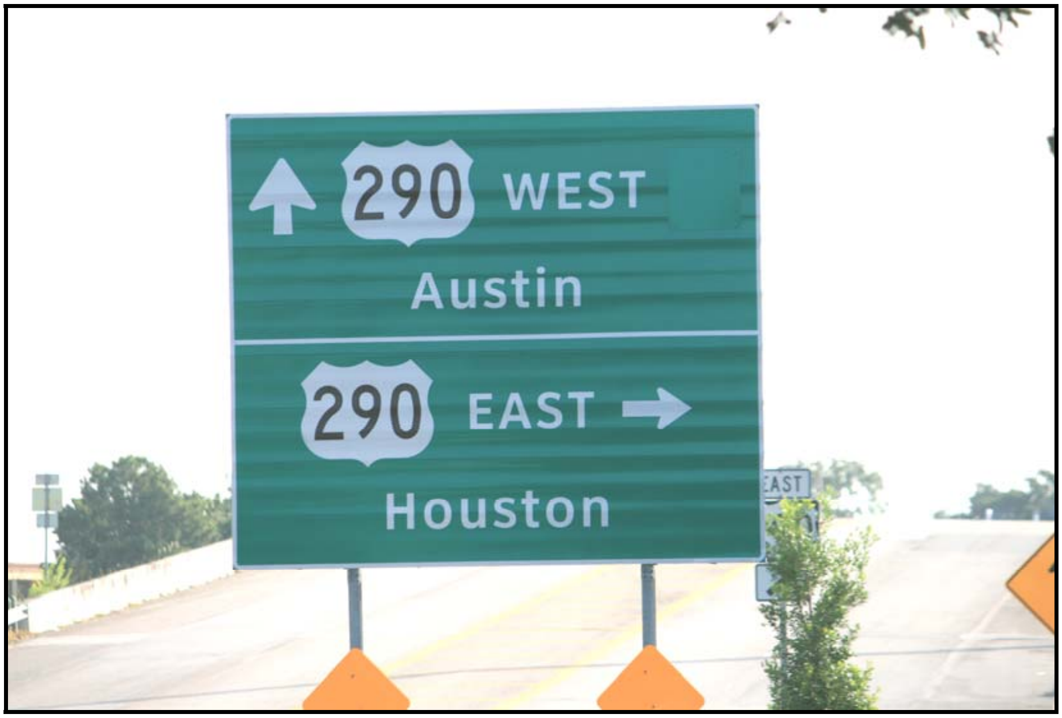


Figure 99. After #1 Sign (West Little York Road at US 290).

Figure 100. After #2 Sign (West Little York Road at US 290).

Operational traffic data were recorded in the same way for each study period. Automatic traffic counters recorded the total amount of approach traffic, and manual counts were completed during peak periods to record turning movements, lane change maneuvers, and illegal movements for relevant eastbound West Little York traffic. The peak periods were defined as 6:00 to 9:00 AM, 10:00 AM to 2:00 PM, and 3:00 to 6:00 PM. The data were collected on weekdays during which traffic was expected to be normal (i.e., no poor weather or traffic incidents causing delay on eastbound West Little York). Manual counts were done only for the peak periods because counting other times of the day would have required video recordings of the interchange, which were not feasible due to the geometric layout of the site and large elevation of the overpass.

For the purposes of determining where the lane changes occurred, the study site was divided into three zones for the eastbound West Little York traffic. Zone 1 began 600 feet prior to the right turn leading to US 290 eastbound and terminated at that right turn. Zone 2 began at the end of Zone 1 and ended at the crest of the overpass. Zone 3 began at the end of Zone 2 and ended 800 feet downstream, just after the cloverleaf ramps to and from US 290 westbound. Each of these zones contains two eastbound lanes. Figure 101 illustrates these zones on a map.

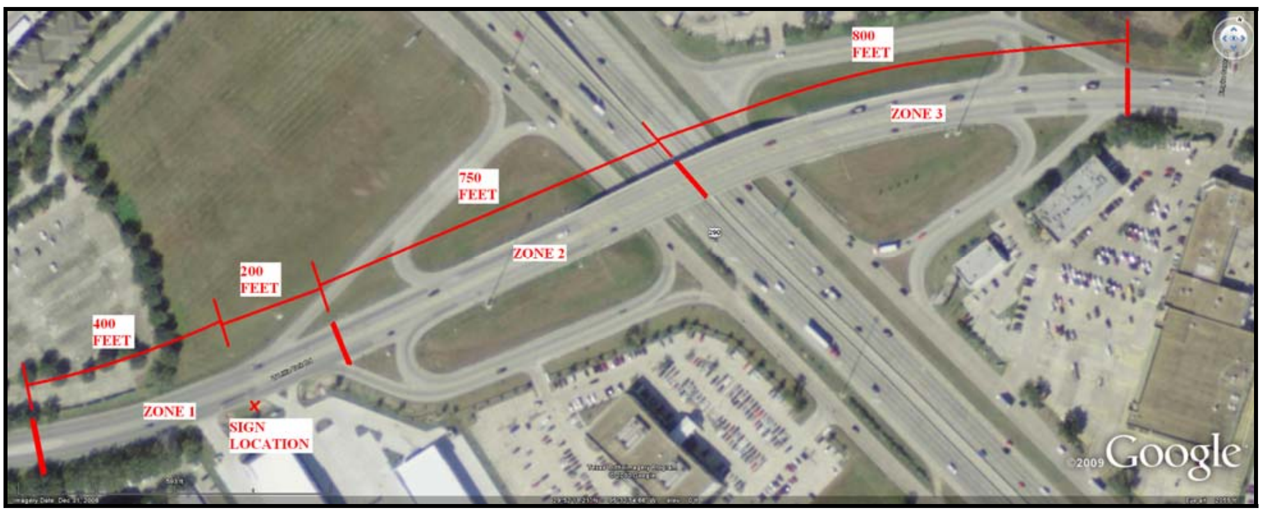


Figure 101. Data Collection Zones for West Little York Road at US 290.

Results

In order to compare the number of lane changes, turning movements, and illegal movements, the manual count data were summarized into peak-period totals (i.e., AM, Midday, PM) for each study period (Before, After #1, After #2). These totals were created separately for each zone.

Table 49. Summarized Results for Zone 1.

Study Period	Date	Peak Period	From Left Lane		From Right Lane		Exited Right to US 290 Eastbound	
			Stay in Left	Left to Right	Right to Left	Stay in Right	From Left Lane	From Right Lane
Before (No Sign)	7/16/2010	6:00-9:00	1135	21	27	903	1	561
	7/15/2010	10:00-14:00	1319	44	31	1364	6	958
	7/15/2010	15:00-18:00	1861	12	22	1569	0	789
After #1	8/12/2010	6:00-9:00	1212	32	10	958	0	606
	8/5/2010	10:00-14:00	1269	66	46	1407	2	960
	8/5/2010	15:00-18:00	1795	21	36	1549	1	826
After #2	8/17/2010	6:00-9:00	1374	41	29	920	0	590
	8/17/2010	10:00-14:00	1306	83	46	1361	1	960
	8/16/2010	15:00-18:00	2065	36	53	1413	1	900

Table 50. Lane Change Percentages for Zone 1.

Study Period	Date	Peak Period	% Changing Lanes Left to Right	% Changing Lanes Right to Left	% Changing Lanes Left to Right (Total of All Peak Periods)	% Changing Lanes Right to Left (Total of All Peak Periods)
Before (No Sign)	7/16/2010	6:00-9:00	1.8%	2.9%	1.8%	2.0%
	7/15/2010	10:00-14:00	3.2%	2.2%		
	7/15/2010	15:00-18:00	0.6%	1.4%		
After #1	8/12/2010	6:00-9:00	2.6%	1.0%	2.7%	2.3%
	8/5/2010	10:00-14:00	4.9%	3.2%		
	8/5/2010	15:00-18:00	1.2%	2.3%		
After #2	8/17/2010	6:00-9:00	2.9%	3.1%	3.3%	3.3%
	8/17/2010	10:00-14:00	6.0%	3.3%		
	8/16/2010	15:00-18:00	1.7%	3.6%		

The summarized results for Zone 1 are shown in Table 49, and percentages of lane changes are shown in Table 50. The columns with "From Left Lane" refer to vehicles that entered Zone 1 in the left lane and exited the zone without turning onto US 290. These vehicles could leave Zone 1 after performing one of two possible actions: 1) stay in the left lane, or 2) change lanes from left to right. Similarly, the columns with "From Right Lane" refer to vehicles that entered Zone 1 in the right lane and exited the zone without turning onto US 290. The two possible actions for these vehicles are: 1) change lanes from the right lane to the left lane, or 2) stay in the right lane. The traffic that exited to US 290 eastbound is shown in the two right columns of Table 49. These exiting vehicles were divided into those that exited from the left lane and those that exited from the right lane. Finally, Table 50 shows the percent of vehicles making each of the two types of lane changes in Zone 1. The columns on the left show the percentages for each peak period, and the columns on the right show the percentages for the total of all the peak periods.

For the Before, After #1, and After #2 study periods, the approach traffic volumes remained similar for each of the eastbound lanes entering Zone 1, so it appears that similar traffic was studied in each of these three study periods. One of the purposes of the added sign was to provide advance information to the driver regarding where to turn for a particular desired destination. Therefore, one anticipated result for Zone 1 was an increase in lane changes from the left lane to the right lane. This would indicate that more drivers are making the lane change earlier for their exits to US 290 westbound on the other side of the overpass. The percent of vehicles changing lanes from left to right increased in all peak periods from Before to After #1 and from Before to After #2. Using the total from all peak periods, this percentage increased from 1.8 percent for the Before study data to 2.7 percent for After #1, and 3.3 percent for After #2. Although it appears that the percentages of left-to-right lane changes increased, it should be pointed out that similar increases in right-to-left lane changes were also observed. Based on these data, the sign used in After #2 seemed to have a greater effect on the percentage of lane changes than the sign used in After #1.

One of the other anticipated results for Zone 1 was a decrease in the number of vehicles exiting to US 290 eastbound from the left lane (an illegal maneuver). The data in Table 49 show that there were seven of these violations in the Before data while there were only three in the After #1 data and two in the After #2 data. It appears that the presence of the sign (either After #1 or After #2) may have had some effect in reducing the number of drivers making the right turn exit from the left lane.

Table 51. Summarized Results for Zone 2.

Study Period	Date	Peak Period	From Left Lane		From Right Lane	
			Stay in Left	Left to Right	Right to Left	Stay in Right
Before (No Sign)	7/16/2010	6:00- 9:00	1206	59	13	363
	7/15/2010	10:00-14:00	1098	164	44	367
	7/15/2010	15:00-18:00	1696	186	39	810
After #1	8/12/2010	6:00- 9:00	1332	65	15	354
	8/5/2010	10:00-14:00	1219	136	25	432
	8/5/2010	15:00-18:00	1665	132	20	644
After #2	8/17/2010	6:00- 9:00	1160	137	25	406
	8/17/2010	10:00-14:00	1043	188	25	384
	8/16/2010	15:00-18:00	1690	182	31	731

Table 52. Lane Change Percentages for Zone 2.

Study Period	Date	Peak Period	% Changing Lanes Left to Right	% Changing Lanes Right to Left	% Changing Lanes Left to Right (Total of All Peak Periods)	% Changing Lanes Right to Left (Total of All Peak Periods)
Before (No Sign)	7/16/2010	6:00-9:00	4.7%	3.5%	9.3%	5.9%
	7/15/2010	10:00-14:00	13.0%	10.7%		
	7/15/2010	15:00-18:00	9.9%	4.6%		
After #1	8/12/2010	6:00-9:00	4.7%	4.1%	7.3%	4.0%
	8/5/2010	10:00-14:00	10.0%	5.5%		
	8/5/2010	15:00-18:00	7.3%	3.0%		
After #2	8/17/2010	6:00-9:00	10.6%	5.8%	11.5%	5.1%
	8/17/2010	10:00-14:00	15.3%	6.1%		
	8/16/2010	15:00-18:00	9.7%	4.1%		

The summarized results for Zone 2 are shown in Table 51 and percentages of lane changes for Zone 2 are shown in Table 52. Traffic entering from US 290 eastbound was excluded from the traffic volumes counted in Zone 2. The lane change maneuvers were counted and categorized in the same way as for Zone 1, using the “From Left Lane” and “From Right Lane” designations each with the same two possible actions. Table 52 shows the percent of vehicles making each of the two types of lane changes in Zone 2, and these data are formatted as for Zone 1.

Just as for Zone 1, one anticipated result for Zone 2 was an increase in lane changes from the left lane to the right lane. This would indicate that more drivers are making the lane change earlier for their exits to US 290 westbound on the other side of the overpass. Based on the data from all peak periods, the percent of vehicles changing lanes from left to right decreased from 9.3 percent to 7.3 percent from Before to After #1, while the percent of vehicles changing lanes from right to left decreased from 5.9 percent to 4.0 percent for the same study periods.

On the other hand, the percent of vehicles from all peak periods changing lanes from left to right increased from 9.3 percent to 11.5 percent from Before to After #2. Based on these data, it appears that the sign used in After #2, which had the up arrow on the right side of the sign, may have had an effect in causing more drivers to make the early lane change from left to right. Conversely, the sign from After #1, which had the up arrow on the left side of the sign, may have caused fewer drivers to make lane changes.

Table 53. Summarized Results for Zone 3.

Study Period	Date	Peak Period	From Left Lane		From Right Lane		Exited Right to US 290 Westbound (WB)			Illegal Left Turns to US 290 WB
			Stay in Left	Left to Right	Right to Left	Stay in Right	From Left Lane	From Right Lane		
								Lane Change	No Lane Change	
Before (No Sign)	7/16/2010	6:00-9:00	1100	60	25	728	0	0	136	1
	7/15/2010	10:00-14:00	1193	66	49	1014	5	24	345	18
	7/15/2010	15:00-18:00	1764	37	31	1038	2	4	411	4
After #1	8/12/2010	6:00-9:00	1230	43	18	755	2	0	125	3
	8/5/2010	10:00-14:00	1208	37	34	1108	11	9	343	17
	8/5/2010	15:00-18:00	1732	39	30	1394	15	0	477	10
After #2	8/17/2010	6:00-9:00	1293	27	15	979	1	4	157	3
	8/17/2010	10:00-14:00	1191	42	32	998	4	17	337	14
	8/16/2010	15:00-18:00	1780	47	26	1383	9	0	470	13

Table 54. Lane Change Percentages for Zone 3.

Study Period	Date	Peak Period	% Changing Lanes Left to Right	% Changing Lanes Right to Left	% Changing Lanes Left to Right (Total of All Peak Periods)	% Changing Lanes Right to Left (Total of All Peak Periods)
Before (No Sign)	7/16/2010	6:00-9:00	5.2%	3.3%	3.9%	3.6%
	7/15/2010	10:00-14:00	5.2%	4.6%		
	7/15/2010	15:00-18:00	2.1%	2.9%		
After #1	8/12/2010	6:00-9:00	3.4%	2.3%	2.8%	2.5%
	8/5/2010	10:00-14:00	3.0%	3.0%		
	8/5/2010	15:00-18:00	2.2%	2.1%		
After #2	8/17/2010	6:00-9:00	2.0%	1.5%	2.6%	2.1%
	8/17/2010	10:00-14:00	3.4%	3.1%		
	8/16/2010	15:00-18:00	2.6%	1.8%		

The summarized results for Zone 3 are shown in Table 53, and percentages of lane changes for Aone 3 are shown in Table 54. The columns with "From Left Lane" and "From Right Lane" refer to the same categories used in the two previous zones. The traffic that exited to US 290 eastbound is shown in the columns marked as "Exited Right to US 290 Westbound," and these exiting vehicles were divided into three categories: 1) exited from left lane, 2) exited from right lane after making a lane change from left to right in Zone 3, or 3) exited from the right lane without making any lanes changes in Zone 3. Finally, Table 54 shows the percent of vehicles making each of the two types of lane changes in Zone 3, and the format for these data is the same as for the percent lane change data in Zones 1 and 2.

The data recorded for Zone 3 includes traffic that entered from US 290 eastbound into Zone 2. This entering traffic would not have been able to observe the signs installed for this study, but this traffic could not be excluded because of line of sight limitations encountered during the traffic counting process. Because the added sign was the only physical change to the site during the study periods, it was assumed that drivers who entered West Little York past the location of the sign would not have behaved any differently during any of the three study periods.

One anticipated result for Zone 3 was a decrease in lane changes from the left lane to the right lane. This would indicate that fewer drivers were making lane changes late (i.e., in Zone 3) for their exits to US 290 westbound. Based on data from all peak periods, the percent of vehicles changing lanes from left to right in Zone 3 decreased from Before to After #1 (3.9 percent down to 2.8 percent) and from Before to After #2 (3.9% down to 2.6%). It appears that the percentages of left-to-right lane changes decreased, and similar reductions were noted in the right-to-left lane changes. Based on these data, it appears that both signs tested may have caused fewer drivers to make lane changes in Zone 3.

One of the other anticipated results for Zone 3 was a decrease in the number of vehicles exiting to US 290 westbound from the left lane (an illegal maneuver). The data in Table 53 show that there were seven of these violations in the Before data while there were 28 in the After #1 data and 14 in the After #2 data. These data seem contrary to the expected results, and a possible explanation is as follows. The large increase in the number of vehicles turning right from the left lane during the After #1 period may be attributed to the fact that the sign had the up arrow on the top left of the sign. Some drivers may have inferred that the sign was indicating the turn for US 290 westbound was on the left or from the left lane. By the time the driver crossed the overpass and realized the turn was on the right, a decision had to be made as to whether or not to turn right from the left lane. Alternatively, the sign used for After #2 had the up arrow on the top right of the sign, so it is less likely drivers may have inferred the sign to mean that the turn was on the left. However, the number of turns from the left lane was still higher than in the Before study period, and it is difficult to explain this outcome.

The final measure of performance involves vehicles making an illegal left turn to access US 290 westbound. In Zone 3, eastbound vehicles on West Little York can potentially navigate a left turn to access US 290 westbound by utilizing the exit intended for westbound West Little York traffic. These vehicle maneuvers were counted, and a total of 23 were noted during the Before study period. In each of the After study periods, a total of 30 of these illegal maneuvers was recorded. Once again, this seems contrary to the anticipated results.

Discussion

In Zone 1 during both of the After periods, fewer drivers were recorded taking an illegal right turn from the left lane, and the percentage of lane changes increased. Compared to After #1, responses to the sign shown in After #2 period (see Figure 100) showed slightly larger increases in the percentage of lane changes. In Zone 2, the After #1 period showed reductions in left-to-right lane changes while the After #2 period showed increases in the left-to-right lane changes. Finally, in Zone 3, the After #1 and After #2 periods showed decreases in the percentages of both types of lane changes, with the After #2 period showing slightly greater reduction in the percentage of lane change maneuvers. There were mixed results regarding the illegal movements recorded for Zone 3, and the After periods produced increases in these illegal movements, with the After #1 period showing the largest number of right turns from the left lane.

All of the changes recorded and summarized for these results are relatively small changes on the order of a few percentage points, and detailed statistical testing would not reveal any statistically significant findings for the percent of lane changes. A similar assessment can be made for the illegal turn movements that were recorded. The results were mixed, but few statistically significant differences could be found in these data. Furthermore, findings that may prove to be statistically significant would still point to the same small percent changes in vehicular movements, so the "real-world" significance may still be small.

The general findings from this field test indicate that the signs may have caused a few more drivers to make lane changes earlier (in Zones 1 and 2) and that the After #2 sign (with the up arrow on the top right) may have done a slightly better job with this. It appears that the After #1 sign (with the up arrow on the top left) may have led to a large increase in the illegal turns from the left lane in Zone 3. Of the two signs tested, the After #2 sign seemed to perform slightly better.

EVALUATION SITE #2: FRONTAGE ROAD APPROACH TO A SIGNALIZED INTERSECTION

The second selected site was the southbound approach of the IH 45 frontage road to Cypresswood Drive in the Houston District. The southbound frontage road is a three-lane, one-way roadway that flares out to five lanes at the signalized intersection with Cypresswood Drive. The posted speed limit on the IH 45 southbound frontage road is 45 mph, and the ADT for this roadway is 13,200 vehicles per day. Figure 102 shows a map of this site with arrows showing the southbound frontage road path.

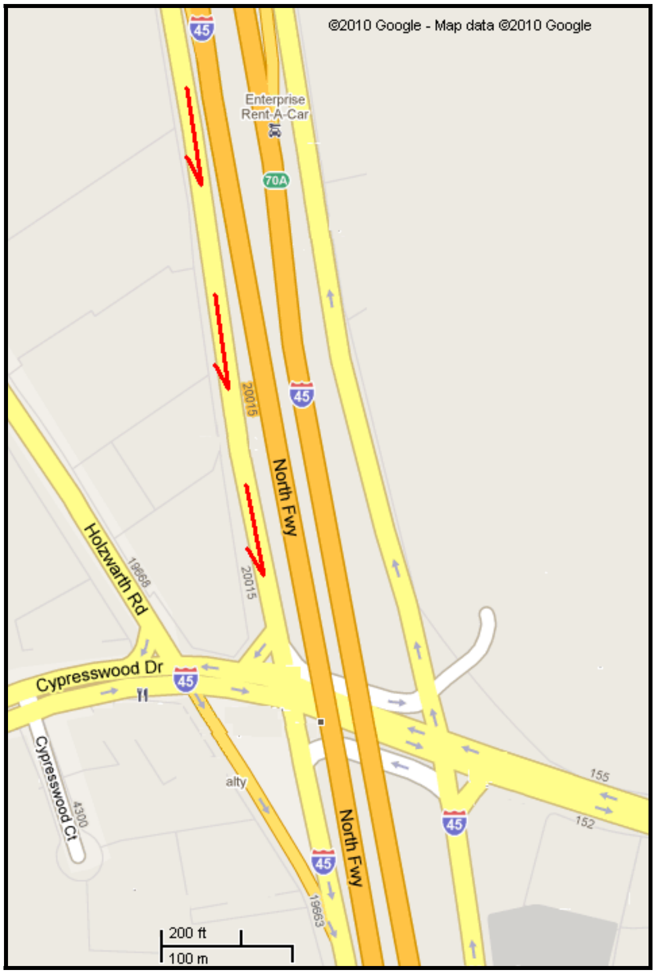


Figure 102. Site 2: Map of Southbound IH 45 Frontage Road at Cypresswood Drive, Houston, Texas.

Study Methodology

A before-and-after study approach was selected to evaluate the operational effects of the selected sign. Specifically, the site was to be observed during three data recording study periods: Before, After #1, and After #2. In the Before period, no changes were made to the site. The existing signage remained, and no additional signage was added. In the After #1 period, proposed signs were added on both sides of the frontage road, approximately 635 feet prior to the intersection stop line. The location of these signs was the same point where the three-lane roadway section begins to flare out to a fourth lane. In the After #2 period, the previous two signs were left in place, and a third sign was added on the right side of the roadway approximately 1135 feet prior to the intersection stop line. All three signs displayed the same information and were essentially the same except that the sign on the left side of the roadway could not be permanently mounted and was mounted on a temporary sign post. The sign being tested was an advance intersection lane control sign that displayed all allowable movements for each of the five lanes that meet the intersection. Figure 103 and Figure 104 show the signs used for After #1 and After #2, respectively. Appendix H shows the sign in measured detail.

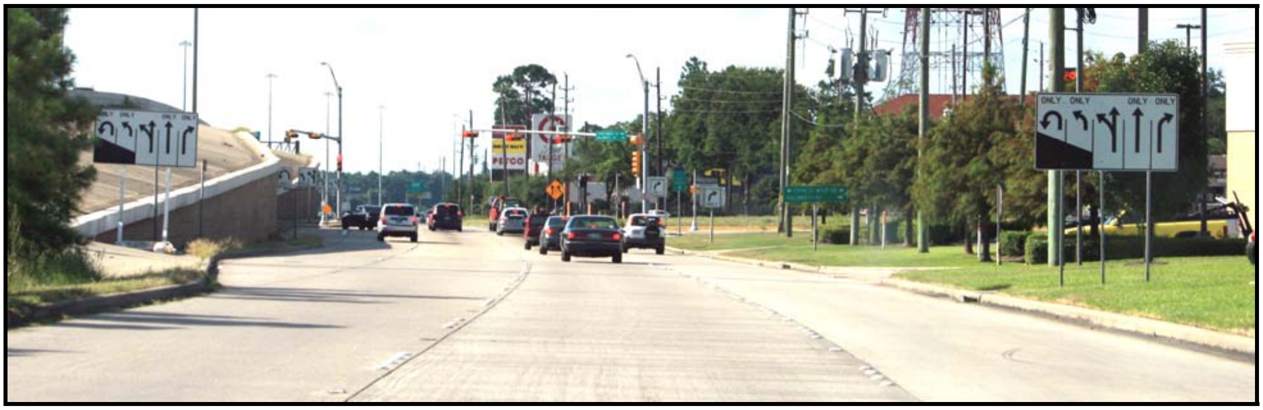


Figure 103. After #1 Signs (IH 45 Southbound at Cypresswood Drive).

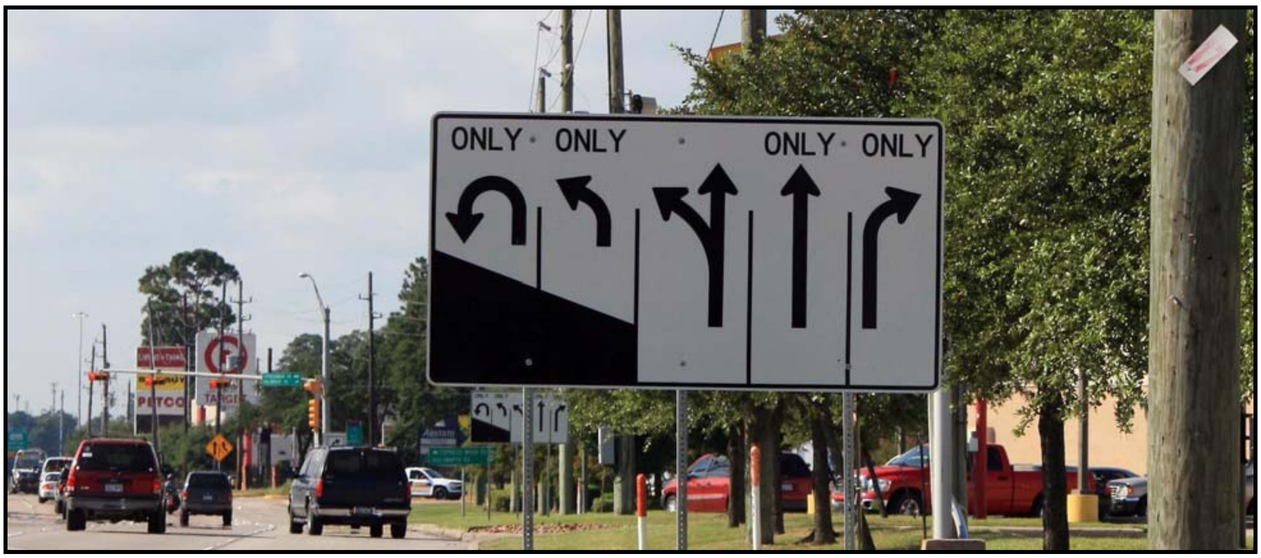


Figure 104. After #2 Sign (IH 45 Southbound at Cypresswood Drive).

For each study period, video was recorded at the intersection approach for a period of at least two full 24-hour periods per study period. Additionally, automatic traffic counters recorded the total amount of approach traffic, and this was used to identify which day and time periods would be manually observed and counted. The data were collected on weekdays during which traffic was expected to be normal (i.e., no poor weather or traffic incidents causing delay on the frontage road).

One day of video recordings was counted for each study period. Manual counts were completed in 15-minute intervals for 12:00 midnight to 8:00 PM for the Before and After #1 study periods. For the After #2 study period, only the midday hours between 10:00 AM and 2:00 PM were counted manually. This abbreviated amount of data reduction for After #2 was largely due to time constraints. In order to complete the project in a timely manner, some portions of the data had to be excluded. TTI researchers felt that the After #1 results would provide the most relevant information and that the midday times would be sufficient to show the results for the After #2 study period.

For the purposes of determining where the lane changes occurred, the study site was divided into four zones for the southbound frontage road traffic. Zone 1 began at the painted intersection stop line and ended 315 feet upstream of the stop line, at the point where the taper begins for the fifth lane to be added. Zone 2 began at the end of Zone 1 and ended 635 feet upstream of the painted stop line, at the point where the taper begins for the fourth lane to be added. This point was where the two signs were added for the After #1 study period. Zone 3 began at the end of zone 2 and ended 1135 feet upstream of the painted stop line, at the point where the additional sign was placed for the After #2 study period. Zone 4 began at the end of Zone 3 and ended 1635 feet upstream of the painted stop line. Zones 3 and 4 were each 500 feet long.

A lane number was assigned to each lane starting with the U-turn lane (farthest left lane). The U-turn lane was called lane 1, and the lane to the right of that was called lane 2. The next three lanes to the right were labeled lanes 3, 4, and 5, respectively. Table 55 shows the lane numbers and allowable vehicle movements at the intersection for each lane. Figure 105 illustrates the zones and lane numbers on a map.

Table 55. Traffic Movements for the IH 45 Southbound Frontage Road Approach to Cypresswood Drive.

Lane Assignments	Allowable Movements as Shown on Signs and Pavement and Lane Number								
	1	2		3		4			5
Possible Turning Movements	U-turn	Left	Thru*	Left	Thru	Left*	Thru	Right*	Right
Allowable Movement (YES/NO)	YES	YES	NO*	YES	YES	NO*	YES	NO*	YES

*movements considered lane use violations

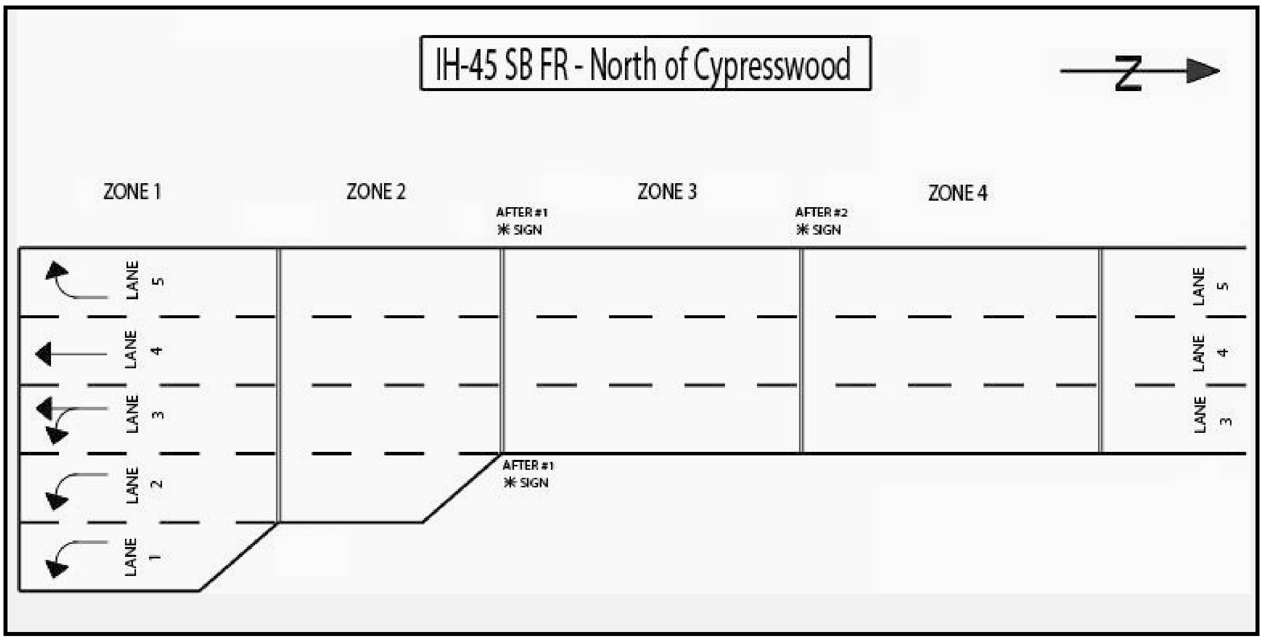


Figure 105. Data Collection Zones for IH 45 Southbound Frontage Road at Cypresswood Drive.

Results

In order to compare the number of lane changes, turning movements, and illegal movements, manual counts were completed for 12:00 midnight to 8:00 PM for the Before and After #1 study periods. The data from these two study periods were summarized into peak-period totals (i.e., AM, Midday, PM). Finally, the data for After #2 were completed for the midday peak period. These totals were created separately for each zone. In addition to lane changes, vehicle turning movements were also counted at the intersection for each study period.

Table 56 shows the turning movement count totals per lane at the intersection for the Before and After #1 study periods for the 20 hours between 12:00 midnight and 8:00 PM. Table

57 shows the lane utilization percentages for left turns and through movements for the same study periods and times of day.

Table 56. Turning Movement Counts for 12:00 Midnight to 8:00 PM.

Study Period	Date	Lane 1	Lane 2		Lane 3		Lane 4			Lane 5		All Lanes
		U-turn	Left	Thru*	Left	Thru	Left*	Thru	Right*	Thru*	Right	
Before	May 27, 2010	2,829	1,778	2	1,491	1,139	1	2,748	7	1	2,255	12,251
After #1	July 13, 2010	2,654	1,496	0	1,368	651	1	2,231	2	0	2,329	10,732

*movements considered lane use violations

Table 57. Turning Movement Lane Utilization Percentages for 12:00 Midnight to 8:00 PM.

Study Period	Date	Percent of All Left Turns		Percent of All Through Movements	
		Lane 2	Lane 3	Lane 3	Lane 4
Before	May 27, 2010	54.4%	45.6%	29.3%	70.7%
After #1	July 13, 2010	52.2%	47.8%	22.6%	77.4%

The total number of vehicles approaching the intersection decreased from the Before to the After #1 period; however, the reduction appears to be proportionately spread across each of the movements in each lane except for one particular movement. As seen in Table 57, the percent of all through movement vehicles using lane 3 dropped from 29.3 percent down to 22.6 percent. The percent drop in the number of through vehicles in lane 3 (43 percent drop from 1139 to 651) far exceeded any of the other percent changes for any other particular traffic movement. It appears that fewer vehicles utilized lane 3 for a through movement in the After #1 study period.

One anticipated effect of the sign installations was to reduce the number of illegal turn movements; however, very few of these movements were observed in the Before and After #1 study periods. There was an observed reduction (from 2 to 0) of the number of through movements from the left-only lane (lane 2), and a similar observed reduction (from 7 to 2) in the number of right turns from the through-only lane (lane 4). It is possible that the signs used in After #1 may have led to these reductions by helping drivers determine the proper lane from which to turn, but both the Before and After totals for these movements were quite small. Many additional observations would be required to determine if any significant changes occurred.

Table 58 shows the turning movement count totals per lane at the intersection for the Before and After #1 study periods for the three morning peak hours between 6:00 AM and 9:00 AM. Table 59 shows the lane utilization percentages for left turns and through movements for the same study periods and times of day. Most of the results in these two tables are similar to the results for the midnight to 8:00 PM time period. The total volume of vehicles decreased in the After #1 study period; however, there were large drops in the number of left-turning vehicles from lanes 2 and 3. These drops in left-turn volume are attributed to a nearby high school that was open during the Before period and closed during the After #1 period.

Table 58. Turning Movement Counts for Morning Peak (6:00 AM to 9:00 AM).

Study Period	Date	Lane 1	Lane 2		Lane 3		Lane 4			Lane 5		All Lanes
		U-turn	Left	Thru*	Left	Thru	Left*	Thru	Right*	Thru*	Right	
Before	May 27, 2010	391	231	0	126	272	0	445	0	0	211	1,676
After #1	July 13, 2010	306	142	0	125	202	0	370	0	0	232	1,377

*movements considered lane use violations

Table 59. Turning Movement Lane Utilization Percentages for Morning Peak (6:00 AM to 9:00 AM).

Study Period	Date	Percent of All Left Turns		Percent of All Through Movements	
		Lane 2	Lane 3	Lane 3	Lane 4
Before	May 27, 2010	64.7%	35.3%	37.9%	62.1%
After #1	July 13, 2010	53.2%	46.8%	35.3%	64.7%

Table 60 shows the turning movement count totals per lane at the intersection for the Before and After #1 study periods for the three afternoon peak hours between 4:00 PM and 7:00 PM. Table 61 shows the lane utilization percentages for left turns and through movements for the same study periods and times of day. Most of the results in these two tables are similar to the results for the midnight to 8:00 PM time period. The total volume of vehicles decreased in the After #1 study period; however, there was a slightly disproportionate drop in the number of through vehicles in lane 3, causing the percent utilization of through movements in lane 3 to drop as well.

Table 60. Turning Movement Counts for Afternoon Peak (4:00 PM to 7:00 PM).

Study Period	Date	Lane 1	Lane 2		Lane 3		Lane 4			Lane 5		All Lanes
		U-turn	Left	Thru*	Left	Thru	Left*	Thru	Right*	Thru*	Right	
Before	May 27, 2010	597	507	0	435	109	0	498	1	1	579	2,727
After #1	July 13, 2010	591	438	0	365	80	0	494	0	0	584	2,552

*movements considered lane use violations

Table 61. Lane Utilization Percentages for Afternoon Peak (4:00 PM to 7:00 PM).

Study Period	Date	Percent of All Left Turns		Percent of All Through Movements	
		Lane 2	Lane 3	Lane 3	Lane 4
Before	May 27, 2010	53.8%	46.2%	18.0%	82.0%
After #1	July 13, 2010	54.5%	45.5%	13.9%	86.1%

As mentioned previously, the Before and After #1 study periods were counted for midnight to 8:00 PM, and the After #2 study period was only counted for the midday hours. The results for the four midday hours are similar to those for the midnight to 8:00 PM hours. The total traffic volume decreased slightly, and fewer through vehicles were counted in both lanes 3 and 4. No notable differences were found between the After #1 and After #2 results. Very minor changes can be noted, but it appears that the added sign for the After #2 study period did not greatly affect the turning movements per lane at the intersection.

Table 62. Turning Movement Counts for Midday (10:00 AM to 2:00 PM).

Study Period	Date	Lane 1	Lane 2		Lane 3		Lane 4			Lane 5		All Lanes
		U-turn	Left	Thru*	Left	Thru	Left*	Thru	Right*	Thru*	Right	
Before	May 27, 2010	904	445	0	402	293	0	775	0	0	695	3,514
After #1	July 13, 2010	957	447	0	428	198	0	606	0	0	785	3,421
After #2	July 27, 2010	913	423	0	376	182	0	636	1	0	690	3,221

*movements considered lane use violations

Table 63. Turning Movement Lane Utilization Percentages for Midday (10:00 AM to 2:00 PM).

Study Period	Date	Percent of All Left Turns		Percent of All Through Movements	
		Lane 2	Lane 3	Lane 3	Lane 4
Before	May 27, 2010	52.5%	47.5%	27.4%	72.6%
After #1	July 13, 2010	51.1%	48.9%	24.6%	75.4%
After #2	July 27, 2010	52.9%	47.1%	22.2%	77.8%

Table 64 shows the number of lane changes that were observed in Zone 1 for the Before and After #1 study periods between midnight and 8:00 PM. Table 65, Table 66, and Table 67 contain the number of observed lane changes for Zone 1 for the morning peak period, afternoon peak period, and midday period, respectively. Similar to the turning movement count data, only Before and After #1 are compared for the midnight to 8:00 PM, morning peak, and afternoon peak periods. The midday period contains observed lane change data for the Before, After #1, and After #2 study periods.

Table 64. Lane Changes in Zone 1 for 12:00 Midnight to 8:00 PM.

Study Period	Date	From Lane 2			From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		2 to 1	2 to 3	2 to 4 and 2 to 5	3 to 1	3 to 2	3 to 4 and 3 to 5	4 to 1 and 4 to 2	4 to 3	4 to 5	5 to 1 and 5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	2,480	6	0	141	545	31	53	669	168	6	29	288	4,416
After #1	July 13, 2010	2,287	14	0	255	570	20	48	554	236	14	19	379	4,396

Table 65. Lane Changes in Zone 1 for Morning Peak (6:00 AM to 9:00 AM).

Study Period	Date	From Lane 2			From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		2 to 1	2 to 3	2 to 4 and 2 to 5	3 to 1	3 to 2	3 to 4 and 3 to 5	4 to 1 and 4 to 2	4 to 3	4 to 5	5 to 1 and 5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	311	0	0	15	69	6	7	162	22	0	10	43	644
After #1	July 13, 2010	205	3	0	83	93	5	6	89	21	2	1	18	526

Table 66. Lane Changes in Zone 1 for Afternoon Peak (4:00 PM to 7:00 PM).

Study Period	Date	From Lane 2			From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		2 to 1	2 to 3	2 to 4 and 2 to 5	3 to 1	3 to 2	3 to 4 and 3 to 5	4 to 1 and 4 to 2	4 to 3	4 to 5	5 to 1 and 5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	561	0	0	37	138	9	10	72	31	1	3	59	921
After #1	July 13, 2010	560	3	0	17	110	2	8	113	47	1	4	99	964

Table 67. Lane Changes in Zone 1 for Midday (10:00 AM to 2:00 PM).

Study Period	Date	From Lane 2			From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		2 to 1	2 to 3	2 to 4 and 2 to 5	3 to 1	3 to 2	3 to 4 and 3 to 5	4 to 1 and 4 to 2	4 to 3	4 to 5	5 to 1 and 5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	797	5	0	31	143	4	18	178	61	2	6	96	1,341
After #1	July 13, 2010	798	2	0	84	201	9	19	180	88	8	4	117	1,510
After #2	July 27, 2010	836	9	0	41	164	4	26	251	71	5	28	188	1,438

For Zone 1, the number of lane changes is represented by the lane from which the lane change originated (e.g., "From Lane 2") and the lane change movement shown in origin to destination format listed by the lane number (e.g., "2 to 1"). All lane changes shown in the previous four tables occurred entirely within Zone 1.

Zone 1 is the closest to the intersection stop line, and a large number of lane changes were expected for this zone. The results for the midnight to 8:00 PM time period show that the total number of lane changes remained almost exactly the same from Before to After #1. Individual lane change movements fluctuated somewhat between the study periods, but most maintained relatively the same. The only exceptions were small increases in the number of lane changes from lane 3 to lane 1 (U-turn only lane) and lane 4 to lane 5 (right only lane).

The results from the morning peak and afternoon peak periods showed similar trends, and the total number of lane changes remained close between the study periods for these two peak periods. The results for the midday period include all three study periods (Before, After #1, and After #2), and the data show that the total number of lane changes between all three study periods remained quite similar for the midday period. The sign added for After #2 was added far upstream of Zone 1, so not many additional effects were expected in Zone 1 for the After #2 study period. The only notable difference between After #1 and After #2 was an observed increase in the number of lane changes from right to left, particularly from lane 4 to lane 3 and from lane 5 to lane 4.

Table 68 shows the number of lane changes that were observed in Zone 2 for the Before and After #1 study periods between midnight and 8:00 PM. Table 69, Table 70, and Table 71 each contain the number of observed lane changes for Zone 2 for the morning peak period, afternoon peak period, and midday period, respectively. Similar to the turning movement count data, only Before and After #1 are compared for the midnight to 8:00 PM, morning peak, and afternoon peak periods. The midday period contains observed lane change data for the Before, After #1, and After #2 study periods.

Table 68. Lane Changes in Zone 2 for 12:00 Midnight to 8:00 PM.

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		3 to 2	3 to 4	3 to 5	4 to 2	4 to 3	4 to 5	5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	3,711	33	15	191	1,106	266	24	52	603	6,001
After #1	July 13, 2010	3,299	20	7	143	683	268	13	8	421	4,862

Table 69. Lane Changes in Zone 2 for Morning Peak (6:00 AM to 9:00 AM).

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		3 to 2	3 to 4	3 to 5	4 to 2	4 to 3	4 to 5	5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	584	5	2	21	244	41	3	11	93	1,004
After #1	July 13, 2010	482	6	0	4	60	29	0	0	51	632

Table 70. Lane Changes in Zone 2 for Afternoon Peak (4:00 PM to 7:00 PM).

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		3 to 2	3 to 4	3 to 5	4 to 2	4 to 3	4 to 5	5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	879	14	1	50	166	62	5	11	127	1,315
After #1	July 13, 2010	816	5	3	63	179	72	5	5	112	1,260

Table 71. Lane Changes in Zone 2 for Midday (10:00 AM to 2:00 PM).

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		3 to 2	3 to 4	3 to 5	4 to 2	4 to 3	4 to 5	5 to 2	5 to 3	5 to 4	
Before	May 27, 2010	1,052	1	2	41	289	66	7	15	197	1,670
After #1	July 13, 2010	880	5	0	26	156	63	2	0	92	1,224
After #2	July 27, 2010	965	13	6	59	208	62	8	11	106	1,438

For Zone 2, the number of lane changes is represented in the same format as for Zone 1, and all lane changes shown in the previous four tables occurred entirely within Zone 2. Because Zone 1 often had vehicles waiting in queue at the traffic signal, there was a limit to the number of lane changes that could occur in that zone. Due to this limitation and the proximity to the intersection, Zone 2 had the most observed lane changes of all the zones analyzed. The results for the midnight to 8:00 PM time period show that the total number of lane changes decreased substantially from Before to After #1 (from 6,001 to 4,862 observed lane changes). The largest decreases occurred in the right-to-left changes, particularly lane 3 to lane 2 and lane 4 to lane 3. It appears that fewer drivers were moving into the left lanes within Zone 2.

The results from the morning peak showed similar trends, but the afternoon peak period showed almost no changes between the Before and After #1 study periods. The results for the midday period include all three study periods (Before, After #1, and After #2), and this midday data show mixed results between all three study periods. There was a noted reduction in total lane changes from Before to After #1 but an increase from After #1 to After #2; although, the After #2 total was still lower than the Before total.

Table 72 shows the number of lane changes that were observed in Zone 3 for the Before and After #1 study periods between midnight and 8:00 PM. Table 73, Table 74, and Table 75 each contain the number of observed lane changes for Zone 3 for the morning peak period, afternoon peak period, and midday period, respectively. Similar to the turning movement count data, only Before and After #1 are compared for the midnight to 8:00 PM, morning peak, and afternoon peak periods. The midday period contains observed lane change data for the Before, After #1, and After #2 study periods.

Table 72. Lane Changes in Zone 3 for 12:00 Midnight to 8:00 PM.

Study Period	Date	From Lane 3		From Lane 4		From Lane 5		All Lane Changes
		3 to 4	3 to 5	4 to 3	4 to 5	5 to 3	5 to 4	
Before	May 27, 2010	91	25	799	239	39	229	1,422
After #1	July 13, 2010	40	6	473	196	24	161	900

Table 73. Lane Changes in Zone 3 for Morning Peak (6:00 AM to 9:00 AM).

Study Period	Date	From Lane 3		From Lane 4		From Lane 5		All Lane Changes
		3 to 4	3 to 5	4 to 3	4 to 5	5 to 3	5 to 4	
Before	May 27, 2010	21	2	121	30	8	50	232
After #1	July 13, 2010	14	0	70	28	3	15	130

Table 74. Lane Changes in Zone 3 for Afternoon Peak (4:00 PM to 7:00 PM).

Study Period	Date	From Lane 3		From Lane 4		From Lane 5		All Lane Changes
		3 to 4	3 to 5	4 to 3	4 to 5	5 to 3	5 to 4	
Before	May 27, 2010	17	7	158	52	9	38	281
After #1	July 13, 2010	7	2	98	48	6	38	199

Table 75. Lane Changes in Zone 3 for Midday (10:00 AM to 2:00 PM).

Study Period	Date	From Lane 3		From Lane 4		From Lane 5		All Lane Changes
		3 to 4	3 to 5	4 to 3	4 to 5	5 to 3	5 to 4	
Before	May 27, 2010	10	5	223	73	9	68	388
After #1	July 13, 2010	11	3	140	54	1	62	271
After #2	July 27, 2010	34	7	222	63	6	70	402

For Zone 3, the number of lane changes is represented in the same format as for Zones 1 and 2, and all lane changes shown in the previous four tables occurred entirely within Zone 3. One of the anticipated results for the added signs in the After #1 study period was an increase in early lane changes, particularly in Zones 3 and 4. Because the signs were added at the end of Zone 3, they were visible to drivers as they traveled through Zone 4. Therefore, an increase in total lane changes was expected for this zone, but instead total lane changes actually decreased. The results for the midnight to 8:00 PM time period show that the total number of lane changes decreased from Before to After #1 (from 1,422 to 900 observed lane changes), and these decreases were observed for each particular lane change maneuver.

The results from the morning peak, afternoon peak, and midday periods showed similar trends with decreases in lane changes between the Before and After #1 study periods. However, the number of lane changes during the midday period was greater in the After #2 study period. There were more lane changes than in either the Before or After # 1 study periods, so it appears that the additional sign in After #2 may have led to a small increase in Zone 3 lane changes.

Table 76 shows the number of lane changes observed in Zone 4 for the Before and After #1 study periods between midnight and 8:00 PM. Table 77, Table 78, and Table 79 contain the number of observed lane changes for Zone 4 for the morning peak period, afternoon peak period, and midday period, respectively. Similar to the turning movement count data, only Before and After #1 are compared for the midnight to 8:00 PM, morning peak, and afternoon peak periods. The midday period contains observed lane change data for the Before, After #1, and After #2 study periods.

Table 76. Lane Changes in Zone 4 for 12:00 Midnight to 8:00 PM.

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		No Change	3 to 4	3 to 5	4 to 3	No Change	4 to 5	5 to 3	5 to 4	No Change	
Before	May 27, 2010	3,814	80	5	301	4,322	410	35	270	3,388	1,101
After #1	July 13, 2010	3,397	31	12	175	3,658	296	15	189	3,128	718

Table 77. Lane Changes in Zone 4 for Morning Peak (6:00 AM to 9:00 AM).

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		No Change	3 to 4	3 to 5	4 to 3	No Change	4 to 5	5 to 3	5 to 4	No Change	
Before	May 27, 2010	527	25	2	47	715	31	4	37	437	146
After #1	July 13, 2010	403	2	0	21	590	13	0	23	327	59

Table 78. Lane Changes in Zone 4 for Afternoon Peak (4:00 PM to 7:00 PM).

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		No Change	3 to 4	3 to 5	4 to 3	No Change	4 to 5	5 to 3	5 to 4	No Change	
Before	May 27, 2010	961	18	0	75	798	100	7	51	841	251
After #1	July 13, 2010	907	6	1	52	795	70	2	54	781	185

Table 79. Lane Changes in Zone 4 for Midday (10:00 AM to 2:00 PM).

Study Period	Date	From Lane 3			From Lane 4			From Lane 5			All Lane Changes
		No Change	3 to 4	3 to 5	4 to 3	No Change	4 to 5	5 to 3	5 to 4	No Change	
Before	May 27, 2010	1,063	16	1	77	1,138	143	10	105	1,060	352
After #1	July 13, 2010	1,098	20	3	56	1,134	131	8	62	1,073	280
After #2	July 27, 2010	979	12	3	68	1,144	84	2	66	1,102	235

For Zone 4, the number of lane changes is represented in the same format as for the other zones with one additional category. The column marked "No Change" means that those vehicles did not change lanes in Zone 4 and that they stayed in the lane where they originated. All lane changes shown in the previous four tables occurred entirely within Zone 4.

As with Zone 3, an increase in total lane changes was expected for this zone, but instead total lane changes actually decreased. The results for the midnight to 8:00 PM time period show that the total number of lane changes decreased from Before to After #1 (from 1,101 to 718 observed lane changes), and these decreases were observed for each particular lane change maneuver. The results from the morning peak, afternoon peak, and midday periods showed similar trends with decreases in lane changes between the Before and After #1 study periods.

The number of vehicles not making a lane change ("No Change") also decreased for the midnight to 8:00 PM period. This means that there were fewer vehicles entering Zone 4 in the After #1 study period. However, the percent drop in vehicles not changing lanes was only

11.6 percent, while the percent drop in vehicles changing lanes was 34.8 percent. So, the number of vehicles changing lanes still appears to have decreased much more than the number of those not changing lanes. This trend of the percent drop in lane changes exceeding the percent drop in vehicles not changing lanes was observed in the morning peak and afternoon peak periods as well.

The results from the midday period showed that total lane changes dropped from Before to After #1 and dropped again in After #2. However, the number of vehicles not making lane changes remained relatively constant. Therefore, the results from the midday data seem to suggest that the added signs for After #1 did not help increase lane changes in Zone 4 and the last added sign from After #2 did not help increase the number of lane changes either. In fact, the total number of lane changes decreased even more.

Discussion

All of the results were divided into the four zones, and comparisons were made between the Before, After #1 (one set of signs at the taper), and After #2 (addition of a second sign 500 feet upstream of the tapers) study periods for turning movements and numbers of lane changes. The results included a comparison of all available time periods for the Before and After #1 study period, but only the midday results were available for the After #2 study period. This means that statements regarding After #2 are based only on the observations from the midday period.

When comparing the turning movement data, not many changes were noted. For the After #1 study period, it appears that fewer vehicles making through movements utilized lane 3. Similar results were found for After #2. The number of illegal movements at the intersection was reduced slightly from Before to After #1; however, the total number of these violations was very small in both study periods, so more observations would be needed to determined if any significant changes occurred. There was no evidence suggesting that the effect on illegal movements would be any different in the After #2 study period.

One of the anticipated results was a decrease in the number of lane changes near the intersection (Zones 1 and 2) and an increase in the number of lane changes farther from the intersection (Zone 3 and 4). The actual results did not support this notion. The total number of lane changes remained relatively the same for Zone 1 in all three study periods. Although the number of lane changes did decrease in Zone 2, there was not a corresponding increase in those lane changes for Zones 3 and 4. In fact, lane changes decreased for those zones as well. Ultimately, the total number of lane changes (for all zones combined) decreased from Before to After #1. The signs from After #1 and After #2 were easily visible from outside of the data recording zones (i.e., prior to the beginning of Zone 4), so it is possible that the number of lane changes did change for areas that could not be recorded. If this is the case, it would explain why data showed such a reduction in the number of lane changes across all zones. If many vehicles were making early lane changes prior to Zone 4, there would be fewer lane changes in Zones 1 through 4.

CHAPTER 9: FINDINGS

LITERATURE REVIEW

This report documents an evaluation of the effectiveness of various signing and pavement marking applications through focus groups and driver surveys and two sign concepts tested in the field. These concepts were derived from a series of practitioner surveys of Texas Department of Transportation districts and state departments of transportation, driver focus groups, and driver surveys. These prototype signs are intended to assist motorists in the correct selection of a lane on approach to a freeway interchange with a cross street, and vice-versa. Currently there is inconsistency in conveying to drivers how they should align themselves upstream of a diamond intersection to maneuver for their desired turning movement as the intersection widens. These inconsistencies can result in drivers making incorrect lane selections, which may result in late lane changes or illegal turns. The proper placement of signs and markings may be some distance back from the intersection, prior to where the roadway widens.

The search for existing literature revealed that very little research documentation is available regarding design guidelines for advance lane assignment traffic control devices at interchanges. There appears to have been very little previous research conducted on the signs and markings needed on frontage road and cross-street approaches that widen at diamond interchanges. However, the 2003 federal and 2006 Texas MUTCD documents are similar in their applications of lane control (or intersection control) signs, and the discussion on current Texas practice in Chapter 3 summarizes the applicable TxMUTCD sections that control lane assignment signing and pavement marking standards and practices. The intersection control signs are divided into three applications:

- Mandatory movement lane control (signs R3-5, R3-5a, and R3-7).
- Optional movement lane control (R3-6).
- Advance intersection lane control (R3-8 series).

Further guidance on the use of the signs is provided by both the federal and Texas versions of the MUTCD. They state a standard: "when Intersection Lane Control signs are mounted overhead, each sign should be placed over the lane or a projection of the lane to which it applies." Additionally, both the federal and Texas MUTCD specifies that the use of one sign does not require all lanes to be signed. In Texas, post-mounted lane assignment signs on the right side of the roadway and projected signs on signal mast arms are more common than upstream overhead gantry signing.

Regarding horizontal pavement words and symbols, both the federal and Texas MUTCDs state that symbol messages are preferable to word messages. The MUTCDs also state as standard practice that "where through traffic lanes approaching an intersection become mandatory turn lanes, lane-use arrow markings shall be used and accompanied by standard signs." Thus pavement markings are generally supplementary devices to regulatory lane use signs.

Several examples of guide and regulatory signing and pavement markings that address lane assignment upstream of intersection widening were found in review of international guidelines. Australia, New Zealand, the United Kingdom and Scotland, and Germany were all found to have applicable concepts for alternative lane use signing and combination lane use and guide signing. There were fewer examples of lane use pavement markings in international practice, but the UK specifies several concepts to use pavement markings on approach to intersections for lane use.

DISTRICT AND STATE DOT SURVEYS

Overall, the TxDOT district survey results and state DOT survey results were very similar. Practitioners suggested that engineering judgment is extensively and/or exclusively used in making decisions for design and implementation of lane assignment control signs and markings. There were typically no standard guidelines regarding spacing between signs, distance from the intersection for sign placement, or the number of signs that should be used. Some states (and TxDOT districts) have developed policies, standards, and typical applications for use within their jurisdictions; however, these practices vary widely.

HUMAN FACTORS SURVEYS

The focus groups and driver surveys provided significant insight on driver expectation and preferences regarding lane use signing and pavement markings. Highlights of the findings included:

- Most subjects do not feel advanced pavement markings are necessary to mark an upcoming intersection on simple two lane frontage roads, although advance signing is still desired. For more complex intersection approaches, the use of *lane assignment pavement marking* <u>*arrows*</u> across all lanes of travel may convey an appropriate amount of information to drivers, leaving the "ONLY" text for the turn-only lanes as optional guidance that could be omitted as necessary.

- Lane assignment signs should likely be split for approaches of more than four lanes. Signs installed on either side of the road could represent only the exclusive turn lanes, or could include all turn-only lanes and shared or optional turn lanes. The through-only lanes do not appear to be critical information to drivers with respect to their comprehension of "split" signing versus signing depicting all lanes.

- The use of the "AT SIGNAL" plaque may be beneficial to attach to lane assignment signs in advance of intersection approaches that violate driver expectation or for intersections close in proximity.

- When using advance pavement markings for a lane drop where the intersection approach is out of sight, drivers best respond to a pavement marking configuration that used the word "AHEAD" on the pavement (either a "ONLY" + arrow + "AHEAD or "TURN" + "ONLY" + "AHEAD" configuration).

- The lane addition taper graphic can be utilized on lane assignment signs to show where lane additions will occur. However, lane assignment signs that incorporate the taper geometry graphically are the most effective for cases where the downstream geometry varies from driver expectations.

- Where driver expectations may be violated related to lane use, additional signing may be necessary to clarify lane assignments further upstream.

    - Drivers approaching an unsignalized intersection of a freeway frontage road and a cross street are equally split on their assumptions of the interchange geometry and where they should turn, indicating that advance guide signing and/or lane assignment signing is warranted in these situations.

    - If an intersection approach has an optional turn lane next to an exclusive turn lane, the optional turn lane should always be signed along with the mandatory turn lane to avoid unnecessary lane changes.

FIELD STUDY

Following the results of the focus groups and driver surveys, sign types for two different applications were chosen for field installation and observational testing. The first sign type was selected for use on an arterial cross-street approach to a cloverleaf-type of freeway interchange. The second sign type was selected for use on a frontage road approach to a signalized intersection where the frontage road flares out to include additional lanes at the intersection.

For the cross-street approach to a freeway intersection, researchers found that upstream of the sign fewer drivers were recorded taking an illegal right turn from the left lane, and the percentage of lane changes increased, indicating that the sign was having some impact on lane use. However, all of the changes recorded and summarized for these results are relatively small changes on the order of a few percentage points, and detailed statistical testing would not reveal any statistically significant findings for the percent of lane changes or violation/illegal movements. The general findings from this field test indicate that the signs may have caused a few more drivers to make lane changes earlier and that the After #2 sign (with the up arrow on the top right) may have had slightly more effect. It appears that the After #1 sign (with the up arrow on the top left) may have led to an increase in illegal turns from the left lane farther downstream, and drivers may have interpreted the arrow placed on the left as an indication that the turn ahead was to the left.

For the frontage road approach to a cross street field sign test, only very subtle changes were noted. The number of illegal movements at the intersection was reduced slightly from Before to After #1, but not at any perceivable statistically significant level. One of the anticipated results was a decrease in the number of lane changes near the intersection and an increase in the number of lane changes further from the intersection. However, researchers did not conclude this to occur on this approach, albeit with a limited dataset. The total number of lane changes remained relatively the same for the zone nearest the intersection in all three study periods. Ultimately, the total number of lane changes (for all zones combined) decreased from Before to After #1. The signs deployed in the After #1 and After #2 cases were easily visible from outside of the data recording zones (i.e., prior to the beginning of Zone 4), so it is possible that the number of lane changes did change for areas that could not be recorded. If this is the case, it would explain why the researchers noted a reduction in the number of lane changes across all zones.

CHAPTER 10: GUIDELINES FOR THE USE OF LANE ASSIGNMENT TRAFFIC CONTROL DEVICES ON FRONTAGE ROADS AND CONVENTIONAL ROADS AT INTERCHANGES

This chapter outlines TTI's proposed guidelines based on the finding of this study and the literature review. While this research has found that additional guidance regarding lane assignment may be necessary, particularly in some cases when driver expectations may be violated or atypical conditions exist, the researchers did not identify required changes necessary to the Texas MUTCD or other standard guidance. The research did find that additional sign concepts may be used (for example, the modified R3-8 sign with "taper" graphic) to supplement standard signing as necessary without any perceived or quantifiable adverse impacts. We have identified modifications that could be made to figures in the Texas Freeway Signing Handbook and have included those suggested modifications herein, but those modifications would include the use of a non-standard R3-8 sign which is not currently in the Texas MUTCD. While this sign could be a tool to use in some cases, we would defer to the Traffic Operations Division on whether to provide a new standard sign useable statewide.

PROPOSED GUIDELINES FOR USE OF ENHANCED LANE ASSIGNMENT SIGNING

Guideline 1. When drivers' assumptions are violated, adequate signing should be included.

The majority of drivers assume that on a three-lane frontage road, the far left lane will be forced to turn left at the upcoming intersection. If intersection geometry violates this assumption, adequate signing should be included. Project results show drivers in the left lane may make unnecessary lane changes if they do not want to turn and there is no signing available telling them they can go straight from that lane. Adding lane addition tapers on the lane assignment signs should be considered for only the geometries that violate driver assumptions, and the current standard format sign should be considered for the rest.

For unsignalized intersections of a freeway frontage road and a cross street, drivers are split on their assumptions of the interchange geometry and where they should turn (see Table 13 and Table 14). Effort should be placed in adequately signing the unsignalized interchange regardless if it is a diamond, cloverleaf, or other geometry.

Drivers' assumptions may also be violated in corridors where there is much variability from interchange to interchange geometry. An example would be IH 45 on the north side of Houston, where signalized interchanges and unsignalized diamond and cloverleaf interchanges all exist in close proximity.

Based on findings from a focus group discussion of older drivers conducted by Staplin et al. in 1997, when a lane becomes a turn-only lane, use multiple advance signs *(8)*. Recommended distances for the advance signs from the turn location should range from 20-30 seconds before the approach of the first sign, and 10 seconds before the approach for the second sign.

Guideline 2. More aggressive lane assignment signing is required when there is limited sight distance.

For interchanges with limited viewing distance (such as in the picture shown in Figure 106) drivers have fewer cues to tell them what the lane they need to choose to reach their destinations. In these cases, signs may need to be placed farther upstream.

Figure 106. Example of an Upcoming Intersection with Limited Sight Distance.

Guideline 3. When necessary, use overhead signing.

Drivers prefer overhead signing for lane guidance and have a high comprehension of turn movements when lane assignment arrows are placed directly over lanes, such as the example in Figure 107. Overhead lane use assignment signing may be more critical to provide when sight distance is limited and/or when congestion and queues spill back far enough where providing an overhead sign could impact lane selection further upstream of the intersection.

Figure 107. Example of Overhead Signing Used on a Cross-Street Approach to a Freeway.

Guideline 4. Avoid using right-angled arrows on guide signs for lane assignment.

Right-angled arrows as seen in Figure 108, used on guide signs, rather than the straight through movement arrows, lead drivers to believe the turn is immediate and not farther down the road. It is recommended that a through arrow be used at a location where the first turn is in view, and the right-angled arrow be used when placed on an additional sign past the first turn.

Figure 108. Example of Guide Signs Using a Right-Angled Arrow vs. a Straight Arrow.

Guideline 5. Always sign all <u>*turn*</u> *movements, not just the exclusive turn lanes.*

If a roadway has an optional turn lane next to an exclusive turn lane, as seen in Figure 109, researchers recommend signing for both lanes to avoid unnecessary maneuvers by drivers who may think there is only one turn lane. If there is only a sign for the turn-only lane, drivers tend to believe that is the only lane they can use if turning.

Figure 109. Example of an Optional Turn Lane Adjacent to a Turn-Only Lane.

Guideline 6. Use symbols (such as arrows over text) for lane guidance on guide signs.

The terminology "KEEP RIGHT" may cause misconceptions on the distance/immediacy of the turn. The term "NEXT" is recommended over "KEEP" for an immediate turn, although researchers recommend the use of a guide sign with directional arrows over text to indicate where and which direction to turn if there will not be both sign types on the approach to the interchange.

Guideline 7. Supplement lane assignment regulatory signs with an "AT SIGNAL" plaque when feasible.

Drivers' wording preference for a plaque added to the bottom of a lane assignment sign is "AT SIGNAL." Researchers recommend the addition of this plaque, especially when drivers do not have a clear view of the road geometry downstream or on approaches which have a driveway or T-type unsignalized intersection between the sign and the traffic signal.

Guideline 8. Supplement lane assignment signs with advance pavement markings for exclusive turn lanes when feasible.

Drivers have a high comprehension of pavement markings for a lane drop. When using advance pavement markings for a lane drop where the signal is out of sight, drivers best respond to an option that uses the word "AHEAD" on the pavement such as "TURN [arrow] AHEAD," as seen in Figure 110, although all advance markings proved effective.

Figure 110. Example of Advanced Pavement Markings for a Turn-Only Lane with the Text "AHEAD."

Guideline 9. Utilize lane addition tapers on lane assignment signs placed in advance of the lane widening, especially with geometries that may violate driver expectations, or when the lane widening is blocked from view.

The lane addition taper, shown in Figure 111, can be utilized on lane assignment signs to show where lane additions will happen. If there is room on the sign, increase the taper length for better comprehension. Lane assignment tapers are the most effective for a geometry downstream that varies from driver expectations, and could actually cause confusion when used for geometries that meet driver expectations. These new concept signs should be placed before the flare in the roadway. At the intersection, signs should be kept simple and minimal.

Figure 111. Example of a Lane Assignment Sign with Lane Tapers Placed before the Flare of the Roadway.

Guideline 10. When lane assignment signs must represent more than four lanes, consider breaking up the sign into a left- and right-mounted sign and only show the exclusive and optional turn movements.

Drivers feel that identical signs placed on either side of the road with five lanes of travel provide too much information. Although there is concern that a sign on one side of the road can be blocked from view, sign splitting should only be considered when the signs can be repeated, and the through-only movements should not be shown to avoid confusion (see Figure 112).

For lane assignment signs with lane tapers placed before the flare, the "ONLY" legends from the sign can be removed to reduce the bits of information for signs representing more than four lanes of travel.

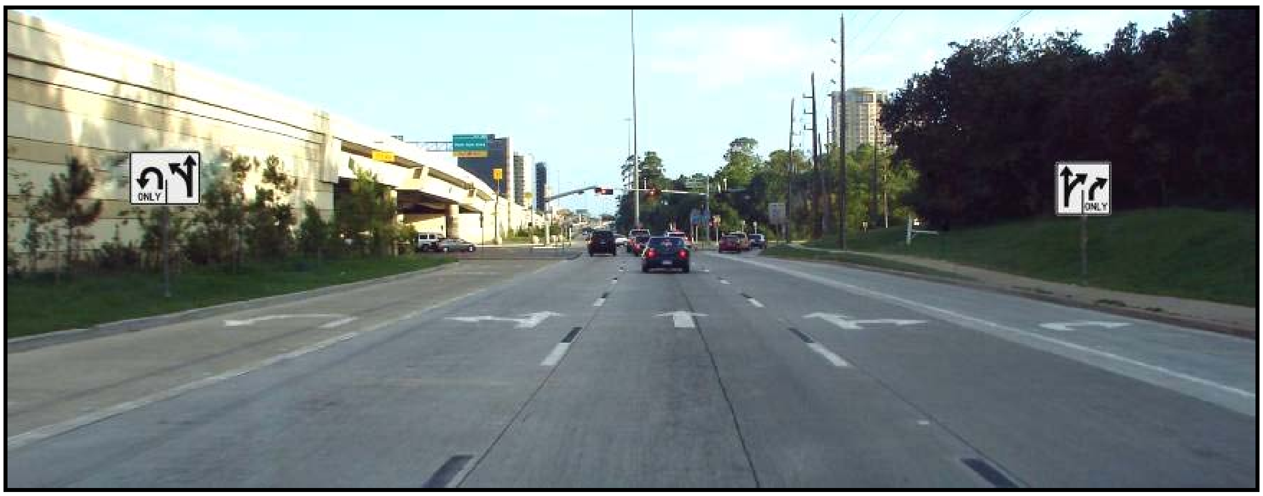


Figure 112. Example of Signing Only the Turn Movements of an Intersection with Five or More Lanes.

Guideline 11. Placement for lane assignment signs should be as consistent as possible.

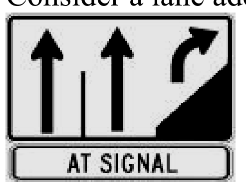
Standard R3-8 signs should generally be placed within 150 feet of the intersection stop line and, if necessary, within 150 feet of where lanes are added on an intersection approach. If R3-8 modified signs are used (with the taper geometry on the sign), they should be located at or within 150 feet upstream of where lanes begin to add via taper. If frontage road traffic tends to queue upstream of where lane adds are made, consider adding additional R3-8 modified signs with the taper geometry at least 500 feet upstream.

Guideline 12: Use horizontal pavement arrows on a two-way frontage road approaching a signalized intersection.

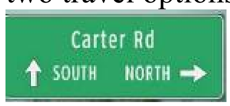
As determined by the TxDOT research project 0-4471, Field Evaluations and Driver Comprehension Studies of Horizontal Signing, white, horizontal pavement arrows indicating the correct direction of travel proved very beneficial in reducing wrong-way driving maneuvers on two-way frontage road as seen in Figure 113 *(3)*.

Figure 113. View of Frontage Road Lane Use Guidance after Arrow Pavement Marking Installation. *(3)*

Table 80. Possible Expectancy Violations and Considerations

Possible Expectancy Violations	Possible signing and pavement marking considerations
General Situations	
A lane becomes an optional turn lane	• Always sign for all turn movements to avoid unnecessary lane changes
Approach to Signalized Interchange from Frontage Road	
On a 3 lane frontage road, the far left lane is not forced to turn left	• Use multiple advance signs to provide confirmation of the through movement being legal from left lane
A right lane becomes a turn-only lane	• Use multiple advance signs to provide confirmation of the right lane being used for right-turns only. • Consider use of advanced pavement markings in the turn-only lane 
A frontage road flares before an interchange	• Consider a lane addition taper sign at and/or before the flare  • Use multiple advance signs • Can remove the "ONLY" text from a lane addition taper sign to reduce the amount of information provided to the driver
Lane additions at a flare add more lanes to the right than to the left	• Consider a lane addition taper sign before the flare • Consider overhead lane assignment signs past the flare if sight distance and/or queuing is judged to impact lane choice • Use multiple advance signs

<table>
<tr><th colspan="2">Approach to Signalized Interchange from Cross Street</th></tr>
<tr><td>Drivers are unsure which lane will turn and which lanes will go through on the other side of the interchange</td><td>Consider overhead signing, including placing lane assignment arrows on the overpass at the interchange, although placement should be considered carefully in order to not confuse drivers into thinking the turn is before the overpass.

</td></tr>
<tr><th colspan="2">Approach to Cloverleaf Interchange from Frontage Road</th></tr>
<tr><td>Driver unsure if they will turn before or after the overpass</td><td>Use two separate arrows or a diagrammatic arrow to represent the two travel options


Avoid using a right-angled arrow on the right side of the sign
Consider advanced pavement markings if there is a lane drop</td></tr>
<tr><th colspan="2">Approach to Diamond Interchange from Cross-street</th></tr>
<tr><td>If the driver’s turn is on the opposite side of the overpass, they are unsure if it’s on the left or right side of the road</td><td>Use multiple advance signs
Use arrows over text on guide signs
Consider placing your arrow for the first turn on the right side of the sign and the second turn to the left side of the sign
Consider a left, right-angled arrow for the turn on the other side of the overpass</td></tr>
<tr><th colspan="2">Approach to Diamond Interchange from Cross-street</th></tr>
<tr><td>If the driver’s turn is on the opposite side of the overpass, they are unsure if it’s on the left or right side of the road</td><td>Use multiple advance signs
Use arrows over text on guide signs
If text is used, use the phrase “NEXT RIGHT” over “KEEP RIGHT” for the first turn
Avoid using a right-angled arrow on the right side of the sign
Consider placing both your turn arrows on the right side of the sign</td></tr>
</table>

Other Issues	
Limited Sight Distance	• Use multiple advance signs • Consider a lane addition taper sign before the flare • When necessary, use overhead lane assignment signs after the intersection approach flares out  • Place signs further upstream • Place an “AT SIGNAL” plaque below your advance lane assignment sign 
Frontage Road is 2-way	• Use arrow pavement markings 

EXAMPLES OF GUIDELINE APPLICATIONS

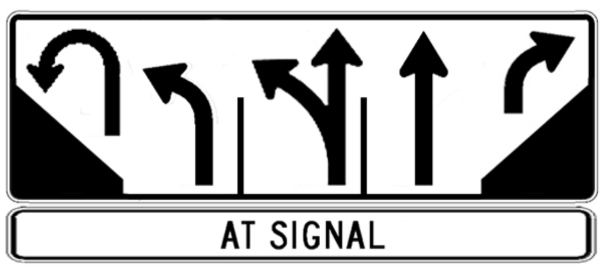
Figure 114 from the TxDOT Freeway Signing Handbook was previously discussed in this report, but is revisited here to illustrate how TTI's guidelines can be applied. The labels A-D in the figure correspond to the comments below.

A – Guideline 1 recommends that when drivers' assumptions may be violated and a lane becomes a turn-only lane, multiple advance signs should be used; therefore, the advanced lane assignment sign shown at 300 ft should be desirable rather than an option.

B – Guideline 7 recommends the use of the "AT SIGNAL" plaque.

C – Guideline 10 recommends considering sign splitting when there are more than 4 lanes, as long as the advanced information is repeated. If sign splitting is used, Guideline 5 recommends including all turn movements on the split signs.

D – Guideline 9 advices to consider using a lane addition tape sign in advance of the gore location only.



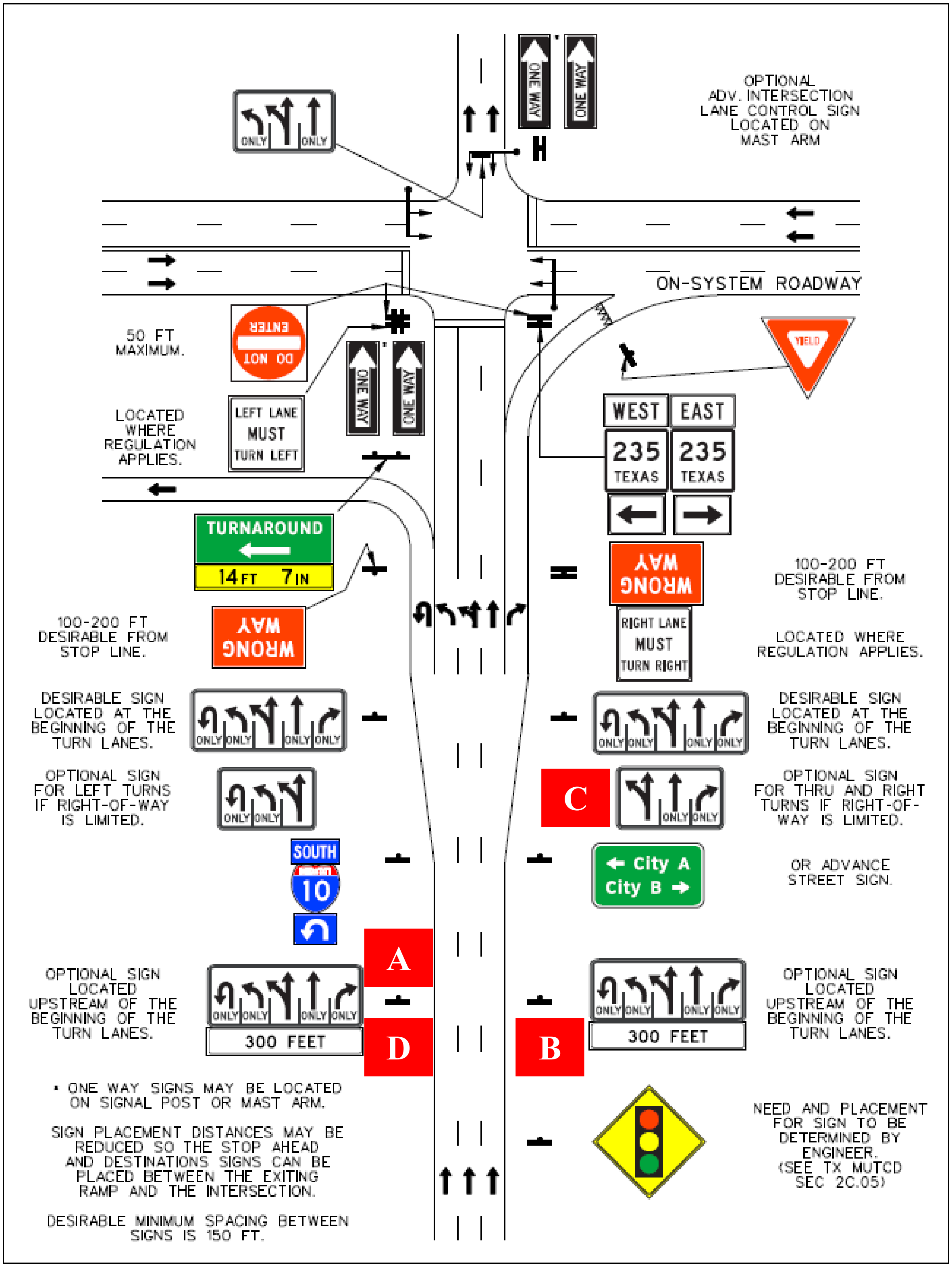


Figure 114. Amended from TxDOT Freeway Signing Handbook Figure 6-17 (1).

Figure 115 shows another Freeway Handbook figure that was previously discussed. Again, the letters on the figure correspond to the comments below.

A – Referring to TTI's Guideline 12, even though this is not a signalized interchange, because drivers will be turning onto a two lane frontage road and they could get confused on which lane to be in, horizontal pavement arrows should be considered in the correct direction of travel.

B – Referring to Guideline 3, overhead signing should be used and the route assemblies can be placed on the overpass similarly to Figure 107.

C – Although not a Guideline, moving the top arrow on the guide sign to the side of the sign adjacent to the turn should be considered for better understanding.

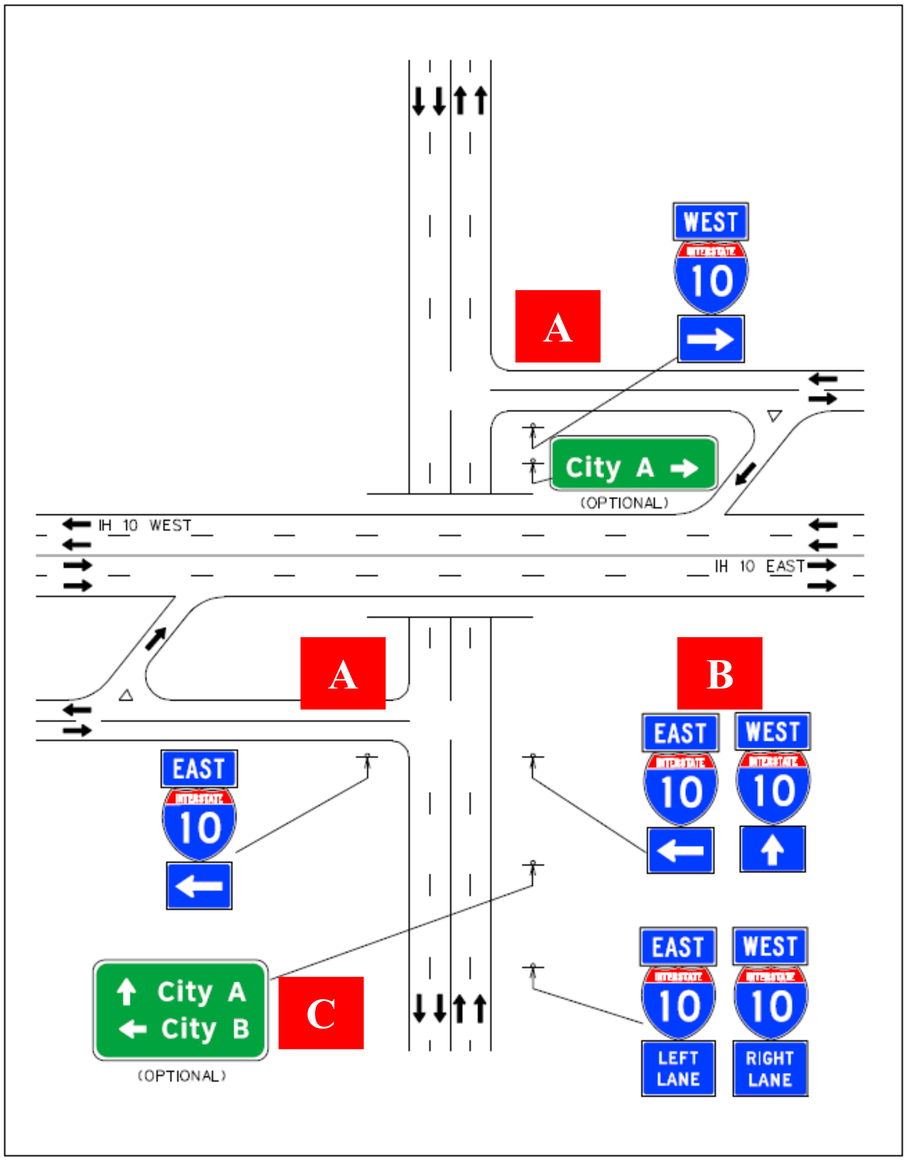


Figure 115. Amended from TxDOT Freeway Signing Handbook Figure 6-21 *(1)*.

Figure 116 shows the Intersection and Mandatory Movement Lane Control Signs in the Texas MUTCD. TTI recommends splitting this figure into the following two figures to distinguish signs placed before a flare and after:

1) Intersection and Mandatory Movement Lane Control Signs Prior to a Lane Flare – This first figure would also include several examples of the lane addition taper sign. The "AT SIGNAL" supplemental plaque would also be included. Because these taper signs are often needed for roads that flare to greater than 4 lanes, the option to leave off the "ONLY" legend should be presented to prevent an overload of information.

2) Intersection and Mandatory Movement Lane Control Signs After the Flare – This figure would be altered to include an example of split signing for more than 4 lanes at the intersection. An optional version of the split signing would only show the lanes with turn movements.

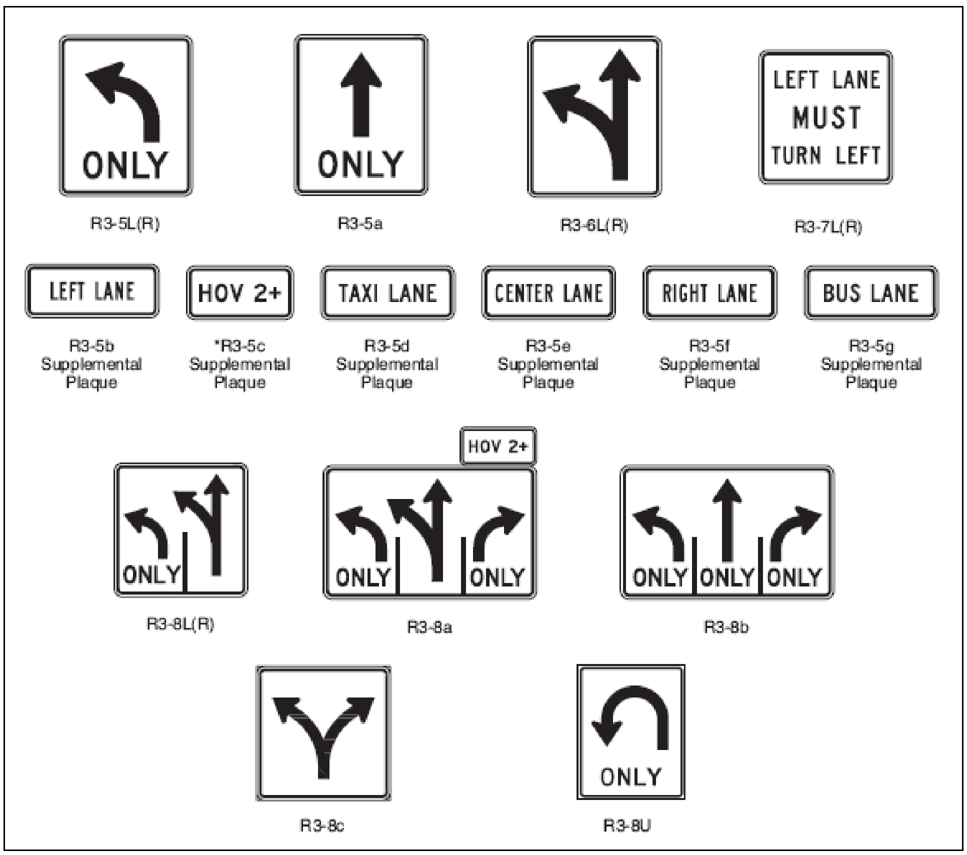


Figure 116. Intersection and Mandatory Movement Lane Control Signs. (from Figure 2B-4, Texas MUTCD *(5)*)

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APPENDIX A: SURVEY OF TXDOT DISTRICTS RESULTS

Q1: Does your District have (or had) intersections or interchanges where the approach flares to more lanes than you have upstream AND with lane assignments that are not typical? For example, adding a left turn bay adjacent to the left lane would be typical (something most drivers would expect), but forcing a left turn from the middle or right lane would not be as common.

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Yes	15	79%
No	4	21%
Total responses	19	100%

Q2: Does your District have (or had) interchanges where the lane assignment for a particular turn movement may be problematic or violate driver expectation? For example, trying to sign for a "left turn" movement at a cross-street approach to a cloverleaf interchange (where the motorist must take the second right).

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Yes	7	37%
No	12	63%
Total responses	19	100%

Q3: If YES to either question #1 or #2, to your knowledge have these situation(s) caused an increased frequency of crashes?

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	3	20%	3	16%
No	12	80%	12	63%
No response			4	21%
Total responses	15	100%	19	100%

Q4: If YES to either question #1 or #2, have these situations prompted public or law enforcement concerns (calls, letters, etc.)?

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	5	33%	5	26%
No	9	60%	9	47%
No response	1	7%	5	26%
Total responses	15	100%	19	100%

Q5: With respect to problematic intersection or interchanges where lane assignment causes operational difficulty or resulted in unusually high crash history in your District, please list below:

City	Primary Roadway	Cross Street	Type of Interchange	Type of Issue / Problem
El Paso	I-10 (EB) Frontage	Redd	Diamond	4 lanes at approach w/u-turn, left turn, straight, right turn
El Paso	I-10 (EB) Frontage	Airway	Diamond	5 lanes at approach w/u-turn, left-straight turn, straight, straight, right turn
Robinson	US 77	Loop 340	Cloverleaf	Drivers want to take the first exit and turn left rather than take 2nd loop. Also get in left lane for a left turn rather than in the right to loop.
Waco	IH 35	Various locations	diamond	Drivers on the frontage road assume it is ok to turn left from the right lane (or middle lane) when it is not marked to do so
Rural McLennan County	IH-35	FM 3149	Jug handle	Motorists are confused where they should turn off FM 3149 to get on IH 35 going the correct direction
Odessa	B1-20	LP 338	unconventional	-
Midland	LP 250	Midrift	unconventional	-
Midland	LP 250	Midland Dr	conventional	-
Midland	B120	Midriff	conventional	-
Midland	SS588	BR 20	conventional	-
Texarkana	I-30	FM 559	unconventional diamond	2-way frontage road ramps adjacent to frontage road
Texarkana	I-30	Summerhill	unconventional diamond	2-way frontage road ramps adjacent to frontage road
Texarkana	I-30	989	unconventional diamond	2-way frontage road ramps adjacent to frontage road
Mont Belvieu	IH-10	SH 146	Conventional	2-lane approach, lane shifts and opens to 4 lanes
Orange	IH-10 FR	SH 87	Half cloverleaf	Access to I-10EB is misdirection from what is expected.
Port Arthur	SH 347NB	FM 365	Half cloverleaf	traffic not turn at 1st cross street when getting into left turn lane
Brenham	US 290	BU-290-F	Cloverleaf	
Harris County	IH 45	Bay Area Blvd	Cloverleaf	2 and 3 lane frontage roads where vehicles have to stay right and loop for left turns
Harris County	IH 45	FM 2351	Cloverleaf	2 and 3 lane frontage roads where vehicles have to stay right and loop for left turns
Houston area	various	various	-	A majority of frontage road intersections have dual left turns in Houston area.

City	Primary Roadway	Cross Street	Type of Interchange	Type of Issue / Problem
San Angelo	Loop 306	College Hills	Diamond	Some motorists will treat as a dual left but it is not. Motorist turning left from inside lane make a wide left turn not expecting a second left turning vehicle to be there. Not a high crash history location.
San Angelo	Loop 306	Southwest Blvd	Diamond	Same issue as at Loop 306 and College Hills interchange
Abilene	WB LP 322	Sam Waldrop	Cloverleaf	Right lane is dedicated to 25 mph cloverleaf and left lane is an entrance ramp onto US 84. Last minute decisions cause problems
Cedar Park	NB US183 frontage	Avery Ranch Rd	Diamond	4 lanes on approach w/double left-turn only lanes, through/right shared lane and a right-turn only lane. Exit ramp is close to intersection. U-turn bay on left. High volume of weaving and queue jumping causing crashes.
Austin	SB US183	Cameron Rd	Diamond	4 lanes on approach with u-turn only, left-turn only lane, through lane and a through/right shared lane. High volume of weaving by inattentive drivers on left-turn only lane wishing to go straight
Williamson County	WB 290	Patton Ranch Rd.	Conventional	2 lanes on the freeway section and 1 lane from the frontage merge into 3 lanes with a left-turn only bay within short distance at the Joe Tanner Signalized intersection. The freeway ends at this point. Again within a short distance, right-turn only lane ends at the Patton Ranch signalized intersection further reducing to 2 lanes. High volume of weaving. Drivers using the right-turn only lane to queue jump causing crashes.
Williamson County	NB 183	US183A Tie In	Conventional	2 lanes on the NB US 183 approach at the US 183A tie-in with a right-turn bay. The approach is on a sharp curve with a left turn just prior to this intersection for Co. Rd. 276. The visibility to signalized intersection is limited by the curve and the geometry of the roadway layout causing run-off type accidents.
Blanco County	WB 290	US 281	Conventional	2 lanes on WB US290 split into NB and SB directions at US 281. Left lane on WB US290 leads to SB US281 and the right lane leads to NB US281/US290. Drivers often fail to be on the proper lane and to see the sharp curves at the approaches.
Pharr (District wide)	US highway Frontage roads	Multiple locations	Diamond	3 lanes on approach with dual left turn lanes sometimes inside lane drivers try to go straight across and cause accidents with the middle lane driver trying to make the left turn.

Q6: If YES to either question #1 or #2, please answer questions 6A through 6L below about countermeasures that you may have used to address these issues.

Q6A Part1. Intersection Lane Control Signs:

MANDATORY MOVEMENT LANE CONTROL SIGNS MOUNTED ROADSIDE HAVE USED: ☐ YES ☐ NO

(R3-5, R3-5a, and R3-7 SIGNS, see Figure below)

R3-5L(R)

R3-5a

R3-7L(R)

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	15	100%	15	79%
No	0	0%	0	0%
No response			4	21%
Total responses	15	100%	19	100%

Q6A Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Roadside placed Mandatory LCS	Of the 15 Districts that have used Roadside mounted Mandatory LCS (see Q6A-Part 1)		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At far side of intersection	7	47%	7	37%
At turn bay	14	93%	14	74%
At intersection	14	93%	14	74%
At other locations	3	20%	3	16%
No response			4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Q6B Part1. Intersection Lane Control Signs:

MANDATORY MOVEMENT LANE CONTROL SIGNS MOUNTED OVERHEAD HAVE USED: ☐ YES ☐ NO

(R3-5, R3-5a, and R3-7 SIGNS, see Figure below)

R3-5L(R)

R3-5a

R3-7L(R)

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	13	87%	13	68%
No	2	13%	2	11%
No response			4	21%
Total responses	15	100%	19	100%

Q6B Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Overhead Placed Mandatory LCS	Of the 13 Districts that have used overhead mounted Mandatory LCS (see Q6B-Part 1)		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Signal pole	7	54%	7	37%
Signal span	5	38%	5	26%
Mast arm	12	92%	12	63%
Other structures	3	23%	3	16%
No response			4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other structures as specified:

Mast arms in advance.

Bridge protective assembly for lane designation signs for cross street or arterial approach.

Overhead structures in advance of intersection.

Q6C Part1. Intersection Lane Control Signs:

OPTIONAL MOVEMENT LANE CONTROL SIGNS MOUNTED ROADSIDE HAVE USED: ☐ YES ☐ NO

(R3-6 SIGNS, see Figure below)

R3-6L(R)

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	13	87%	13	68%
No	2	13%	2	11%
No response			4	21%
Total responses	15	100%	19	100%

Q6C Part2 - Mounting Locations Used (check any/all that apply):

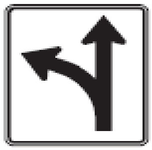
Mounting Location for Roadside placed Optional LCS	Of the 13 Districts that have used Roadside mounted Optional LCS (see Q6C-Part 1)		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At far side of intersection	5	33%	5	26%
At turn bay	10	67%	10	53%
At intersection	10	67%	10	53%
At other locations	1	7%	1	5%
No response			4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other location as specified:

Left and right in advance of intersection.

Q6D Part1. Intersection Lane Control Signs:
OPTIONAL MOVEMENT LANE CONTROL SIGNS MOUNTED OVERHEAD ***HAVE USED: ☐ YES ☐ NO***
(R3-6 SIGNS, see Figure below)



R3-6L(R)

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	13	87%	13	68%
No	2	13%	2	11%
No response			4	21%
Total responses	15	100%	19	100%

Q6D Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Overhead Placed Optional LCS	Of the 13 Districts that have used overhead mounted Optional LCS (see Q6D-Part 1)		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Signal pole	4	31%	4	21%
Signal span	4	31%	4	21%
Mast arm	12	92%	12	63%
Other structures	1	8%	1	5%
No response			4	21%

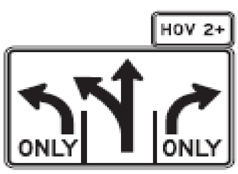
Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other structures/locations as specified:

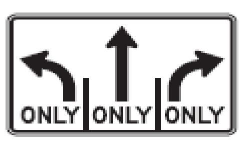
Left and right in advance of intersection.

Q6E Part1. Intersection Lane Control Signs:
ADVANCE MOVEMENT LANE CONTROL SIGNS MOUNTED ROADSIDE ***HAVE USED: ☐ YES ☐ NO***
(R3-8 Series SIGNS, see Figure below)

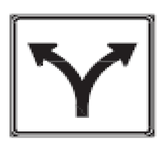
R3-8L(R)



R3-8a



R3-8b



R3-8c

R3-8U

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	15	100%	15	79%
No	0	0%	0	0%
No response			4	21%
Total responses	15	100%	19	100%

Q6E Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Roadside placed Advance LCS	Of the 15 Districts that have used Roadside mounted Advance LCS (see Q6E-Part 1)		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Turn bay transitions	15	100%	15	79%
X' in advance of turn bay transitions	7	47%	7	37%
Other location	1	7%	1	5%
No response			4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments/ Other location as specified:

Depends on traffic queue and geometrics.

Q6F Part1. Intersection Lane Control Signs:

ADVANCE MOVEMENT LANE CONTROL SIGNS MOUNTED OVERHEAD HAVE USED: ☐ YES ☐ NO

(R3-8 Series SIGNS, see Figure below)

R3-8L(R) R3-8a R3-8b R3-8c R3-8U

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	9	60%	9	47%
No	5	33%	5	26%
No response	1	7%	5	26%
Total responses	15	100%	19	100%

Q6F Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Overhead Placed Advance LCS	Of the 9 Districts that have used overhead mounted Advance LCS (see Q6F-Part 1)		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Turn bay transitions	5	38%	5	26%
X' in advance of turn bay transitions	3	23%	3	16%
Other location	2	15%	2	11%
No response			5	26%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other structures/locations as specified:

Signal mast arm.

Signal pole.

Q6G. Intersection Lane Control Signs with the words "OK", "THRU" and/or "ALL" used.
HAVE USED: ☐ YES ☐ NO

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	2	13%	2	11%
No	13	87%	13	68%
No response			4	21%
Total responses	15	100%	19	100%

Q6H. Intersection Lane Control Signs with supplemental plaques denoting route or place names.
HAVE USED: ☐ YES ☐ NO

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	2	13%	2	11%
No	13	87%	13	68%
No response			4	21%
Total responses	15	100%	19	100%

Q6I. Pavement markings, either arrows or words (not including arrows and/or word "ONLY" for typical turn bays) or other types of markings to indicate lane use or assignment. For example, have you put route numbers, route markers, or street names in pavement markings for lane assignment guidance? HAVE USED: ☐ YES ☐ NO

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	8	53%	8	42%
No	7	47%	7	37%
No response			4	21%
Total responses	15	100%	19	100%

Q6J. Signing and/or pavement markings on exit ramps close to cross street interchanges to indicate allowable lane use ahead.
HAVE USED: ☐ YES ☐ NO

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	5	33%	5	26%
No	10	67%	10	53%
No response			4	21%
Total responses	15	100%	19	100%

Q6K. Other non-standard signing (signing other than MUTCD standard R3-5 through R3-8 signs) or pavement markings to address a specific location or application in your jurisdiction? (please specify in the space below or on the back of this page): HAVE USED: □ YES □ NO

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	3	20%	3	16%
No	10	67%	10	53%
No response	2	13%	6	32%
Total responses	15	100%	19	100%

Non-standard signing as specified:

At diamond intersections, ie: US 190 at FM 2410, One district has placed the words "left turn lane" on the pavement where they want to queue vehicles on the far side of the interchange on the arterial.

Modified R3-8 for additional lane assignments. Modified for closely spaced intersections.

Interstate shield markings

Q6L. Other techniques used to mitigate or address the issue of advance lane assignment information (please specify in the space below or on the back of this page): HAVE USED: □ YES □ NO

Response	Of the 15 Districts responding "Yes" to Q1 or Q2		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	3	20%	3	16%
No	11	73%	11	58%
No response	1	7%	5	26%
Total responses	15	100%	19	100%

TxDOT districts responding "Yes" to other techniques, specified the folowing techniques:

Pavement markings (several sets).

Where signs are used on frontage road cross streets, one district uses divided highway signs.

One district uses guide signs to supplement regulatory signs. For example, "left two lanes - NB 290 only" or "Right lane - RM1431 only" were used to reinforce the intent of advance lane assignments signs.

Q7: If you answered YES to any of questions A through L in #6, what driver behavior did you observe that led to make these improvements? (Check all that apply).
(If you answered NO to all questions in #6, skip to #10.)

Response	Of the 15 Districts responding "Yes" to any of the Questions 6A through 6L		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Crash experience	6	40%	6	32%
Late decisions/lane changes	10	67%	10	53%
Erratic or indecisive lane changes	10	67%	10	53%
Illegal turns from through lanes	11	73%	11	58%
Illegal movements from turn-only lanes	9	60%	9	47%
Other	3	20%	3	16%
No response			4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments / Other reasons as specified:

Improvements/signs are used to improve traffic flow.
Improvements/signs are done while in design.
One district thought that the above mentioned driver behaviors reduce capacity of intersection.

Q8: Did the changes make a difference in the driver behavior and/or violations observed?

Response	Of the 15 Districts responding "Yes" to any of the Questions 6A through 6L		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	13	87%	13	68%
No	0	0%	0	0%
No response	2	13%	6	32%
Total responses	15	100%	19	100%

Comments regarding difference in behavior due to changes/signs:

Advance signing informed the drivers what to expect as they approach the intersection.
Better overall flow was observed.
Familiar motorists are OK. Unfamiliar motorists still have problems.
One district mentioned that not all locations have been fixed, some worked, other still have problems.
Driver compliance with lane assignments.
It appeared to clarify intended lane use for drivers.
Better understanding.
Drivers were observed or reported to be making less erratic or illegal movements.
In most cases countermeasures have made a difference in one district.
Improve signing and pavement marking in advance and improve signs on far side of intersections.

Q9: Were any before-to-after differences for any of the treatments mentioned above documented in a study (documented changes in crashes, violations, citations, erratic driver behavior, or other measures of effectiveness), or are they qualitative (e.g., seems to be a reduced number of phone calls from the public or law enforcement, "looks like better operation")?
☐ DOCUMENTATION AVAILABLE ☐ NO STUDY, QUALITATIVE OBSERVATION ONLY

Response	Of the 15 Districts responding "Yes" to any of the Questions 6A through 6L		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Documentation available	0	0%	0	0%
No study, qualitative observations only	13	87%	13	68%
No response	2	13%	6	32%
Total responses	15	100%	19	100%

General Questions

Q10: At what staff level is signing and pavement marking decisions for at-grade interchanges/intersections made to mitigate existing operational issues(check all that apply)?

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
District Engineer	5	26%
Area Engineer	9	47%
District Traffic Operations Engineer	19	100%
District Maintenance Office	1	5%
Area Maintenance Office	4	21%
Other (Please specify below)	4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Responses under "Others" specified the following:

Director of Maintenance.
Safety Review team if necessary.
Signal Maintenance Operations staff, Traffic Engineering staff.
Traffic Engineer.

Q11: Does your District use <u>advance</u> intersection lane control signs (R3-8 Series , see Figure below) at all approaches or only at specific types approaches? Please check all that apply.

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
All approaches	2	11%
Approaches that have turn-only lanes	13	68%
Approaches that have additional lanes at the intersection (more at the intersection than upstream)	15	79%
Approaches that have one or more thru lanes changing to turn-only lane/lanes (trap lane)	12	63%
We do not use R3-8 series signs	0	0%
Others (Please specify below)	3	16%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Responses under "Others" specified the following:

Frontage road approaches to cross street intersections, controlled access only.

One district uses the supplemental signs further back from the intersection when queues are long and drivers cannot see them until they are too close to intersection, ie: high volume locations.

Another district tries to sign for the turn only lanes and optional turns. However they do have some signs indicating normal operation lanes.

Q12: What guidelines, standards, or specifications do you follow when designing and/or placing lane assignment related traffic control devices on roadways that flare-out, or add lanes at the intersection?

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Federal MUTCD	0	0%
Texas MUTCD	17	89%
TxDOT Sign Crew Field Book	10	53%
TxDOT Freeway Signing Handbook	9	47%
Don’t use manuals, rely on engineering experience & judgment	1	5%
Others:	3	16%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Three responses under "Others" specified the following:

District developed typical applications similar to sign crew field book.

Use engineering experience and judgment with standards.

District policies.

Q13: What are the most frequent challenges or obstacles to a “by-the-book” placement of lane control signs?

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Utilities/utility poles	3	16%
Trees and/or vegetation	5	26%
Sign placement interferes with proper development of intersection sight distance box	6	32%
Other signs	15	79%
Upstream geometric feature (exit ramp, other intersection, sound walls/limited space, etc.)	14	74%
Others:	4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Responses under "Others" specified the following:

Driveways.

Private property owners.

Limited right-of-way.

Q14: What criteria are used for implementing <u>advance lane assignment signs</u> at an approach? Check any criteria used, but rank the top three criteria that might carry the most weight and rank them from 1 to 3 in the column to the right, with 1 being the most important.

Response	Of the Total TxDOT Districts Responding to Survey		Responses for Rank 1		Responses for Rank 2		Responses for Rank 3	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Turn only lanes at intersection	16	84%	6	33%	4	22%	1	6%
Public complaints about confusing intersection geometry	14	74%	3	17%	2	11%	5	28%
More lanes at the intersection than upstream	13	68%			6	33%	5	28%
Different lane arrangement compared to all other intersections along the roadway	11	58%	3	17%	1	6%	1	6%
High incidence of illegal turns	8	42%			3	17%	1	6%
Agency policy	6	32%	3	17%				
Crash patterns on the intersection approach	6	32%	2	11%			2	11%
Lack of vertical or horizontal sight distance	5	26%			1	6%	2	11%
High percentage of older drivers in the area	1	5%						
Other, please specify:	1	5%	1	6%	1	6%	1	6%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments:

Freeway signing handbook was specified as the only criterion by one district.

Another district selected multiple response options as criteria but did not provide any ranks for the criteria.

Q15: What criteria are used for implementing <u>advance lane assignment pavement markings</u> at an approach? Check any criteria used, but rank the top three criteria that might carry the most weight and rank them from 1 to 3 in the column to the right, with 1 being the most important.

Response	Of the Total TxDOT Districts Responding to Survey		Responses for Rank 1		Responses for Rank 2		Responses for Rank 3	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Turn only lanes at intersection	14	74%	6	33%	3	17%	1	6%
Public complaints about confusing intersection geometry	14	74%	2	11%	2	11%	5	28%
More lanes at the intersection than upstream	13	68%			8	44%	3	17%
Different lane arrangement compared to all other intersections along the roadway	10	53%	3	17%	1	6%	3	17%
High incidence of illegal turns	8	42%			1	6%	3	17%
Agency policy	6	32%	4	22%			1	6%
Crash patterns on the intersection approach	5	26%	1	6%				
Lack of vertical or horizontal sight distance	3	16%			2	11%		
High percentage of older drivers in the area	1	5%	1	6%				
High number of trucks	1	5%						
Other, please specify:	1	5%	1	6%	1	6%	1	6%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments:

District policies was specified as the only criterion by one district.

Another district selected multiple response options as criteria but did not provide any ranks for the criteria.

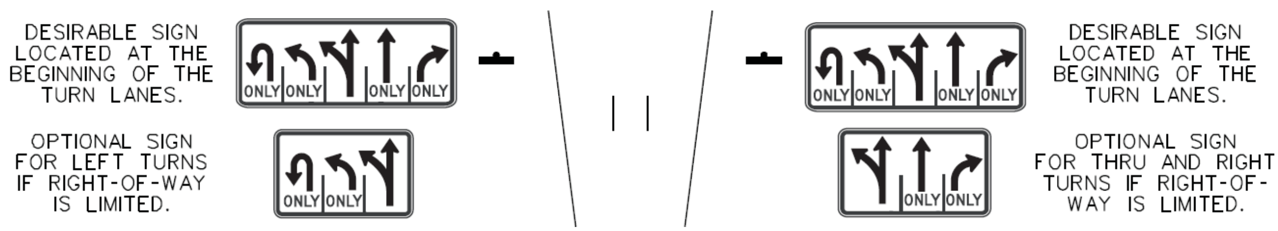
Sign Placement

Q16: Which type of sign placement does your agency currently employ for advance intersection lane control signs (check all that apply)?

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Overhead	6	32%
Roadside mounted on right side	11	58%
Roadside mounted on left side	7	37%
Roadside mounted on both the left and right side	12	63%
Both overhead and roadside mounted signs	8	42%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Q17: If you use roadside mounted signs for the advance intersection lane control signs mentioned in the previous question, would you ever split up this information and put part of it on the left side of the road and part on the right ? See example below:



If YES, what would be your justification to do this? Do you think it would cause any confusion to drivers?

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Yes, Our district would split the sign	6	32%
No, Our district woul dnot split the sign	13	68%
Total Responses	19	100%

Comments:

One district felt that the second option makes it seem like there are 6 lanes instead of 5 lanes.

Not sure but it appears ok.

One district has split up the signs on occasion due to the width and geometry of the intersection.

Justification for splitting:

If intersection has 4-5 total lanes and/or they observe road signs cannot be read from inside buffer.

Less information for the motorist to think about. Not confusing. If drivers are wanting to turn left they will be more towards the left lanes and don't care what the lane config for the right lanes is going to be.

The drivers cannot be expected to remember multiple lane assignments as they pass by. It is only relevant to sign for movements that affect drivers decision making, ie: look and drive on the left side if turning left and vice versa.

It is more a matter of visibility from their respective lanes (Driver Expectancy) and to minimize the "Information Overload" in one sign.

Existing multilane approach may need 'Right Lane Must Turn Right' at later date, may add 'Left Lane Must Turn Left'.

Q18: If you use overhead advance intersection lane control signs, what criterion does your District when making this decision?

Response	Of the 14 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Number of through lanes is more than two	3	21%	3	16%
Observed operational issues (frequency of improper and/or late lane changes)	4	29%	4	21%
Approach speed	1	7%	1	5%
Proximity to freeway/tollway off-ramp	2	14%	2	11%
Our District does not use overhead lane control signs as a matter of policy	4	29%	4	21%
Based on engineering judgment or other factors (Please specify below)	7	50%	7	37%
No response			5	26%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments / Other factors:

One district specified that overhead signing is always installed.

Use at intersections with dual lanes or unusual lanes.

One district though does not have a policy not to use them, but that district just does not use these.

If hard to see ground mounted sign due to other signs or geometry of the intersection - used only at certain intersections.

Sight distance limited or unexpected geometric condition of the intersection.

High traffic volume.

Q19: For what reason would you not use overhead mounted lane control signs? Check all that apply.

Response	Of the 15 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Initial cost	7	37%	7	37%
Ongoing cost of maintenance	3	16%	3	16%
Availability of right-of-way	4	21%	4	21%
Aesthetics	1	5%	1	5%
Do not feel overhead signs are necessary	7	37%	7	37%
Policy	2	11%	2	11%
Safety	2	11%	2	11%
Other (Please specify below)	2	11%	2	11%
No response			4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Two districts that responded "Other" specified the following reasons:

Smaller intersections.

One district does not have the traffic or number of lanes to justify overhead signing.

Q20: When advance lane control signs are used for lane assignments, how far ahead of the turn lane beginning location (or where the intersection "flares-out") are these located? If you place the devices at multiple locations, please check all that apply and comment.

Part A. Overhead Signs

Response	Of the 15 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At the beginning of the additional lane	3	20%	3	16%
Upstream of beginning of additional lane (please indicate distance criteria used below)	4	27%	4	21%
5 seconds distance (at operating speed) in advance of the intersection	1	7%	1	5%
On the signal mast arm or span wire at the intersection	9	60%	9	47%
Other (Please specify below)	0	0%	0	0%
Overhead sign not used in District	2	13%	2	11%
No Response			4	21%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Following comments were provided for distance criteria:

Dependent on field conditions.

In one district signs have been in place for a long time - respondents was not sure about the distance criteria used.

Judgement signs must be a adequate distance in advance to make the appropriate lane change before reaching the stopped vehicles.

As available.

Part B. Roadside mounted signs

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
At the beginning of the additional lane	15	79%
Upstream of beginning of additional lane (please indicate distance criteria used below)	10	53%
5 seconds distance (at operating speed) in advance of the intersection	2	11%
At the intersection	8	42%
Other (Please specify below)	0	0%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Following comments were provided for distance criteria:

Distance is not consistent.

TxDOT sign crew field book and Texas MUTCD.

Upstream of turn lane-approx 500'.

Dependent on field conditions.

Upstream of turn lane signs have been in place for a long time - not sure what distance criteria was used.

As available.

Q21: If you are using R3-8b sign at an approach where there are only two lanes upstream where the sign is located, and another lane is added downstream of the sign, do you somehow inform motorists whether the lane is being added on the left or the right? □ Yes □ No

R3-8b

If yes, can you provide a picture or describe the method used in providing this information to motorists (be it plaques on the R3-8B, additional signs, pavement markings, and/or other techniques or devices)?

Response	Of the 17 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	2	12%	2	11%
No	15	88%	15	79%
No response			2	11%
Total Responses	17	100%	19	100%

The two districts that responded "Yes", provided the following information:

One disitrict typically splits R3-8b. Left-turn, through sign used on the inside (left) and right turn only sign used on the outside (right).

Another district installs the sign on the side of the lane that is being added.

Q22: Does your District use advance intersection lane control signs for thru lanes that become turn-only at the intersection (also known as “trap Lanes”). Typically R3-5 and R3-7 signs may be used. □ Yes □ No

R3-5L(R)

R3-7L(R)

If yes, how many and how far apart these signs are located? Are there standard criteria used?

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Yes	18	95%
No	1	5%
Total Responses	19	100%

Summary of the responses for number of signs and spacing suggests there is no standard criteria available, but is dependent upon field conditions, MUTCD, sign crew field book, geometry, standard spacing for speed. Usually two signs are installed, one in advance of the intersection and other close to the intersection. The distance for the advance sign for different TxDOT districts varied from 300' to 1000'.

Q23: On the approach to an intersection on a frontage road, have you (or would you) include cross street information on a lane control sign to provide road users with advance information to identify the names of the intersecting street? ☐ Yes ☐ No
If so, how would you incorporate (or how have you incorporated this information on a sign?

Response	Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses
Yes	1	5%
No	18	95%
Total Responses	19	100%

One district that responded "Yes" incorporate this information by installing the D-1 type series signs separately / independently.

Q24: If you were to include supplemental information on lane control signs, what types of information would you consider it important to include on advance signs on the approach to the intersection? Check all that apply.

Response	Of the 9 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Cross street names	1	11%	1	5%
Distance to intersection	7	78%	7	37%
Yield to bikes	0	0%	0	0%
Distance to turn lanes (where the intersection “flares”)	1	11%	1	5%
Railroad ahead	1	11%	1	5%
Other (Please specify below)	1	11%	1	5%
No response			10	53%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

One district that responded "Other" specified 'None' as response.

Q25: At some intersections, particularly those with loop ramps, a driver may have to make a right turn from the arterial to the loop connector to make a directional left turn (for example, at a cloverleaf-type interchange).
Part A. What guidelines, standards, or specifications do you follow when designing and/or placing lane assignment related traffic control devices on roadways that have loop ramps?

Response	Of the 16 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Federal MUTCD	0	0%	0	0%
Texas MUTCD	15	94%	15	79%
TxDOT Sign Crew Field Book	9	56%	9	47%
TxDOT Freeway Signing Handbook	9	56%	9	47%
Don’t use manuals, rely on engineering experience & judgment	1	6%	1	5%
Other	1	6%	1	5%
No response			3	16%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

One district commented that they do not have a good way of signing for this situation and did not select any of the guidelines/standards provided in the response options.

Part B. In your opinion, is there additional guidance needed for placement of signs and/or pavement markings at cloverleaf type interchanges/intersections? □ Yes □ No

Response	Of the 15 Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	6	40%	6	32%
No	9	60%	9	47%
No Response			4	21%
Total Responses	15	100%	19	100%

If yes, please comment on the issues that you feel are most important to address or where you think the current guidance falls sh

Comments:

It is difficult for the unfamiliar driver to know which lane they should be in to make their turns.
If tight turns or numerous direction changes.
Current guidelines are not enough.
Destination names and location of route and guide signs.
Advanced pavement markings on freeway facilities in correlation to existing overhead sign bridges.

Part C. Please list locations where you feel that lane assignment signing and/or markings are implemented particularly well (or not so well) for intersections with loop ramps.

Locations provided by respondents:

Joe Battle at I-10
Loop 250 Midland
BI 20 Midland
BI 20 Odessa
LP 338 Odessa
SH 286 at SH 358 interchange, overhead sign bridges with route markers, pavement markings
Frontage roads: US 75 from: Spur 366 (Downtown Dallas) to: SH 121 (McKinney)

Lane Assignment Pavement Marking

Q26: When pavement markings are used to indicate advance lane assignments, how far ahead of the turn location are these located? If you place the devices at multiple locations, please circle all that apply.

Response	Of the 16 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At the beginning of the additional lane	11	69%	11	58%
Upstream of beginning of additional lane (please indicate distance criteria used below)	5	31%	5	26%
5 seconds distance (at operating speed) in advance of the intersection	1	6%	1	5%
Other (Please specify below)	1	6%	1	5%
No Response			3	16%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

One district that responded "Other" specified that they use markings as supplemental to signs and are placed for reassurance near the intersection.

Following comments were provided for distance criteria:

Distance is not consistent.

In the turn lane

Depends on queue.

Follow research guide lines.

At the intersection, if needed to supplement lane assignment signs.

Depending on approach speeds and historical information on queue lengths during peak periods in order to make sure that those additional markings are visible as motorists approach.

Q27: Does your District use any other type of advance lane assignment pavement markings to guide motorists on frontage roads or cross streets on approach to intersections that add lanes or "flare out"? □ Yes □ No

Response	Of the 18 Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	1	6%	1	5%
No	17	94%	17	89%
No Response			1	5%
Total Responses	18	100%	19	100%

One district that responded "Yes" specified use of route marker shields.

Q28: If you were to include supplemental information as pavement markings, what types of information would you consider it important to include on advance approach to the intersection? Check all that apply.

Response	Of the 7 TxDOT Districts Responding to this Question		Of the Total TxDOT Districts Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Cross street names	0	0%	0	0%
Distance to intersection	3	43%	3	16%
Yield to bikes	0	0%	0	0%
Distance to turn lanes (where the intersection "flares")	1	14%	1	5%
Other	4	57%	4	21%
No response			12	63%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Four districts that responded "Other" specified 'None' as response.

APPENDIX B: SURVEY OF STATE DEPARTMENTS OF TRANSPORTATION RESULTS

Q1: Does your State have (or had) intersections or interchanges where the approach flares to more lanes than you have upstream AND with lane assignments that are not typical? For example, adding a left turn bay adjacent to the left lane would be typical (something most drivers would expect), but forcing a left turn from the middle or right lane would not be as common.

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Yes	10	59%
No	7	41%
Total Responses	17	100%

Q2: Does your State have (or had) interchanges where the lane assignment for a particular turn movement may be problematic or violate driver expectation? For example, trying to sign for a "left turn" movement at a cross-street approach to a cloverleaf interchange (where the motorist must take the second right).

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Yes	10	59%
No	7	41%
Total Responses	17	100%

Q3: If YES to either question #1 or #2, to your knowledge have these situation(s) caused an increased frequency of crashes?

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	3	30%	3	18%
No	7	70%	7	41%
No Response			7	41%
Total Responses	10	100%	17	100%

Q4: If YES to either question #1 or #2, have these situations prompted public or law enforcement concerns (calls, letters, etc.)?

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	6	55%	6	35%
No	5	45%	5	29%
No Response			6	35%
Total Responses	11	100%	17	100%

Q5: With respect to problematic intersection or interchanges where lane assignment causes operational difficulty or resulted in unusually high crash history in your State, please list below:

City	Primary Roadway	Cross Street	Type of Interchange	Type of Issue / Problem
Little Rock, AR	I-630	Pine St	Diamond	3 lanes on cross street turn into 3 lane frontage road w/dual lefts, trapping vehicles in the inside Left Turn Lane.
Jefferson City, MO	US 50	Truman Blvd	Partial folded diamond	3 lane app, single left with dual right, one right lane must make a right turn at the outer road that is less than 200' away.
Camdenton, MO	US54	MO5	Partial folded diamond	Because of the folded on ramp, traffic that would normally make a left turn to get on 5 South, must turn right (similar to cloverleaf).
Springfield, MO	I-44	MO13	Diverging Diamond Interchange	One of the right turn lanes on the WB off ramp is channelized to force traffic to turn right onto the outer road. Vehicles would get trapped and be forced to make U-turn on outer road.
Eureka, MO	I-44	Six Flags Rd	Diamond	Dual right was underutilized and created backups onto IS70 during operations of Six Flags Theme Park.
Independence, MO	I-70	MO7	Diamond	One of the left turn lanes turned behind the bridge columns, therefore we needed to restrict trucks from that lane.
Johnson County, KS	I-435 Corridor	Quivera to State Line	-	Multiple turn lanes at off ramps
Greenfield, MA	I-91 NB/SB	MA2 and MA 2A	Diamond with Traffic circle	Secondary roadway is traffic circle within interchange - merging and weaving issues between traffic exiting and entering I-91 ramps with local traffic on secondary roads.
Methuen, MA	I-93 NB/SB	MA 110 and MA 113	Diamond with traffic circle,	Secondary roadway is traffic circle within interchange - merging and weaving issues between traffic exiting and entering I-93 ramps with local traffic on secondary roads.
Boston, MA	I-93 NB/SB	Various local street connections	-	Mainline roadway in tunnel with multiple exit/entrance slip ramps on left and right sides, Most exits within tunnels multiple added "exit only" lanes which force drivers entering tunnel system from local streets to merge left in short distances.
Woburn, MA	I-95 NB	I-93 NB/SB	Cloverleaf with mainline lane drop	Right lane through traffic must merge out of dropped lane within weave area for cloverleaf traffic exiting/entering I-95 NB

Q6: If YES to either question #1 or #2, please answer questions 6A through 6L below about countermeasures that you may have used to address these issues.

Q6A Part1. Intersection Lane Control Signs:

MANDATORY MOVEMENT LANE CONTROL SIGNS MOUNTED ROADSIDE HAVE USED: □ YES □ NO

(R3-5, R3-5a, and R3-7 SIGNS, see Figure below)

R3-5L(R) R3-5a R3-7L(R)

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	8	73%	8	47%
No	3	27%	3	18%
No Response			6	35%
Total Responses	11	100%	17	100%

Q6A Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Roadside placed Mandatory LCS	Of the 8 State DOTs that have used Roadside mounted Mandatory LCS (see Q6A-Part 1)		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At far side of intersection	0	0%	0	0%
At turn bay	7	88%	7	41%
At intersection	6	75%	6	35%
At other locations	1	13%	1	6%
No Response			6	35%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Q6B Part1. Intersection Lane Control Signs:

MANDATORY MOVEMENT LANE CONTROL SIGNS MOUNTED OVERHEAD HAVE USED: □ YES □ NO

(R3-5, R3-5a, and R3-7 SIGNS, see Figure below)

R3-5L(R) R3-5a R3-7L(R)

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	7	64%	7	41%
No	3	27%	3	18%
No Response	1	9%	7	41%
Total Responses	11	100%	17	100%

Q6B Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Overhead Placed Mandatory LCS	Of the 7 State DOTs that have used overhead mounted Mandatory LCS (see Q6B-Part 1)		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Signal Pole	1	14%	1	6%
Signal Span	3	43%	3	18%
Mast Arm	6	86%	6	35%
Other Structures	4	57%	4	24%
No Response			7	41%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other structures as specified:

Single tube trusses.

Overhead span wire.

Q6C Part1. Intersection Lane Control Signs:

OPTIONAL MOVEMENT LANE CONTROL SIGNS MOUNTED ROADSIDE HAVE USED: ☐ YES ☐ NO

(R3-6 SIGNS, see Figure below)

R3-6L(R)

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	7	64%	7	41%
No	3	27%	3	18%
No Response	1		7	41%
Total Responses	11	91%	17	100%

Q6C Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Roadside placed Optional LCS	Of the 7 State DOTs that have used Roadside mounted Optional LCS (see Q6C-Part 1)		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At far side of intersection	1	14%	1	6%
At turn bay	4	57%	4	24%
At intersection	4	57%	4	24%
At other locations	1	14%	1	6%
No Response			7	41%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other location as specified:

Sign posts.

Q6D Part1. Intersection Lane Control Signs:
OPTIONAL MOVEMENT LANE CONTROL SIGNS MOUNTED OVERHEAD ***HAVE USED: ☐ YES ☐ NO***
(R3-6 SIGNS, see Figure below)

R3-6L(R)

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	8	73%	8	47%
No	2	18%	2	12%
No Response	1	9%	7	41%
Total Responses	11	100%	17	100%

Q6D Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Overhead Placed Optional LCS	Of the 8 State DOTs that have used overhead mounted Optional LCS (see Q6D-Part 1)		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Signal Pole	0	0%	0	0%
Signal Span	4	50%	4	24%
Mast Arm	6	75%	6	35%
Other Structures	3	38%	3	18%
No Response			7	41%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other structures/locations as specified:

Single tube trusses.

Q6E Part1. Intersection Lane Control Signs:
ADVANCE MOVEMENT LANE CONTROL SIGNS MOUNTED ROADSIDE ***HAVE USED: ☐ YES ☐ NO***
(R3-8 Series SIGNS, see Figure below)

R3-8L(R) R3-8a R3-8b R3-8c R3-8U

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	10	91%	10	59%
No	1	9%	1	6%
No Response			6	35%
Total Responses	11	100%	17	100%

Q6E Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Roadside placed Advance LCS	Of the 10 State DOTs that have used Roadside mounted Advance LCS (see Q6E-Part 1)		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Turn bay transitions	8	80%	8	47%
X' in advance of turn bay transitions	3	30%	3	18%
Other location	2	20%	2	12%
No Response			6	35%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other location as specified:

At the intersection.

Q6F Part1. Intersection Lane Control Signs:

ADVANCE MOVEMENT LANE CONTROL SIGNS MOUNTED OVERHEAD HAVE USED: ☐ YES ☐ NO

(R3-8 Series SIGNS, see Figure below)

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	5	45%	5	29%
No	5	45%	5	29%
No Response	1	9%	7	41%
Total Responses	11	100%	17	100%

Q6F Part2 - Mounting Locations Used (check any/all that apply):

Mounting Location for Overhead Placed Advance LCS	Of the 5 State DOTs that have used overhead mounted Advance LCS (see Q6F-Part 1)		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Turn bay transitions	3	60%	3	16%
X' in advance of turn bay transitions	3	60%	3	16%
Other location	2	40%	2	11%
No Response			7	37%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other location as specified:

Around 200 feet from intersection.

Q6G. Intersection Lane Control Signs with the words "OK", "THRU" and/or "ALL" used.
HAVE USED: □ YES □ NO

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	1	9%	1	6%
No	8	73%	8	47%
No Response	2	18%	8	47%
Total Responses	11	100%	17	100%

Q6H. Intersection Lane Control Signs with supplemental plaques denoting route or place names.
HAVE USED: □ YES □ NO

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	6	55%	6	35%
No	5	45%	5	29%
No Response			6	35%
Total Responses	11	100%	17	100%

Q6I. Pavement markings, either arrows or words (not including arrows and/or word "ONLY" for typical turn bays) or other types of markings to indicate lane use or assignment. For example, have you put route numbers, route markers, or street names in pavement markings for lane assignment guidance? HAVE USED: □ YES □ NO

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	8	73%	8	47%
No	3	27%	3	18%
No Response			6	35%
Total Responses	11	100%	17	100%

Q6J. Signing and/or pavement markings on exit ramps close to cross street interchanges to indicate allowable lane use ahead.
HAVE USED: □ YES □ NO

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	7	64%	7	41%
No	4	36%	4	24%
No Response			6	35%
Total Responses	11	100%	17	100%

Q6K. Other non-standard signing (signing other than MUTCD standard R3-5 through R3-8 signs) or pavement markings to address a specific location or application in your jurisdiction? (please specify in the space below or on the back of this page):
HAVE USED: □ YES □ NO

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	4	36%	4	24%
No	7	64%	7	41%
No Response			6	35%
Total Responses	11	100%	17	100%

Non-standard signing as specified:

One state mentioned lane assignments for multi-lane roundabouts. For example there is a triple left where trucks need to be assigned to particular lanes. And another example of a triple left where buses use the right thru lane on the cross street and turn onto the shoulder of the TH mainline.

A shared left-turn/through lane and a shared left-turn/through/right-turn was also mentioned as non-standard signing.

Q6L. Other techniques used to mitigate or address the issue of advance lane assignment information (please specify in the space below or on the back of this page): HAVE USED: □ YES □ NO

Response	Of the 11 State DOTs responding "Yes" to Q1 or Q2		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	2	18%	2	12%
No	6	55%	6	35%
No Response	3	27%	9	53%
Total Responses	11	100%	17	100%

State DOTs responding "Yes" to other techniques, specified the folowing techniques:

Lane drop markings.

Q7: If you answered YES to any of questions A through L in #6, what driver behavior did you observe that led to make these improvements? (Check all that apply).
(If you answered NO to all questions in #6, skip to #10.)

Response	Of the 11 State DOTs responding "Yes" to any of the Questions 6A through 6L		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Crash Experience	4	36%	4	24%
Late decisions/lane changes	7	64%	7	41%
Erratic or indecisive lane changes	5	45%	5	29%
Illegal turns from through lanes	5	45%	5	29%
Illegal movements from turn-only lanes	4	36%	4	24%
Other	1	9%	1	6%
No response	2	18%	8	47%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments / Other reasons as specified:

One state mentioned that each installation is unique. Some were designed and installed from opening day. Others were modified due to crash or operational experience.

One state observed that often, approaches to freeways on-ramp facilities were not detailed enough to provide adequate advanced warning to road users unfamiliar with the on-ramp entries, prompting the DOT to conduct public outreach.

In one state, signs are installed when the turn lanes are constructed.

Another state has not completed any analysis, but expect better understanding from drivers.

Signs are used as standard practice on multi-lane approaches in one of states responding to the survey.

Q8: Did the changes make a difference in the driver behavior and/or violations observed?

Response	Of the 11 State DOTs responding "Yes" to any of the Questions 6A through 6L		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	5	45%	5	29%
No	1	9%	1	6%
No Response	5	45%	11	65%
Total Responses	11	100%	17	100%

Comments regarding difference in behavior due to changes/signs:

Standard MUTCD intersection control signing can be effective in giving motorists advance notice and information on which lane they should be in.

The signs were installed with the construction, it was not a change.

One state expected the signs and markings would provide better guidance.

Another state commented that improvements typically occur.

Q 9: Were any before-to-after differences for any of the treatments mentioned above documented in a study (documented changes in crashes, violations, citations, erratic driver behavior, or other measures of effectiveness), or are they qualitative (e.g., seems to be a reduced number of phone calls from the public or law enforcement, "looks like better operation")?

☐ DOCUMENTATION AVAILABLE ☐ NO STUDY, QUALITATIVE OBSERVATION ONLY

Response	Of the 11 State DOTs responding "Yes" to any of the Questions 6A through 6L		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Documentation available	0	0%	0	0%
No study, qualitative observations only	9	82%	9	53%
No Response	2	18%	8	47%
Total Responses	11	100%	17	100%

General Questions

Q10: At what staff level is signing and pavement marking decisions for at-grade interchanges/intersections made to mitigate existing operational issues(check all that apply)?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
State DOT Traffic Operations Engineer	11	65%
State DOT District Traffic Operations Engineer	11	65%
State DOT Area Engineer	4	24%
Local (non-State DOT) Agency Engineer	3	18%
Other (Please specify below)	4	24%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Responses under "Others" specified the following:

Decision on traffic controls are made at the Traffic Branch which has jurisdiction over the whole state. Either the Traffic Design Section or the Operations Section would normally make these types of decisions.

State DOT Engineer only involved if outside of policy.

Typically state and district traffic operations personnel.

Unit of the state signing engineer and/or unit of the state traffic engineer.

Comments:

Local agency engineer only for local streets not under State DOT jurisdiction).

Traffic Design office.

Q11: Does your District use advance intersection lane control signs (R3-8 Series , see Figure below) at all approaches or only at specific types approaches? Please check all that apply.

R3-8L(R) R3-8a R3-8b R3-8c R3-8U

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
All approaches	0	0%
Approaches that have turn-only lanes	10	59%
Approaches that have additional lanes at the intersection (more at the intersection than upstream)	11	65%
Approaches that have one or more thru lanes changing to turn-only lane/lanes (trap lane)	11	65%
We do not use R3-8 series signs	0	0%
Others (Please specify below)	10	59%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Responses under "Others" specified the following:

Used in a very limited number of locations with complex geometry.
As needed based on geometry, engineering judgment.
One state specified use of advance lane assignment signs is based on the State's Traffic Engineering Manual.
Signs are included at locations where extended queues may develop.
State MUTCD has variations of R3-8 signs because there are many multilane facilities that R3-8 series may not describe.
Unusual lane configurations.
based on need detrmined by a traffic study.
Multilane intersection approaches with a combination of turn-only lanes, through-only lanes, and/or shared through/turn lanes.
One state mentioned that sometimes they use advance signing at all of the situations provided in the questions, but not always.

Q12: What guidelines, standards, or specifications do you follow when designing and/or placing lane assignment related traffic control devices on roadways that flare-out, or add lanes at the intersection?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Federal MUTCD	15	88%
State MUTCD	4	24%
Don't use manuals, rely on engineering experience & judgment	3	18%
Others:	0	0%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Q13: What are the most frequent challenges or obstacles to a "by-the-book" placement of lane control signs?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Utilities/utility poles	7	41%
Trees and/or vegetation	4	24%
Sign placement interferes with proper development of intersection sight distance box	2	12%
Other signs	13	76%
Upstream geometric feature (exit ramp, other intersection, sound walls/limited space, etc.)	13	76%
Others:	2	12%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Responses under "Others" specified the following:

Driveways, Sidewalk edge, and limited right-of-way.

Q14: What criteria are used for implementing <u>advance lane assignment signs</u> at an approach? Check any criteria used, but rank the top three criteria that might carry the most weight and rank them from 1 to 3 in the column to the right, with 1 being the most important.

Response	Of the Total State DOTs Responding to Survey		Responses for Rank 1		Responses for Rank 2		Responses for Rank 3	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Public complaints about confusing intersection	13	76%	1	6%	3	19%	5	31%
Turn only lanes at intersection	11	65%	6	38%				
More lanes at the intersection than upstream	8	47%			3	19%	4	25%
Different lane arrangement compared to all other intersections along the roadway	7	41%	2	13%			1	6%
Crash patterns on the intersection approach	7	41%	2	13%	3	19%	1	6%
High incidence of illegal turns	6	35%			2	13%	2	13%
Lack of vertical or horizontal sight distance	6	35%	1	6%	1	6%	2	13%
Agency policy	5	29%	1	6%	3	19%		
Other, please specify:	3	18%	3	19%	1	6%	1	6%
High percentage of older drivers in the area	0	0%						

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments:

Field conditions was specified as the only criterion by one state.

High speed approaches.

Atypical lane assignments at approaches.

One state selected multiple response options as criteria but did not provide any ranks for the criteria.

Q15: What criteria are used for implementing <u>advance lane assignment pavement markings</u> at an approach? Check any criteria used, but rank the top three criteria that might carry the most weight and rank them from 1 to 3 in the column to the right, with 1 being the most important.

Response	Of the Total State DOTs Responding to Survey		Responses for Rank 1		Responses for Rank 2		Responses for Rank 3	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Crash patterns on the intersection approach	10	59%	3	19%	3	19%	3	19%
Public complaints about confusing intersection geometry	9	53%			4	25%	2	13%
More lanes at the intersection than upstream	9	53%	1	6%	1	6%	4	25%
Agency policy	8	47%	3	19%	4	25%		
Turn only lanes at intersection	7	41%	6	38%				
Different lane arrangement compared to all other intersections along the roadway	6	35%	2	13%	2	13%		
High incidence of illegal turns	6	35%			1	6%	2	13%
Lack of vertical or horizontal sight distance	4	24%					3	19%
Other, please specify:	1	6%	1	6%	1	6%	1	6%
High percentage of older drivers in the area	0	0%						
High number of trucks	0	0%						

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments:

Field conditions was specified as the only criterion by one state.

Another state selected multiple response options as criteria but did not provide any ranks for the criteria.

One state provided only two criteria.

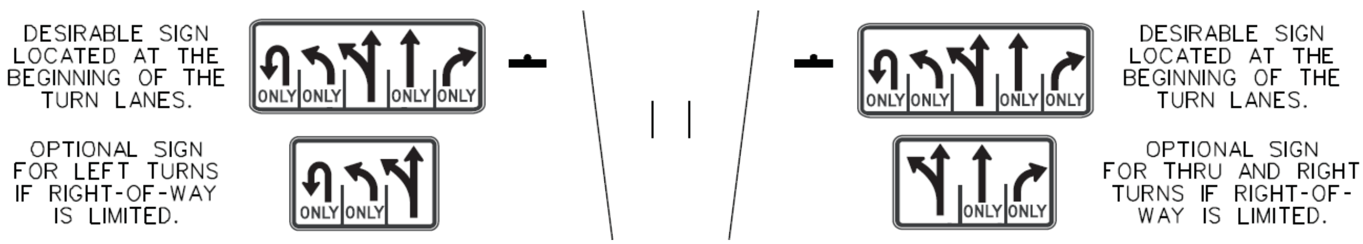
Sign Placement

Q16: Which type of sign placement does your agency currently employ for advance intersection lane control signs (check all that apply)?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Overhead	10	59%
Roadside mounted on right side	13	76%
Roadside mounted on left side	7	41%
Roadside mounted on both the left and right side	10	59%
Both overhead and roadside mounted signs	8	47%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Q17: If you use roadside mounted signs for the <u>advance</u> intersection lane control signs mentioned in the previous question, would you ever split up this information and put part of it on the left side of the road and part on the right ? See example below:



If YES, what would be your justification to do this? Do you think it would cause any confusion to drivers?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Yes, our state would split the sign	1	6%
No, our state would not split the sign	16	94%
Total responses	17	100%

Comments:

One state mentioned that there frequently is insufficient room for the wider sign and that they have had both types of installation. The respondent's personal opinion was that splitting the sign is less confusing. When dealing with so many lanes drivers have difficulty seeing these signs and are only concentrating on "their side", ie: they want to go right or left.

Q18: If you use overhead advance intersection lane control signs, what criterion does your State when making this decision?

Response	Of the 15 State DOTs Responding to this Question		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Number of through lanes is more than two	5	33%	5	29%
Observed operational issues (frequency of improper and/or late lane changes)	8	53%	8	47%
Approach speed	1	7%	1	6%
Proximity to freeway/tollway off-ramp	1	7%	1	6%
Our State does not use overhead lane control signs as a matter of policy	0	0%	0	0%
Based on engineering judgment or other factors (Please specify below)	14	93%	14	82%
No response			2	12%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Other factors:

Unexpected lane assignments at the approaching intersection or due to close proximity of an outer road, the operations staff may want the vehicles positioned in certain lanes.

For unique situation: short approach, crash history, unusual geometry (triple left), high volumes, etc.

For one state cost usually prohibits their use. But they would consider overhead signs if side mounted signs were thought to be inadequate or were difficult to place.

Based on engineering judgment and crash experience.

Use State MUTCD for guidance.

Limited ROW space, number of driveways.

Geometrics and space availability.

Driver behavior along the roadway.

Limited right-of-way to install ground mounted signs.

Q19: For what reason would you not use overhead mounted lane control signs? Check all that apply.

Response	Of the 16 State DOTs Responding to this Question		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Initial cost	11	69%	11	65%
Ongoing cost of maintenance	5	31%	5	29%
Availability of right-of-way	8	50%	8	47%
Aesthetics	3	19%	3	18%
Do not feel overhead signs are necessary	7	44%	7	41%
Policy	0	0%	0	0%
Safety	1	6%	1	6%
Other (Please specify below)	1	6%	1	6%
No response			1	6%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

One state that responded "Other" specified the following reason:

Insufficient room for proper overhead sign support protection.

Q20: When advance lane control signs are used for lane assignments, how far ahead of the turn lane beginning location (or where the intersection "flares-out") are these located? If you place the devices at multiple locations, please check all that apply and comment.

Part A. Overhead Signs

Response	Of the 14 State DOTs Responding to this Question		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At the beginning of the additional lane	10	71%	10	59%
Upstream of beginning of additional lane (please indicate distance criteria used below)	5	36%	5	29%
5 seconds distance (at operating speed) in advance of the intersection	0	0%	0	0%
On the signal mast arm or span wire at the intersection	6	43%	6	35%
Other (Please specify below)	0	0%	0	0%
No Response			3	18%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Following comments were provided for distance criteria:

Based on field conditions.

Around 200' in advance of turn lanes.

No specific criteria, other than good engineering judgement. Also overhead signs are much more expensive than roadside signs and depend upon available structures, mast arms. In general, overhead signs on special structures are installed only when there is a specific reason for the use of overhead sign. But there is a point at which 3 or more lanes may require overhead guidance and regulatory signs to assist road users to anticipate the approapriate lane to be in to make a smooth transition to a critical turning point.

One state mentioned that where it is not feasible to install overhead signs at the beginning of the additional lane, the signs are placed as close as practical to the begining of the additional lane, but normally no more than 50 to 75 feet either upstream or downstream of the begining of the lane.

Part B. Roadside mounted signs

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
At the beginning of the additional lane	15	88%
Upstream of beginning of additional lane (please indicate distance criteria used below)	8	47%
5 seconds distance (at operating speed) in advance of the intersection	0	0%
At the intersection	4	24%
Other (Please specify below)	0	0%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Following comments were provided for distance criteria:

Based on field conditions.

Min. 150' in advance of additional lane.

Upstream of the taper.

Based on approach speed (reaction time).

One state mentioned that where it is not feasible to install roadside mounted signs at the beginning of the additional lane, signs are installed as close as practical to the begining of the additional lane, but normally no more than 50 to 75 feet either upstream or downstream of the begining of the lane.

Q21: If you are using R3-8b sign at an approach where there are only two lanes upstream where the sign is located, and another lane is added downstream of the sign, do you somehow inform motorists whether the lane is being added on the left or the right? ☐ Yes ☐ No

R3-8b

If yes, can you provide a picture or describe the method used in providing this information to motorists (be it plaques on the R3-8B, additional signs, pavement markings, and/or other techniques or devices)?

Response	Of the 15 State DOTs Responding to this Question		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Yes	2	13%	2	12%
No	13	87%	13	76%
No response			2	12%
Total Responses	15	100%	17	100%

The two states that responded "Yes", provided the following information:

Signs are placed so as to reflect the lanes of the section that drivers are entering at the beginning of the taper.

One state's policy is that the design of R3-8b advance signs reflects the lane configuration at the intersection, even if lanes are added downstream of the advance sign. To minimize the chances for driver confusion, advance signs are placed as close as possible to the begining of the additional lane.

Q22: Does your District use advance intersection lane control signs for thru lanes that become turn-only at the intersection (also known as "trap Lanes"). Typically R3-5 and R3-7 signs may be used. ☐ Yes ☐ No

R3-5L(R)

R3-7L(R)

If yes, how many and how far apart these signs are located? Are there standard criteria used?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Yes	17	100%
No	0	0%
Total Responses	17	100%

Summary of comments for number and spacing of signs indicates, there is no standard criteria rather a combination of engineering judgment, site conditions, approach speed, available space, and sight distance are used. Most respondents indicated use of at least one sign placed at the begining of the additional lane or end of the expected traffic queue during peak periods. When two signs are used, the second sign is placed at the intersection.

Q23: On the approach to an intersection on a frontage road, have you (or would you) include cross street information on a lane control sign to provide road users with advance information to identify the names of the intersecting street? □ Yes □ No

If so, how would you incorporate (or how have you incorporated this information on a sign?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Yes	3	18%
No	14	82%
Total Responses	17	100%

Comments:

One state felt that roundabouts as the intersection control diamond interchanges will likely change their practice of not providing additional information on lane assignment signs. This state often provides advance street name signs on the ramp (ie: a green sign with street name and a double-headed arrow). But as spacing becomes limited (more lane control signs needed or logo signs), additional information is omitted. At one location the respondent mentioned use of a yellow "trail crossing" plaque under the right lane must turn right sign becuase of numerous serious bike/ped crashes.

Another state uses guide signs that provide cross street names at signalized intersections as per the state vehicle code.

Another state specified that if the cross street intersection is signalized and is not a numbered route (where directional signs would normally be provided), a separate "Next Signal" advance street name sign is usually placed prior to the advance lane control sign for the intersection.

Use of separate adjacent sign was mentioned by one state.

Q24: If you were to include supplemental information on lane control signs, what types of information would you consider it important to include on advance signs on the approach to the intersection? Check all that apply.

Response	Of the 10 State DOTs Responding to this Question		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Cross street names	7	70%	7	41%
Distance to intersection	2	20%	2	12%
Yield to bikes	0	0%	0	0%
Distance to turn lanes (where the intersection “flares”)	2	20%	2	12%
Railroad ahead	0	0%	0	0%
Other (Please specify below)	0	0%	0	0%
No response			7	41%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Q25: At some intersections, particularly those with loop ramps, a driver may have to make a right turn from the arterial to the loop connector to make a directional left turn (for example, at a cloverleaf-type interchange).

Part A. What guidelines, standards, or specifications do you follow when designing and/or placing lane assignment related traffic control devices on roadways that have loop ramps?

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Federal MUTCD	15	88%
State MUTCD	4	24%
Don't use manuals, rely on engineering experience & judgment	3	18%
Other	1	6%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Comments:

One state that responded "Other" specified engineering judgment.

Part B. In your opinion, is there additional guidance needed for placement of signs and/or pavement markings at cloverleaf type interchanges/intersections? ☐ Yes ☐ No

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Yes	2	12%
No	15	88%
Total Responses	17	100%

If yes, please comment on the issues that you feel are most important to address or where you think the current guidance falls short:

Comments:

Combination arrows / or guide signs may help.

Part C. Please list locations where you feel that lane assignment signing and/or markings are implemented particularly well (or not so well) for intersections with loop ramps.

Locations/Signing provided by respondents:

Indian trail WB @ I-85 in Gwinnett County, Georgia
On a 4 lane divided arterial where one leg goes WB and a loop goes EB, One of the two states that answered Q25B have implemented the following: the first sign says TH 212 RIGHT LANE (gets both directions in the right lane as needed). The second sign is at the taper to take the leg to WB 212, West TH 212 right arrow. A third sign at the loop would say EAST TH 212 right arrow.

Lane Assignment Pavement Marking

Q26: When pavement markings are used to indicate advance lane assignments, how far ahead of the turn location are these located? If you place the devices at multiple locations, please circle all that apply.

Response	Of the 16 State DOTs Responding to this Question		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
At the beginning of the additional lane	12	75%	12	71%
Upstream of beginning of additional lane (please indicate distance criteria used below)	3	19%	3	18%
5 seconds distance (at operating speed) in advance of the intersection	0	0%	0	0%
Other (Please specify below)	4	25%	4	24%
No Response			1	6%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Following comments were provided under "Other" and for distance criteria:

Based on field conditions, available spacing, approach speed and engineering judgment.

Just prior to intersection (ie: 75').

Not generally used in one state.

Plus or minus 200' ahead of turn lane.

Q27: Does your State use any other type of advance lane assignment pavement markings to guide motorists on frontage roads or cross streets on approach to intersections that add lanes or "flare out"? ☐ ***Yes*** ☐ ***No***

Response	Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses
Yes	1	6%
No	16	94%
Total Responses	17	100%

Other type of markings:

Horizontal signing (route shields and cardinal direction legends).

Q28: If you were to include supplemental information as pavement markings, what types of information would you consider it important to include on advance approach to the intersection? Check all that apply.

Response	Of the 7 State DOTs Responding to this Question		Of the Total State DOTs Responding to Survey	
	Number of Responses	Percent of Responses	Number of Responses	Percent of Responses
Cross street names	3	43%	3	18%
Distance to intersection	0	0%	0	0%
Yield to bikes	0	0%	0	0%
Distance to turn lanes (where the intersection “flares”)	0	0%	0	0%
Other	5	71%	5	29%
No response			10	59%

Note: Due to the possibility of multiple responses by individual respondents, sum of percentages may not add up to 100%

Information provided by respondents under "Other" that they would like to include as pavement markings:

Route shields, No right on red, No trucks, or other "special" restrictions.

Destinations for lane use.

One respondent commented that wise application of engineering judgement may require some innovative pavement marking solutions. However, signs are typically more effective from distances further back to advise road users to turn in whatever lane is needed for safe navigation of intersections and turns.

One state uses just arrows and "Only" marking to indicate what the purpose of the lane is.

APPENDIX C: FOCUS GROUP TRANSCRIPTS

COLLEGE STATION TRANSCRIPT

F-What assumptions you have as you approach an intersection.

F-Have any of you been driving on a frontage road and as you approach an intersection found yourself confused as to what lane you might be in?

All- yes

1- Yes, because there is always a little white sign and its way over on the right hand side.

10- Yes, at the merge lane a lot of people stop there and think it's a yield.

7- I think that people who stop thee are trying to get way over in that fourth lane to make a turn.

F- Have you ever found yourself in the turn lane and you don't want to be there?

All- yes

4- I keep on going until I find a place where I can turn around

5- "Thank you" that bothers me when someone wants to turn left at the light and they just stop because they are not in the lane they want to be in.

4- Well a lot of drivers are not friendly.

F- So let's say now that we are on university drive going towards 6, do the same issues happen in terms of turn lanes?

2- I think so you can still be in the wrong lane.

9- as far as turn lanes yeah when you are at university and the bypass it turns on to the feeder road but you are not aware that you have to be in that lane and the traffic will back up way far past the stop light to turn right.

7- I think some people think they can just get ahead of everyone else by going up there and hope someone will let them in.

F- So what safety problems do you see, because people are confused about what lane to be in?

4- As an older driver I think that those signs that are on the curb with two arrows going straight need to be larger and raised up higher because you have so many trucks that you can't see around.

F- What about you Carla what safety problems do you see?

8- newer people in the area, people need to post the signs as if they have never been there before, they need to be back farther so that someone new to the area can make a decision before they get the intersection.

6-In Houston on 6-10 the marks on the lanes of traffic is the best thing I have seen yet.

F- In your travels have you seen something that is good?

5 -that is something I liked like on 6-10 I like the symbols of the highway coming up that were painted on the pavement

10- A lot of times when they have those big signs with the arrows pointing down, it’s kind of hard to tell where they are pointing.

F- Can we do the same kind of thing on a frontage road? (2lane slide) on a simple frontage road coming up do you think there will be a stoplight or a stop sign?

9- If it’s rural enough there will probably be a stop sign.

7- There is no way to tell, there is nothing to tell you what it’s going to be.

1- Well you don’t see any big buildings like you are in downtown or something.

6- You are coming to a city limits with the lights out there

F- So would you expect there to be some type of off ramp off the highway between here and that intersection?

Many say yes

7- There is an on ramp so the off ramp could not be too close.

F- So lets assume that there is not an off ramp, if you were going to go up to that intersection right there and you wanted to turn left which lane would you be in?

All- A

6- a lot of them are making left merge into right if there is an exit ramp

1- Sometimes

7- If there is no right intersection

F- So do you think it depends on how busy the area is?

10- If it’s like a three lane road then yeah

F- What if you wanted to turn right at the intersection?

All say “B”

F- How many lanes do you think are at the intersection? Do you think they will add a lane or will it widen out?

6- I’d say possibly 3 because you have an exit down there

10- There might be a third lane that goes right in front of the stop sign

9- If it’s more rural, I would say you would have those two lanes and that’s it.

F- If you wanted to go straight through that intersection what lane you be in?

All- A or B

F- So, back at the intersection if a lane was added, is it more common for a left lane to be added or a right lane?

5 people say “right”

F- How would you know?

10- If the majority of the people are going straight, the right lane has to wait. So if there is an extra lane they can go ahead and jump ahead

F- Is there anything that would tell you if it was possible to make a “u turn”?

Many say no

F- Is there a chance that one of these two lanes would become a turn only lane?

7- Yes

6- There could be a “U Turn” under the underpass

F- We have talked about the entire thing it could be coming up; do you want to know what is coming up?

All- Yes

F- Then is this too far away to tell you that?

7- I don’t think so if it’s rural where there is not a lot of traffic then you don’t need to know this early, but if it’s heavily traveled you need to know early enough to get one way or the other and not have to do it at the last min.

5- The land on the right is not developed, there does not appear to be a neighborhood or anything on the right where we would be looking for oncoming traffic so I don’t need a sign.

F- So if we all assume that this is the typical two lane street that pulls up to a stop sign do we really need a sign?

10, 9- No

F- So when I asked you said you all expected this (she draws two lanes, “A” goes left and straight, “B” goes straight and right)

All- Yes

F- So do I need a sign?

All- No

F- Now I’m going to show you a busier road that’s three lanes and around the corner is an intersection. At that intersection there are five lanes, draw on your paper what you expect.

F - How many think that the far left lane is a u turn lane?

5- I think it could be.

F - So is it a u turn only or is it a u turn and left?

F - Now you draw me what a traffic sign should look like to tell me what the lanes are labeled as. Tell me where you would like the signs, like on either side on the ground or up above.

F - Everyone thinks the middle lane “B” goes straight.

F - What confusion do you think a driver might have as they approach this intersection?

6- You have to make the center lane straight ahead.

All agree

5- But this road is curvy so you can’t really predict where the lanes are going to go.

2- I think at this point you have no idea what’s going to show up.

3- Hang the signs overhead

F- If I was going to put a sign up here while it is still three lanes but its about to be five lanes, would that be ok?

7- Yes

8- I think there needs to be pavement markings.

6- Agrees

7- The pavement markings alone won’t tell you, you need a sign on the side too

F- (Slide with 5 arrow signs)

F- What confusion might this cause?

6- The 2nd lane from the left, someone is going to want to go straight ahead when the person in the center is going to want to turn and there might be an accident.

9- Maybe at the top of the sign put five lanes ahead, and in the left lane put a sign that says “left turns only from this lane”

10- I would think that would be some kind of issue with a curve in the middle of the road

8- The only problem with that is, I just taught four people how to drive and going into a curve and being given all of that information is hard for them.

F- I’m just curious, how many people on their drawings put signs on both sides of the road?

F- Do you think they should be?

Some say yes

2- Now that I see it on there, I don’t think it’s necessary.

7- what if you are in the right lane and there is a truck between you and the sign, there are a lot of high profile vehicles there all you have to do is get next to a big SUV of some sort and you can’t see a sign on the other side of the road.

4- How many lanes are on the cross street? (Confused by 3 arrows to the left)

F- Do you think we need the word “only”?

All- Yes

F- (split sign left and right)

10- I think that is a bad idea

7- That’s very confusing

No one likes this idea

5- I drive with a navigator so I’m looking at the signs on the left when I need to see the signs on the right, so I’m always looking at two different things.

F- I want to talk about being on a cross street, a busy road, if you were back a ways would you assume the street was going to go over or under the highway?

All- Under

F- What factors affect that?

7- Where they decided to add roads after the freeway was built.

F do you think it matters whether you go under or under?

All- no

F- Do you have a better sense of what's going on if you are going over or under?

9- The under does gives you more line of sight,

F- Does anyone have problems at Briarcrest and University in terms of being able to see the lanes,

Because it goes over

Many say No

5- Yes, because if you want to turn left you have to know to be in the far left lane because of high traffic. I do like how if I was going straight on Briarcrest and University, I just stay in the center lane and go.

7- the difference in the two is that University has 2 straight lanes and the turn lane goes off of the straight lane, whereas Briarcrest has a turn lane and a straight lane but that still does not stop people who want to turn that are in the straight lane go ahead and turn anyways.

S- do you think that when it is arched like that is it harder to see the directions of the lanes?

7- it is on University because you don't know that the turn lane is two separate lanes, but Briarcrest has the turn lane that starts at the light, so that is easier.

F- So do you think that that poses problems?

10- I think it is a lot of problems when they don't know what they want to do

7- The confusing part on Harvey is that the 2 lanes turn left and only 1 goes straight

F- so what could we do there in terms of markings and signs to prevent the confusion?

7- I could for the pavement markings

5- I think you could hang a sign on the bridge

3- On the bridge it is too late.

Others agree

5- Thinks you could hang a sign on the bypass

F -No traffic light on frontage road, it's a stop sign, this is a freeway, and this is a very big frontage road, and this is the cross street way up overhead. How do you know which way is which, if you go up that ramp how do you know what is going to happen?

1,2- I think there will be a stop sign where you will either go right, left or stay straight and get back on.

Half of the people agree

9- Like in the Woodlands, it just merges right with the traffic going straight.

S- So where do you go if you want to go left?

3, 5, 9- Go underneath the bridge and circle back up

8- Maybe too late

F- What kind of signs help here?

1- Put up a sign that says “Exit to Oak Street”

5-“West go straight”

9- Put the sign that says exit Oak Street, but if you can only go one way put some kind of cardinal direction like “East Oak Street”.

3- Likes to see signs side by side telling him that one way is east and if he goes a little bit farther down the road there will be a road going west.

F - (Diamond slide)

F (half clover slide)

F - What is the most common, what do people expect?

10- Clover, prevents people from stopping, it keeps the flow of traffic going.

8-it depends on the traffic.

6- Clover is the more modern way

F- So, now let’s say we are on the cross street and we are going west but we want to go north, how do we get there?

7- Take that second turn?

10-there is another one like this in the Woodlands

1- You are going head east then turn left and go up, then go all the way down and get on the ramp.

That’s very confusing.

F- Street view, I want to make a left, how do I know if it’s a left turn to go north or is it a loop and a right turns to go north?

8, 1- You don’t know.

F - What's more common, what is your expectation?

8- When it looks this old, you should go left.

Others agree

3- It would be 50-50 for me, I wouldn't know I can think of just as many that go right as go left.

3- I would expect different things depending on the town I was in, like if I'm in a rural town it's going to turn left more than likely.

F- (Aerial, two cross streets)

F- Now to go north I have to turn right, what can I tell you here so that you know that?

8- Sign that say, north 290 exit right, now.

9- Or a pavement marking, US 90 North this lane.

7- Right lane only.

F - Let's assume that there is a traffic signal up there and there is no on/ off ramp between here and there. People are confused because they don't know what street is coming up. So when you are approaching, how do you know what street is coming up?

8- GPS

F- Is this something you would like to know this far back? Would it help you?

All- Yes

9- Yes, well before the intersection, that is always too late.

F -(warning sign slide) have you seen a sign like this?

Yes, it's for a cross street, it's got the name of the street and I like that

F- Have you seen that sign in other applications?

4- On state Highways and Farm to Market roads

F- Does that matter to people; do you think we should not use it in a situation like this?

7- I like the one that tells you there is the intersection up ahead and tells you whether it is a four way stop or if cross traffic does not stop.

F- Have you seen the yellow sign with a traffic light on it?

Many say yes

F- Many of you have said that you like the rout markers on the highway; do you think we could paint the name of a street on the road?

Many say Confusing

If you put the name of the street coming up on the road, people might think that that is the name of the street that they are on.

Many agree. And say it is not a good idea for a cross street.

F- “Gessner Slide” here is another place that we might put the name of the cross street.

7- Yes, it needs to be there but you need to know before you get there.

5- I also would like the street numbers on there

F- What are your thoughts of overhead signs versus ones on the side of the roads?

1- Definitely overhead

Others agree

8- You can see it further back.

5- There are so many signs and other stuff on the sides of the road, from the price of gasoline to the price of puppies, but I expect that when I look up at the signal lights I will find driving instructions

F- (Lomas slide)

1- This is confusing because the street names don’t match

F- Maybe we could hang some signs off of the bridge, and what happens after.

8- I learned that the green signs are what you are actually at, and the white signs are what are coming up.

F- Do you like the idea of turn arrows, even without the street names?

10- Nods yes

7- I don’t think at the intersection they would be of much use you have several lanes and when you get up there and see which is supposed to be the right lane and which is supposed to be the left, it is already too late especially if there is a lot of traffic.

9- Agrees

5- If I’m new to the area and I know I need to make a right under the freeway, then when I get off I will get all the way to the far right lane.

9- That sign could say “ahead” or “next intersection” I’m not sure if that would be too cluttered but I think it would help.

F- Now we might put bigger signs (SA Slide)

9- I like it

7- Now that makes a lot of sense to me, I know exactly where I am going and which lane.

F- In what way might people get confused by this?

1-Well obviously the middle lane will go straight but will eventually branch three different ways.

F- This says 20 mph on the yellow sign. Do you like that?

Several like this

F- Is it clear that if you are in the right lane you must turn right?

All say yes

F- Do you think that this is working because of the pavement markings or the combination of them with the signs?

All- Say it is the combination of the two.

F- With the pavement markings, how do you interpret the word “only”?

All understand

8- The only thing I don’t like about this is that you already have the solid white lines before the pavement markings so if you need to be in or get out of that lane you have to break the law. I think you need to see the markings earlier or you need to not have the solid white lines there.

F-So if I have the pavement markings do I still need a sign?

7-i think that the pavement only reinforces what the sign says.

9- Agrees and so do others.

8- If you are new to the area you don’t know if that is the street or if you have any other options later.

F- Right after the intersection, something is going to happen. So this is a “U turn” lane, there is only two lanes because there is a ramp coming in and that lane will end shortly after the light. Do I need to tell you now?

7- Well the sign you see on the freeway signaling those people to get off gives you a hint, but I still think you need something.

8- Well I think common sense would tell you that if you want to go straight, that you should not be in the left lane.

7- If there is nothing there to tell you that there is a left turn then people will assume that you can go straight.

7- They should have left turn only in that lane if you have to decide that quickly.

9- Agrees, so do others.

9- I think you should extend that curb out and make it a left turn only lane.

F-I don't have a slide to show this but, like at Texas and University the right lane becomes its own lane, do I need to tell you that I'm adding this fourth lane after the intersection?

8- The only reason you would need to know this is if you need to get over to turn on campus and need to get in their lane.

F - So I'm going south on Texas and there are three lanes, but this lane just came off to make four. So back here do I need to tell you there is an added turn lane?

Several say no

F -one more important thing, if I'm going to put a sign there should it be one to let you know im going to add a lane or take on away?

All say they want to know if a lane is going to be taken away.

F- (Cross Street W/ Signal) would you make a left turn or a right turn?

Left- 8, 5 all agree

5- There is going to be a signal up there for a left turn.

3- I think it's different here, I would assume that you would turn left there is not a big chance that you would go right.

6- If there is a traffic light on this side of the feeder road, I would expect that there would be one on the other side.

F- What do you think about the green bridge signs?

Many say that they are too small

8- I think they are helpful.

9- The LED lights that they have now would be more helpful than the signs because it is hard to see those at night.

8- Too expensive.

4- They are hard to see at night unless they are lit up

8- That's the normal set up, so I'm not sure if those are that necessary.

7-if it is a heavy traffic area then you will need to know before that point where you need to turn, I think it need to be before the intersection.

F - Do you think people will get confused at this light?

No

F- So if I took this set of signs and moved them back, would people get confused?

Many say yes.

9- That's so unusual, that when you see those signs that's where you expect to turn.

8- If you are not familiar with whether it is a one way frontage road or a two way frontage road, you wouldn't know.

F- Other than the signs do you like the color?

5- Yes

8- It is easy to read because it is consistent with the other signs you see in the state of Texas.

F-(white arrow signs) now that you see white do you have a preference?

4- That's good

8- I still think that white means that it is coming on ahead and green is more immediate.

9- As far as being able to see, the contrast is good with black on white. Whereas green on white is not that good of a contrast.

What's confusing to me is that the signs don't line up with the lanes. Many agree.

F- Do you think we could have left some of those out?

3- I think you could have left the center one out.

8- Could they do two left lanes?

F- (Albuquerque sign) what's that telling us?

8- It is in conjunction with the second sign.

F- Do you think you need the second sign?

9- Yes

3- If you were making a left turn, you wouldn’t see the first sign.

Many agree.

F - (Goes back to SA slide) do you see any place here where if you wanted to go south on 35, turn left? Is that good or bad?

1- If you are from Texas, most know that that’s interstate 35 going through there, if you are visiting that can be very confusing.

F- So do you think it is ok if we split the position of those two signs? Like one is on the ground and one is overhead?

9- Its okay until the ground sign is blocked by another vehicle.

8- it’s too confusing, especially if you are not familiar with the area.

7- You definitely need something high up,

5- I like how this sign is exactly the same as the one behind it, it does not reword it to make it confusing it is the exact same

SAN ANTONIO TRANSCRIPT

F- When we drive we all make assumptions about what to expect. We are going to talk to day about driving on major streets, cross streets and frontage roads. Busy roads that might have special turn lanes. Have you ever driven on a frontage road and as you approached an intersection, suddenly realized that you were in the wrong lane?

All- Yes

9- Nods—yeah I was going until I saw the arrow and moved over.

F--Do you think that it happens more common where you are in a lane and you want to go straight and suddenly you are in a turn lane? So what do you do when that happens?

10- I try to get on the road going straight, I'll put on my blinker and try to get over.

7- Yeah, I do the same thing I put on my blinker and try to get over. I'll stick my vehicle out a little bit and see if anyone is nice enough to let me in.

2- The problem is there are not many nice people, you have to cut in or else you won't get where you need to go.

5- Unless you have a big truck like mine, you can just make your way in there.

F- On cross streets, just on major streets like when you are approaching at a big intersection do you ever find yourself in the wrong lane? What kind of things do you look for on the road to help you figure out which lane to be in?

5- I look for the signs before you get to the actual intersection.

F –So, how do you know at the last minute?

2- Because, I look for the street names.

9- Looks for arrows. I used to be in construction so I'm used to going straight like in both lanes and now they put the middle lane goes straight and the right lane goes right.

F- What are some of the safety problems you see?

10- Not good

3- Accidents, if it's not marked and you need to turn an accident could happen; you sometimes just have to improvise.

7- Sometimes when I go down 4-010 and that traffic is stacked up and you can't see, I kind of watch and see where other cars are going.

Others Agree

F- So can anyone think of any particular sign that they might have seen that you think that is really helpful?

10- I think the ones that are on the express way now that has the little arrows, I think that is helpful because I can see that that lane is closed so I can start hopping over.

7- I think that that little turnaround signs where you can just turn around and get on the other sides

F- do you think those signs are in the right place

7 -It's usually a loud yellow sign with a turnaround, it's usually on the left hand side.

F- Is that pretty common here in San Antonio to have those turnaround signs?

All say yes

F- this is a simple two lane frontage road lets say down here is an intersection, if this is all you see what would be your expectations, do you think there would be a traffic light down there or a stop sign?

5- For an intersection, I would expect a stop light.

1-I would look for a slow down sign

F- How many think there would be a stop light?

All- Agree that there would be a stoplight.

F -So what kind of things in this environment will help you know what to expect?

2- A sign or something that says intersection.

F- Does it matter that there are trees there? Do you think that there is a stop light vs. a stop sign, does it depend on what else is around there?

10- It looks deserted; if it's more commercial there is more traffic.

5- If there is more traffic there is more business

6 There should be a sign.

F-so you think that when there is trees and little traffic that there is more likely to be a stop sign?

Most- Agree

F- Would you expect there to be a freeway off ramp between here and the corner?

9- Maybe

3- Yeah I would

F- So what do you think is going to happen in lanes A & B if there is a freeway off ramp?

10 I think that the traffic coming off of the highway will go into the “A” lane.

F- So if you wanted to take a left turn at the corner up there what lane would you get into?

All but 3 say “A”

3- Sometimes when you are driving on streets like that in rural areas it will trick you and it will shut off, you will think you are going that way and that lane will end and the only thing you can do is get on the freeway.

F- If you wanted to know what was going on at the corner do you think this is too far for putting a slow down sign?

--- Sure there needs to be a warning

F- If you wanted to go straight through the intersection, what lane do you think you would have to be in?

9- “B” Because the freeway comes into “A” and in lane “B” you would have more options.

7- if I was going to make a left hand turn I would be in “A” if I was going to get on the express way I would be to the left, because I know that the road that was most likely to get on would probably be to the left.

F- (Draws on board) example with no ramp. Up ahead there is an example with a cross street. What lane do you need to be in to go straight?

4- It does not matter

3-10- all agree

F- What about turning right?

All- “B”

F- Do you think that one of these lanes could become a turn only lane? Would that be unusual?

“A” could be

F- Is that something you would like to know this far back?

10- It would be helpful

4- Don’t they have signs on the right hand side that tell you that already before you come to a cross street?

F- How soon do you need to know this?

2- The earlier the better

8 Agrees, so that you don't have to make a last minute decision.

7- At least about a hundred feet.

F- If this is what you expect or is the average do I need a sign at all?

All- Yes

F- Why?

7- To make sure I don't run over anybody

8- To avoid going the wrong way

9- To get ready

F-(slide with 3 lanes and a freeway up ahead, coming around the curve) how many lanes do you think would be at the corner?

10-3

2- Maybe 4 with a turnaround.

Most agree there will be a turnaround

F- What other types of lanes might be added at that intersection?

5- A right only lane

F- Do you think that the right only is more common than the left only?

5- No

F- Drawing Task

F- What kind of confusion might happen at a place like this? Especially where you can't see?

7- You won't know which way to go until you get around the corner.

F- What if you stay in lane "B" do you think you will still end up in the middle lane and be able to go straight?

7- I think so

F- If you wanted to go straight through the traffic light and stay on the access road, which lane do you think you would have to be in?

Most say "B" or "C"

F- What if you wanted to turn right?

All say “C”

F- What about if you wanted to turn left?

All- say,”A”

F- Based on your experience do you want to know now that there is a turnaround lane available to you? Does that change your position at all?

Many nod “yes”

F- Does it ever happen where the left lane is to where you have to turn around?

2- Not at this distance you would have to turn left

F- What kind of information could we put here to inform you that we will be adding lanes? Or do you need to know that there will be extra lanes up ahead?

Many say “yes”

F- Drawing Task

F- Did anyone just put paint on the road?

3 did

2- I just drew a sign that said “more lanes ahead”

5 I put one that said “turn around”

7 I put one that said “turnaround” and “left lane turn”

10- 5 lanes

4 &6 – 5 Lane arrows

F- Has a slide with 5 arrows

8- Drew signs on both sides of the road.

F- Do you think there needs to be signs on both sides of the road?

10- I think it would be helpful but confusing

F- Why do you think it would be confusing?

2- Because it is hard to read two sides at once

8- You would just get distracted

5- We are used to just having one sign on the right side of the road

F- Are there any down sides to having only one sign?

8- You could miss reading it because you are driving too fast.

2- You could have it painted on the road too

10- You could stagger signs

7- That's not a bad idea because if you got two signs and you are going to the right, you can ignore the sign on the left, and if you are going to the left you could just ignore the one on the right.

F- Has it ever happened to you where you are trying to find the sign? Do you think it's confusing to have a sign with five lanes when we only have three?

2- A little confusing, it's just too busy

Others shake head no

F- How far back should we tell you this?

3- If it's a busy city, during rush hour it would be nice to know further back

F- (Another split sign slide, with left info on left and right info on right)

All shake head no

4- That would be confusing

All agree and say it is confusing because with a sign on each side with three lanes make it look like you have six lanes

F- Do you think an idea of putting a left sign for the left movement sound good?

5- Yes

F- Do you like the text signs only, better than the arrow?

4- I think they are simpler

2- it's easier to read the arrow

Others agree

3- Can we have signs that have both arrows and text?

7- I like the words better "turnaround"

F- So, this “U” turn symbol is new to most of you?

Most say “yes” they have seen them before

F- When any of you drew your signs, did you write the word “only”? Do you think you need the word?

5- Just the arrow, several agree

F- Do you think that would make the sign less busy?

2- I think it’s ok, just does not need two signs.

F- (Slide 9) in lane “A”, would you take the turnaround or go straight?

7- If I saw that sign I would think I could turn around or make a left turn, and the same with the lane next to it.

F- if you wanted to go straight what lane do you think you would be in?

4&9- B & C

F- if you were in “C”, and wanted to turn right, would you stay in lane “C”?

Some- Yes

F- Look at the sign, who thinks “C”, will become a right turn only?

F- If you were in “C” and you wanted to go straight would you stay in “C”?

Many say yes they would stay in “C”

1- I’d move over to “B”

7&9- Agree

F- Do you think that this sign is making you more confused?

7- I think that if you had a pretty good idea of where you wanted to go, then you would go to either side. If you wanted to make a left or turn around then you would get in the left lane, if you wanted to make a right you would get in the right lane, and if you wanted to go straight you would stay in the middle.

10- Its logical if “A” is left, “B” is straight, and “C” is right.

F- So, do does there still need to be a sign that says you can go straight in “B”?

8- I think you still need a sign, --- others agree

F- Now on a cross street approaching the same intersection, do you expect the cross street to go over the freeway or under it?

Most say over

F- Does it matter? Do you think going over or under makes it harder or easier to understand the turn lanes?

7- Thinks it would be easier, some have an upper level lane going the same on the freeway, just on an upper level.

10- The upper level is less congested where as going under the freeway is more bunched up

F- What do you think determines whether the road goes over or under the highway?

9- Accidents, safety, amount of traffic

F- When you are on a cross street of either kind, do you always think that there is going to be a traffic light at an intersection frontage road?

2- It depends on the amount of traffic

F -What clues, when you are on the cross street, do you look for when you are approaching an intersection?

Many say “signs”

F- Is it different on a cross street than when you are on a frontage road?

3- Actually, do they even have signs? Some streets don’t.

F- Did anyone draw their signs overhead?

Most say no

F- (Frontage road slide with a cross street) if you wanted to go left where do you think you would have to turn?

3- The right lane

4- Turn around, others agree

8- Think that there is a ramp under the bridge

F- If you weren’t sure and you wanted to go left, what would you do?

7- I’d go all the way down the access road.

1, 10, 9- would go up ramp and stop at top

F- What kind of sign here would help you about what’s up on that bridge?

4- East or west with arrows

Others agree

4- Have a word/ street sign

10 word sign

F- Slide aerial diamond

7, 6- have concern for backup

F- (Slide with half clover, aerial)

F- Any ideas?

7- Put “oak Street” exit

Many agree

F (aerial for cross street) how do I get to north?

Group is talking it out

2- You are going to need a lot of signs

F- (Street view shot) what do I need to tell you to let you know you need to turn left?

10- Maybe a highway number sign with an arrow--- others agree

1-An intersection sign

8- Should all get GPS in cars

F- so sometimes when you are approaching a freeway on a cross street, have you ever had it happen to you where you were not really sure if it was a left turn or a right turn?

F- (Aerial cloverleaf)

All- take a right and loop

4- Keeps traffic going

F- (Street view) how do I tell you it’s a right turn? Is this a good place to tell you it is left or right?

Everyone nods

9- Paint an arrow on the ground whether it’s left or right

F- Is that more common to turn left or right?

Most say left

F- Do I need to tell you or only when it is an uncommon one?

Most say both

BREAK

F- Some of you mentioned earlier that knowing the name of the street helps you know when to turn, so thinking about frontage roads, and access roads, how would you know what street it is?

9- Should be a sign with a name, like 50 feet away

4- Usually on the right hand side

F- Do you think it should be before you get to the corner?

4 yeah

5- It should but not all streets have them that way

F- (Signal slide) what is this sign telling you?

All- signal light

F- Have you ever seen a sign like this before? Is it too much to put both together

No

F- (slide with Cross) better or worse?

7- No I think its worse

10 it's not telling you what's ahead whether it's a turn signal or a stop light.

F- Do you think if you saw this cross street sign like this do you think you would assume that there is not a stop sign

All yes

F- Do you think you could paint the street name on the road?

9- No a sign is better

Sometimes you are driving too fast to see it

If there was a traffic jam you could not see it

F- Would you think someone might misunderstand it and think that they are on "1st" street?

4- Yes, I would think I was on that street, not that it was the one coming up

F- Why does the paint on the road work on the highway and not here?

9- It shows you where you are going,

F- Sometimes they don't put the street name ahead, they put it on the corner(Gessner Slide)

2- I guess because you are going to be looking at the light anyways so you will see the street

4- If you have another one before saying that that street is coming up, the one at the street can just be the one to confirm it. Wants to know ahead of time.

5-Wants to know ahead of time because sometimes you are looking for these roads and you can't see them till you are there?

F- So if I informed you ahead of time where the street is would you need to know at the street also, if you are paying?

- Don't need two.

8- You don't need too many, just enough to let you know where you are and where you are going.

3- It sure helped me in Houston to have two signs to look at.

F- What about the block numbers, do people use those?

9- Oh yeah they are helpful--- others agree

F- (Lomas slide) we could try and put the turn signs on the light, is that a good place to put arrow signs or better on ground?

8- They are easier to see up top.

F- Would you rather see these signs further back, is this too late to tell you?

7&6- Like the signs on the ground.

F- (San Antonio Sign)

3- (Is familiar with the sign) If I was not from here it would be very helpful

F- These signs are overhead is this necessary?

7- A sign that big with that much information would have to be overhead

F- How could I put it on the ground?

7- That's a lot of information, put a sign with east commerce on the right, going west you would put one on the left, and I don't know what you would do about the middle.

4- No way

F- The yellow panels say 20 mph. is that a good thing to put on those signs.

10- Sure

F- Can you think of anywhere else do you see on a highway where you see a green sign with yellow?

9 exit ramp

F- Should it say exit only? Like on the sign? Pavement markings are saying exit only, is that something you would like to be on the sign? So the arrow is good?

All- yes

F- So let's talk about pavement markings, what does it mean if you see the word "only" and an arrow?

All --- only can go that way

F- Could I turn right from the center lane?

All—no

F- So do I need the signs if I have pavement markings or vice versa?

3- It helps

10- If you were only going to have one it would be to keep the signs on top—others agree

F- (slides of dropped lane on other side of intersection) I'm at the stoplight, they are going to end the left lane, and I want to go straight, do I need to know that the lane up ahead is going to end?

All- say yes

10- You can put a "lane merges" sign before the light

F- Then would people think that the lane merges before the light? Do you think that you should be allowed to go straight?

All- no

F- What do you think about the overhead signs?

7- Too small and too high

10 I like the size but maybe if they were on the light pole.

F- What about the color?

9- I think they should be yellow and black.

F- Who likes Green?

Everyone likes the Green

F- Do you think they need the word only?

No

F- Do those arrows tell me about whats at the stop light or what's coming up?

All- what's coming up

1-Some people are talking and miss the signs.

F- If I wanted go south on 35 where do I go

All –left lane from the arrow

F- Is this a good place for this sign?

10- Put it on the light pole

3- If you put it on the light pole you would have to change the arrows because people would turn at the light

8- People should know not to turn left on the light because of other cars

7- I'm sure there is a one way street there

8- Maybe have it at the next light

F -in general do you like the idea of them being up high, do you like that better than the black and white signs on the side of the roads?

7- I don't like the signs up there the only people that look up there are truck drivers

5- I think it's good because if you are stuck in traffic and it's bumper to bumper you can look up there and know which lane to be in.

HOUSTON TRANSCRIPT

F- We always make assumptions when we drive, have you ever driven on a frontage road parallel to a major freeway, and not been sure about which lane to be in?

All- Yes

2- Tonight, some lanes curve around and go underneath only, some are left turn only, some are straight ahead and left turn, and some are straight ahead only. It gets confusing especially at night if you can't see the clear direction as to which lane you need to be in.

7- I have seen the intersections that he is talking about and found myself in the wrong lane because I wanted to make a left turn, and when I got closer up it did not indicate back where I was that I needed to move over. So I ended up having to make a u turn and not going to the intersection.

F- How about on cross streets? Does the same type of thing happen when you are coming up on cross streets?

10- Yes

4- The problem I have is not knowing the street I'm supposed to be at. I have noticed that a lot of streets don't even have the signs on the freeway portions, not even at the light.

8- Agrees

9- I like the street signs

10- yes

9- It would be nice if there was a "North/ South" reference sign occasionally too.

5- yes, it was confusing for me I was so happy when they started hanging the street signs up there.

F- Can anyone remember some kind of sign or something that was really helpful?

4- I like how they have painted on the freeway like I-10.

2- One thing they have done around the Galleria is they have put up signs that tell you what street you are on and what street are around you.

9-One thing I have found confusing is the signs that have the street name, and under it they have the name of the street coming up with an arrow in that direction. It makes me think I'm about to turn on the street that is farther down the road.

10- I grew up in a rural area, and they were constantly telling you what was coming up all the time, I think they do an ok job on the freeways here but sometimes I feel like it's just "right there" and I don't have enough warning.

F- What kind of safety problems do you think this kind of confusion result s in?

3- I have missed my exit like a million times.

2- People veering when they suddenly discover that they are in the wrong lane, veering and not looking especially if they are on a cell phone.

7- Or they are stopped because they want to be in that lane and can't get over.

4- I have been driving for 45 years and had my first accident this year and it was from someone trying to veer out of the middle lane because they realized they were in the wrong lane, and when they pulled out in front of me I hit the trailer next to me. I don't like that on main intersections they have turn lanes going into places like grocery stores that are right in the middle of the heavy intersection before you get to the light, so you have people stalling traffic because they are trying to turn left to go into a grocery store.

F-(slide 1- two lane frontage road) let's pretend there is an intersection down there someplace, if you wanted to go straight at that intersection, which lane would you be in?

7- "B" others agree, left is usually "left turn only" so I would get in that lane just to be sure.

6- Eventually the frontage road would lead you to get on the freeway, so I would think "A" would put you back on the freeway.

F- So if you wanted to go straight at the next intersection, how many of you would pick "B"?

All but 2&9 say "B"

2- I'm usually in a rush and the left lane is a little bit quicker.

3- But sometimes people are exiting the freeway and you have to veer over to get out of their way.

9- I usually look at the lines; they are suggestions to get over.

F- How many people think that there might be a freeway exit coming up?

Many think so

F- Given the surrounding do you think there will be a stop light coming up or a stop sign?

Multiple say stop sign, but few are agreeing.

8- Thinks it is a stop sign because the freeway is not very congested.

6- Thinks it is a stop sign because "it just looks like it is in the country to me."

F- If you wanted to turn right at the corner, what lane would you be in?

All say "B"

F- Is there anything here that tells you that there might be a “U turn” lane?

All say no

F- Is there a chance that one of these lanes might turn into a turn only lane?

7- On this particular road probably not because it looks rural and not much traffic.

F- (3 lane pic going to 5 lanes) sketch

F- What confusion would people have as they approached this intersection?

4- There would be confusion about which lane to get in, I always get in the middle lane

4-5 others agree

F- Where do you think that the lanes will be added?

4- I think there will be a right turn only, a left turn only w/ a u turn.

F- What would you want to know at this point? Would you want to know now about the lanes coming up?

3- it would help if there was a sign at that turning point on a pole.

5- Agrees

3- It would be good there because you don’t want to make a decision too late. Just do it one time don t repeat it too much.

7- I think it needs to be further back, and given more warning because if you are driving during the day its not bad but at around 5 or 6 o’clock you might be way back there, and if you are not given enough warning you might not have enough time to get over. I think you need a couple of signs.

F- Did anybody draw their signs on both sides of the road?

A few put their overhead

5- Would put hers on the left side.

8- Put the signs on a pole on the ground.

7- It would help if it was on the pavement and overhead.

4- If you are in a small car it is sometimes hard to see the signs with the big trucks all around

F- How can we show what’s happening up ahead, because the road is coming to 5 lanes?

F- (Double sign example)

Several drew the same

4- I think that optional turn lane is dangerous.

F- Do we like this?

Many say no

9- I think it adds too much confusion, it's too busy

3- I think you just need one sign.

10- Agrees

8- Its confusing because there is five arrows and still only three lanes here, it's not warning you that there is 5 lanes.

3- Well that is the warning that it's going to be 5

8- Well you could put lane change ahead, and another 500 feet or so put this sign.

10- Well I think that it's a lot better than nothing.

Others agree.

Many think it should be higher

7- Drew something similar but put it over.

5- If you are next to a big truck and you can't see the sign on the left it may be good to have it up there.

All agree

2- I like having the two signs, one on either side of the road

10- You could stagger the signs rather than having them right up close together.

Others agree

F- Another thing we could do is split up the signs, put on a sign what's going on over on the right side and the same with the left side.

All say no

F- In general do you think that the cross street is going to go over or under the freeway?

All say under

F- Can you think of examples where the cross street goes over?

5- Pinemount

6-Barker, Cypress

F-What kind of things do you think affect that?

10- When it was built.

5- Flooding

F- Do you like one better than the other? Do you think it matters?

5- I like the over because you can see it from a distance and know what’s coming up.

10- Well the over, here is good for flooding because here it happens so fast.

F- What other clues do you use to help you know if it is a turn, what are you looking for if you are on an unfamiliar road?

8- I try to look and see if there are lights at the intersection.

4-if it’s a two lane you know that right is right, and left is left and there is usually a turn lane under the freeway

1- I look for the arrows on the stop lights

5- Look ahead at the other cars.

F- Now we are going to talk about other types of frontage roads (Slide with cross street)

F- If you want to go in the left direction on a cross street, what direction do you need to go?

8- in this picture it looks like you need to go to the next intersection and take a left, find somewhere to u turn and come back.

3- I think that you would take that right here and curve around.

1- There are usually two options, you go on that lane and then you go up to that cross street and you can continue to go towards the right, or you can go beyond the bridge and there is an entrance over the bridge so that you can get on the overpass.

10- I know that when I get off at Studemont, and I’m trying to get on Heights, I have to keep going, you are not always able to do that.

F- If you weren’t sure what kind this was, what strategy would you use?

4- I would straddle that right lane and start going slower.

10- You have to watch that traffic because they are exiting quickly

3- Well there is one like that in Humble where you can turn, and there is a light there where you can make a left turn

4- I think we need to have a sign there that lets you know which way is east and which is west.

F- (Diamond example) is this pretty common?

10- Yes

1, 2- I have seen this when you are out in more rural areas, not so much in the city.

F-(next slide) does this look more familiar to you?

All say yes

7- I prefer the other way where you can get off and you have a signal and then decide, so that you can go either way

F- so at a sign like this, if this sign says “oak street” east next right?

6- be sure to put an arrow

2- I think you should just put a circle above the freeway with a curved line

Others like

F- So, on the interstate do we need to use city names or like destination names?

No’s

4 -that signage is pretty common/ good

1-signage like that is usually on the outskirts of town, before you get to a main city.

4- Like on highway 6 or 290, it will give you city names on the way there, it gives you cities.

F- Do you think that it could be adapted to something more in a city?

8- You could use landmarks

4- I think that it would have to be in a well known area, but not for this small area.

F- (Driving on cross street) alright so I’m driving east on the cross street and I want to turn north on the highway, how do I know which way I go to turn north?

7-you would turn left.

F-(street view)

4- Need signage

F- What do you expect?

4-to turn left (others agree)

1- I would expect where that sign is, to indicate 290 east or west with an arrow.

5- Can you put it on the pavement?

F- Have you ever found yourself in places maybe not in Houston, but other parts of the state where it's not a left turn or you are not sure?

6- In San Antonio, others agree

F-(double clover slide) is it surprising that you are going to have to turn right to go north? Do I need to put a sign up if it's what you expect?

2- I would put at least one sign up indicating that you have a classic clover leaf, and that pretty much describes itself.

F- Does that tell you whether you need to turn left or right?

2- Yes

10-no not necessarily, I think you do need to mark it when it is the unexpected.

8- It depends on what side of town you are on; if you are on the older side of town you might see the clover leaf more.

F- how we know what cross street is coming up (light slide)

6- At the light it is 1st street.

2- And there will be a light.

F- Do you like having both of those pieces of information?

Many say yes

10- I love the yellow

F- Do you think that it is saying you are on first street?

Many no's

3 yes's

And one maybe

2- People might think that if you had an arrow pointing ahead.

F-(cross sign) Does anyone else think that this is not a stop light?

4- For me, I think it's a four way intersection, four way stop sign.

F- (Light slide) is there any way we could change that; do you think we do need an arrow up ahead?

3- Yeah, anything to bring more clarity to it. It does tell me that I'm eventually going to come up to an intersection, especially with the arrow.

Others like the arrow

F- Do you think it belongs at the bottom or at the top of the sign, under the street name or above it?

All say under

F- (Gessner)

1- I think it should be between the traffic lights. (Others agree)

F- Do the numbers help you?

All say yes

F-(Sign past intersection)

9- Sometimes the sign is too early, sometimes that is confusing.

7- I like it there because that tells me, if I'm looking for those two streets, that they are past Gessner (others agree)

4- I think that on the exit signs on the freeways, there is just not enough room to put everything coming up, maybe there could be a better way to let you know what street is coming up.

F- So some of you like it up high? If I put it up here, do you also want it back here on the side of the road?

2-Yes, others agree

10- If it's a major street, yeah. I don't think I'll need it for every single one.

(Others agree)

F-(Lomas Sign) do you like having this type of sign up on the signal?

All say yes, it is easier to see.

F- (San Antonio sign)

All like this type of sign

F- Did any of you think about putting a green sign?

Many say yes green is the color they thought it would be.

F- Where else do we see green signs like this?

Many say, on the freeway

F- Since this is green, would you think you are on a freeway?

Many say no

4- so you are saying most people associate the green signs with the freeway and the white signs more like with the suburban areas?

Most all say yes green is associated with the freeway.

F- What other things do you like about that display?

All say that they like the arrows, and pavement signs

1- I have never seen the speed limit on the sign; I don't think it's necessary.

2- I think it's a problem with people going too fast and exiting way too fast.

6- I think that the warning is good.

4- I also like that it says east and west.

F- (Pavement markings only) what does the word "only" mean to you?

- That is your only choice
- The lane ends
- Turn only

F- Am I allowed to turn right from the center?

Many say no

2-Not if it does not indicate it.

1- You can see up ahead that the lane ends so there is only one lane for you to turn right.

2-i would think that if you were allowed to turn right from the center, then there would be an arrow in that lane.

F- Do I need something in the center lane?

4- It does not bother me, because if I'm going straight ill stay in the center lane, if I want to turns then ill get over in the right lane.

F- So if I have the pavement markings do I need the signs too?

All say yes

6- If there is a lot of traffic then sometimes you won't see the pavement markings.

F- So if I was only going to do one thing, it should be the signs?

All say yes

1- Sometimes the markings fade and you really can't see them.

2-you can't always look down when it's raining or there is a lot of traffic, you have to look straight ahead.

F- Do you think we could paint the name of the street on the road?

Many say no

4-i think that the signs up above the street signs is too much reading.

2- Its much easier and less to read with numbers.

F- (Other side of the intersection) sometimes you are in a lane, and the lane ends. Do you think that people should be allowed to go straight here?

All say no

F- If we are going to let people go straight back here, do you think we need to be telling people back here?

4- I think you should have those little cone things so that they can't go straight. I think it will prevent accidents.

F-(cross street) let's say you are driving east and you want to go north, where do you expect that you will have to turn?

All say left

F-do I need to put signs there saying that?

8- Yes

4- If it's weird or different then you need to tell me.

Some say you need to tell me anyway

F-(arrow on bridge) what do you notice about that picture?

Some say they would not notice.

Some say that they are too high up; they would rather have them on the light.

F- Do you like that they are green?

All say yes

F- Do you think that they are necessary up high, or would you rather see them on the ground further back?

10- I would rather have them further back

6- I think they are fine right there

F- Do you still need the S35 Sign with the arrow? Is that the right place for it?

8- It needs to be on the signal.

5- I think it would be cluttered if you put it on the left.

10- I'm used to looking at the right for information.

F- When I'm stopped at this stop light right here, do you think people will think that I have to turn left?

Some say no

10- Some people might

F- What if I hung them on the traffic light?

Mixed

2- Yeah they might get really confused and turn into traffic.

1- Usually you can't turn left onto the access road because it is a one way.

10- I don't think you want room for confusion.

F- (Dallas Black on White) do you like those?

Many say yes

3- No

F- Is this something you associate more with a street or a highway?

F- So you don't think we even need the word "only"?

4- No

7- I think so (others agree) people will go down there thinking you can go either way but if you put the word “only” then it’s pretty clear that you can only turn.

1- I would think that the two “only” lanes end so you have to get in the other lanes if you want to go straight.

8-Why isn’t the only on the street?

- Now would be a good time to tell you that you are coming up on a street ex. (Left turn only on Commerce street)

F- Do I need to tell you the straight ahead part?

3- I think ill automatically know that it is straight, if there is no other signs letting me know that I need to go left or right then I assume I can only go straight.

F- Albuquerque sign.

Woah

Too much for me

Too much to process

F-is there anything you like about this sign?

3- Well it’s kind of clear, huh?

10- It gives you sufficient information, I like the arrows.

F- Let’s make it simpler, would it be better if we took off a street name?

Yes

F- Do you like that we have combined the black and white of the streets with the green?

All say yes

1- Having the combo sign is less confusing because you have it all on one sign.

F- Do you think we need to repeat it?

10- It doesn’t hurt

3- They’ve said it enough.

8- I like it

F- If you only had enough money for one, which one would you pick?

All say the one on the bridge

F- So you want it ahead of time?

All say yes

2- I might think that that sign is saying that there is something coming up ahead and I need to turn there.

AUSTIN TRANSCRIPT

F- We are going to talk about assumptions we make while driving, and how you know what lane to be in as you approach an intersection?

3- Sometimes the Frontage roads are difficult, because it is not very well marked.

5- One of the things that I find is that every intersection is different so I never really know what lane to be in.

2- it upsets me when people stop when they could keep going

7- People slow way down to get over three lanes.

- Sometimes you do have to stop and it upsets people, that's why there needs to be more lights and slower areas in the downtown area

8- In other cities, when exiting the freeway you have to yield to the people on the frontage road.

7- one other thing I had a problem with was, a lot of these businesses are so busy that you have cars darting in and out when you are trying to make a turn, it's kind of scary

9- I assume, when I'm on a frontage road that the left most lane is going to be left turn only, the next lane would be left turn or straight, the third lane from the left is going to be straight, and the right lane will be right turn only. Some signage would be great, especially consistency.

8- Agrees

F- In Round Rock, are there still any two way frontage roads?

6- Most are eliminated, but it took some getting used to which was pretty dangerous. I drive all over the state and country and have found that if there was more consistency when it comes to frontage roads, it would be much safer.

- I know in San Antonio they put up these big white poles so that people cannot come straight off and over. If you get all of these big white poles you have to stay where you are.

7- I think there must be a better way, because that is so much damage to cars, I think if they just put up a cement thing it would be damage to tires and axles not cars, that's a little safer in general.

4-Personally I think that the signage on the frontage road is good. For the most part, when you come up to an intersection there is a free u turn, two left turns, a through, and right, normally those are signed, and the problem is that they are not signed far enough in advanced.

- all agree and say typically during rush hour.

4-On the right turns lanes, I think what they should do is put up those little things in the road that pop up, it indicates that it is a free lane.

7- Sometimes those things will pop up and it scares me because I did not know that they were there, it's a little threatening to me.

6- In Houston recently they have painted the lanes,

- I like the lighting where sometimes you can turn right and sometime s you can go straight.

7- I don't like that because you don't know when it is going to change

F- so do you feel like there is a difference on a cross street, and when approaching an intersection and trying to figure out which lane to be in, do you think that's any different than coming up the frontage road?

- I think so because frontage roads tend to have businesses, but on cross streets you tend to have businesses on both sides, you have a middle turn lane and it gets pretty complex.

Many agree

F- So when you found yourself in those situations, you have said there are many safety problems, what problems do you think there are?

6- The biggest concern is having an accident, because of the traffic stacking up and the big speed differences

7- people don't want to pass up their street and have to come all the way back, and also the curbs are not curved enough if you are going on a turn then sometimes your back tire will hit the curb.

4- On the access roads, the curbs are too small.

3- that exit is terrible, in my opinion you are not going to fix down town Austin, so if you are focusing on signage, the only way to make it safe is to put a physical barrier and a sign saying if you want to turn on 15th, then turn then turn.

7- I don't think that is a good idea, I don't know how people are going to understand a sign like that.

3- Basically like a detour through town to help them get to the street they need to be on.

6- Now we have been taught in the drivers' handbook that you do not cross a shaded lane or a solid line, so if you wanted to get where you are going you could cut across that line

8- I have had so many people cross right in front of me over a solid white line when they could have gone 50 feet to where it turned into a dotted line.

F- So you think that we should have the sign past the solid white line?

Many agree

1- A lot of times you don't get enough advanced warning to know what lane you need to be in.

F-(slide of a two lane frontage road) somewhere down there, there is an intersection that you can't see. How many lanes do you expect there to be when you get to that intersection?

Many say 2 or 3

1- A quarter mile down there you could put up a lane usage sign that tells what the lanes are

7- Thinks that ¼ mile is too soon

4 people think that they do need it that early

7- Thinks it needs a street sign

Many agree

F- What kind of things helps you generate your expectations?

7- For me, when I see the woods I already want to see a deer crossing sign that freaks me out.

3- Where it is more rural I would expect there to be two lanes, where as if it were more developed I would expect there to be four lanes.

5- Because of the street lights I think I'm coming up to a major intersection.

9&7- say they would like to have more speed limit signs (many others agree)

F- So do you think that there is a chance that one of these lanes might become a dedicated turn lane?

6- it's too soon to determine what's ahead.

F- If you approached this intersection and you wanted to go straight, what lane would you get in?

8 people agree that you would stay in "B" and that "A" could possibly be a turn only lane.

6- "A" could also merge into "B" up ahead.

3- I like the idea of the paint on the road I think it's easier to read since you are paying attention to the road anyways, I think that a street name would be effective too.

F- More urban road slide--- what do you think is going to happen coming up?

1- I think you should have a street name sign there and a lane usage sign

Drawing

7- I think it is confusing when they tell you what three lanes are doing but don't tell you about the other two.

1- I think it needs to tell you what lanes are available at that intersection, I also think you need an intersection sign

F-if you were to use the pavement markings here, how would you do it with three lanes

1- Needs intersection sign?

2- Wants to know the street names.

3-you have a combination of a traditional sign with what the next intersection, and on painted sign put the street name and cardinal direction.

1- I think on the ground there I would have the "C" lane I would have a through arrow with a right turn,"B" lane is

Through, and the "A" lane would have a through with a left turn arrow

F- If "B" was going straight, would you bother painting anything?

All say yes

5- My idea was to have the street name, five lanes ahead, and an under arrow showing what all the lanes are going to do.

8- I like things up overhead.

F- Do you think that on a straight frontage road, is it important to have all of these signs?

Some people say probably not.

F- What kind of things lead you to believe that there might be a U turn

1- You can see the ramp going up, which means at the intersection there will probably be a u turn under the freeway

F- Puts up sign—all like it

1- Says a little bigger

8- Likes it a lot and would have it up high

9- Wants a street name on there.

F- Do I need it on both sides of the street?

Many say yes

F- Do you think that there is any chance if I'm here where there are only three lanes, and the sign says there is five, do you think that could get confusing?

Many suggest that there be a sign saying that there are multiple lanes ahead.

F- So if I wanted to turn left, not make a u turn, what lane would you be in?

Some say "A"

Some say "B"

7- There is no way I would be in "B" I would be too scared of being rear ended.

5- I would be in "B" because I would think that that would give me the most options.

9- If I wanted to go left I'm ok in a or b

7- I put "5 lanes ahead" and then closer, I broke it down to each side

F- (Puts up new slide) what do you think about this?

7- It is a little confusing

8- Now I have to look at two signs

2- I would think in "C" I could either go straight or turn left

F- (Cross streets) as you are approaching a cross street, do you expect the street to go over or under the freeway?

A few say over

5- In a newer neighborhood, over, in an older neighborhood, under.

9- In San Antonio, under.

What kinds of things generate your expectations?

7- How far it is away from town

F- Does it matter in terms of you making your way through the intersection weather the cross street is over or under?

Many say no

6- I think it matters to have direction

F- Is it easier to understand who is turning where if it's an over or an under?

5-yhe ones going under tend to be older which makes them much more unpredictable

F- What other things besides signs help you decide who is turning where and who is going straight?

8- I watch the traffic

5- it's easier to watch the traffic on the over ones, on the under ones there is almost always a chunk of road up there that you can't see.

F- (Frontage road) if I'm going north on the frontage road and I wanted to go left or west on the cross street, where do I need to go?

All say you need to get to the left

7- Thinks it's on the other side, like a turn around.

4- I think it needs to tell more directions

F- So if I'm going north on the highway, so where do I go?

Many say you have to go over the freeway

6- Take a left, make a u turn, and go on over there to the freeway.

9- Does not like the signs with the cardinal directions, wants street names.

F- So I'm going east bound on the cross street to go north on the highway…

> They should have a sign here saying right turn here if you are going north and another sign that says if you are going south you want to go straight.

F- So over that hill there is a stop light, so do you want to know now?

All say yes

6- Older drivers know what to anticipate, younger drivers don't have enough experience to know the different things to anticipate.

F- (cross street slides/ back to the first picture) lets talk about cross street signs, you wanted to know what's up ahead.

5&7 would put a sign that says "ahead"

5- And because this is a rural area, I would also want to know the street/ highway number.

7- The arrows are confusing because I don't know whether I should turn now or if it is coming up.

4- Likes the simplicity of it because at the stop light it says the street name.

F- Do you need both pieces of information?

All say yes

F- (Shows another slide)

7- Does not like it as well

8- That would tell me that it was a four way stop

F- What if I painted the street name on the road?

1- No

4- Not necessary in the urban areas

F- Do you think that there is a chance that people might think I'm on that street if I painted it on the road?

Some say no

9- Well not if you put the name and then put ¼ mile ahead.

3- I would put the name of the street and then put which lane to be in.

F- Someone mentioned that I put the name of the street in the four way sign

Some say maybe

6- It's different

F-(another sign)

8- I would want it in the middle; I don't want to look away from the road.

3- By the time you see it it's too late.

Several nod their heads yes

1- This sign is great but you need to have one further ahead

8- They are giving us some clues as to what is up ahead

F- Let's talk about a couple of features in this picture, its overhead, do you like this?

Several agree that they like the sign

7- I like it and the numbers.

3- It seems like the overhead signs are easier to make larger, you have a limit on how big the street level signs can be and they are hard to read especially at night.

9- What if there is a semi or a big truck next to my sedan

1, 2- agree

F-(Lomas Sign)

Several agree that they like this sign.

F- Would you still like to have a sign in advance?

Most agree that they would like to have something in advance.

5- I like that because I know that if I am in the right lane I am going onto that street.

F- Shows a sign on a frontage road.

7- Signs are immediate, you don't have enough time, when you see it it's there.

3- I think this is where the painting on the pavement would be effective a little further back so that you have the first warning and the sign is the second warning.

(2 people agree)

F- Do you like that these signs are green, or would you rather see them white?

(Most say green)

F- Do you think that since you see the green signs on the highway a lot that might make people drive faster?

8- No

7- I will

F- Where else do you see the use of yellow plaques like this, on a green sign?

Not many people have seen this

F- What about on a freeway sign have you ever seen an exit only sign?

Many say yes

F- So do you think that people might confuse that and think that those plaques mean exit only?

All say no

2- Pavement markings are very faded and hard to read.

(Many agree)

F- What does the word “only” mean when it is with the arrow?

2- If you are in this lane you must turn.

F- May I turn right from the middle lane?

Many say no

1- Would like to see straight arrow if you are not allowed to turn out of it.

3- my assumption is that in that middle lane there is no turn, its permission based meaning that if there is no marking you have to go straight.

F- So you are saying that if you want to turn right you must be in that right “only” lane?

All say yes

3- I just think that if there is no arrow you have to go straight.

8- If you put arrows going straight and certain ways, that would be good, when you give a lot of options it gets confusing.

F- Draws lanes on the board.

Most agree that if you are going to use pavement markings, then you must put them in all of the lanes.

F- Now what happens after the intersection, should you be allowed to go straight?

Most agree no.

7- it’s dangerous because of the people looping around, and I can’t see whether or not they are going to turn right

Many say that there should be a turn only lane there and even a barrier.

F- Say you were allowed to go straight here, should I be telling you now that the lane ends?

Some say yes

Others say there should be no access in that lane at all.

6- I think it is just a bad design.

3- What I might do, if you are going to allow the left lane to go straight is to maybe have a sign before the “u turn” saying “watch merge traffic”

F- Draws on the board--- what could I tell you so that you would know not to slow down and to keep going?

7- Put up a sign that tells what it is-“free flow lane”

Some say they don’t know what that is.

7- Once people start seeing them they will know

6- I think you should put some type of illustration showing that you have a lane that you can continue driving in.

1- The sign should say “no stopping” or “keep moving”

8- How about “designated lane”

7- I like that

3- I think the only fool proof way to do it is to put up a barrier.

Many agree

F- (Shows a frontage road going under the highway) What do you see here that tells you about the lanes?

4- You see above the roadway what the lane usage is.

F- How many people noticed that?

8- I didn’t, it’s too high.

Many agree and also say that they are too small

7- You could put it up by the lights.

1- You could leave it there just make it bigger.

7- Maybe a different color --1 agrees

8- White and black make more sense for this purpose.

Many agree

F- Say I wanted to go south on 35 do you think that some people think I might need to turn left here?

Many say no

9- Could there be a “one way sign” or a “do not enter”

F- Do you think that this is enough or do I need to repeat this further back?

Many say no

3- I think you could take the highway sign and put it there that it is going to be “only”

Many like this idea

7- You can repeat it on the road and at the light.

8- But if you put that sign on this light people might try to go this way

3- But if you put it on the bridge, beyond the light it might be more obvious.

F- Shows black and white signs.

8- It seems like the sign should be green because it is such a big road.

F- So we have our green sign, and now we have the black and white lane usage sign, do you like that?

8- Yes I like that because you are going onto a big expressway.

3- I think that would be very effective.

7- I still don’t know what’s going on straight.

9- Straight is just whatever street you are on

7- I need to know more

F- Do you think that they need to repeat this?

7- I think that it is redundant

5- I don’t think that it ever hurts to remind people where they are or what they are doing, particularly if people are not familiar with the area.

8- The more signs the better.

Many like two and some don’t like having that many or don’t think that it is worth the money

APPENDIX D: FOCUS GROUP CONSENT FORM

Lane AssignmentTraffic Control Devices for Frontage and Conventional Roads at Intersections

Introduction

The purpose of this form is to provide you information that may affect your decision as to whether or not to participate in this research study. If you decide to participate in this study, this form will also be used to record your consent.

You have been asked to participate in a research project studying signs and other devices that are used to direct drivers on frontage roads and conventional roads approaching a freeway intersection. The purpose of this study is to determine the types of devices needed to adequately mark these roadways. You were selected to be a possible participant because you are a licensed driver at least 18 years old, and because you expressed interest in participating in this study. This study is being funded by the Texas Department of Transportation.

What will I be asked to do?

If you agree to participate in this study, you will be asked to participate in a guided group discussion focusing on signs and markings and the information that drivers need to safely maneuver through frontage road intersections. This study will take approximately two hours.

Your participation will be audio recorded.

What are the risks involved in this study?

The risks associated in this study are minimal, and are not greater than risks ordinarily encountered in daily life.

What are the possible benefits of this study?

You will receive no direct benefit from participating in this study; however, the results of the study will be used to recommend sign formats, messages, and other devices that appear to be the most effective along these types of roads.

Do I have to participate?

No. Your participation is voluntary. You may decide not to participate or to withdraw at any time without your current or future relations with Texas A&M University or the Texas Department of Transportation being affected.

Will I be compensated?

You will receive $50 at the completion of this focus group discussion. If you decide to withdraw before the discussion is over, you will receive $20.

Who will know about my participation in this research study?

The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only the researchers conducting the study will have access to the records.

If you choose to participate in this study, you will be audio recorded. Any audio recordings will be stored securely and only the researchers conducting the study will have access to the recordings. Any recordings will be kept for two years and then erased.

Whom do I contact with questions about the research?

If you have questions regarding this study, you may contact Dr. Susan Chrysler at 979-862-3928, e-mail s-chrysler@tamu.edu.

Whom do I contact about my rights as a research participant?

This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, you can contact these offices at (979)458-4067 or irb@tamu.edu.

Signature

Please be sure you have read the above information, asked questions and received answers to your satisfaction. By signing this document, you consent to participate in this study.

______ I agree to be audio recorded as part of this study.

Signature of Participant: ______________________________________ Date: ____________

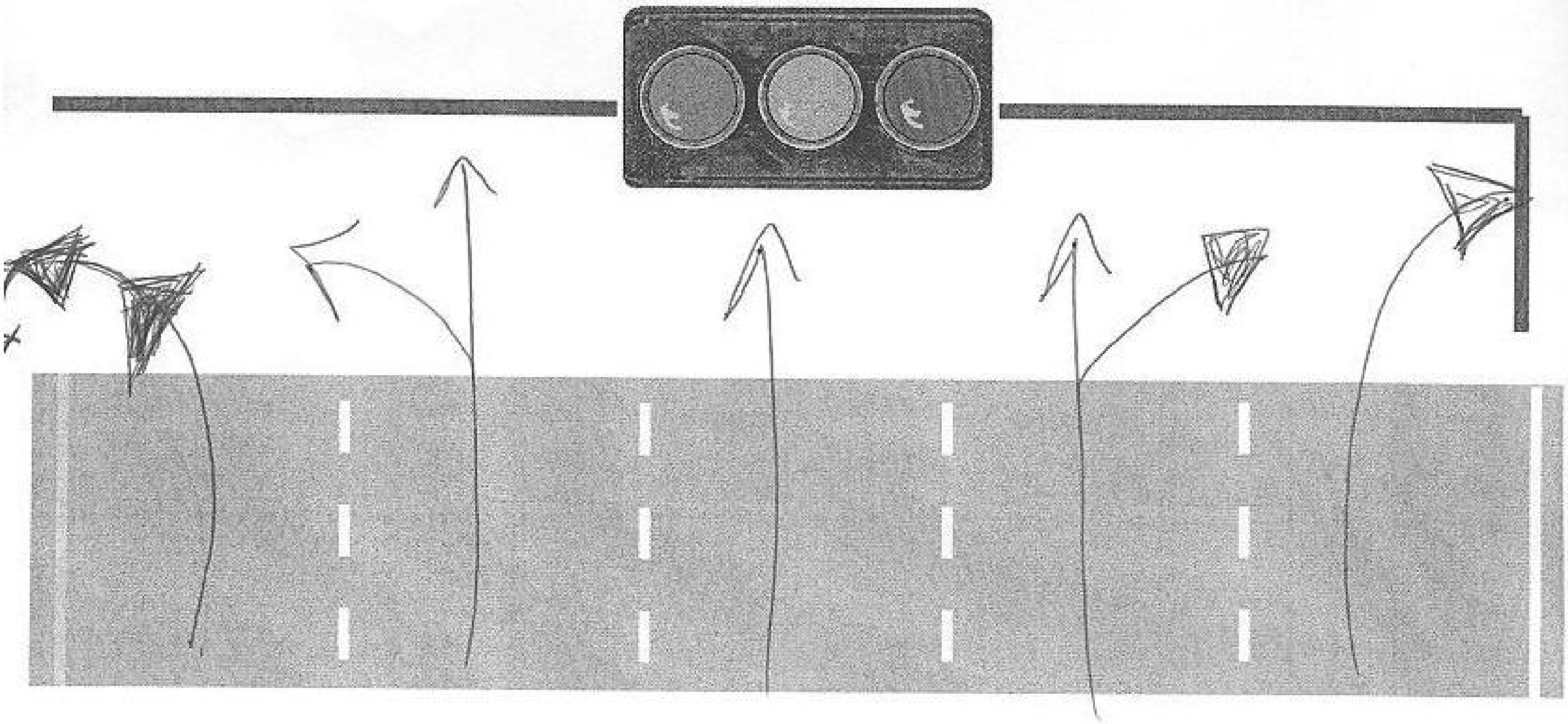
Printed Name: ____

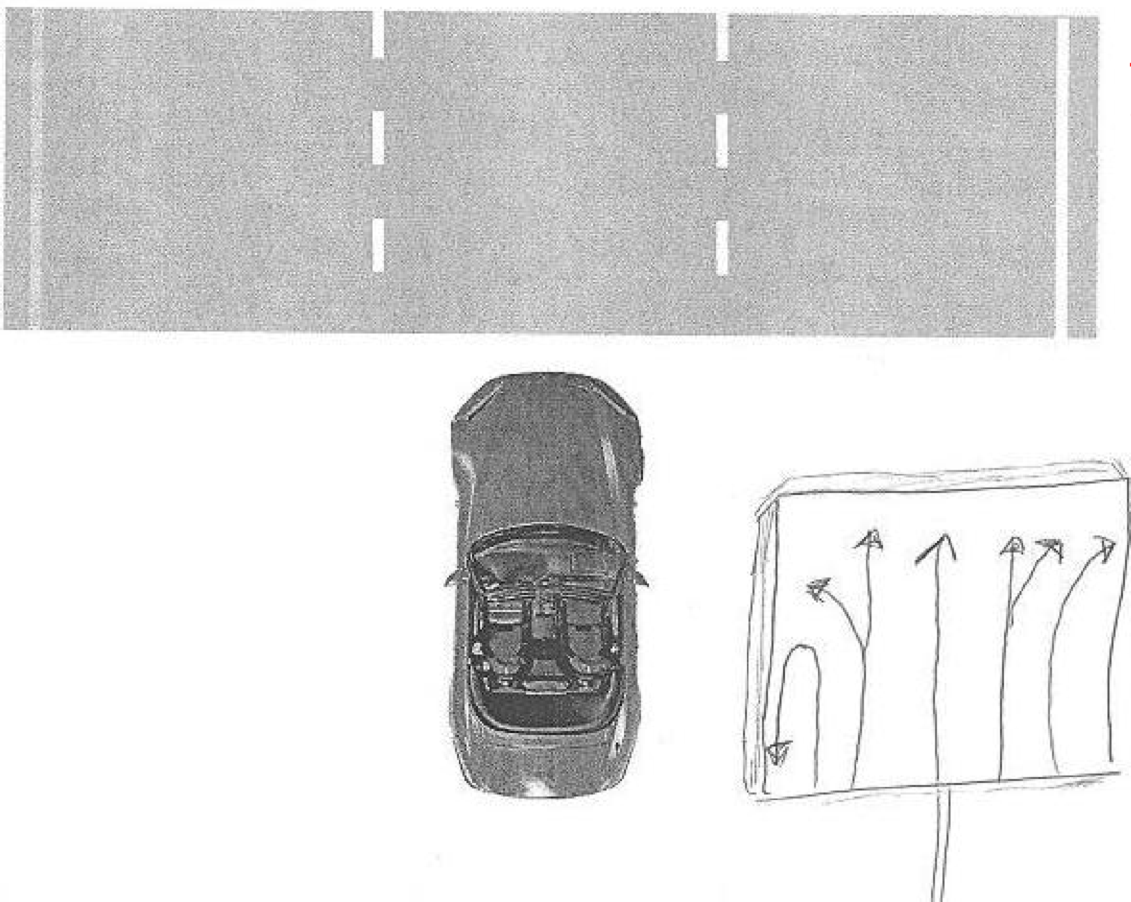
Signature of Person Obtaining Consent: __________________________ Date: ____________

Printed Name: ____

APPENDIX E: FOCUS GROUP ANSWER SHEETS

CS-1





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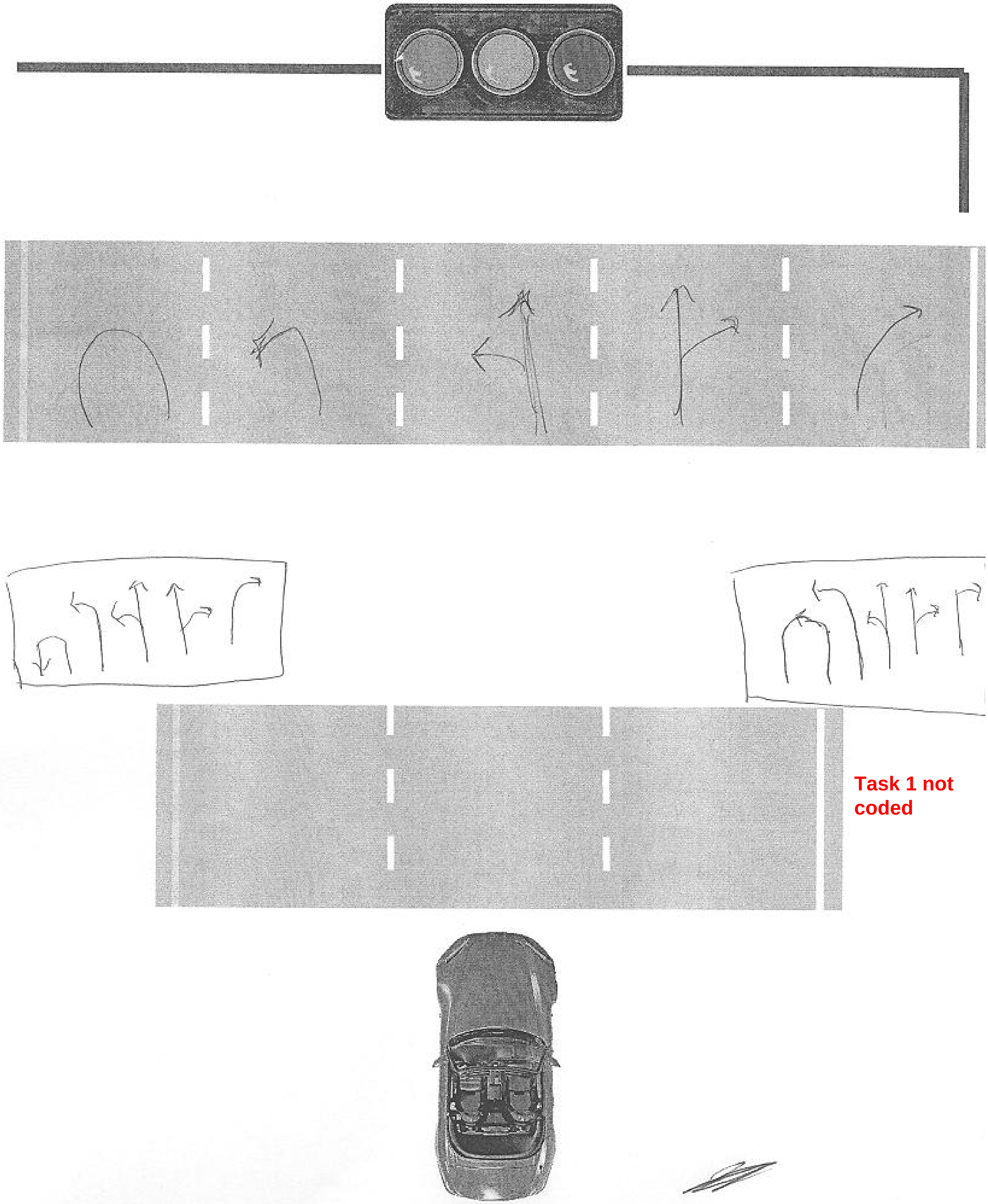
CS-2



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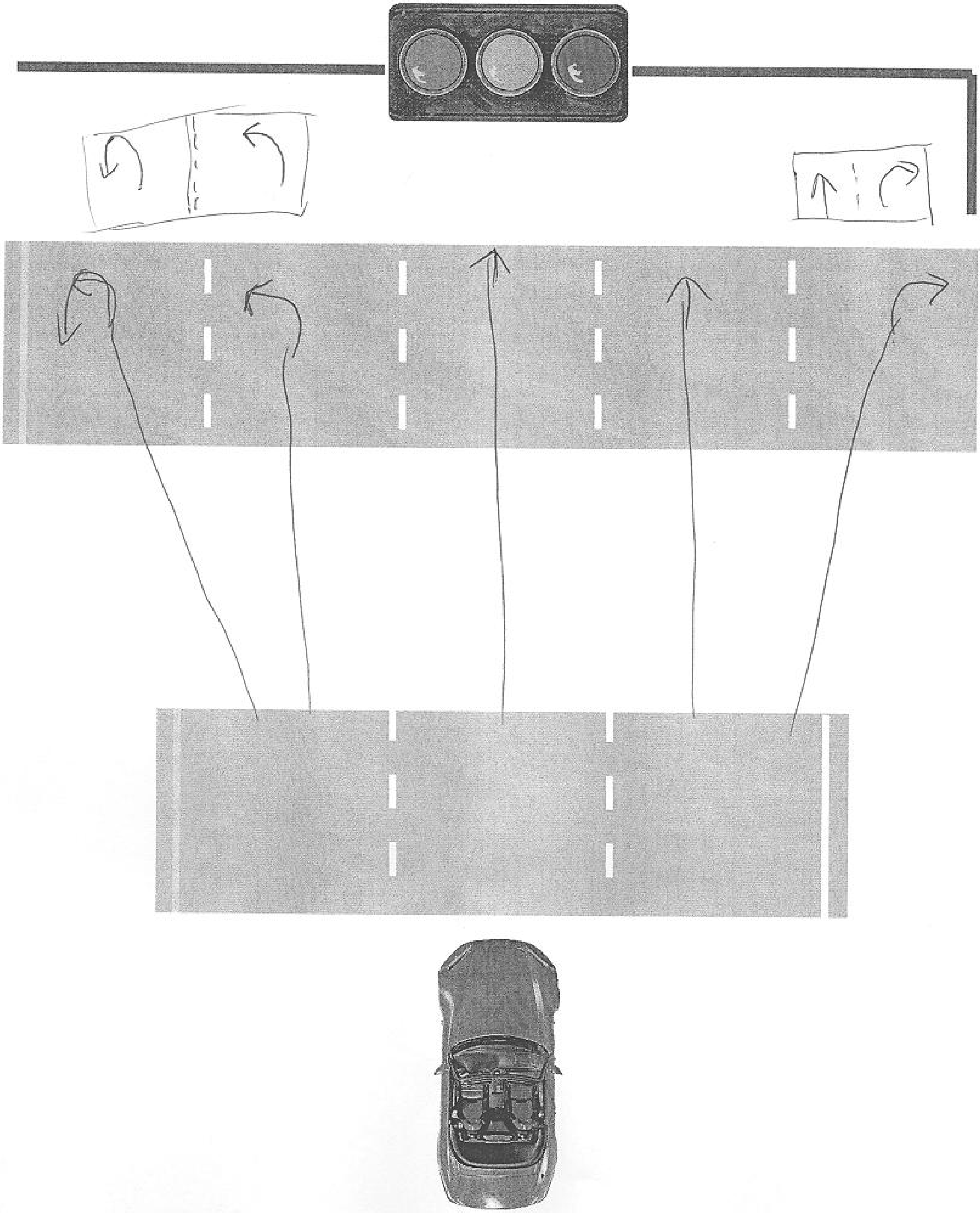
CS-3



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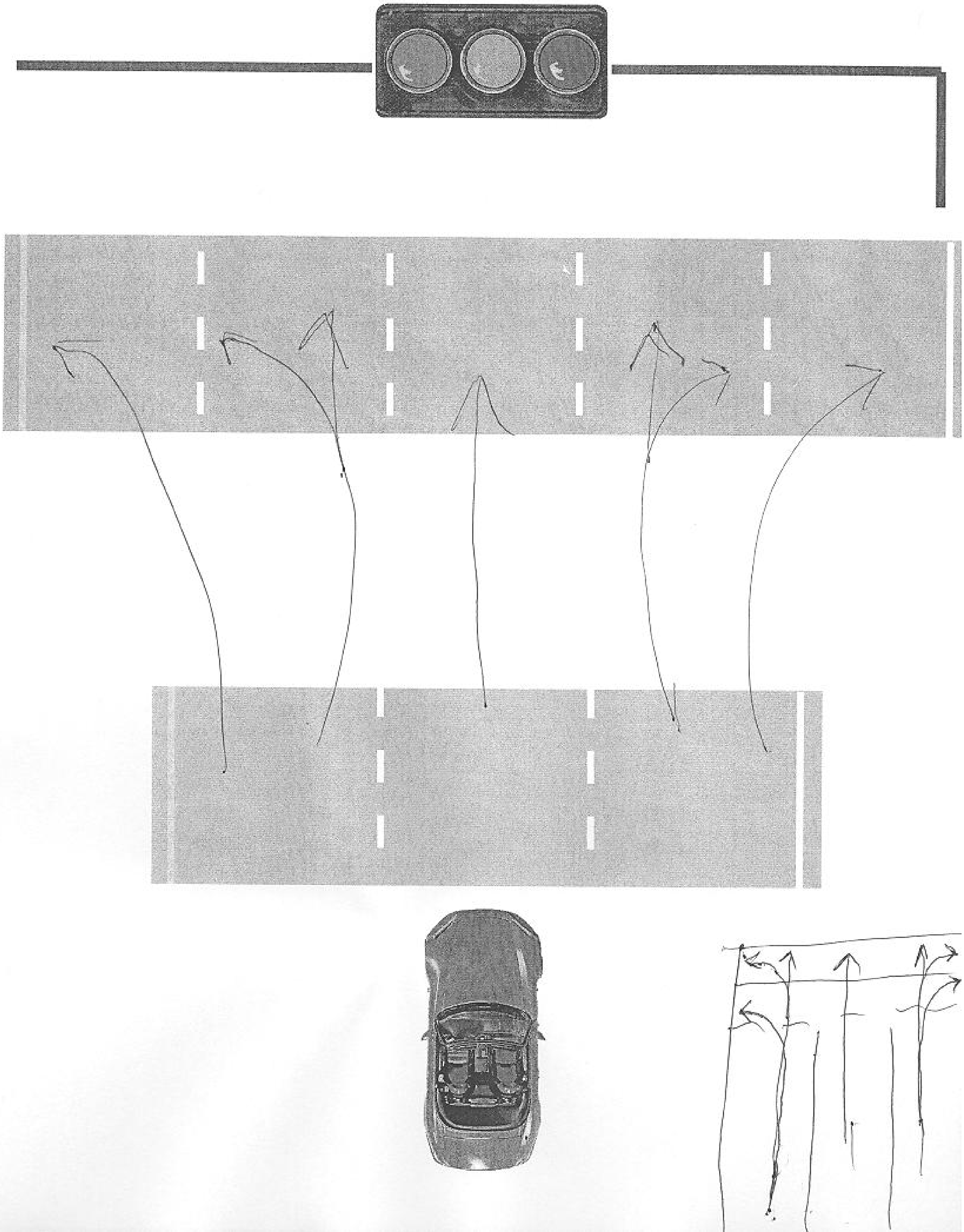

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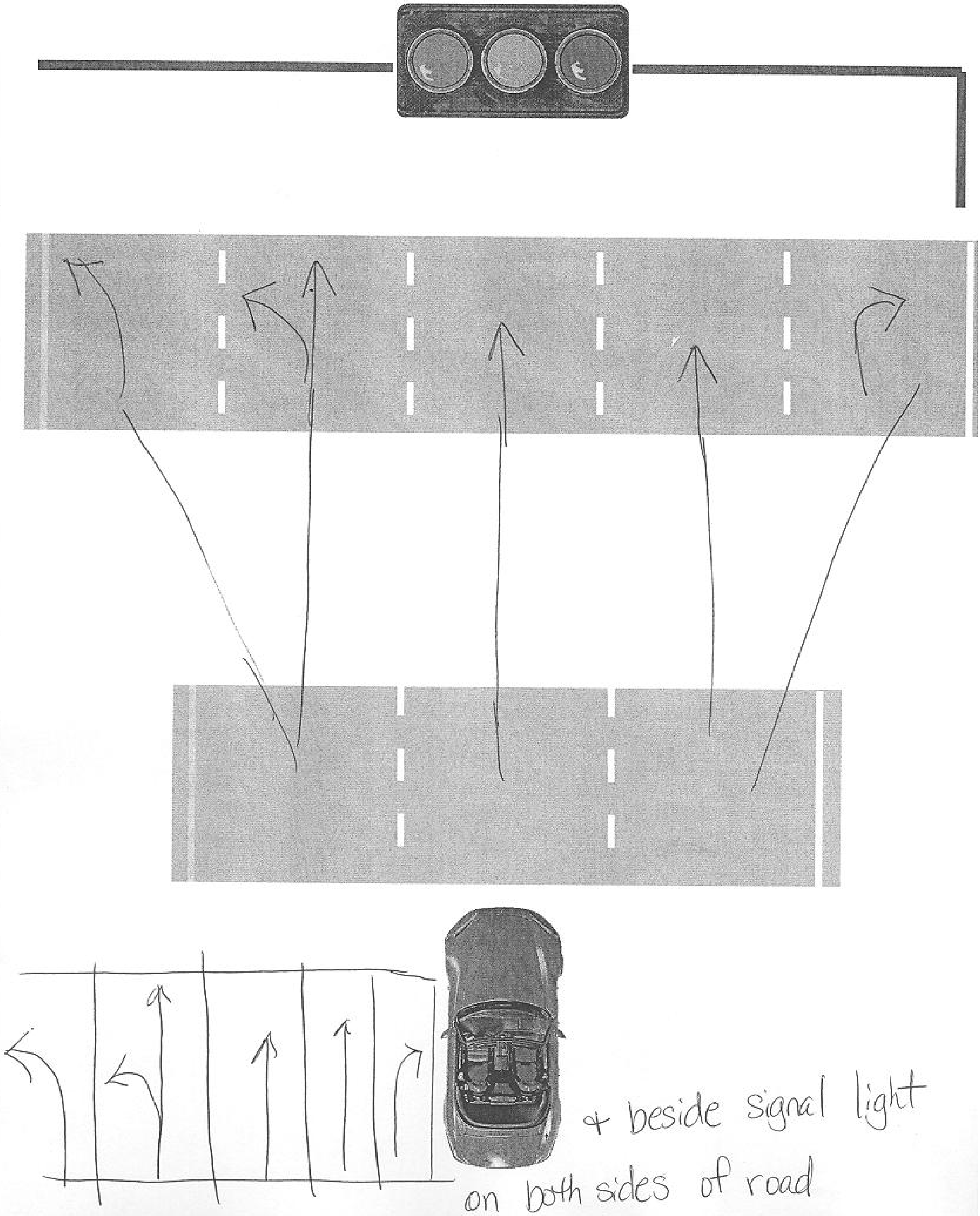
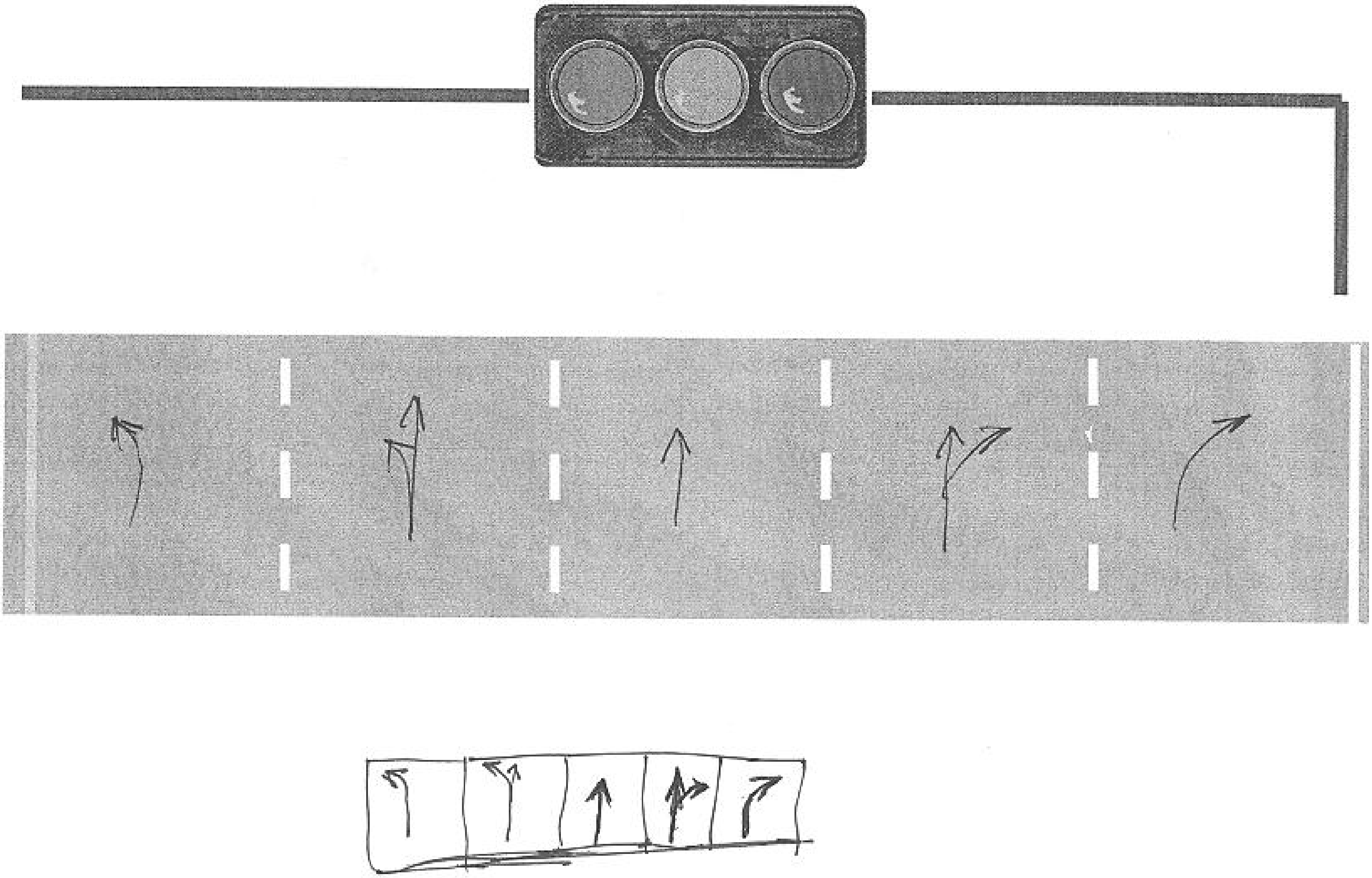
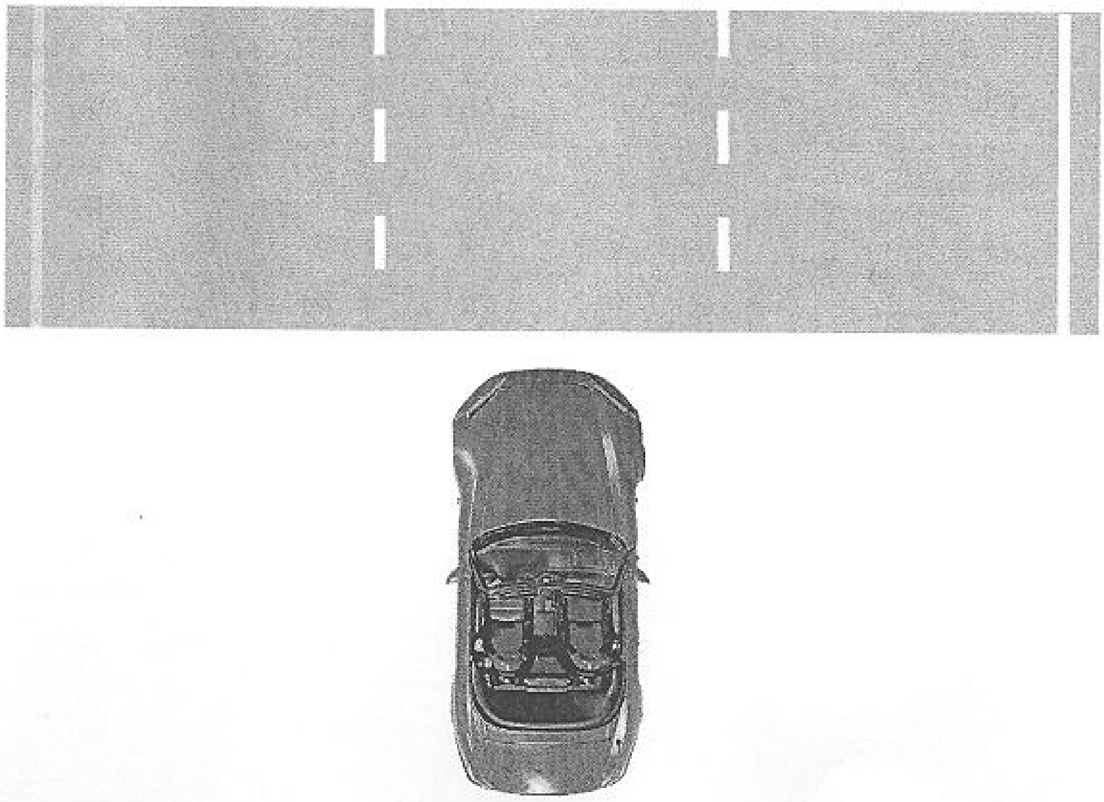


+ beside signal light on both sides of road

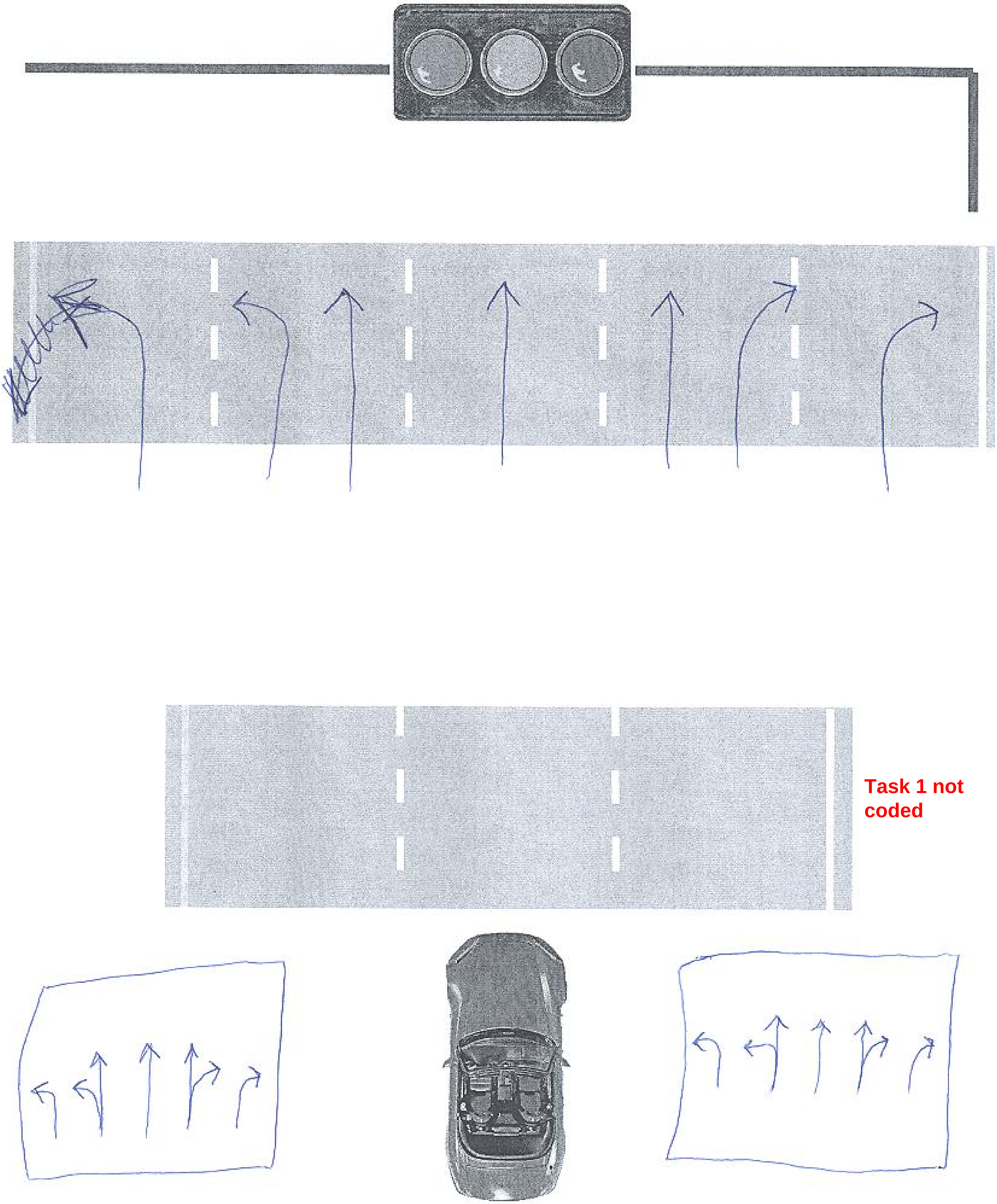
CS-6





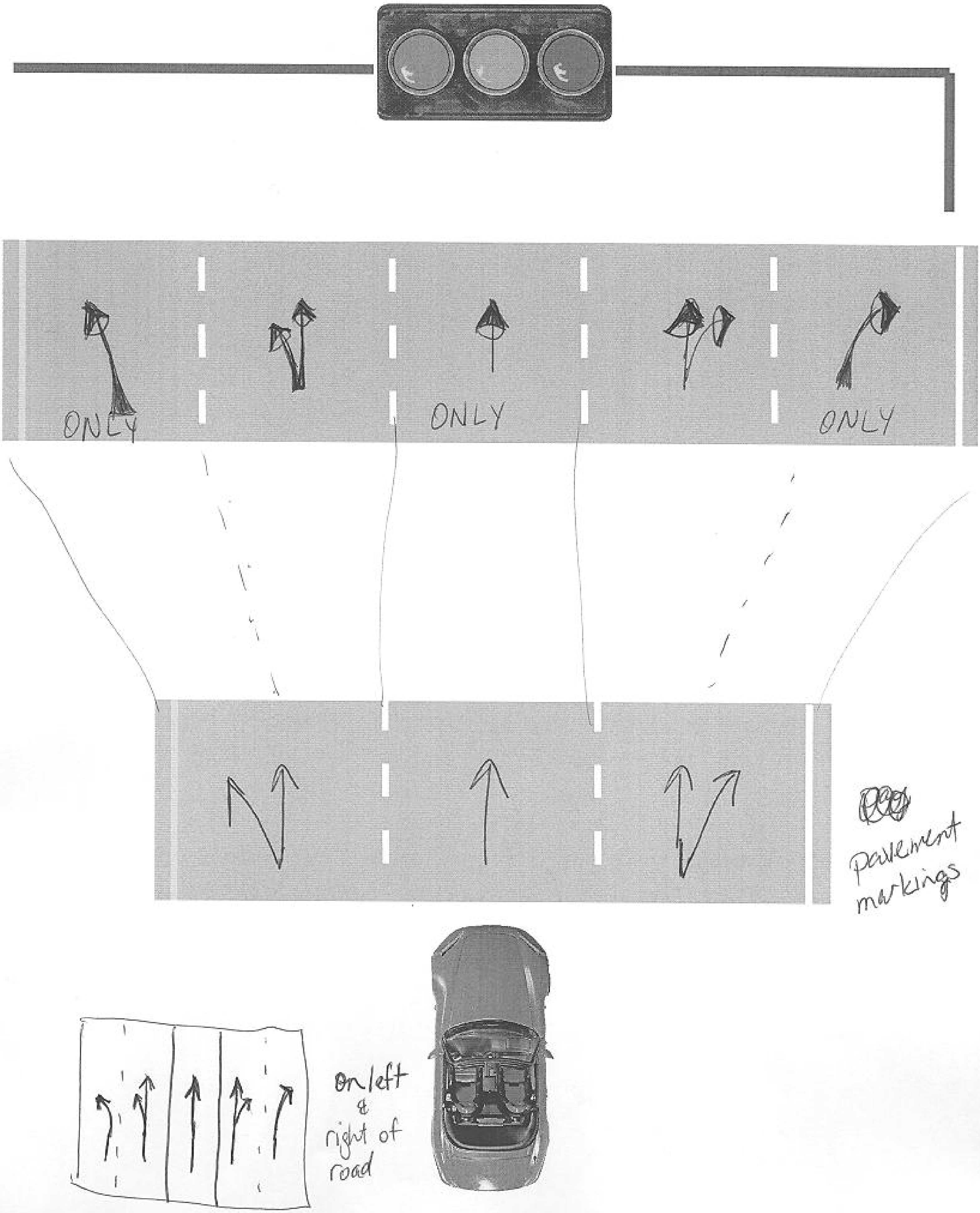
Task 1 not coded

CS-7

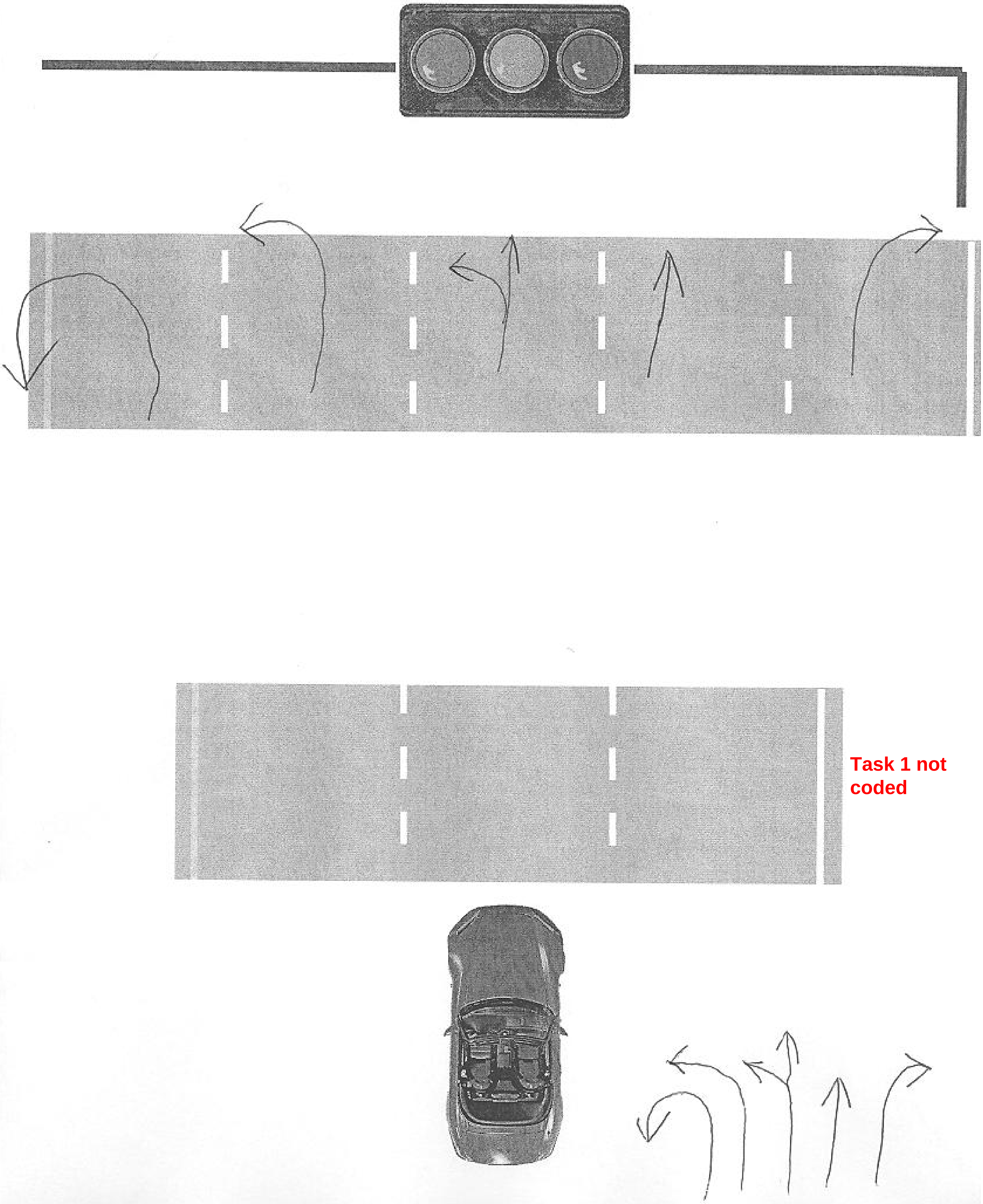


Task 1 not coded

CS-8

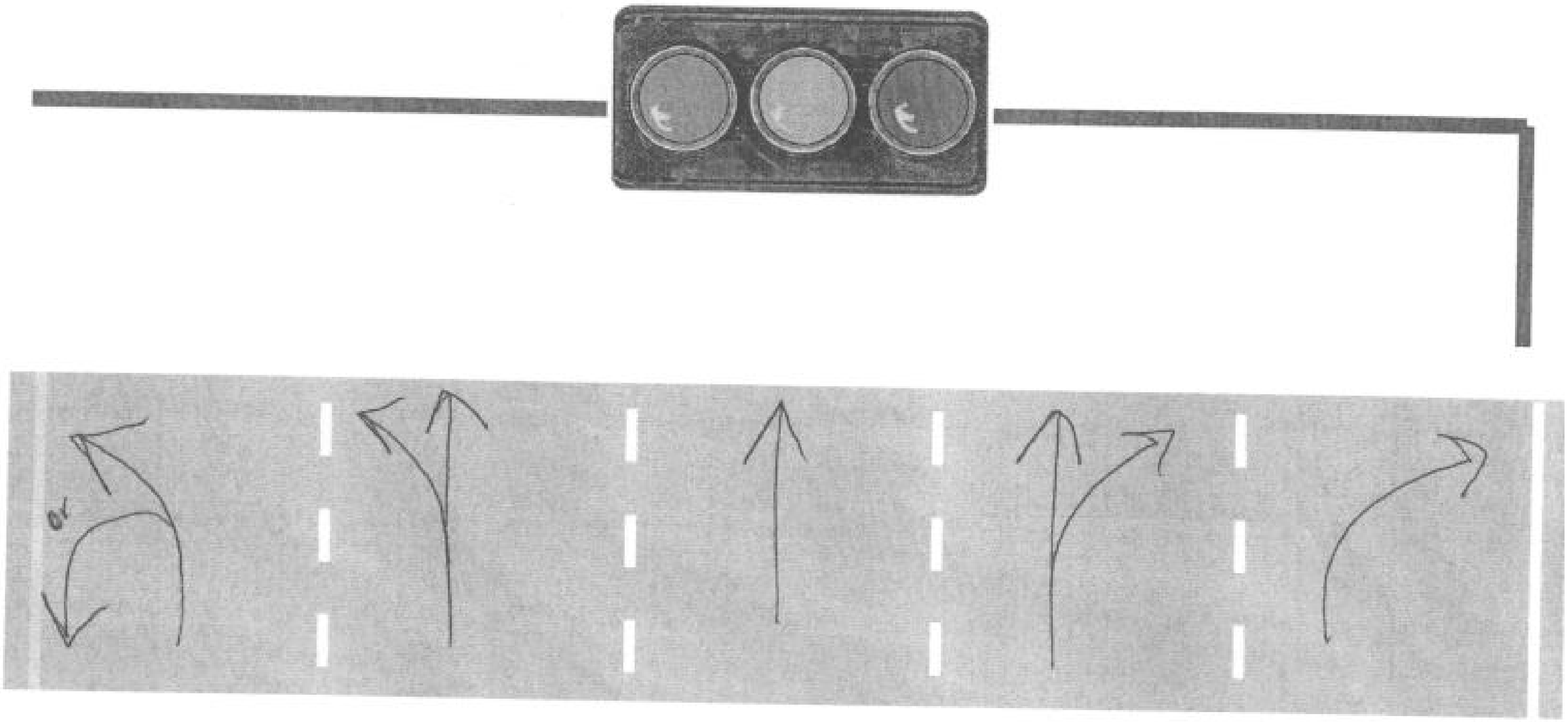


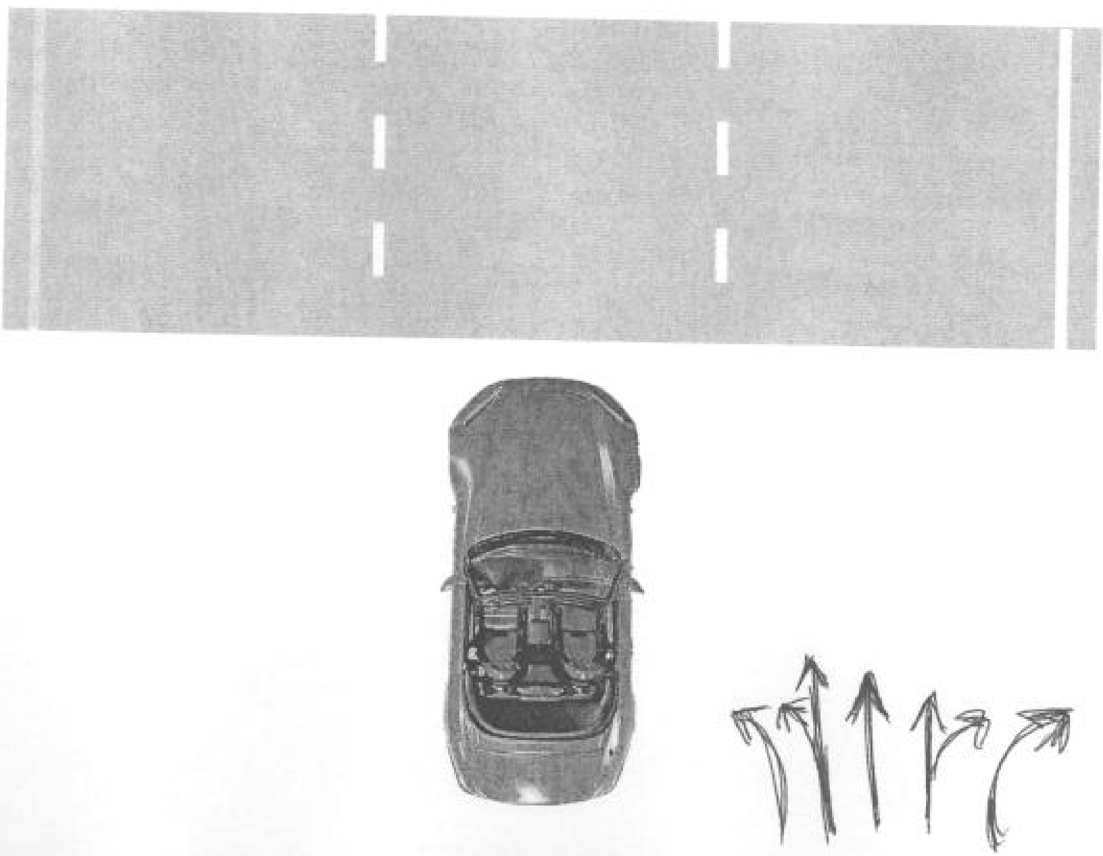
CS-9



Task 1 not coded

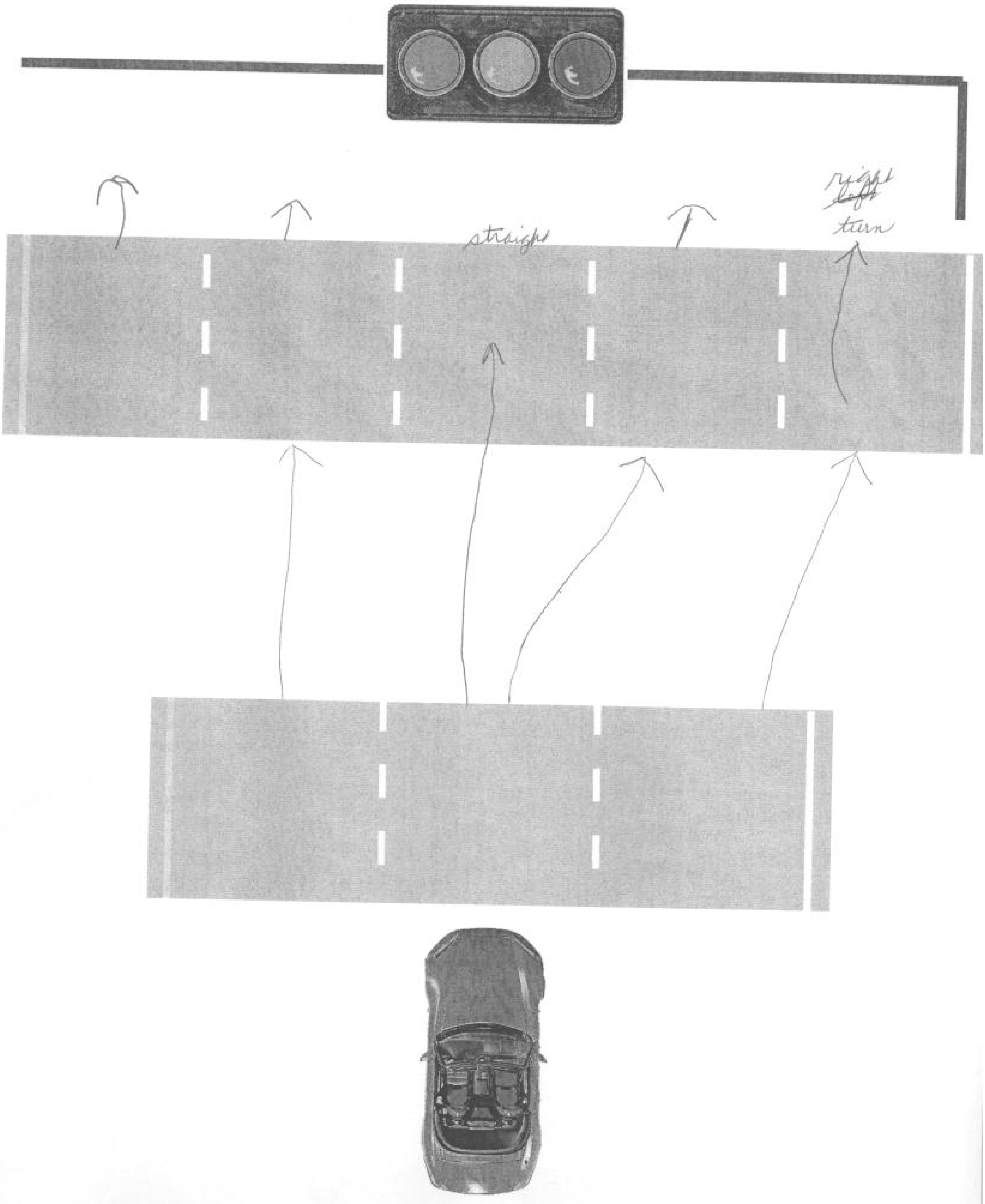
CS-10



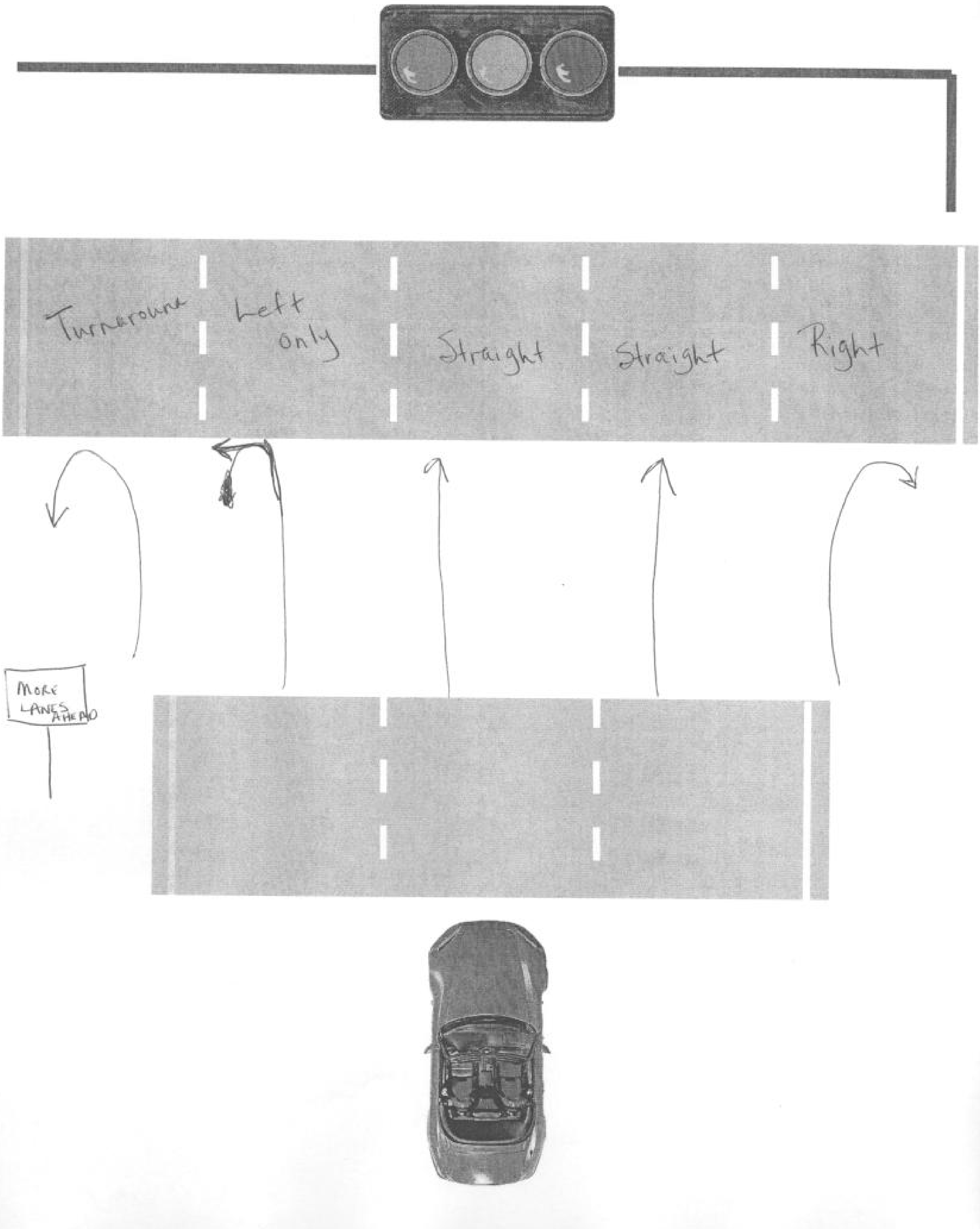


Task 1 not coded

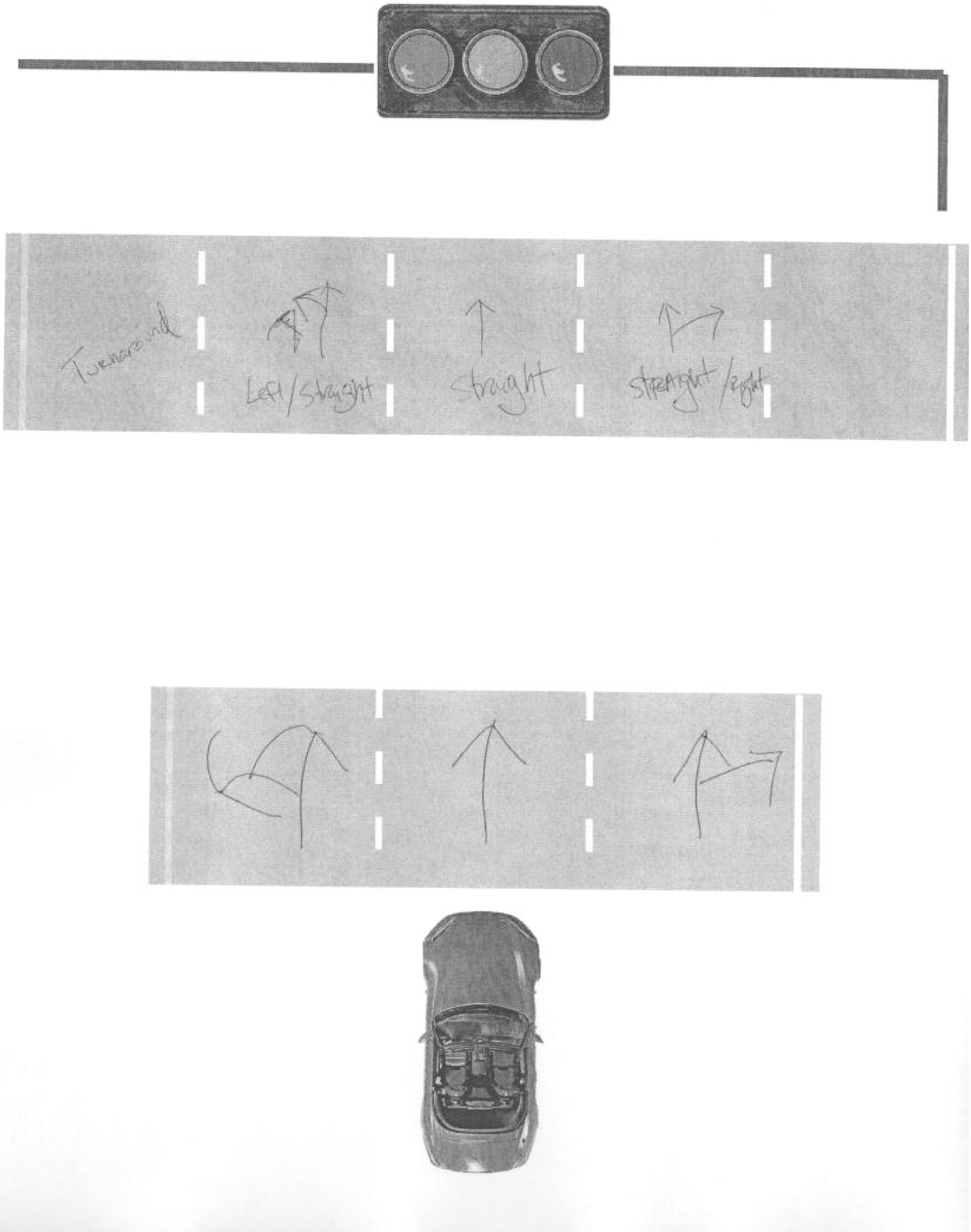
SA-1



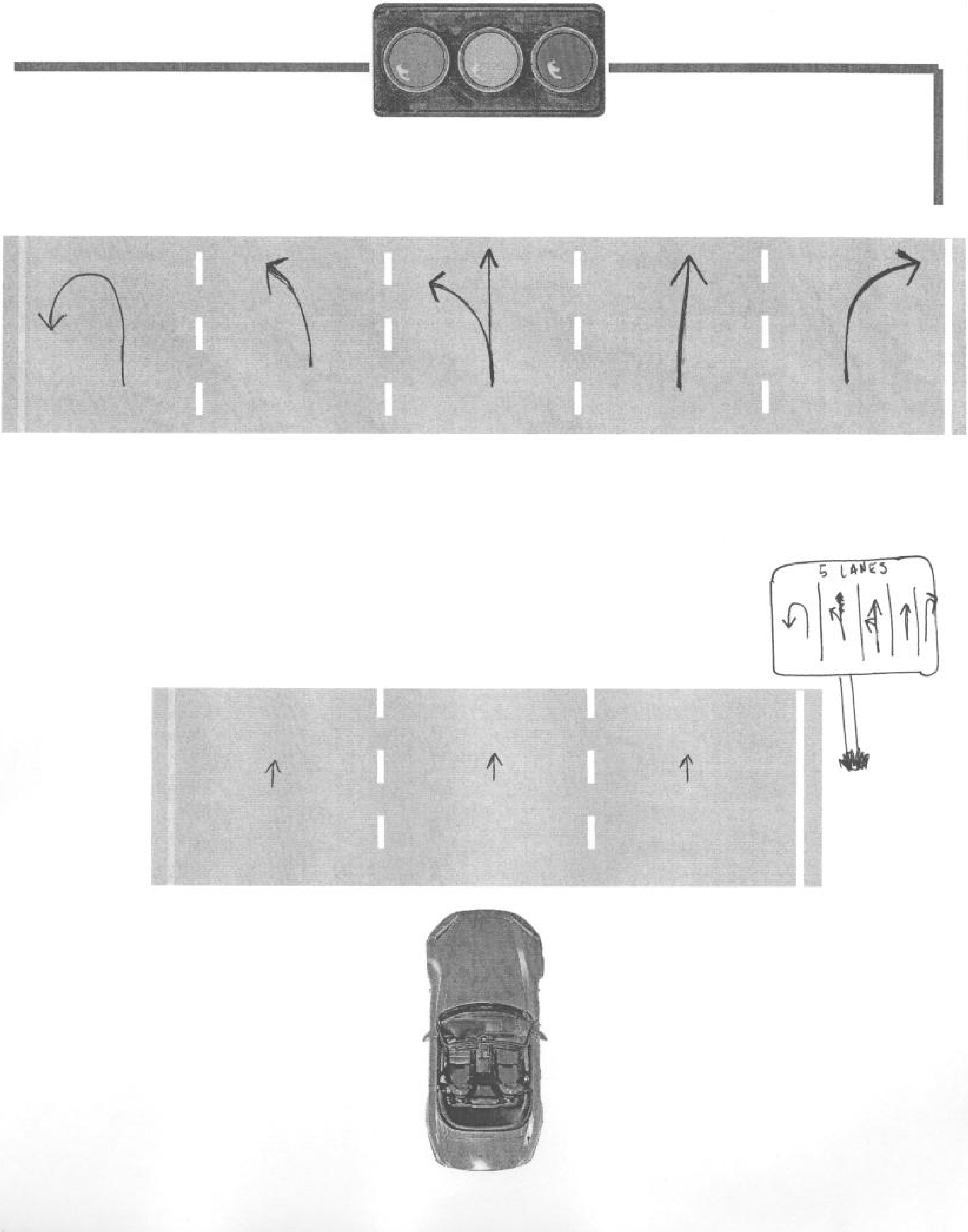
SA-2


Turnaround
Left only
Straight
Straight
Right
MORE LANES AHEAD

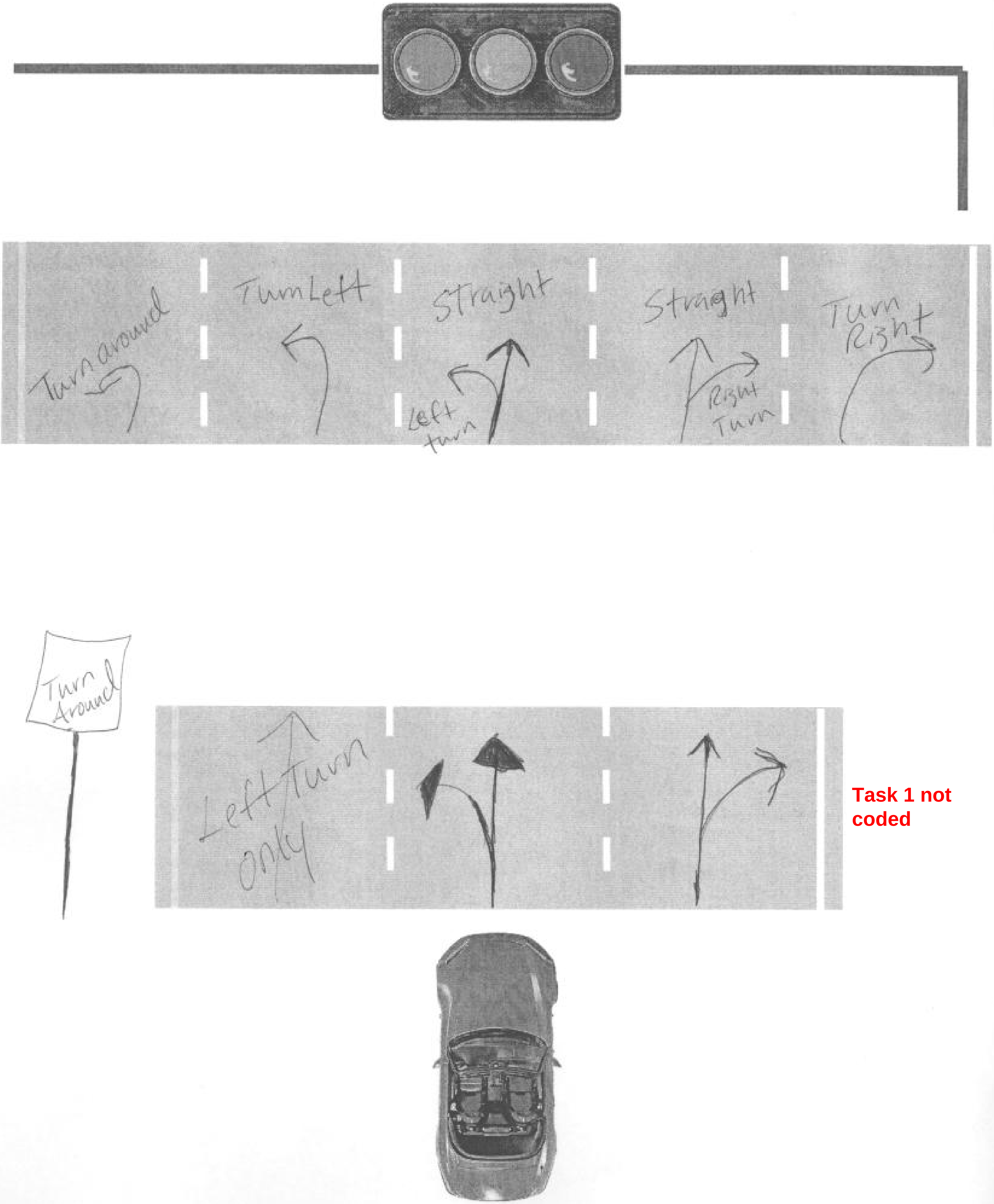
SA-3



SA-4

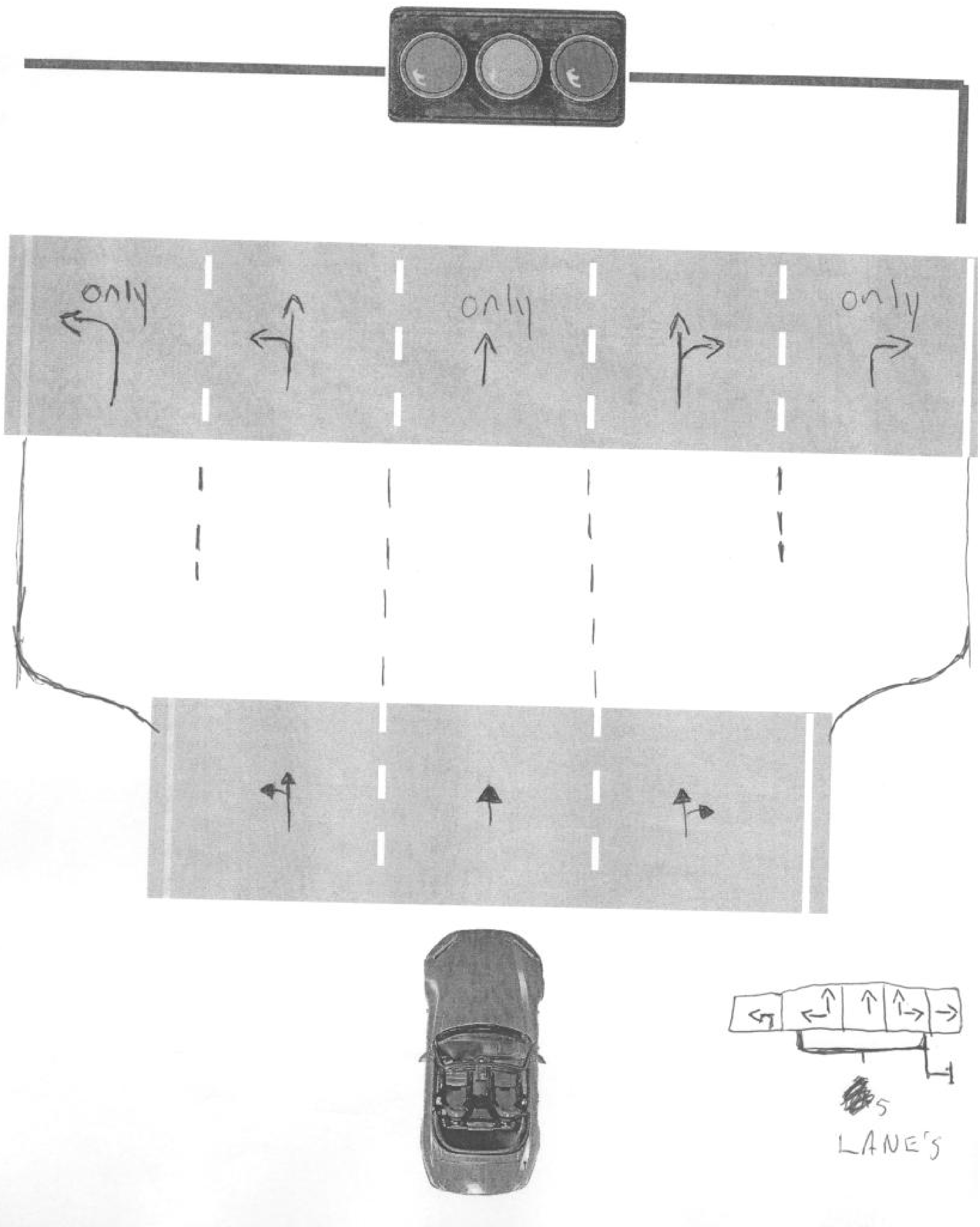


SA-5

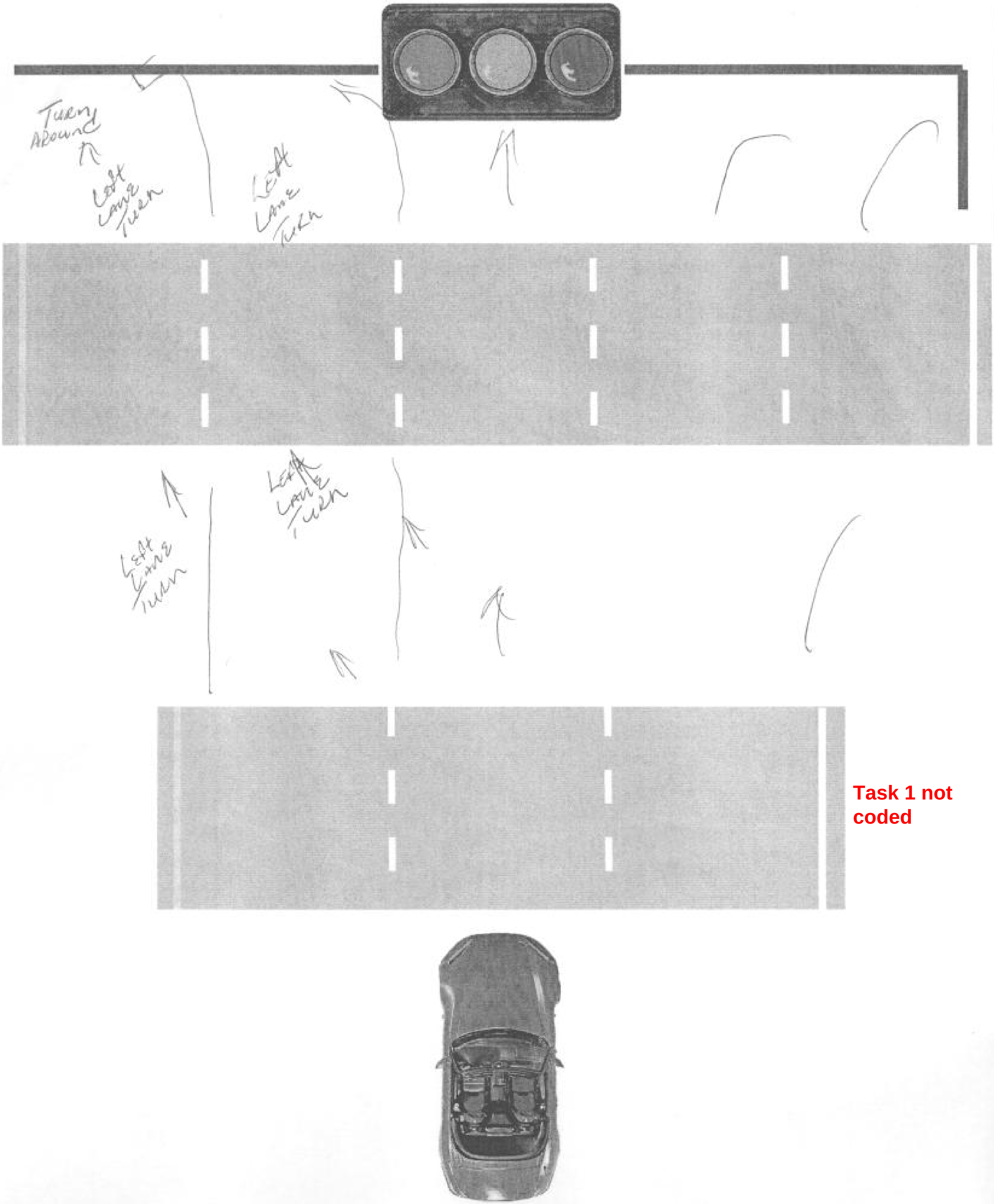


Task 1 not coded

SA-6

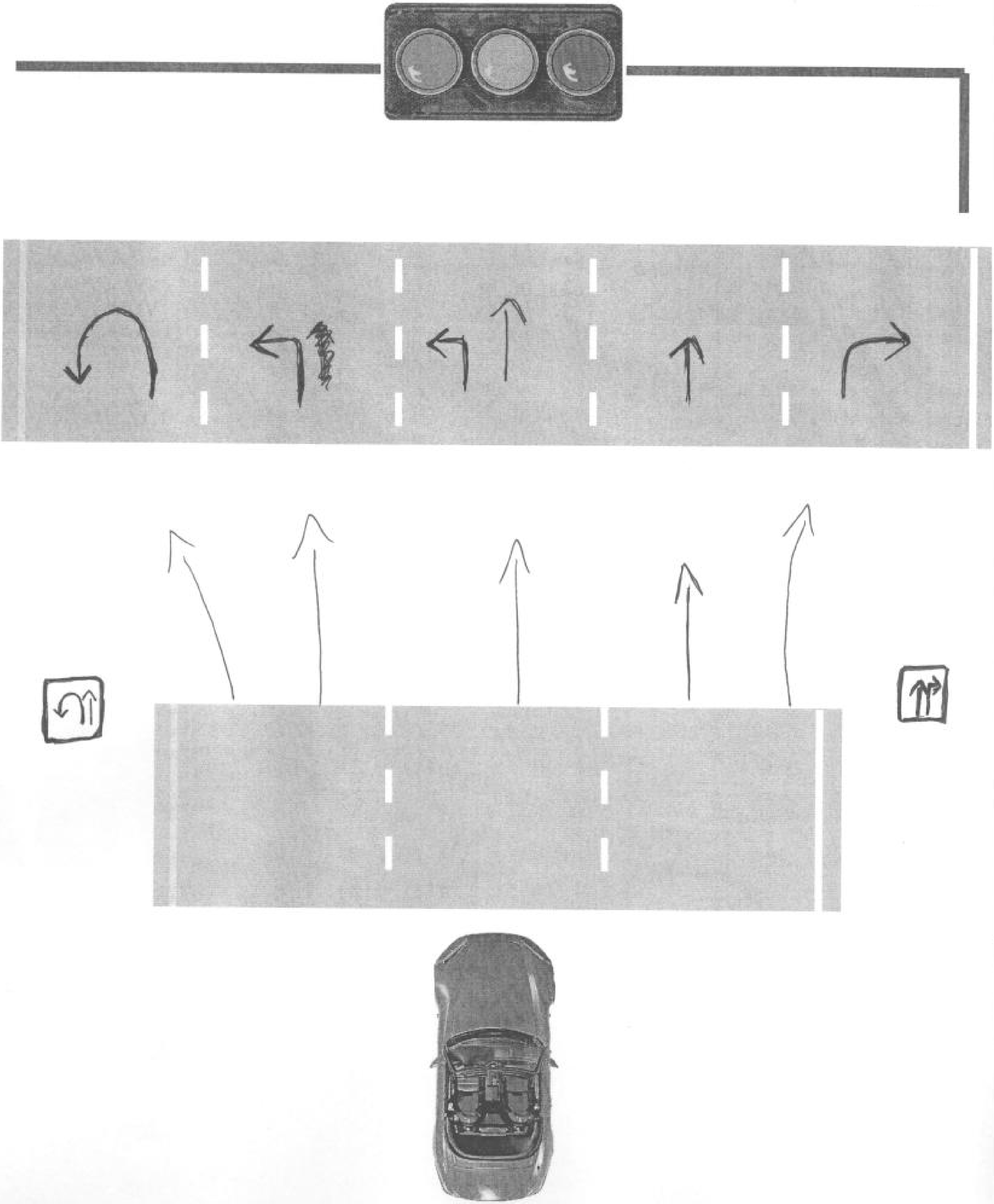


SA-7

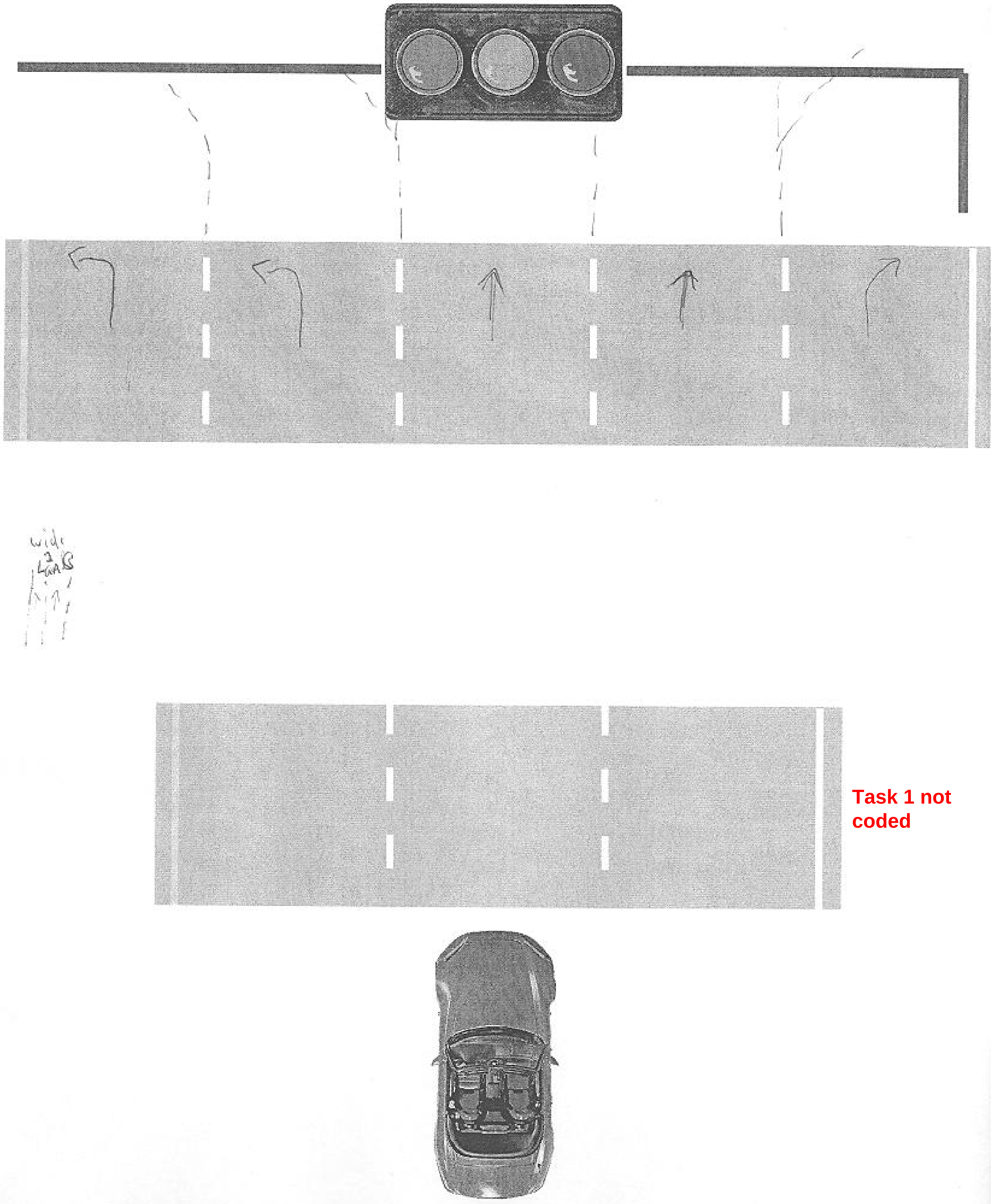


Task 1 not coded

SA-8

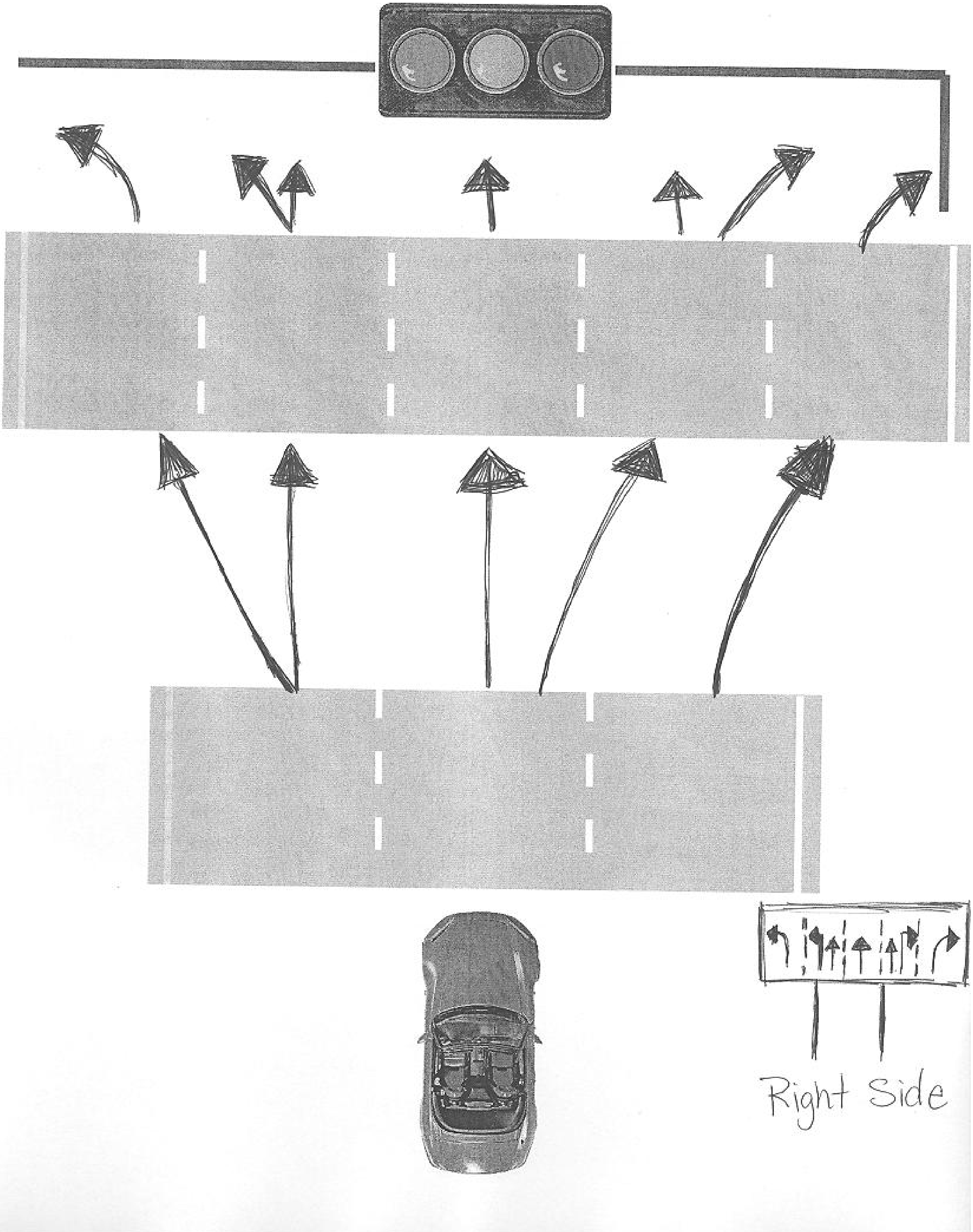


SA-9

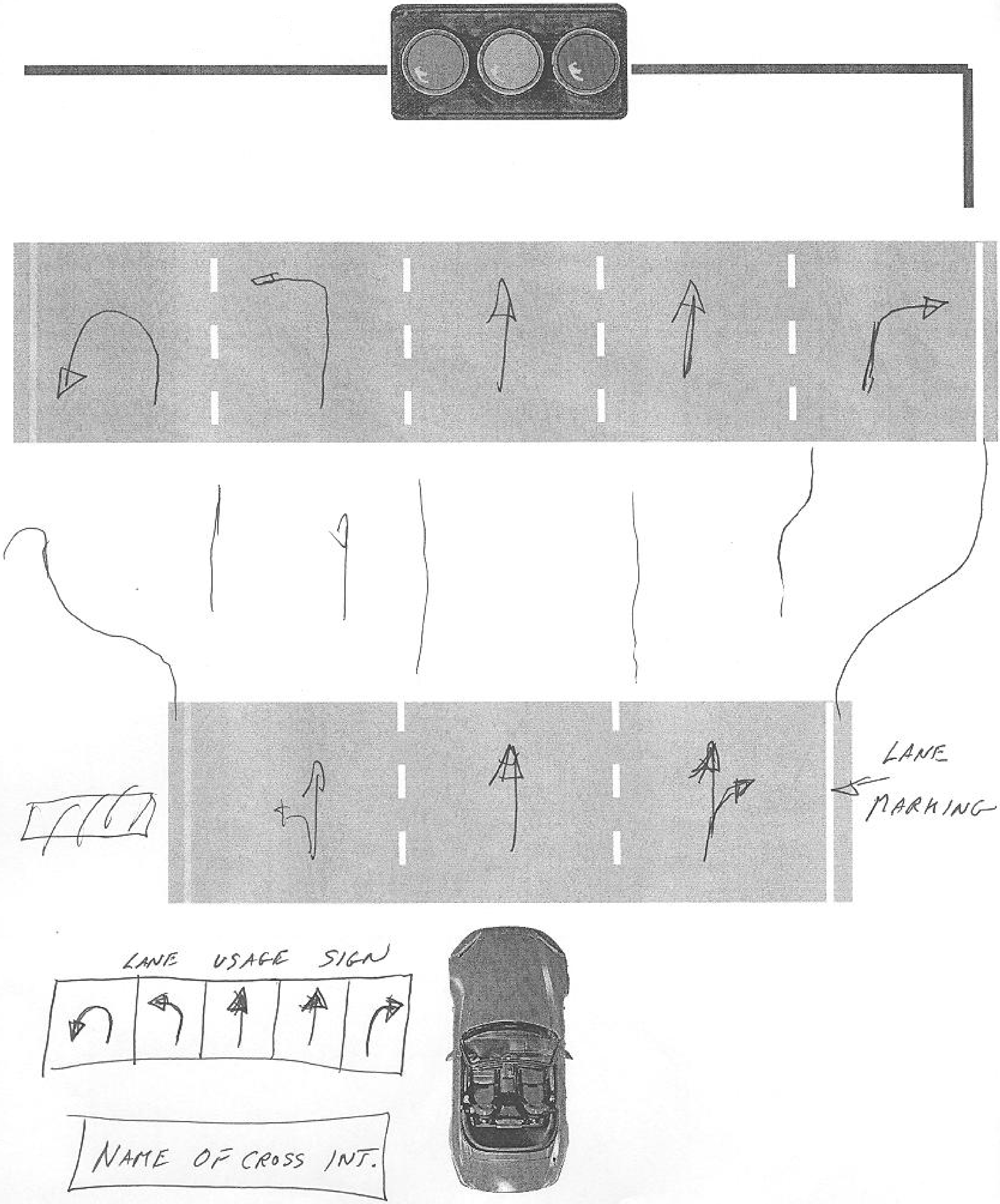


Task 1 not coded

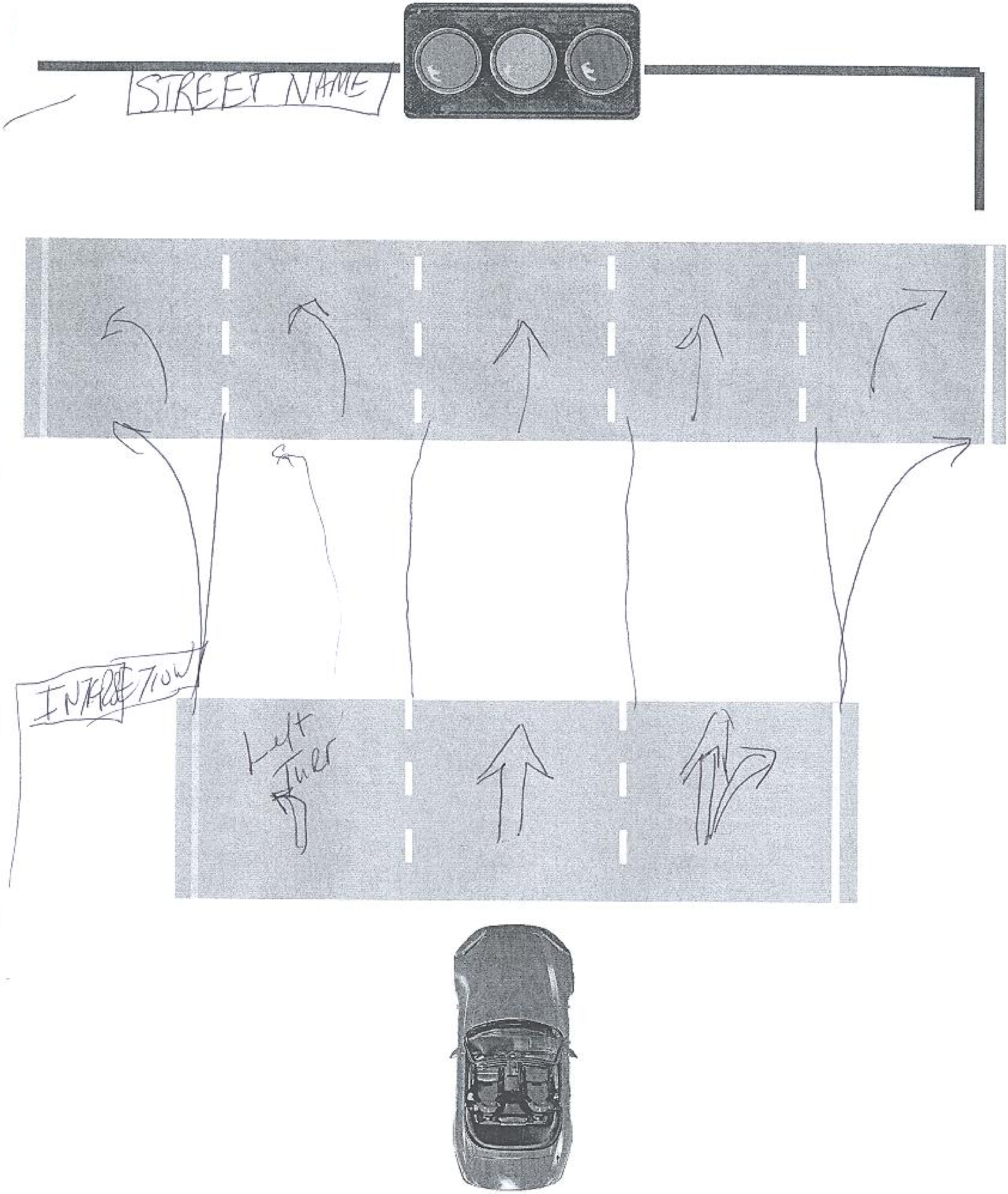
SA-10



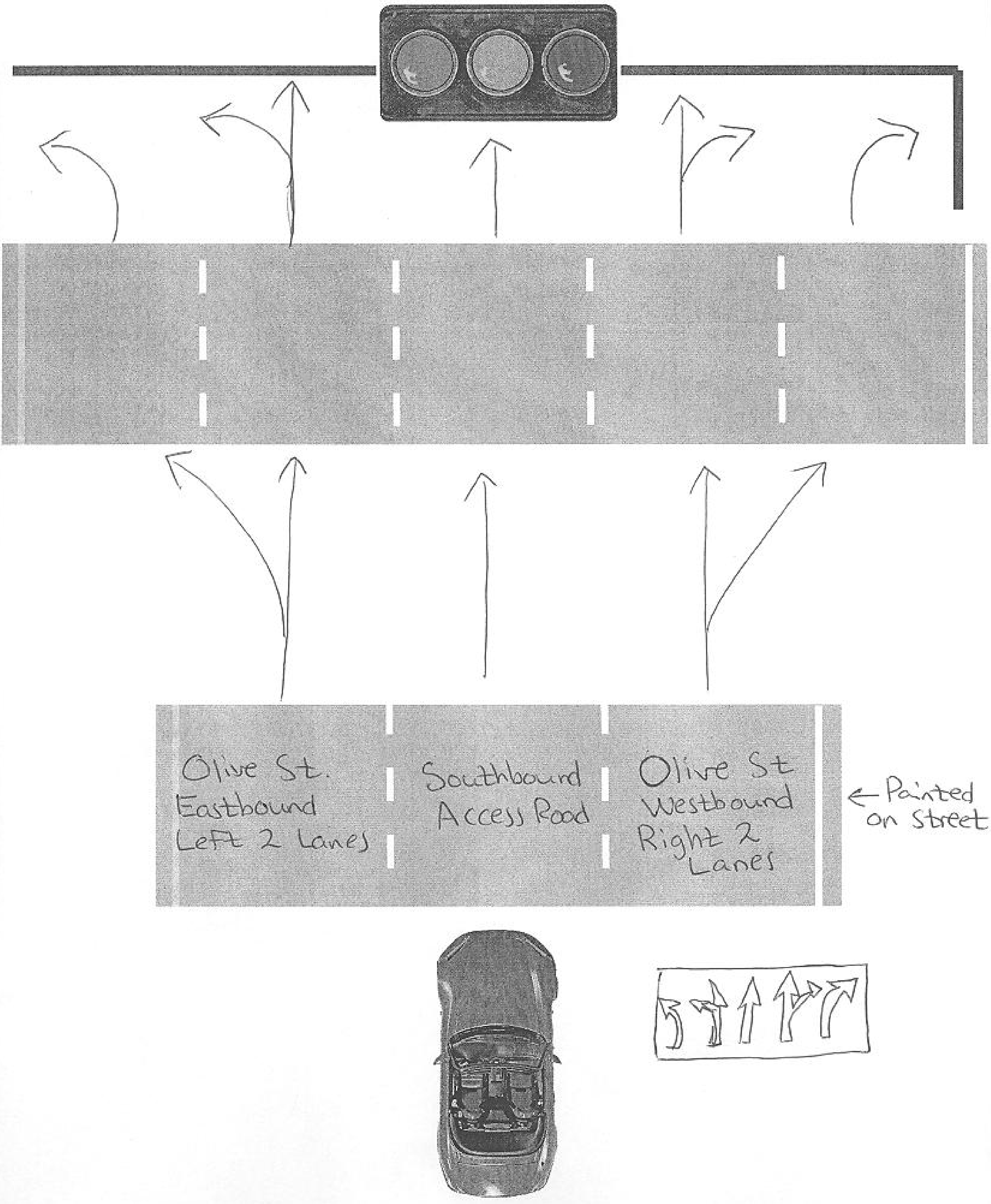
A-1



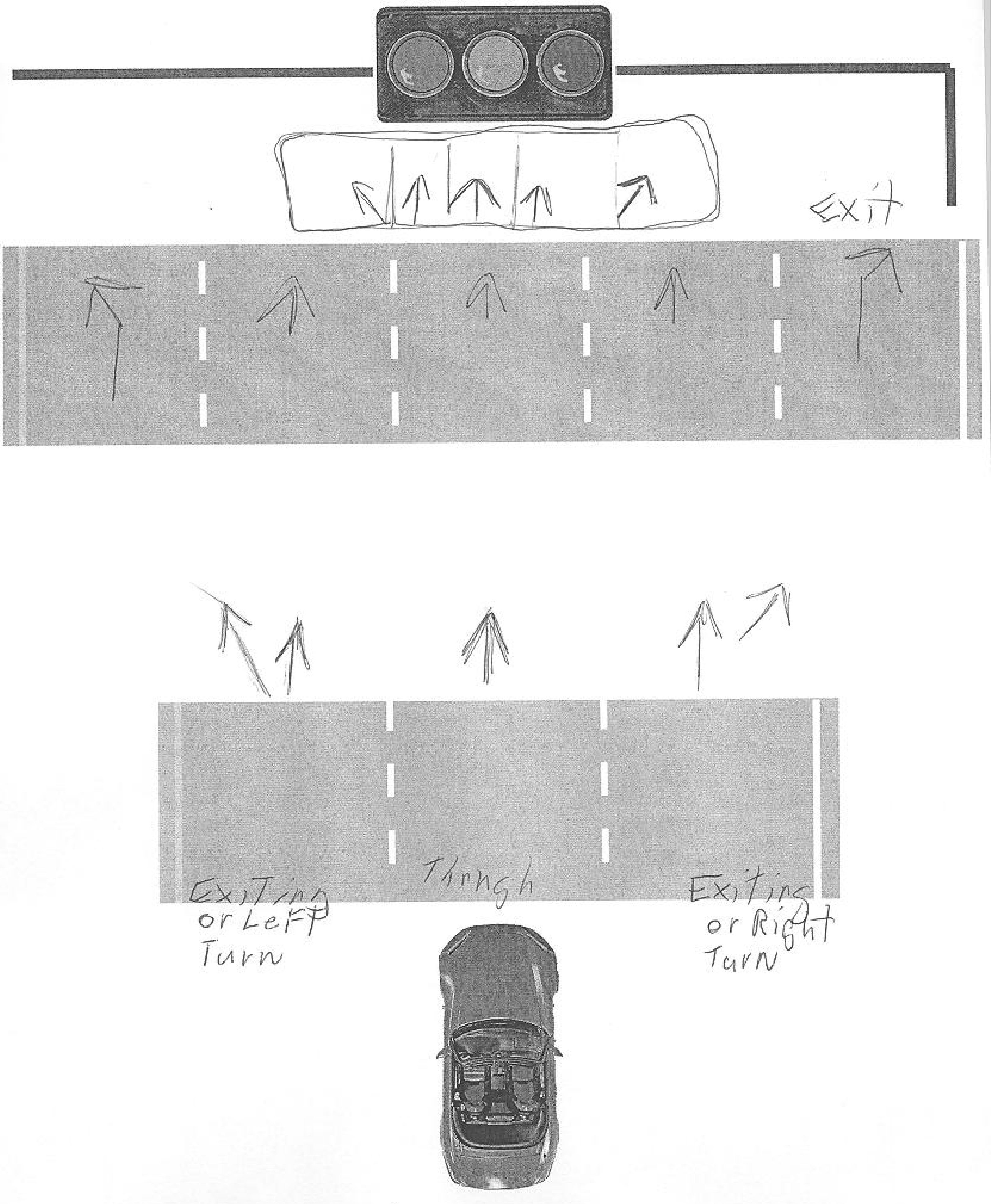
A-2



A-3

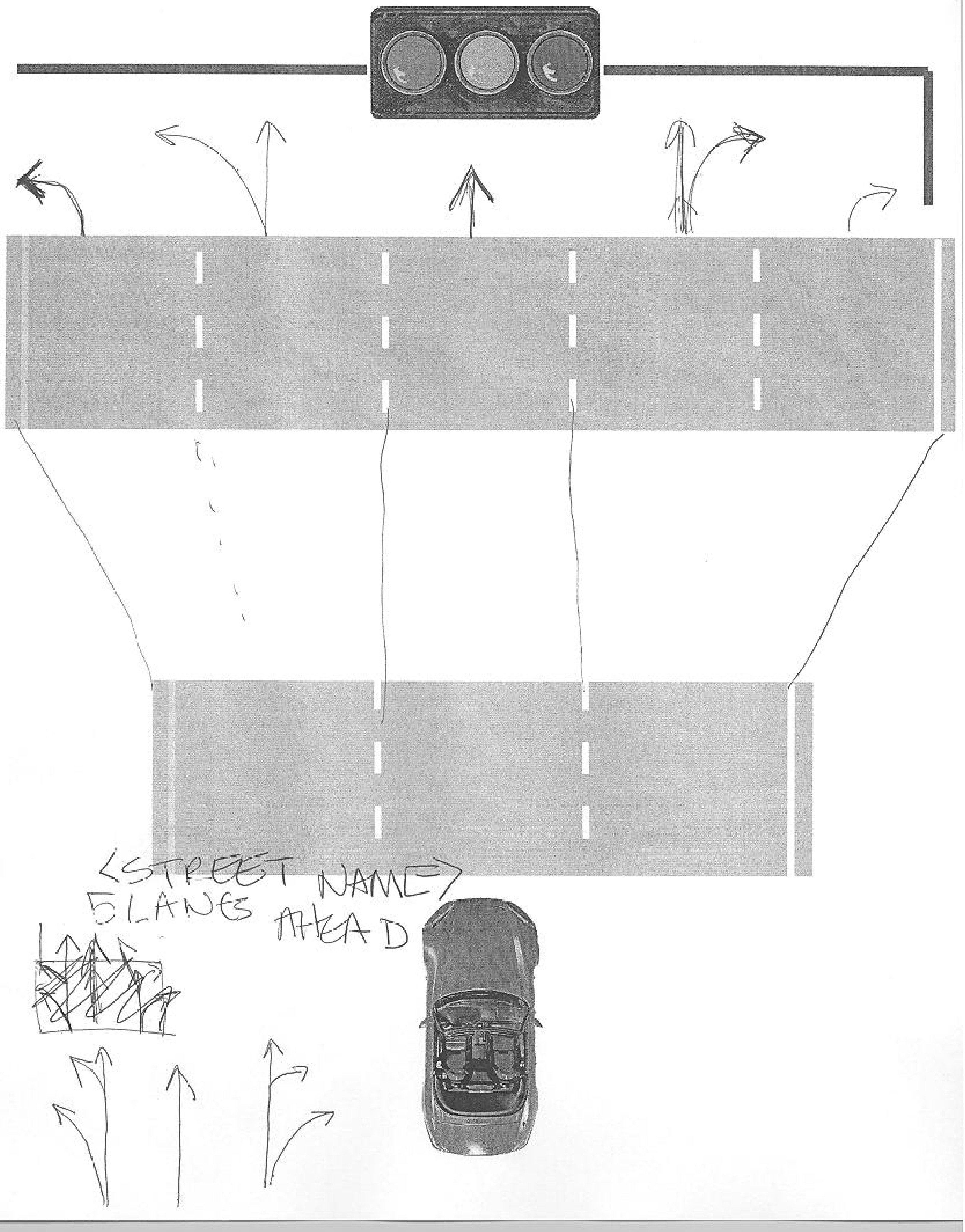

Olive St. Eastbound Left 2 Lanes
Southbound Access Road
Olive St Westbound Right 2 Lanes
← Painted on Street

A-4

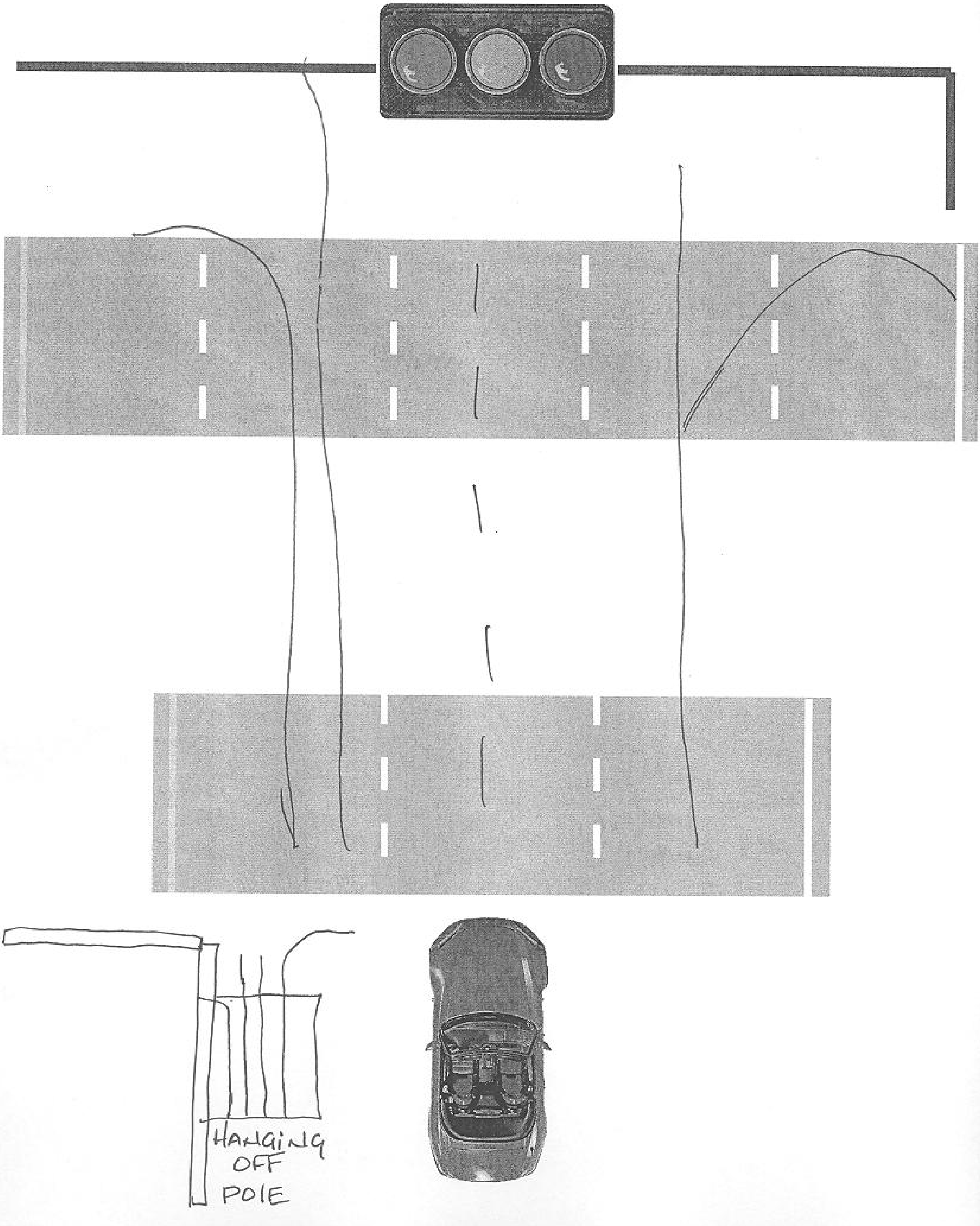


Road sign on Road

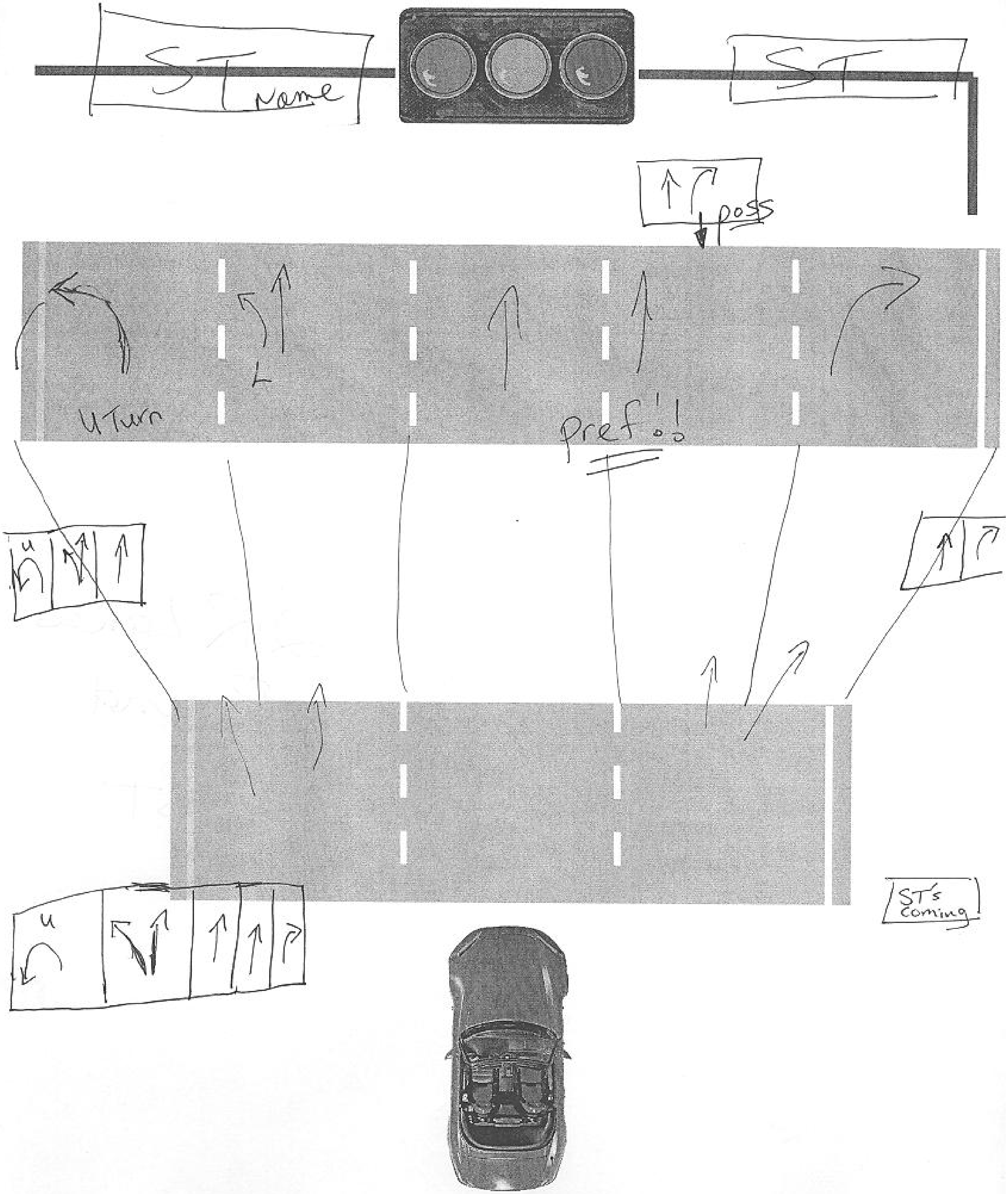
A-5



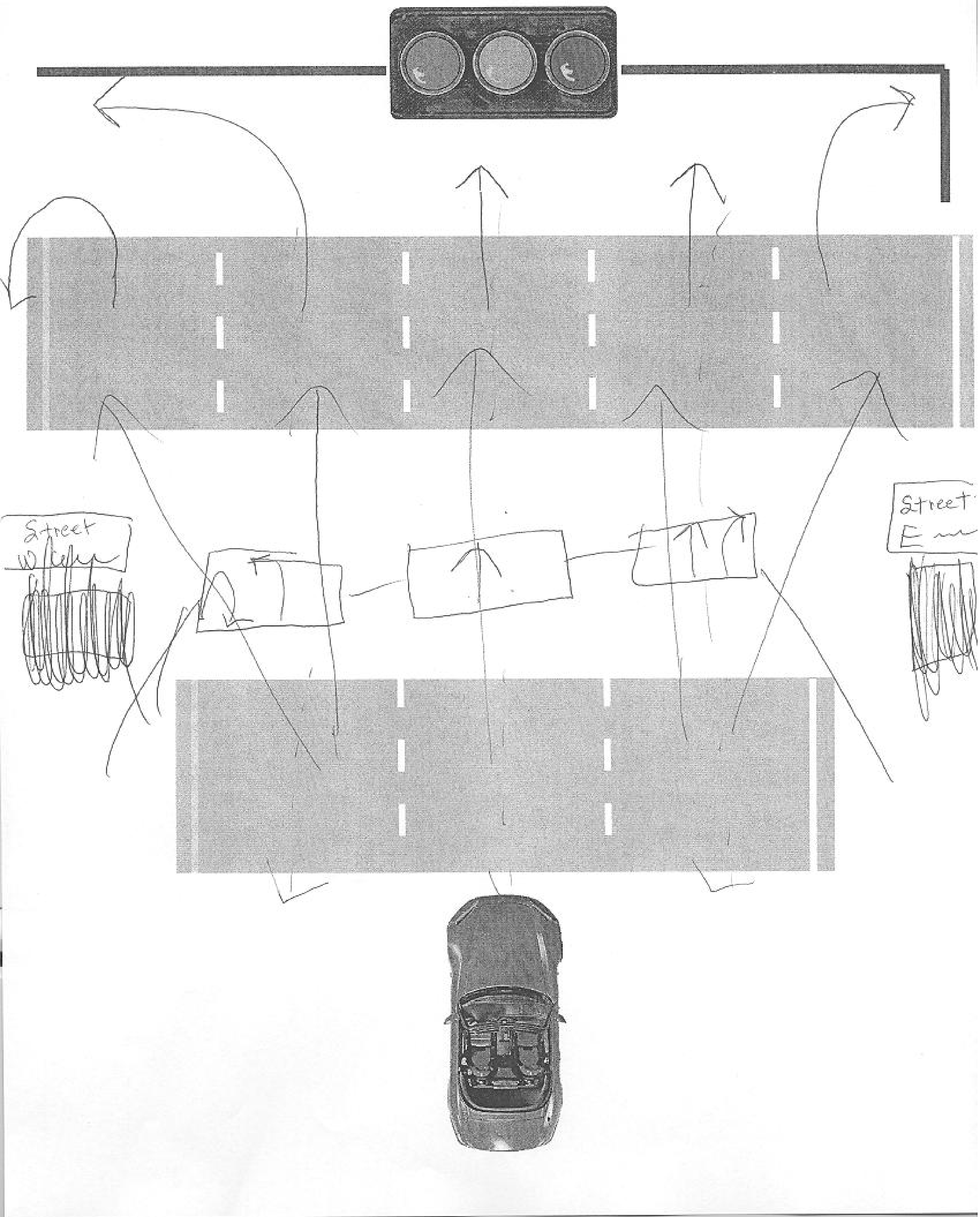
A-6



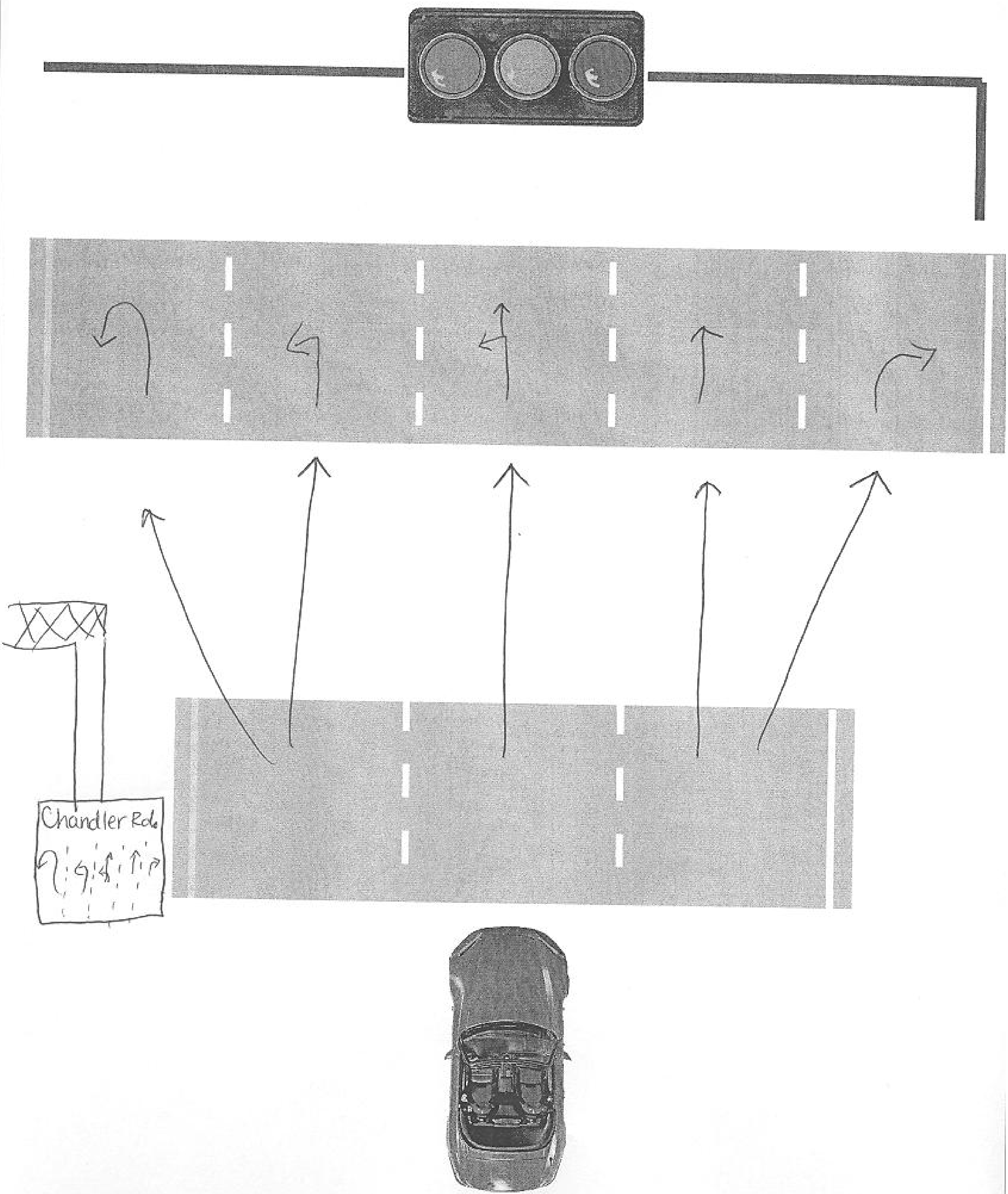
A-7



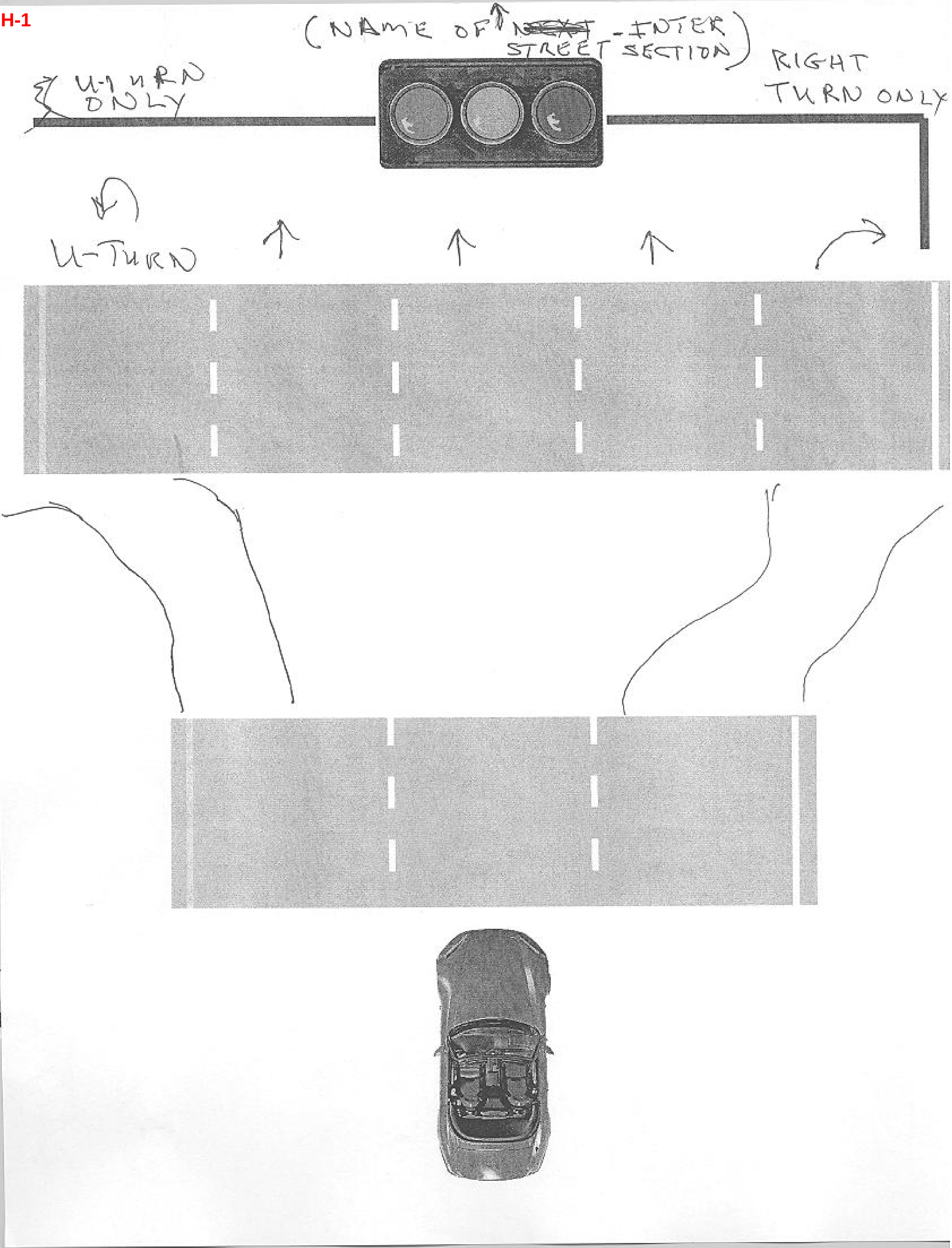
A-8



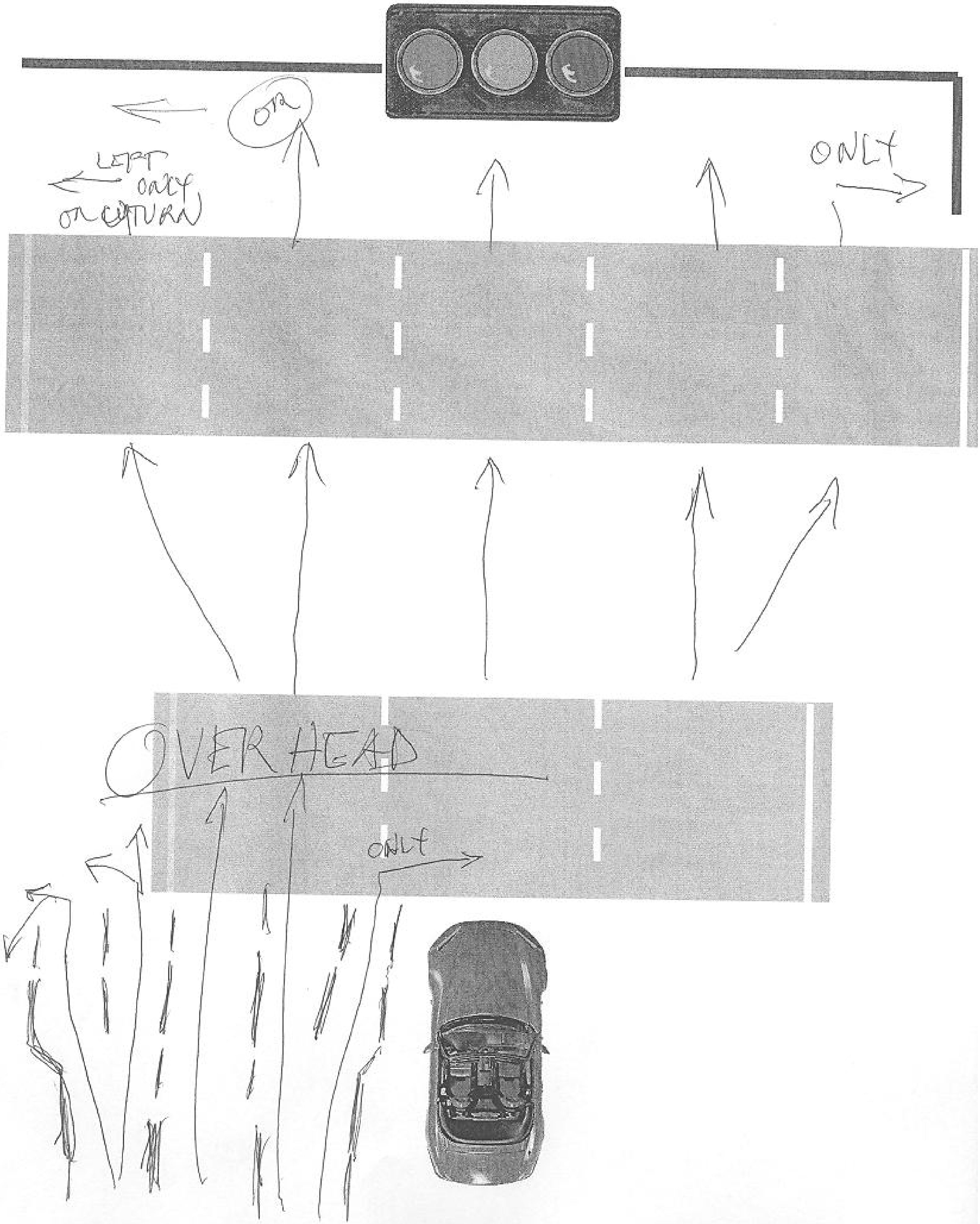
A-9



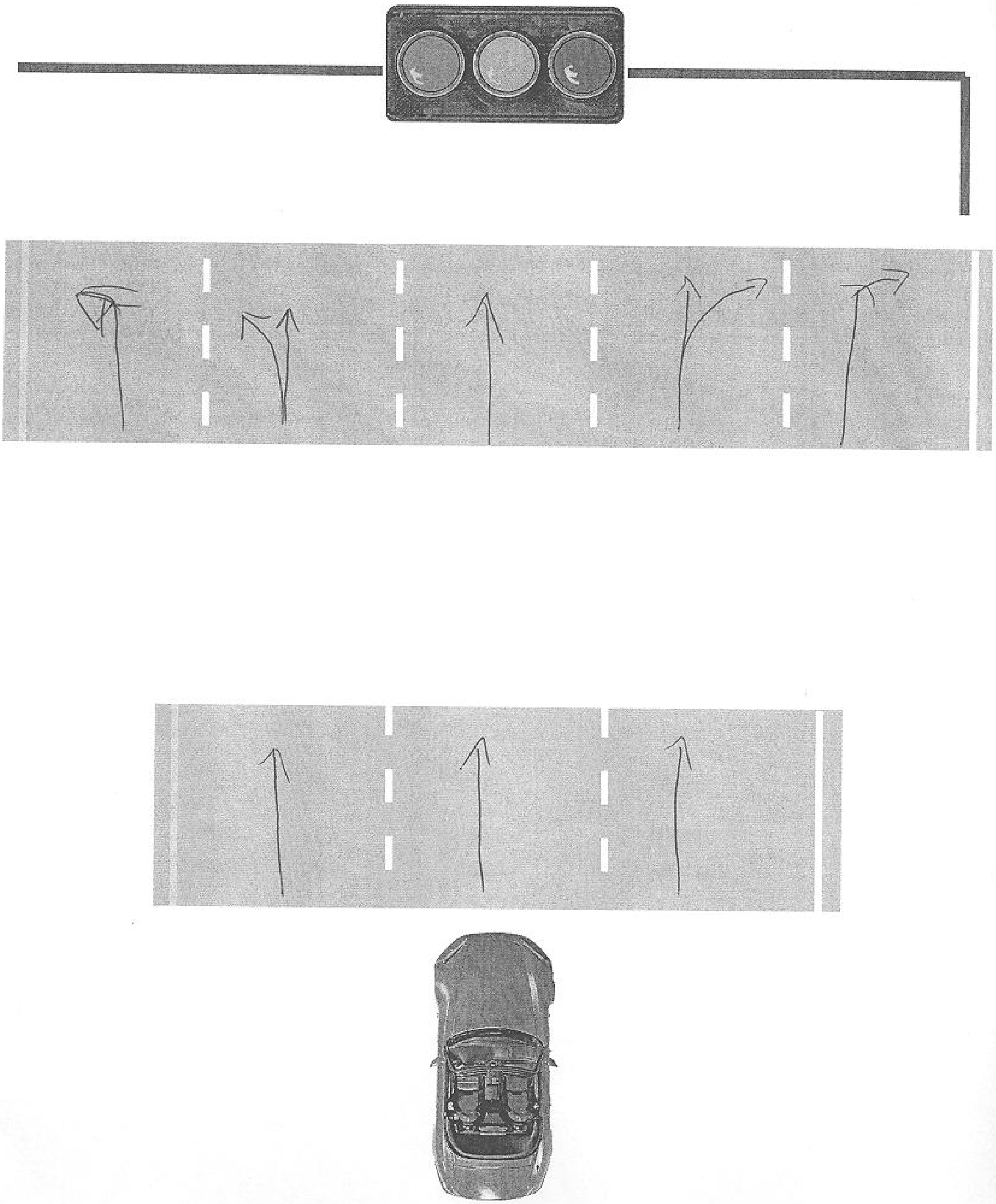
H-1


(NAME OF ~~NEXT~~ - INTER
STREET SECTION)
U-TURN ONLY
RIGHT TURN ONLY
U-TURN

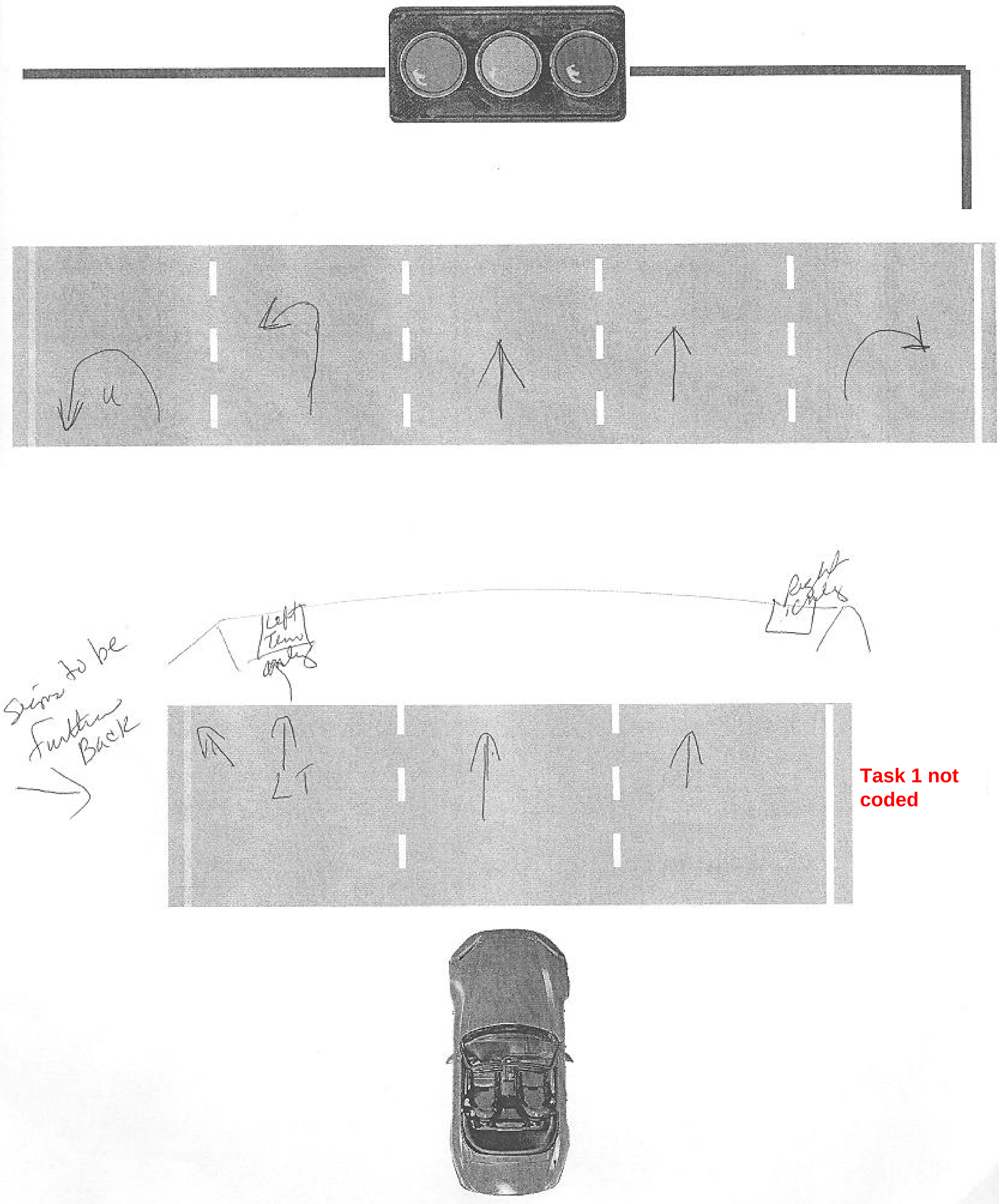
H-2



H-3

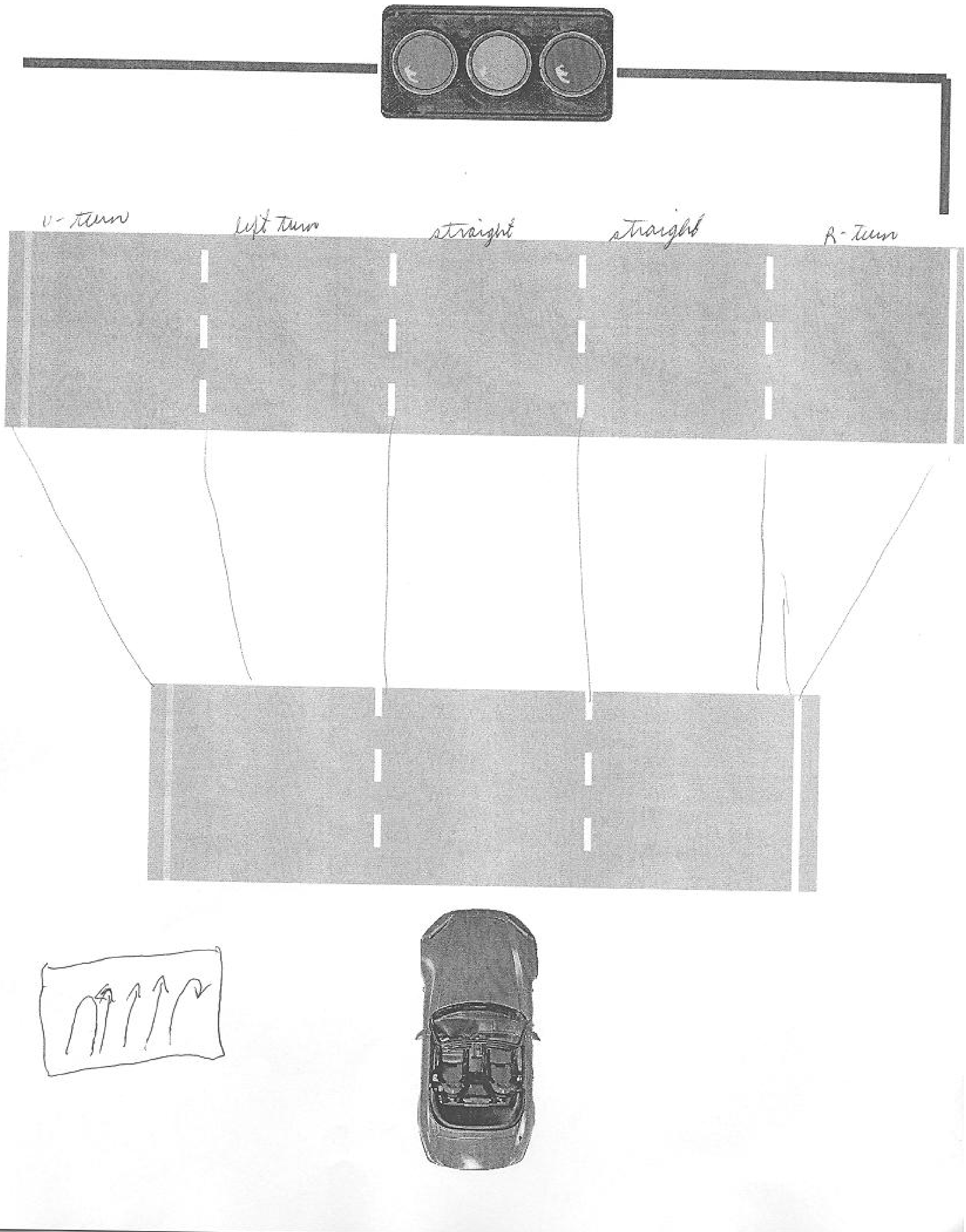


H-4

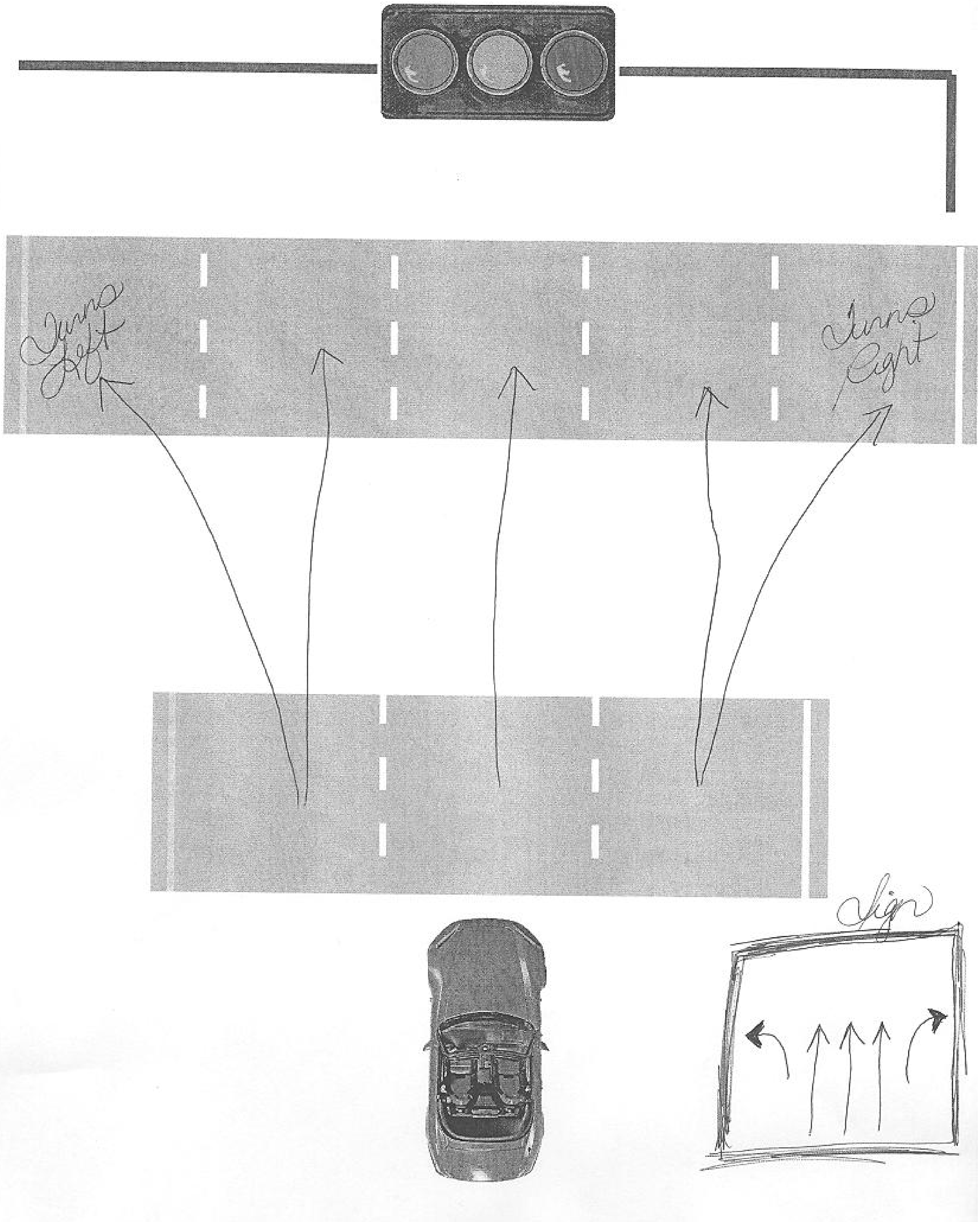


Task 1 not coded

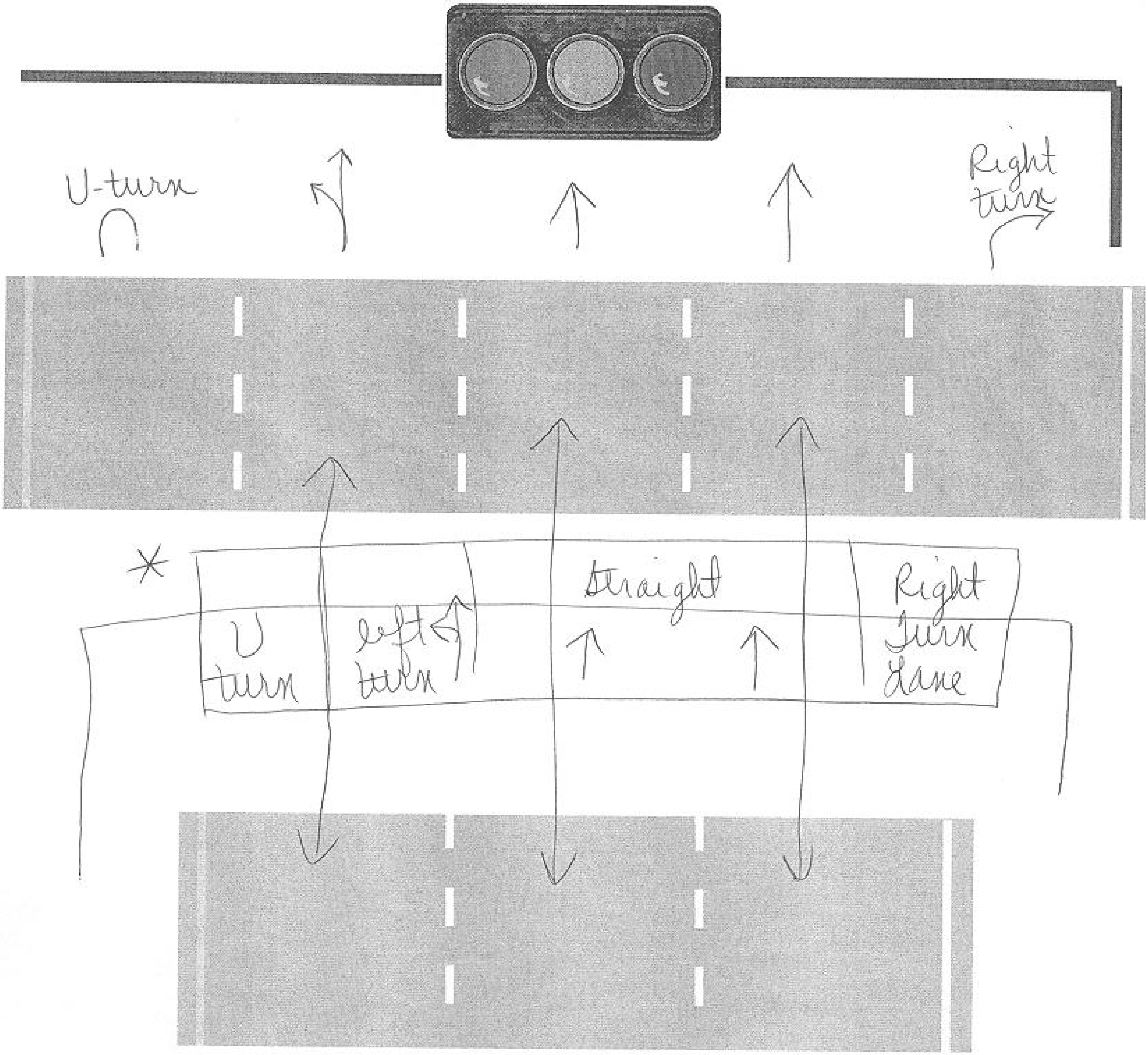
H-5

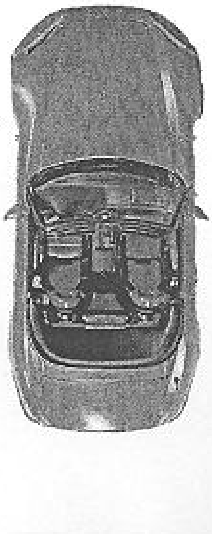


H-6



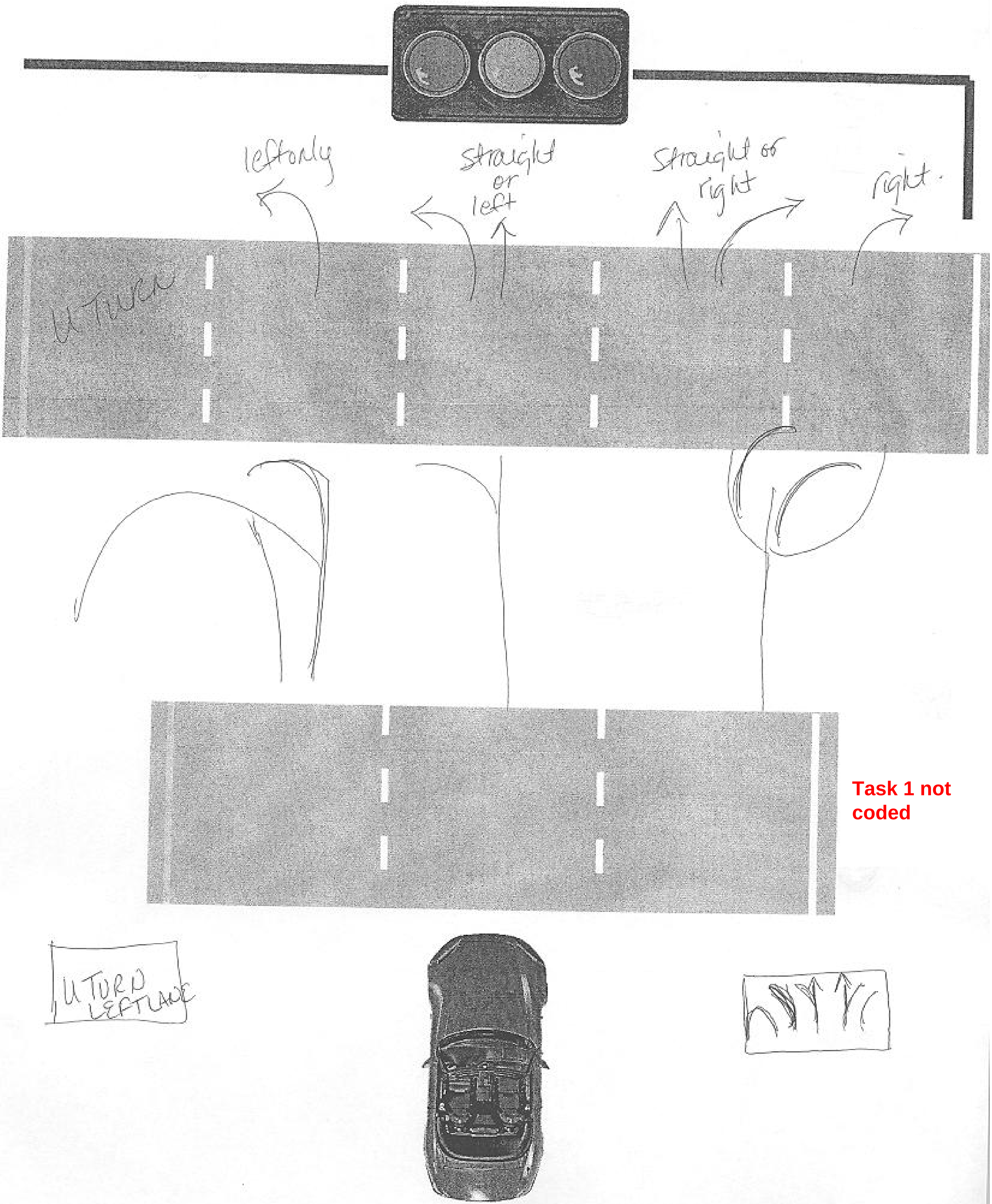
H-7





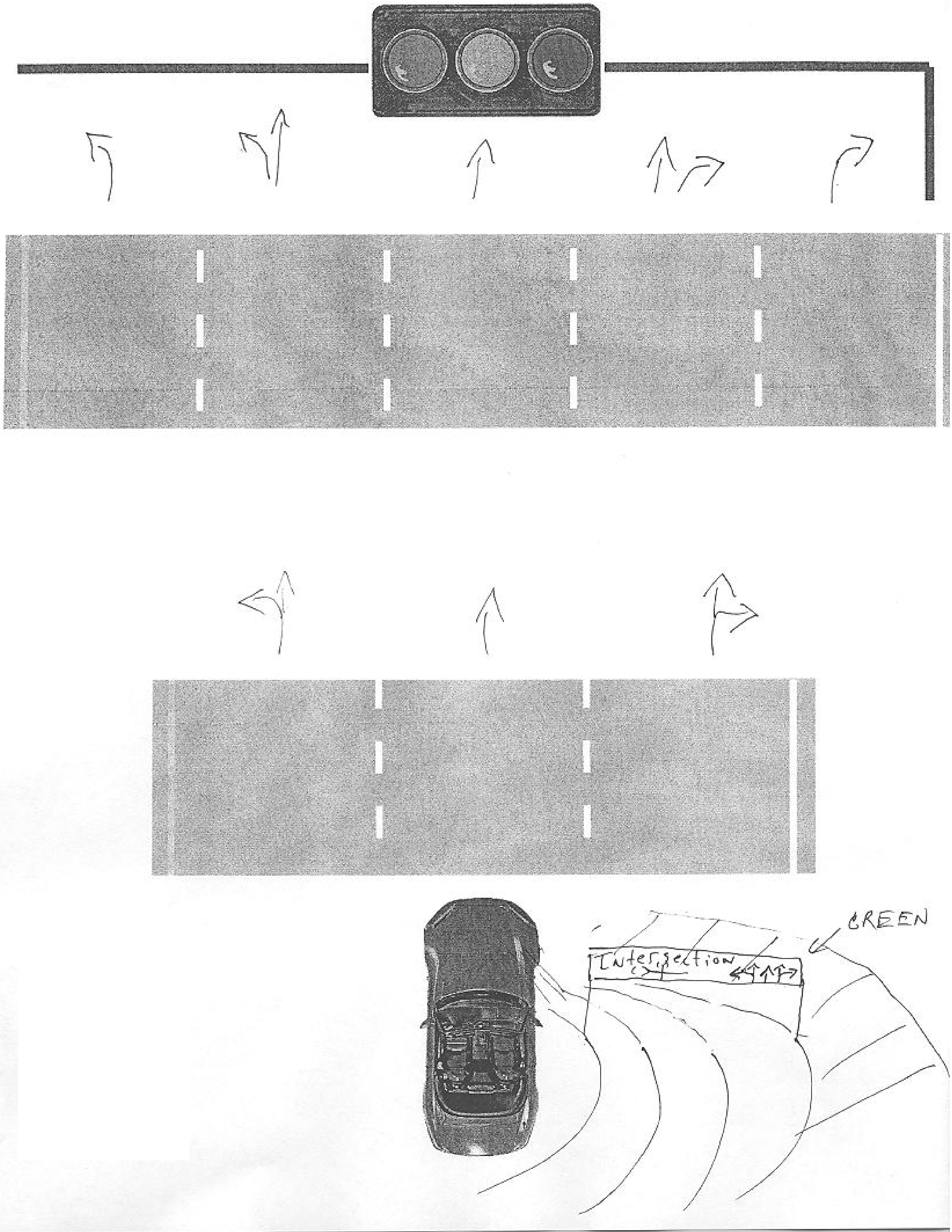
* Basically, a sign that depicts direction of each lane —

H-8

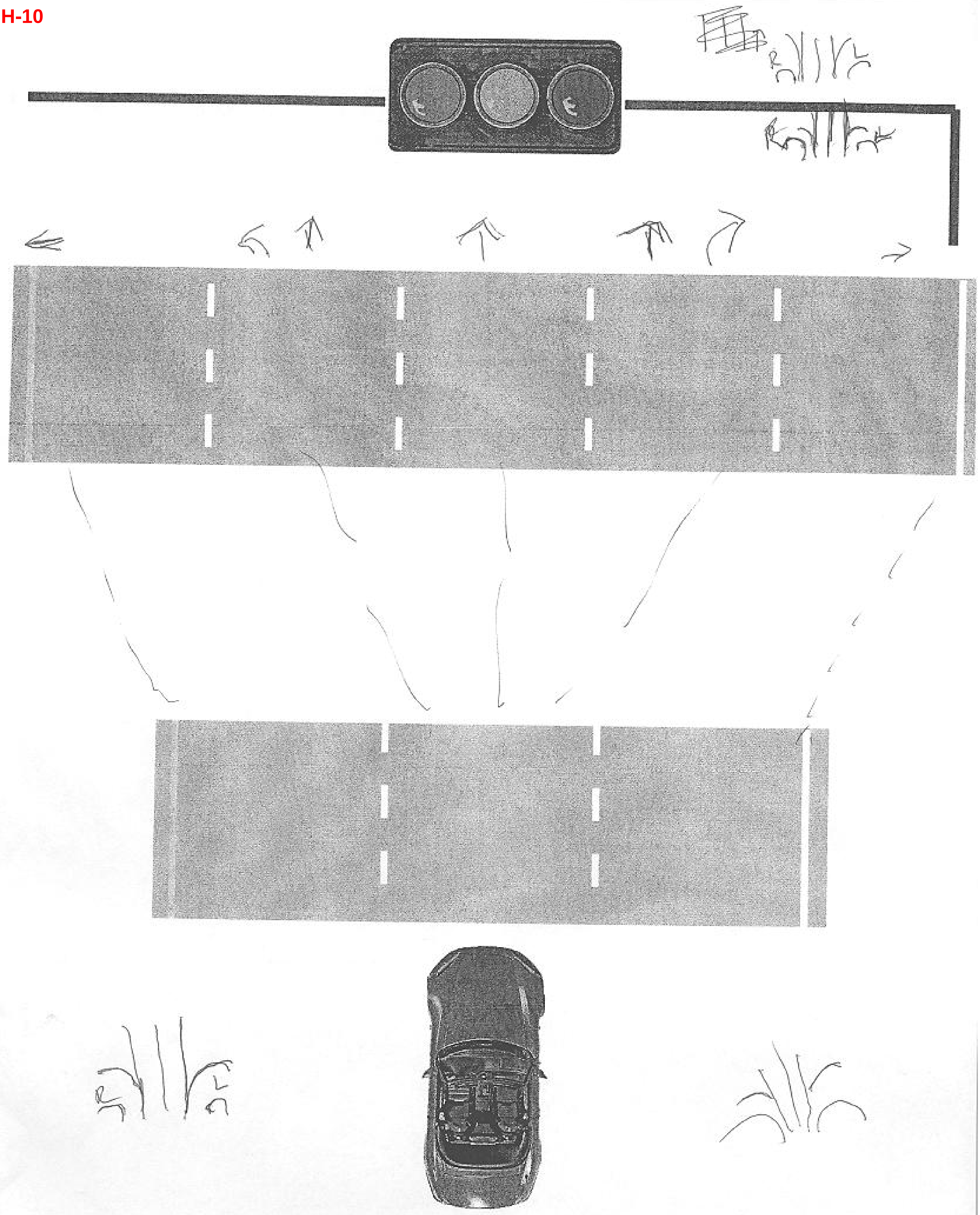


Task 1 not coded

H-9



H-10



APPENDIX F: DRIVER SURVEY INFORMATION FORM

Introduction

The purpose of this form is to provide you information that may affect your decision as to whether or not to participate in this research study. If you decide to participate in this study, this form will also be used to record your consent. You have been asked to participate in a research project studying signs and markings on Texas streets. You were selected to be a possible participant because you are a licensed driver at least 18 years old, and because you expressed interest in participating in this study. This study is being funded by the Texas Department of Transportation.

What will I be asked to do?

If you agree to participate in this study, you will be asked to complete a survey on a laptop.

What are the risks and benefits in this study?

The risks associated in this study are minimal, and are not greater than risks ordinarily encountered in daily life.

You will receive no direct benefit from participating in this study, but the data collected from this study may be used to improve roads in your area.

Do I have to participate?

No. Your participation is voluntary. You may decide not to participate or to withdraw at any time without your current or future relations with Texas A&M University or the Texas Department of Transportation being affected.

Will I be compensated?

You will receive $30 at the completion of this survey.

Who will know about my participation in this research study?

The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only the researchers conducting the study will have access to the records.

Whom do I contact with questions about the research?

If you have questions regarding this study, you may contact Alicia Nelson at 713-686-2971, e-mail a-nelson@tamu.edu.

Whom do I contact about my rights as a research participant?

This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, you can contact these offices at (979)458-4067 or irb@tamu.edu.

Please be sure you have read the above information, and asked questions and received answers to your satisfaction before continuing with the survey.

APPENDIX G: DRIVER SURVEY RESULTS

1.1A On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	28%	20%	28%	25%	25%
2	30%	46%	36%	43%	**39%**
3-Just Enough	40%	32%	36%	29%	34%
4	2%	2%	0%	2%	1%
5-Too Much	0%	0%	0%	0%	0%
Sample Size	50	50	53	51	204

Question 1.1A Stimulus and Results.

1.1B On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	6%	4%	9%	6%	6%
2	12%	16%	23%	27%	20%
3-Just Enough	68%	62%	57%	51%	**59%**
4	14%	18%	11%	16%	15%
5-Too Much	0%	0%	0%	0%	0%
Sample Size	50	50	53	51	204

Question 1.1B Stimulus and Results.

1.1C On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	4%	0%	6%	0%	2%
2	4%	0%	4%	4%	3%
3-Just Enough	38%	44%	49%	47%	**45%**
4	48%	38%	32%	37%	39%
5-Too Much	6%	18%	9%	12%	11%
Sample Size	50	50	53	51	204

Question 1.1C Stimulus and Results.

1.1 On a scale of 1-5, how much information has been provided about the intersection?			
Response	**1.1A**	**1.1B**	**1.1C**
1-Not Enough	25%	6%	2%
2	**39%**	20%	3%
3-Just Enough	34%	**59%**	**45%**
4	1%	15%	39%
5-Too Much	0%	0%	11%
Sample Size	204	204	204

Question 1.1 Comparisons.

1.2A On a scale of 1-5, how much information has been provided about the intersection?

Response	San Antonio	Austin	Dallas	College Station	Total
1-Not Enough	44%	44%	57%	57%	**50%**
2	26%	38%	26%	27%	29%
3-Just Enough	26%	18%	15%	14%	18%
4	4%	0%	2%	2%	2%
5-Too Much	0%	0%	0%	0%	0%
Sample Size	50	50	53	51	204

Question 1.2A Stimulus and Results.

1.2B On a scale of 1-5, how much information has been provided about the intersection?

Response	San Antonio	Austin	Dallas	College Station	Total
1-Not Enough	28%	22%	19%	29%	25%
2	32%	46%	38%	39%	**39%**
3-Just Enough	28%	22%	38%	22%	27%
4	12%	10%	2%	8%	8%
5-Too Much	0%	0%	4%	2%	1%
Sample Size	50	50	53	51	204

Question 1.2B Stimulus and Results.

1.2C On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	2%	0%	6%	0%	2%
2	4%	6%	4%	6%	5%
3-Just Enough	60%	58%	53%	65%	**59%**
4	20%	36%	28%	27%	28%
5-Too Much	14%	0%	9%	2%	6%
Sample Size	50	50	53	51	204

Question 1.2C Stimulus and Results.

1.2D On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	0%	0%	2%	0%	0%
2	0%	2%	0%	0%	0%
3-Just Enough	44%	32%	42%	43%	**40%**
4	36%	44%	40%	41%	**40%**
5-Too Much	20%	22%	17%	16%	19%
Sample Size	50	50	53	51	204

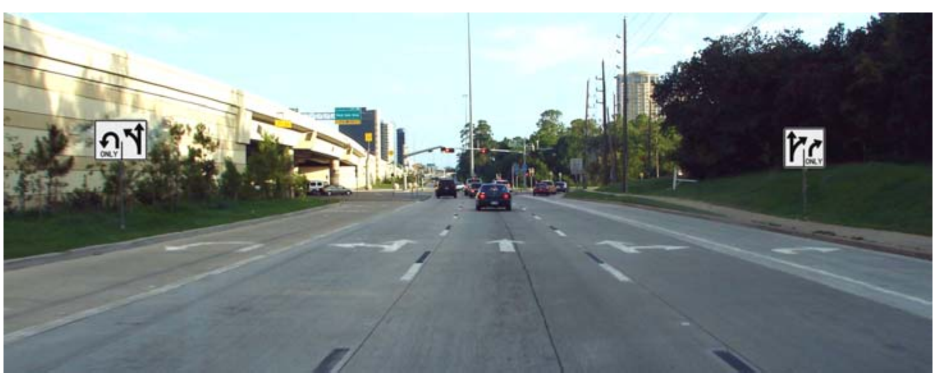
Question 1.2D Stimulus and Results.

1.2 On a scale of 1-5, how much information has been provided about the intersection?				
Response	**1.2A**	**1.2B**	**1.2C**	**1.2D**
1-Not Enough	**50%**	25%	2%	0%
2	29%	**39%**	5%	0%
3-Just Enough	18%	27%	**59%**	**40%**
4	2%	8%	28%	**40%**
5-Too Much	0%	1%	6%	19%
Sample Size	204	204	204	204

Question 1.2 Comparisons.

1.3A On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	8%	16%	17%	16%	14%
2	20%	40%	19%	39%	29%
3-Just Enough	52%	36%	42%	39%	**42%**
4	16%	8%	19%	4%	12%
5-Too Much	4%	0%	4%	2%	2%
Sample Size	50	50	53	51	204

Question 1.3A Stimulus and Results.

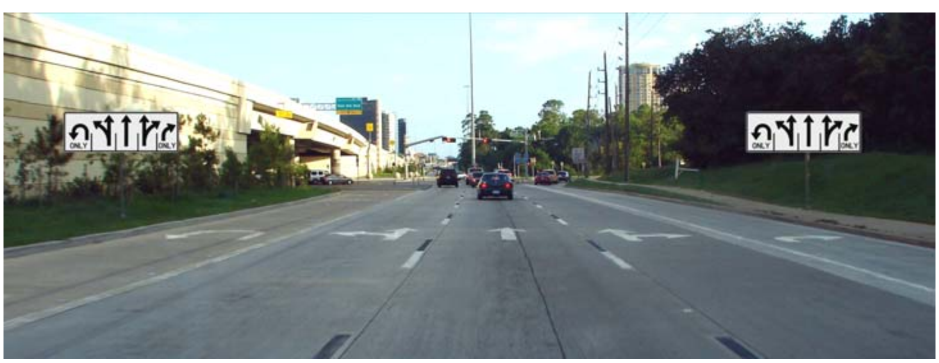


1.3B On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	2%	2%	4%	0%	2%
2	6%	12%	11%	24%	13%
3-Just Enough	40%	64%	40%	45%	**47%**
4	32%	20%	36%	31%	30%
5-Too Much	20%	2%	9%	0%	8%
Sample Size	50	50	53	51	204

Question 1.3B Stimulus and Results.

1.3C On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	0%	0%	0%	0%	0%
2	0%	2%	0%	6%	2%
3-Just Enough	16%	16%	23%	18%	18%
4	16%	20%	19%	29%	21%
5-Too Much	68%	62%	58%	47%	**59%**
Sample Size	50	50	53	51	204

Question 1.3C Stimulus and Results.

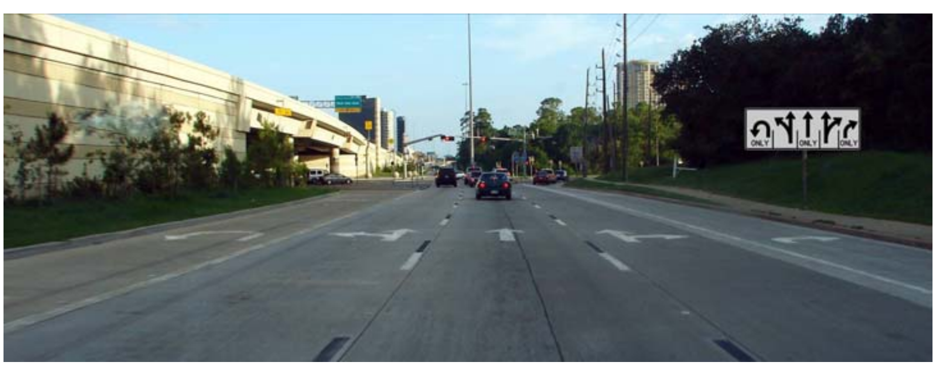


1.3D On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%
3-Just Enough	18%	12%	17%	24%	18%
4	20%	18%	21%	27%	22%
5-Too Much	62%	70%	62%	49%	**61%**
Sample Size	50	50	53	51	204

Question 1.3D Stimulus and Results.

1.3E On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	0%	0%	17%	0%	4%
2	0%	0%	19%	0%	5%
3-Just Enough	16%	10%	64%	14%	26%
4	22%	10%	0%	24%	14%
5-Too Much	62%	80%	0%	63%	**50%**
Sample Size	50	50	53	51	204

Question 1.3E Stimulus and Results.



1.3F On a scale of 1-5, how much information has been provided about the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1-Not Enough	10%	4%	2%	12%	7%
2	6%	18%	6%	18%	12%
3-Just Enough	32%	26%	32%	27%	29%
4	26%	34%	36%	31%	**32%**
5-Too Much	26%	18%	25%	12%	20%
Sample Size	50	50	53	51	204

Question 1.3F Stimulus and Results.

1.3 On a scale of 1-5, how much information has been provided about the intersection?							
Response	**1.3A**	**1.3B**	**1.3C**	**1.3D**	**1.3E**	**1.3F**	**Total**
1-Not Enough	14%	2%	0%	0%	4%	7%	5%
2	29%	13%	2%	0%	5%	12%	10%
3-Just Enough	**42%**	**47%**	18%	18%	26%	29%	30%
4	12%	30%	21%	22%	14%	**32%**	22%
5-Too Much	2%	8%	**59%**	**61%**	**50%**	20%	33%
Sample Size	204	204	204	204	204	204	1224

Question 1.3 Comparisons.

2.1A Which arrow represents what will happen the most often to the lane that Mike is in at the upcoming intersection? (Mike is in the **LEFT** Lane)

Response	San Antonio	Austin	Dallas	College Station	Total
	64%	68%	74%	76%	**71%**
	26%	30%	26%	22%	26%
	10%	2%	0%	2%	3%
Sample Size	50	50	53	51	204

Question 2.1A Stimulus and Results.

2.1B Which arrow represents what will happen the most often to the lane that Mike is in at the upcoming intersection? (Mike is in the **CENTER** Lane)					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
	0%	2%	0%	2%	1%
	40%	30%	15%	29%	28%
	52%	68%	83%	69%	**68%**
	8%	0%	2%	0%	2%
	0%	0%	0%	0%	0%
Sample Size	50	50	53	51	204

Question 2.1B Stimulus and Results.

2.1A Which arrow represents what will happen the most often to the lane that Mike is in at the upcoming intersection? (Mike is in the **RIGHT** Lane)					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
	20%	20%	9%	8%	14%
	52%	52%	45%	49%	**50%**
	28%	28%	45%	43%	36%
Sample Size	50	50	53	51	204

Question 2.1C Stimulus and Results.

2.1 Which arrow represents what will happen the most often to the lane that Mike is in at the upcoming intersection? (Answer Comparison for all 3 lanes)			
Response	**Left Lane**	**Center Lane**	**Right Lane**
	**71%**	1%	n/a
	26%	28%	n/a
	3%	**68%**	14%
	n/a	2%	**50%**
	n/a	0%	36%

Question 2.1 Comparisons.

2.2 What will Mike need to do the most often in order to travel in the **LEFT** direction (over the freeway) on the cross street?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Turn right before the overpass and turn left onto the cross street at a stop sign or signal	38%	68%	42%	55%	**50%**
B. Turn right after the overpass and loop around to join the cross street	62%	32%	58%	45%	**50%**
Sample Size	50	50	53	51	204

Question 2.2 Stimulus and Results.

2.3 What will Mike need to do the most often in order to travel in the **LEFT** direction on the freeway?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Turn left on the other side of the overpass	54%	50%	42%	61%	**51%**
B. Turn right on the other side of the overpass and loop around	46%	50%	58%	39%	49%
Sample Size	50	50	53	51	204

Question 2.3 Stimulus and Results.

3.1 Mike wants to drive on **Pinemill St West**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	27%	22%	9%	9%	17%
B. Right, after the overpass	73%	78%	91%	91%	**83%**
Sample Size	11	9	11	11	42

Question 3.1 Stimulus and Results.

3.2 Mike wants to drive on **Pinemill St West**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	10%	0%	27%	30%	17%
B. Right, after the overpass	90%	100%	73%	70%	**83%**
Sample Size	10	10	11	10	41

Question 3.2 Stimulus and Results.

3.3 Mike wants to drive on **White Oak Dr East**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	40%	40%	64%	50%	49%
B. Right, after the overpass	60%	60%	36%	50%	**51%**
Sample Size	10	10	11	10	41

Question 3.3 Stimulus and Results.

3.3B Which lanes can Mike be in to turn on **White Oaks Dr East**?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Left Only	5%	0%	5%	5%	4%
B. Center Only	5%	0%	0%	0%	1%
C. Right Only	71%	84%	82%	71%	**77%**
D. Left or Center	0%	0%	0%	5%	1%
E. Right or Center	19%	16%	14%	19%	17%
Sample Size	21	19	22	21	83

Question 3.3B Stimulus and Results.

3.3C Which lanes can Mike be in to turn on **Greene Rd North**?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Left Only	0%	0%	0%	0%	0%
B. Center Only	20%	30%	0%	30%	20%
C. Right Only	60%	0%	80%	50%	**48%**
D. Left or Center	0%	10%	0%	0%	3%
E. Right or Center	20%	60%	20%	20%	30%
Sample Size	10	10	10	10	40

Question 3.3C Stimulus and Results.

3.4 Mike wants to drive on **Dover Blvd North**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	21%	19%	14%	5%	15%
B. Right, after the overpass	79%	81%	86%	95%	**85%**
Sample Size	19	21	21	20	81

Question 2.4 Stimulus and Results.

3.5 Mike wants to drive on **Carter Rd South**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	56%	36%	0%	0%	23%
B. Right, after the overpass	44%	64%	100%	100%	**78%**
Sample Size	9	11	10	10	40

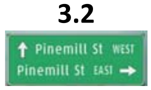
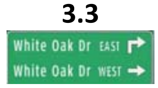
Question 3.5 Stimulus and Results.

3.6 Mike wants to drive on **South Route 8**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	11%	19%	30%	10%	18%
B. Right, after the overpass	89%	81%	70%	90%	**83%**
Sample Size	19	21	20	20	80

Question 3.6 Stimulus and Results.

3.7 Mike wants to drive on **Carter Rd South**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	25%	5%	10%	0%	10%
B. Right, after the overpass	75%	95%	90%	100%	**90%**
Sample Size	20	20	21	20	81

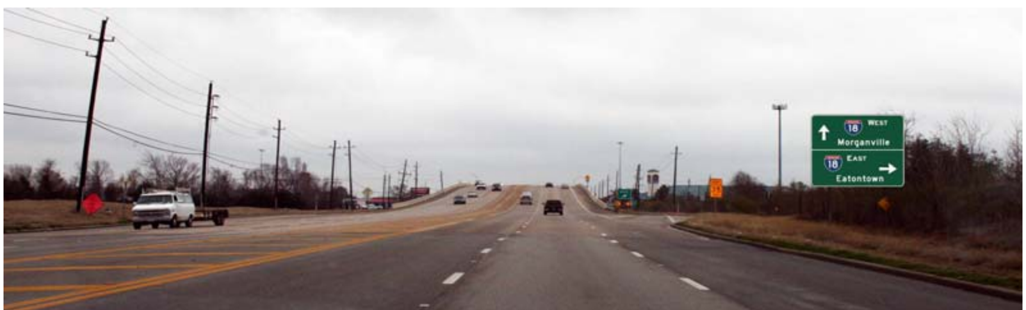
Question 3.7 Stimulus and Results.

3.1-3.7 Compared: Mike wants to drive on [**Pinemill St West**] where will he turn?							
Response	**3.1** 	**3.2** 	**3.3** 	**3.4** 	**3.5** 	**3.6** 	**3.7** 
A. Right, before the overpass	17%	17%	49%	15%	23%	18%	10%
B. Right, after the overpass	**83%**	**83%**	**51%**	**85%**	**78%**	**83%**	**90%**
Sample Size	42	41	41	81	40	80	81

Question 3.1-3.7 Comparisons.

3.3B and 3.3C Which lanes can Mike be in to turn on [**White Oaks Dr East**]?		
Response	**3.3B** 	**3.3C** 
A. Left Only	4%	0%
B. Center Only	1%	20%
C. Right Only	**77%**	**48%**
D. Left or Center	1%	3%
E. Right or Center	17%	30%
Sample Size	83	40

Question 3.3B and 3.3C Comparisons.



3.8 Mike wants to drive towards Morganville, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	18%	11%	0%	18%	12%
B. Left, before the overpass	0%	11%	9%	0%	5%
C. Right, after the overpass	73%	78%	64%	55%	**67%**
D. Left, after the overpass	9%	0%	27%	27%	17%
Sample Size	11	9	11	11	42

Question 3.8 Stimulus and Results.

3.9 Mike wants to drive towards Honover, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	10%	30%	9%	20%	17%
B. Left, before the overpass	20%	10%	36%	10%	20%
C. Right, after the overpass	0%	20%	27%	10%	15%
D. Left, after the overpass	70%	40%	27%	60%	**49%**
Sample Size	10	10	11	10	41

Question 3.9 Stimulus and Results.

3.10 Mike wants to drive towards Middletown, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	60%	50%	82%	60%	**63%**
B. Left, before the overpass	10%	0%	0%	0%	2%
C. Right, after the overpass	30%	50%	18%	40%	34%
D. Left, after the overpass	0%	0%	0%	0%	0%
Sample Size	10	10	11	10	41

Question 3.10 Stimulus and Results.

3.11 Mike wants to drive towards Dayton, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	0%	20%	10%	0%	8%
B. Left, before the overpass	0%	0%	10%	0%	3%
C. Right, after the overpass	80%	60%	60%	50%	**63%**
D. Left, after the overpass	20%	20%	20%	50%	28%
Sample Size	10	10	10	10	40

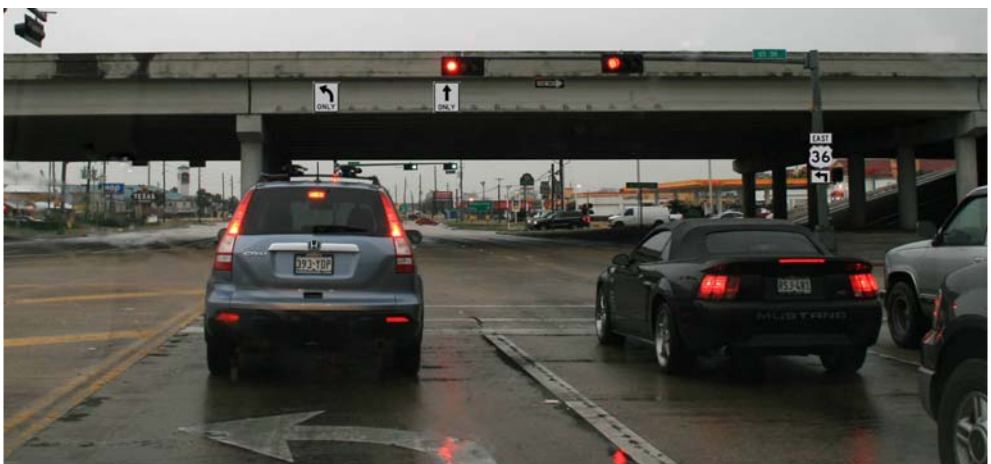
Question 3.11 Stimulus and Results.

3.8-3.11 Compared: Mike wants to drive towards (Fill in the blank), where will he turn?				
Response	**3.8** 	**3.9** 	**3.10** 	**3.11** 
A. Right, before the overpass	12%	17%	63%	8%
B. Left, before the overpass	5%	20%	2%	3%
C. Right, after the overpass	67%	15%	34%	63%
D. Left, after the overpass	17%	49%	0%	28%
Sample Size	42	41	41	40

Questions 3.8-3.11 Comparison.

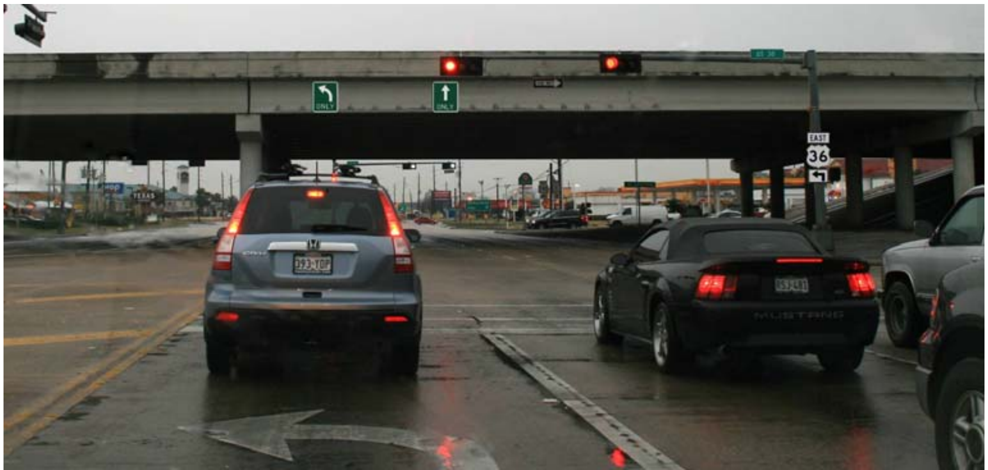
3.12 Mike wants to **enter the freeway**, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. First turn to the right	44%	36%	30%	30%	35%
B. Second turn to the right	56%	64%	70%	70%	**65%**
Sample Size	9	11	10	10	40

Question 3.12 Stimulus and Results.



4.1 Is the black sports car in the lane on your right allowed to turn left at the light?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Yes	2%	2%	2%	0%	1%
B. No	98%	98%	98%	100%	**99%**
Sample Size	50	50	53	51	204

Question 4.1 Stimulus and Results.



4.2 Is the black sports car in the lane on your right allowed to turn left at the light?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Yes	4%	0%	2%	0%	1%
B. No	96%	100%	98%	100%	**99%**
Sample Size	50	50	53	51	204

Question 4.2 Stimulus and Results.

4.1 and 4.2 Compared: Is the black sports car in the lane on your right allowed to turn left at the light?		
Response	**4.1**	**4.2**
A. Yes	1%	1%
B. No	99%	99%
Sample Size	204	204

Questions 4.1 and 4.2 Comparison.

5.1 Mike wants to drive in the LEFT direction when he gets to the freeway, which lane should he be in?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right	57%	63%	64%	71%	**64%**
B. Left	43%	37%	36%	29%	36%
Sample Size	21	19	22	21	83

Question 5.1 Stimulus and Results.

5.2 If Mike stays in this lane what options does he have at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Can turn left only	5%	0%	0%	0%	1%
B. Can turn left or go straight	10%	0%	5%	0%	4%
C. Can go straight only	5%	11%	9%	5%	7%
D. Can turn right or go straight	10%	5%	5%	10%	7%
E. Can turn right only	71%	84%	82%	86%	**81%**
Sample Size	21	19	22	21	83

Question 5.2 Stimulus and Results.

5.3 If Mike stays in this lane what options does he have at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Can turn left only	0%	0%	0%	10%	3%
B. Can turn left or go straight	5%	0%	0%	0%	1%
C. Can go straight only	21%	10%	10%	10%	13%
D. Can turn right or go straight	16%	5%	5%	5%	8%
E. Can turn right only	58%	86%	85%	75%	**76%**
Sample Size	19	21	20	20	80

Question 5.3 Stimulus and Results.

5.2 and 5.3 Compared: If Mike stays in this lane what options does he have at the intersection?		
Response	**5.2**	**5.3**
A. Can turn left only	1%	3%
B. Can turn left or go straight	4%	1%
C. Can go straight only	7%	13%
D. Can turn right or go straight	7%	8%
E. Can turn right only	81%	76%
Sample Size	83	80

Questions 5.2 and 5.3 Comparison.

5.4. Which addition to the sign on the right side of the picture do you prefer for making lane change decisions for an upcoming intersection?

Response	San Antonio	Austin	Dallas	College Station	Total
A. 500 FT RIGHT LANE MUST TURN RIGHT 500 FT	24%	18%	25%	18%	21%
B. AT SIGNAL RIGHT LANE MUST TURN RIGHT AT SIGNAL	50%	66%	60%	76%	**63%**
C. AHEAD RIGHT LANE MUST TURN RIGHT AHEAD	26%	16%	15%	6%	16%
Sample Size	50	50	53	51	204

Question 5.4 Stimulus and Results.

5.5A Imagine there is a signal coming up just out of view. If I am in Lane A, I will be forced to turn left at the signal?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	94%	98%	98%	98%	**97%**
B. False	6%	2%	2%	2%	3%
Sample Size	50	50	53	51	204

Question 5.5A Stimulus and Results.

5.5B Imagine there is a signal coming up just out of view. If I want to turn left, I must be in Lane A?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	90%	74%	91%	78%	**83%**
B. False	10%	26%	9%	22%	17%
Sample Size	50	50	53	51	204

Question 5.5B Stimulus and Results.

5.6A Imagine there is a signal coming up just out of view. If I am in Lane B, I will be forced to turn left at the signal?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	2%	2%	0%	0%	1%
B. False	98%	98%	100%	100%	**99%**
Sample Size	50	50	53	51	204

Question 5.6A Stimulus and Results.

5.6B Imagine there is a signal coming up just out of view. If I want to turn left, I must be in Lane A?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	28%	6%	23%	8%	16%
B. False	72%	94%	77%	92%	**84%**
Sample Size	50	50	53	51	204

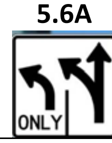
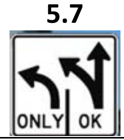
Question 5.6B Stimulus and Results.

5.7 Imagine there is a signal coming up just out of view. If I am in Lane B, I will be forced to turn left at the signal?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. True	6%	0%	0%	0%	1%
B. False	94%	100%	100%	100%	**99%**
Sample Size	50	50	53	51	204

Question 5.7 Stimulus and Results.

5.5B and 5.6B Imagine there is a signal coming up just out of view. If I want to turn left, I must be in Lane A?		
Response	**5.5B** 	**5.6B** 
A. True	**83%**	16%
B. False	17%	**84%**
Sample Size	204	204

Question 5.6A and 5.6B Comparison.

5.6A and 5.7 Compared: Imagine there is a signal coming up just out of view. If I am in Lane B, I will be forced to turn left at the signal?		
Response	**5.6A** 	**5.7** 
A. True	1%	1%
B. False	99%	99%
Sample Size	204	204

Question 5.6A and 5.7 Comparison.

5.8A If you turned left at the next intersection, what road would you turn onto?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Shady Grove Rd	64%	56%	73%	73%	**67%**
B. Pleasant St	36%	44%	27%	27%	33%
Sample Size	11	9	11	11	42

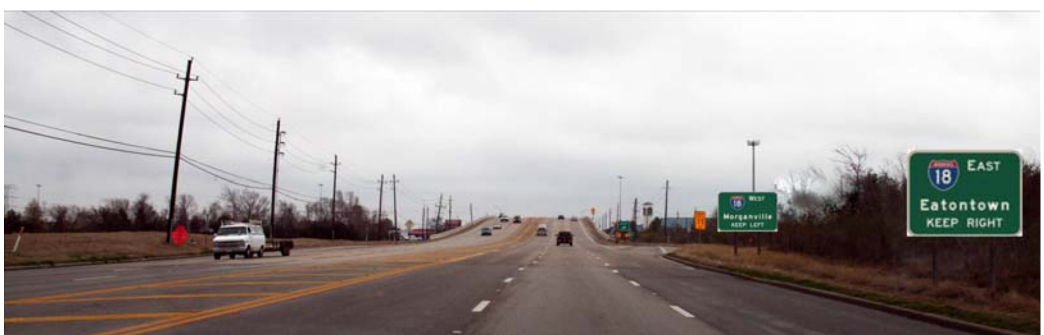
Question 5.8A Stimulus and Results.

5.8B If you turned left at the next intersection, what road would you turn onto?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Scott Blvd	70%	80%	64%	60%	**68%**
B. Lincoln Ave	30%	20%	36%	40%	32%
Sample Size	10	10	11	10	41

Question 5.8B Stimulus and Results.

5.9 Mike wants to drive East on I-10, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	20%	20%	0%	10%	12%
B. Left, before the overpass	10%	10%	0%	0%	5%
C. Right, after the overpass	70%	70%	100%	90%	**83%**
D. Left, after the overpass	0%	0%	0%	0%	0%
Sample Size	10	10	11	10	41

Question 5.9 Stimulus and Results.



5.10 Mike wants to drive towards Eatontown, where will he turn?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Right, before the overpass	60%	70%	80%	60%	**68%**
B. Left, before the overpass	10%	0%	0%	0%	3%
C. Right, after the overpass	30%	30%	20%	40%	30%
D. Left, after the overpass	0%	0%	0%	0%	0%
Sample Size	10	10	10	10	40

Question 5.10 Stimulus and Results.

5.11 Mike wants to drive East on I-18, where will he turn?

Response	San Antonio	Austin	Dallas	College Station	Total
A. Right, before the overpass	67%	64%	60%	60%	**63%**
B. Left, before the overpass	0%	0%	10%	10%	5%
C. Right, after the overpass	33%	36%	30%	30%	33%
D. Left, after the overpass	0%	0%	0%	0%	0%
Sample Size	9	11	10	10	40

Question 5.11 Stimulus and Results.

Binder Picture A

Binder Picture B

Binder Picture C

6.1 Which picture shows the cross street name in a location that does the BEST/WORST job at portraying the information?										
	BEST Job					WORST Job				
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
Picture A.	48%	32%	26%	33%	35%	24.00%	32.00%	43.40%	31.37%	32.84%
Picture B.	30%	48%	45%	31%	**39%**	18.00%	14.00%	5.66%	21.57%	14.71%
Picture C.	22%	20%	28%	35%	26%	58.00%	54.00%	50.94%	47.06%	**52.45%**
Sample Size	50	50	53	51	204	50	50	53	51	204

Questions 6.1A and 6.1B Stimuli and Results.

7.1 What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	18%	11%	0%	0%	7%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	36%	44%	64%	64%	**52%**
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	45%	44%	36%	36%	40%
Sample Size	11	9	11	11	42

Question 7.1 Stimulus and Results.

Omitted Question 7.1B Stimulus due to Survey Error.

7.1C What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	0%	0%	0%	0%	0%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	78%	82%	80%	70%	**78%**
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	22%	18%	20%	30%	23%
Sample Size	9	11	10	10	40

Question 7.1C Stimulus and Results.

7.2 What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	70%	60%	64%	80%	**68%**
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	0%	10%	0%	0%	2%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	30%	30%	36%	20%	29%
Sample Size	10	10	11	10	41

Question 7.2 Stimulus and Results.

7.2B What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	45%	33%	45%	45%	**43%**
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	18%	22%	9%	18%	17%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	36%	44%	45%	36%	40%
Sample Size	11	9	11	11	42

Question 7.2B Stimulus and Results.

7.2C What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	20%	60%	50%	50%	**45%**
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	20%	20%	20%	40%	25%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	60%	20%	30%	10%	30%
Sample Size	10	10	10	10	40

Question 7.2C Stimulus and Results.

7.3 What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	0%	0%	20%	0%	5%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	11%	18%	60%	40%	33%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	89%	82%	20%	60%	**63%**
Sample Size	9	11	10	10	40

Question 7.3 Stimulus and Results.

7.3B What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	20%	0%	0%	20%	10%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	50%	10%	70%	20%	38%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	30%	90%	30%	60%	**53%**
Sample Size	10	10	10	10	40

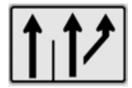
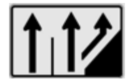
Question 7.3B Stimulus and Results.

7.3C What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	10%	0%	0%	0%	2%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	20%	20%	18%	30%	22%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	70%	80%	82%	70%	**76%**
Sample Size	10	10	11	10	41

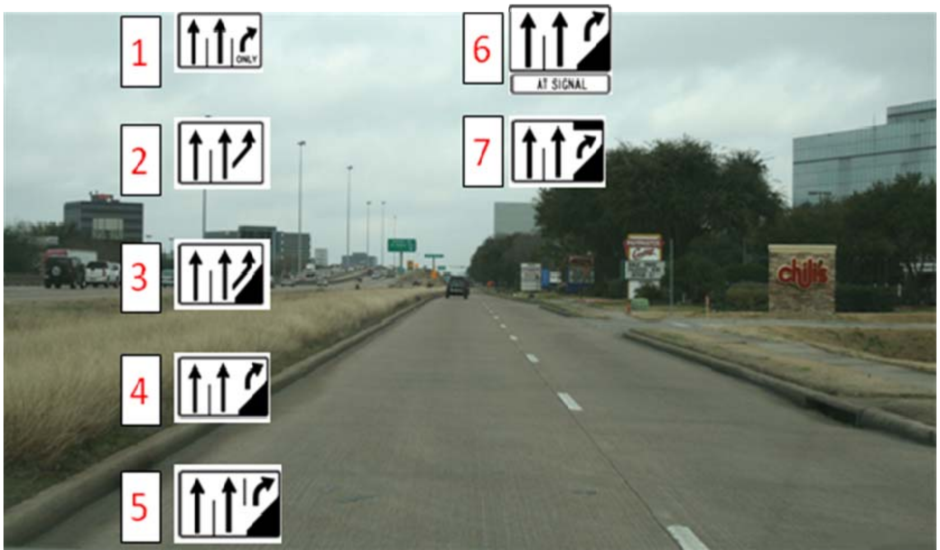
Question 7.3C Stimulus and Results.

7.3D What will happen to the far right lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	30%	20%	27%	10%	22%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	40%	20%	27%	20%	27%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	30%	60%	45%	70%	**51%**
Sample Size	10	10	11	10	41

Question 7.3D Stimulus and Results.

7.1-7.3D Compared: What will happen to the far right lane at the intersection?									
Response	**7.1** 	**7.1C** 	**7.2** 	**7.2B** 	**7.2C** 	**7.3** 	**7.3B** 	**7.3C** 	**7.3D** 
A. The road is widening and there is an additional lane added on the right. You can go straight or turn right from this new lane.	7%	0%	**68%**	**43%**	**45%**	5%	10%	2%	22%
B. At the intersection, if you are in the far right lane, you will be forced to turn right from this lane.	**52%**	**78%**	2%	17%	25%	33%	38%	22%	27%
C. The road is widening and there is an additional lane being added on the right. At the intersection you will be forced to turn right if you are in the new lane.	40%	23%	29%	40%	30%	**63%**	**53%**	**76%**	**51%**
Sample Size	42	40	41	42	40	40	40	41	41

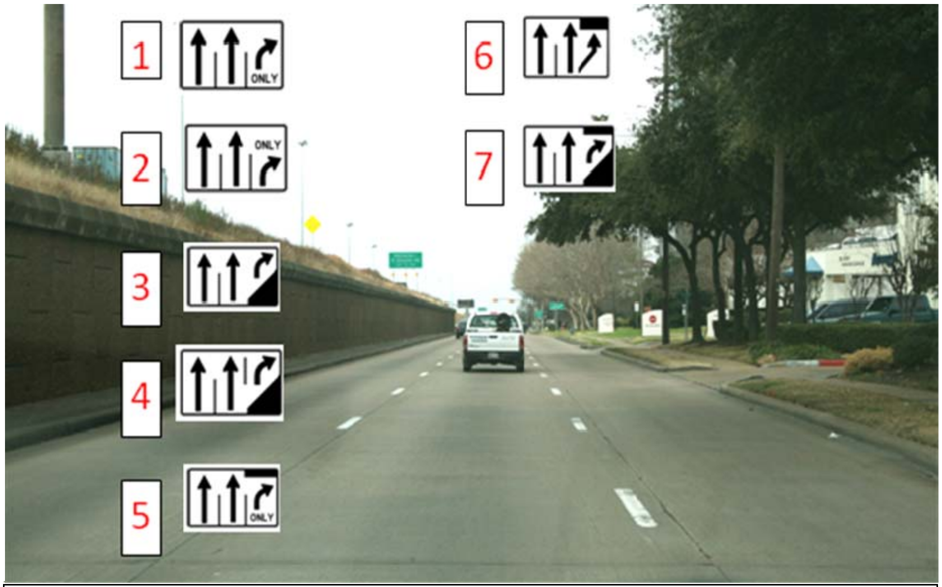
Question 7.3D Stimulus and Results.



7.4 Which of these signs do you think best indicates that the road is widening ahead and there is a lane being added on the right?

Response	San Antonio	Austin	Dallas	College Station	Total
1 - (Sign 7.1)	8%	4%	6%	6%	6%
2 - (Sign 7.2)	12%	4%	13%	14%	11%
3 - (Sign 7.2B)	40%	46%	47%	51%	**46%**
4 - (Sign 7.3)	0%	4%	2%	0%	1%
5 - (Sign 7.3B)	30%	20%	11%	10%	18%
6 - (Sign 7.3C)	6%	18%	15%	16%	14%
7 - (Sign 7.3D)	4%	4%	6%	4%	4%
Sample Size	50	50	53	51	204

Question 7.4 Stimulus and Results.



7.5 Which of these signs do you think best indicates that at the intersection ahead the far right lane MUST turn?

Response	San Antonio	Austin	Dallas	College Station	Total
1- (Sign 7.1)	42%	58%	42%	55%	**49%**
2- (Sign 7.1B)	28%	8%	17%	14%	17%
3 - (Sign 7.3)	4%	4%	2%	0%	2%
4 - (Sing 7.3B)	0%	0%	0%	4%	1%
5 - (Sign 7.1C)	22%	26%	40%	24%	28%
6 - (Sign 7.2C)	0%	0%	0%	0%	0%
7 - (Sign 7.3D)	4%	4%	0%	4%	3%
Sample Size	50	50	53	51	204

Question 7.5 Stimulus and Results.

7.6 What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Will turn left on unknown frontage road	28%	24%	23%	22%	24%
B. Will turn left on 47 South frontage road	36%	50%	47%	43%	**44%**
C. Will turn left on 47 South	30%	22%	19%	31%	25%
D. Will go straight on unknown road	4%	2%	6%	4%	4%
E. Will go straight on 47 South	2%	0%	6%	0%	2%
F. Will go straight on Majesty Ln	0%	2%	0%	0%	0%
Sample Size	50	50	53	51	204

Question 7.6 Stimulus and Results.

7.6B What will happen to the lane Mike is in at the intersection?

Response	San Antonio	Austin	Dallas	College Station	Total
A. Will turn left on unknown frontage road	18%	11%	9%	0%	10%
B. Will turn left on 36 East frontage road	64%	78%	27%	55%	**55%**
C. Will turn left on 36 East	18%	11%	64%	45%	36%
D. Will go straight on unknown road	0%	0%	0%	0%	0%
E. Will go straight on 36 East	0%	0%	0%	0%	0%
F. Will go straight on Palmer Rd	0%	0%	0%	0%	0%
Sample Size	11	9	11	11	42

Question 7.6B Stimulus and Results.

Omitted Question 7.6C Stimulus due to Survey Error.

7.6D What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Will turn left on unknown frontage road	40%	30%	20%	30%	30%
B. Will turn left on 66 East frontage road	20%	50%	60%	50%	**45%**
C. Will turn left on 66 East	30%	10%	20%	10%	18%
D. Will go straight on unknown road	0%	10%	0%	0%	3%
E. Will go straight on 66 East	0%	0%	0%	10%	3%
F. Will go straight on College St	10%	0%	0%	0%	3%
Sample Size	10	10	10	10	40

Question 7.6D Stimulus and Results.

7.6E What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Will turn left on unknown frontage road	0%	0%	0%	0%	0%
B. Will turn left on 55 North frontage road	50%	60%	27%	60%	**49%**
C. Will turn left on 55 North	30%	30%	64%	20%	37%
D. Will go straight on unknown road	10%	0%	0%	0%	2%
E. Will go straight on 55 North	0%	10%	0%	10%	5%
F. Will go straight on Greenwood Ave	10%	0%	9%	10%	7%
Sample Size	10	10	11	10	41

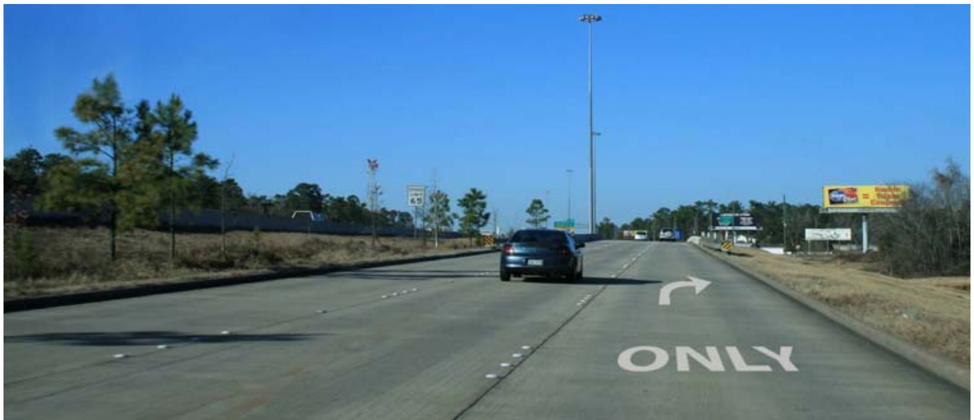
Question 7.6E Stimulus and Results.

7.6F What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Will turn left on unknown frontage road	20%	10%	9%	20%	15%
B. Will turn left on 24 West frontage road	30%	60%	64%	40%	**49%**
C. Will turn left on 24 West	50%	20%	18%	30%	29%
D. Will go straight on unknown road	0%	0%	0%	10%	2%
E. Will go straight on 24 West	0%	0%	0%	0%	0%
F. Will go straight on Crowell Rd	0%	10%	9%	0%	5%
Sample Size	10	10	11	10	41

Question 7.6F Stimulus and Results.

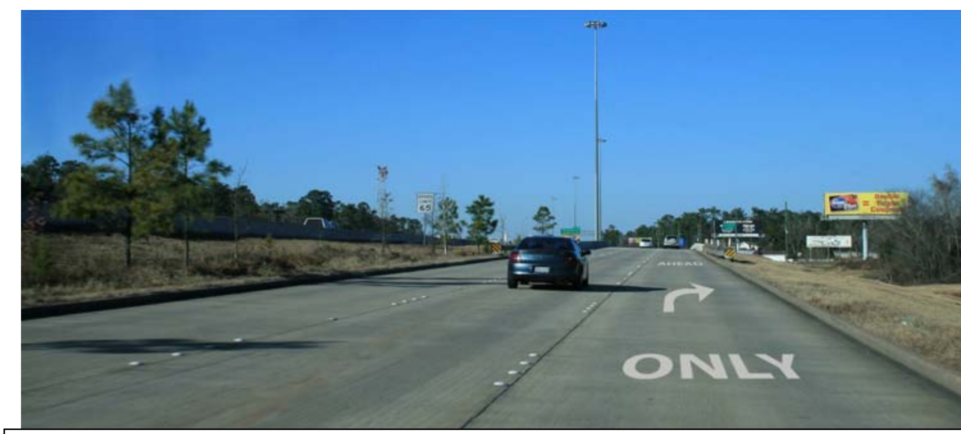
7.6-7.6F Compared: What will happen to the lane Mike is in at the intersection?					
Response	**7.6**	**7.6B**	**7.6D**	**7.6E**	**7.7F**
A. Will turn left on unknown frontage road	24%	10%	30%	0%	15%
B. Will turn left on [36 East] frontage road	**44%**	**55%**	**45%**	**49%**	**49%**
C. Will turn left on [36 East]	25%	36%	18%	37%	29%
D. Will go straight on unknown road	4%	0%	3%	2%	2%
E. Will go straight on [36 East]	2%	0%	3%	5%	0%
F. Will go straight on [Palmer Rd]	0%	0%	3%	7%	5%
Sample Size	204	42	40	41	41

Questions 7.6-7.6F Comparisons.



7.7A What will happen up ahead to the lane Mike is in?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. It will go straight only	40%	0%	10%	20%	18%
B. It can go straight or right	0%	0%	10%	10%	5%
C. It will turn right only	60%	100%	80%	70%	**78%**
Sample Size	10	10	10	10	40

Question 7.7A Stimulus and Results.



7.7B What will happen up ahead to the lane Mike is in?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. It will go straight only	10%	0%	0%	0%	2%
B. It can go straight or right	10%	10%	9%	0%	7%
C. It will turn right only	80%	90%	91%	100%	**90%**
Sample Size	10	10	11	10	41

Question 7.7B Stimulus and Results.

7.7C What will happen up ahead to the lane Mike is in?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. It will go straight only	10%	0%	0%	10%	5%
B. It can go straight or right	0%	10%	0%	10%	5%
C. It will turn right only	90%	90%	100%	80%	**90%**
Sample Size	10	10	11	10	41

Question 7.7C Stimulus and Results.

7.7D What will happen up ahead to the lane Mike is in?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. It will go straight only	22%	0%	30%	0%	13%
B. It can go straight or right	22%	18%	0%	0%	10%
C. It will turn right only	56%	82%	70%	100%	**78%**
Sample Size	9	11	10	10	40

Question 7.7D Stimulus and Results

7.7A-7.7D Compared: What will happen up ahead to the lane Mike is in?				
Response	**7.7A** 	**7.7B** 	**7.7C** 	**7.7D** 
A. It will go straight only	18%	2%	5%	13%
B. It can go straight or right	5%	7%	5%	10%
C. It will turn right only	**78%**	**90%**	**90%**	**78%**
Sample Size	40	41	41	40

Questions 7.7A-7.7D Comparisons.

7.8 Which of these markings do you think best tells you what will happen to the lane at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
1- (7.7A)	4%	8%	9%	4%	6%
2- (7.7B)	38%	30%	34%	37%	35%
3 - (7.7C)	20%	4%	9%	4%	9%
4 - (7.7D)	38%	58%	47%	55%	**50%**
Sample Size	50	50	53	51	204

Question 7.8 Stimulus and Results.

7.9 What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike will be forced to turn left at the intersection	50%	55%	76%	65%	**62%**
B. Mike can turn left or drive straight at the intersection	50%	45%	24%	35%	38%
C. Mike can only drive straight at the intersection	0%	0%	0%	0%	0%
Sample Size	20	20	21	20	81

Question 7.9 Stimulus and Results.

7.9B What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike will be forced to turn left at the intersection	33%	26%	41%	29%	33%
B. Mike can turn left or drive straight at the intersection	62%	68%	59%	71%	**65%**
C. Mike can only drive straight at the intersection	5%	5%	0%	0%	2%
Sample Size	21	19	22	21	83

Question 7.9B Stimulus and Results.

7.10 What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike can only drive straight at the intersection	6%	2%	2%	2%	3%
B. Mike can turn right or drive straight at the intersection	50%	44%	51%	41%	47%
C. Mike will be forced to turn right at the intersection	44%	54%	47%	57%	**50%**
Sample Size	50	50	53	51	204

Question 7.10 Stimulus and Results.

7.10B What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike can only drive straight at the intersection	18%	11%	0%	0%	7%
B. Mike can turn right or drive straight at the intersection	55%	78%	82%	82%	**74%**
C. Mike will be forced to turn right at the intersection	27%	11%	18%	18%	19%
Sample Size	11	9	11	11	42

Question 7.10B Stimulus and Results.

7.10C What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike can only drive straight at the intersection	0%	0%	0%	0%	0%
B. Mike can turn right or drive straight at the intersection	50%	40%	73%	50%	**54%**
C. Mike will be forced to turn right at the intersection	50%	60%	27%	50%	46%
Sample Size	10	10	11	10	41

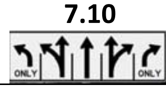
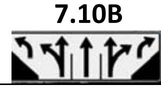
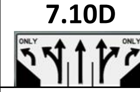
Question 7.10C Stimulus and Results.

7.10D What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike can only drive straight at the intersection	22%	9%	0%	0%	8%
B. Mike can turn right or drive straight at the intersection	67%	45%	80%	80%	**68%**
C. Mike will be forced to turn right at the intersection	11%	45%	20%	20%	25%
Sample Size	9	11	10	10	40

Question 7.10D Stimulus and Results.

7.10E What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike can only drive straight at the intersection	0%	0%	40%	20%	15%
B. Mike can turn right or drive straight at the intersection	60%	90%	30%	70%	**63%**
C. Mike will be forced to turn right at the intersection	40%	10%	30%	10%	23%
Sample Size	10	10	10	10	40

Question 7.10E Stimulus and Results.

7.10-7.10E Compared: What will happen to the lane Mike is in at the intersection?					
Response	**7.10** 	**7.10B** 	**7.10C** 	**7.10D** 	**7.10E** 
A. Mike can only drive straight at the intersection	3%	7%	0%	8%	15%
B. Mike can turn right or drive straight at the intersection	47%	**74%**	**54%**	**68%**	**63%**
C. Mike will be forced to turn right at the intersection	**50%**	19%	46%	25%	23%
Sample Size	204	42	41	40	40

Question 7.10-7.10E Comparisons.

7.11 What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike will be forced to turn left at the intersection	62%	86%	68%	82%	**75%**
B. Mike can turn left or drive straight at the intersection	30%	12%	25%	12%	20%
C. Mike can only drive straight at the intersection	8%	2%	8%	6%	6%
Sample Size	50	50	53	51	204

Question 7.11 Stimulus and Results.

7.11B What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike will be forced to turn left at the intersection	67%	47%	50%	81%	**61%**
B. Mike can turn left or drive straight at the intersection	29%	47%	50%	14%	35%
C. Mike can only drive straight at the intersection	5%	5%	0%	5%	4%
Sample Size	21	19	22	21	83

Question 7.11B Stimulus and Results.

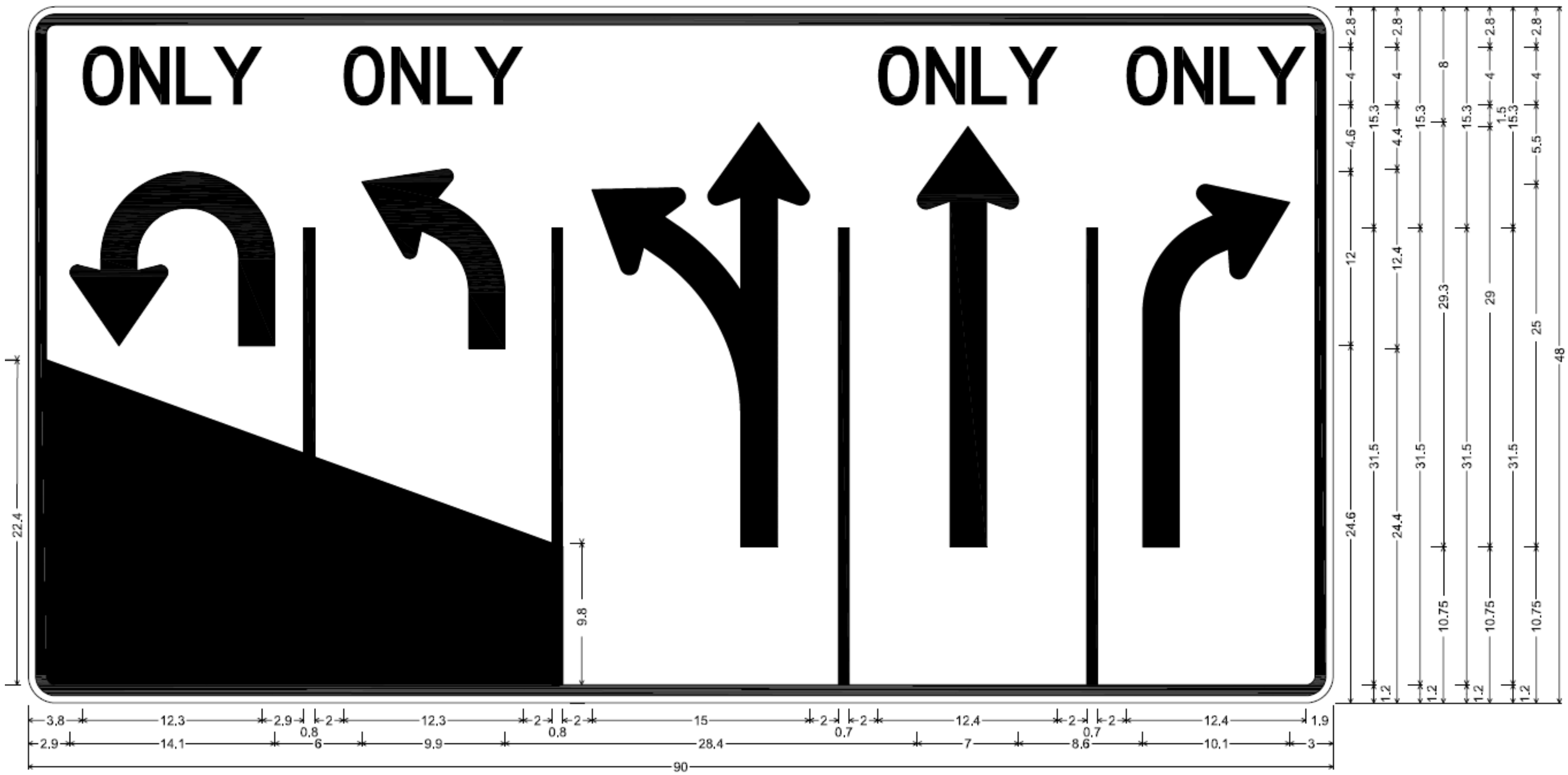
7.11C What will happen to the lane Mike is in at the intersection?					
Response	**San Antonio**	**Austin**	**Dallas**	**College Station**	**Total**
A. Mike will be forced to turn left at the intersection	32%	43%	48%	30%	38%
B. Mike can turn left or drive straight at the intersection	53%	38%	29%	40%	**40%**
C. Mike can only drive straight at the intersection	16%	19%	24%	30%	22%
Sample Size	19	21	21	20	81

Question 7.11C Stimulus and Results.

7.11-7.11C Compared: What will happen to the lane Mike is in at the intersection?			
Response	**7.11** 	**7.11B** 	**7.11C** 
A. Mike will be forced to turn left at the intersection	**75%**	**61%**	38%
B. Mike can turn left or drive straight at the intersection	20%	35%	**40%**
C. Mike can only drive straight at the intersection	6%	4%	22%
Sample Size	204	83	81

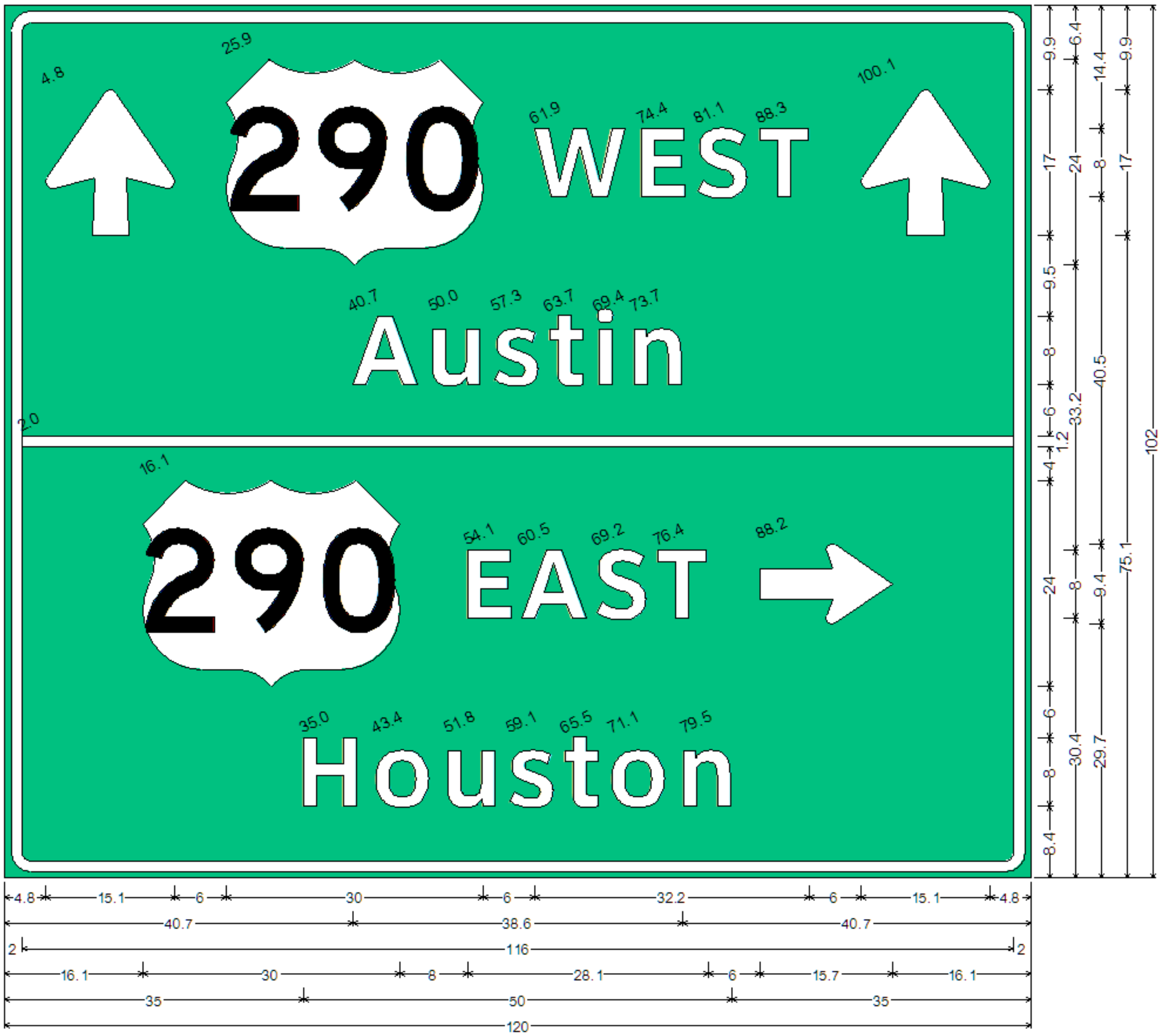
Question 7.11-7.11C Comparisons.

APPENDIX H: FIELD TESTED SIGN DETAILS



R3-8_90X48 (MOD); 1.9" Radius, 0.8" Border, 0.5" Indent, Black on White;
[ONLY] D 50% spacing; UL lr=3.5, s=2.5; [ONLY] D 50% spacing; L lr=4.25, s=2.5; M lr=13.25, s=2.5; [ONLY] D 50% spacing; S h=19.125, s=2.5; [ONLY] D 50% spacing; L lr=4.5, s=2.5;

Figure H-1. Modified R3-8 Sign Used in Field Test on I-45 Southbound Frontage Road at Cypresswood Drive



3.0" Radius, 1.3" Border, 0.8" Indent, White on Green;
Arrow 80 - 17.0" 90°; "WEST" ClearviewHwy-5-W-R; Arrow 80 - 17.0" 90°; "Austin" ClearviewHwy-5-W-R; "EAST" ClearviewHwy-5-W-R;
Standard Arrow Custom 15.6" X 9.4" 0°; "Houston" ClearviewHwy-5-W-R;

Figure H-2. Sign Used in Field Test on West Little York Drive, West of US 290