Reversible Lanes in Utah - Adding Efficiency Safely

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Paper prepared for presentation

at the Innovative Ways to Increase Traffic Safety and Efficiency Session

of the 2010 Annual Conference of the
Transportation Association of Canada
Halifax, Nova Scotia

ABSTRACT

AECOM developed the preliminary concept and final design for a three kilometre long reversible lane system for SR-173 (5400 South) in the Salt Lake City metro area of Utah. The goal of this project was to increase east/west mobility for western Salt Lake County. Reversible lanes were selected to reduce commute times and congestion on SR-173 without the need to construct additional lanes. The system can reverse three lanes of an existing seven lane urban arterial as needed to accommodate peak commute, special event, and emergency traffic. Unlike most reversible lane systems currently in operation, the uniqueness of the SR-173 system is that it can accommodate a two-way left turn lane which shifts with the reversing traffic lanes.

This three kilometre long project required 18 signal structures (gantries) with changeable lane control signals placed over each lane. These gantries were placed and designed to allow for clear and safe transitions into and out of the reversible lane system. Within the system, gantries were placed and interconnected to work together as one system that includes coordination and communication with intersection traffic signals.

Shifting left turns at signalized intersections from one lane to another creates unique safety and operational challenges. These challenges were addressed through innovative design and the application of state of the art traffic signal technology. Traffic signals employed dual function signal heads that can display either a ball or an arrow for the same lane. These signals were supplemented by changeable (blank out) signs to provide clear and positive direction to drivers. AECOM also defined a simple yet effective traffic signal operation plan to ensure that left turn lanes are safely cleared before transitioning the lane to opposing traffic.

Because reversible lanes were new to both UDOT and the local driving public, the project required extensive stakeholder coordination and public outreach. AECOM worked closely with the UDOT TOC (the state-wide traffic management center), UDOT Region 2 Traffic and Safety Division, the City of Taylorsville, and other key stakeholders to meet operational, safety, and functional requirements. In-house experience with this type of project also allowed AECOM to anticipate and effectively address public comments and concerns.

Reversible Lanes in Utah – Adding Efficiency Safely

Introduction

This paper describes the unique solution that was developed for the Utah DOT to improve the efficiency of a major east-west urban arterial using existing road infrastructure, while maintaining a shifting two-way left turn lane and addressing the safety and operational challenges that arose from the design concept.

The paper is divided into two parts, the first providing some basic concepts and some history about reversible lanes, and the second providing a description of the unique features of the system that were designed for this project.

Reversible Lane System (RLS) Concept Background and Concepts

A reversible lane system can be defined as: "*A reversible lane or roadway is one in which the direction of traffic flow in one or more lanes or shoulders is reversed to the opposing direction for a temporary period of time.*"[1]

An RLS is one just treatment of many that can be considered when dealing with congestion issues. They have the capability of making better use of existing infrastructure by utilizing the total capacity of the roadway, and are sometimes a less expensive means of improving mobility under certain circumstances.

They may have application where the roadway right-of-way is constrained or there is an environmentally sensitive area adjacent to the existing roadway, or there is a physical constraint such as on a bridge structure. Before considering an RLS solution, there are some key elements that should exist:

- heavy directional split (~65/35) during peak hours
- heavy recurring congestion (indicating commuter traffic)
- limited left turns to or from the main corridor

Some of the benefits to be derived from and RLS include:

- optimize efficiency of available infrastructure
- flexible response to changing traffic demand
- efficient use of parallel arterials
- reduced congestion (during critical peak periods)

There are also some risks, or negative impacts in the implementation of RLS. They include:

- potential for left turn collisions
- pedestrian safety with the changing lane configurations
- restricted parking
- restricted access

Reversible Lane Systems are not new. The first identified system was on 8th Street in Los Angeles CA in 1928. The one on Wilshire Boulevard in 1937 illustrated in Figure 1 utilizes traffic cones and signs that are manually installed during the peak periods.

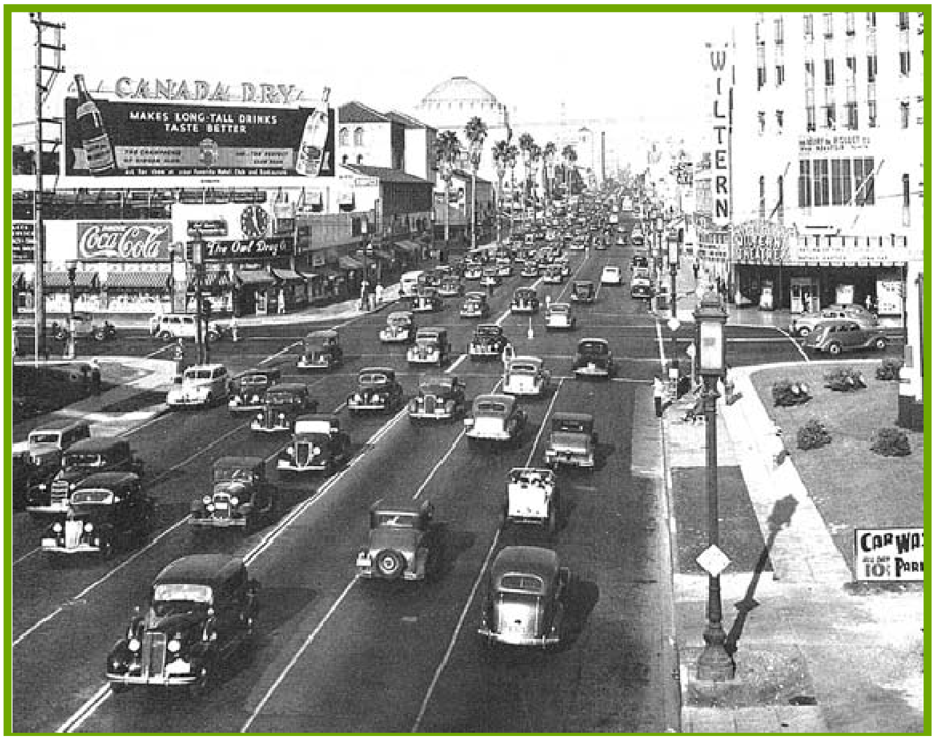


Figure 1 - Wilshire Blvd, Los Angeles, 1937

(Source: http://www.ci.la.ca.us/ladot/TopicsAndTales/Pavementmark4.pdf - Accessed in November 2008)

Design Elements of RLS

There are many design elements that need to be considered when considering an RLS. They include: signing (static or dynamic); pavement markings; transition intervals and interaction with traffic signals.

Signing for RLS can take a static form, where the signs are installed along the corridor indicating what times the reversible lanes are in effect. Figure 2 shows how this is provided. This is an inexpensive method of achieving an RLS, however it also depends on the driver to be very knowledgeable about the roadway and the operating times.

Alternatively, installing lane control signals above each reversing lane (controlled by a central timer or control system) provides positive direction to the drivers as they approach the corridor. Figure 3 shows an example of this type of a system.

Figure 2 – Static Signing on Connecticut Ave, Washington, DC
(Source: NCHRP Synthesis 340)

Figure 3 – Dynamic Signing – Vancouver BC
(Source: http://en.wikipedia.org/wiki/Image:Lions_Gate.jpg – Accessed November 2008)

Another element of an RLS that plays a large role in meeting drivers' expectations is the pavement markings. In this case, it seems to be pretty standard in most systems to use a double yellow skip line on either side of any lanes that are reversible. Figure 4 illustrates this concept.

Figure 4 – Lane Striping - Coleville Road, MD
(source: http://greatergreaterwashington.org/post.cgi?id=2953, accessed May 10 2010)

Transitioning into and out of reversible lanes has two components: temporal transition and spatial transition.

The temporal transition consists of the time periods necessary to move traffic out of one lane and then transition the opposing traffic into that lane. This is illustrated in Figure 5, where there are three lanes in one direction and two in the other. In this case, the "A" direction goes to a yellow "X" for a period of time and them to a red "X" before the middle lane in the opposite direction gets a green arrow. The timing of these intervals is dependent on the speed of traffic, the length of the corridor and the intervening intersections along the corridor.

There are also spatial transition zones to consider in RLS. At the terminus of the facility, the approach and departure zones must be well marked so that the driver's expectations are met. As shown in Figure 6, the entry and exit zones must allow the drivers to move into or out of the reversible lanes, and the travel zone must re-confirm that the driver is still in the correct lane. Depending on the length of the RLS, there may be many gantries in the travel zone to ensure the drivers are still in the correct lanes, as well as to ensure that any entering drivers from side streets know where they should be.

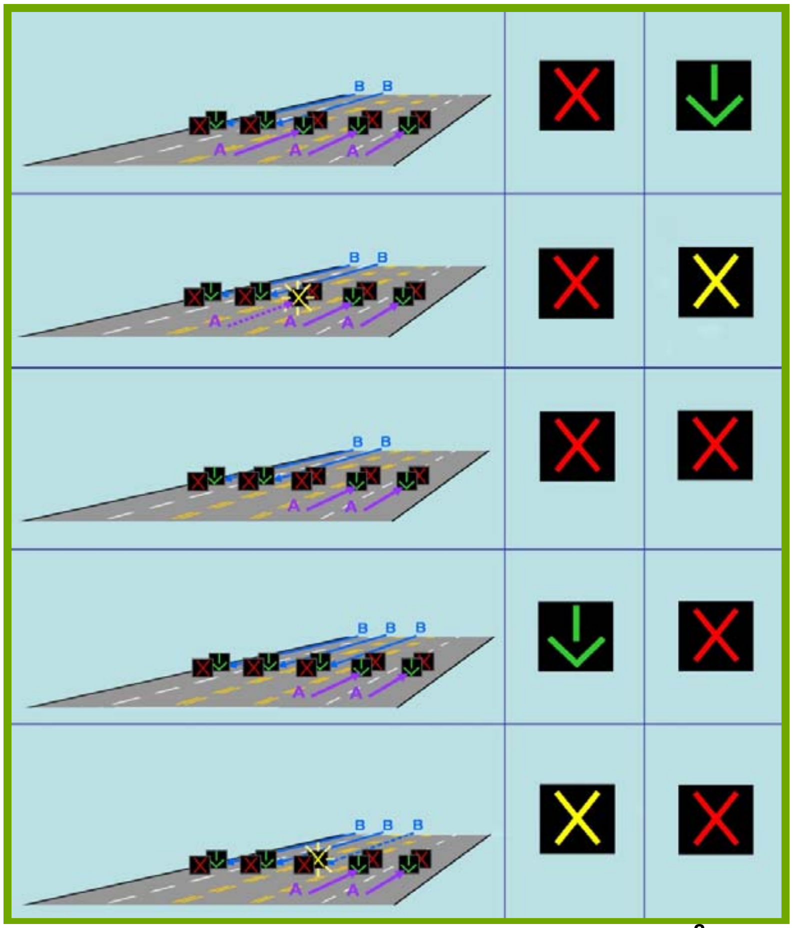


Figure 5 – Temporal Transition Intervals[2]

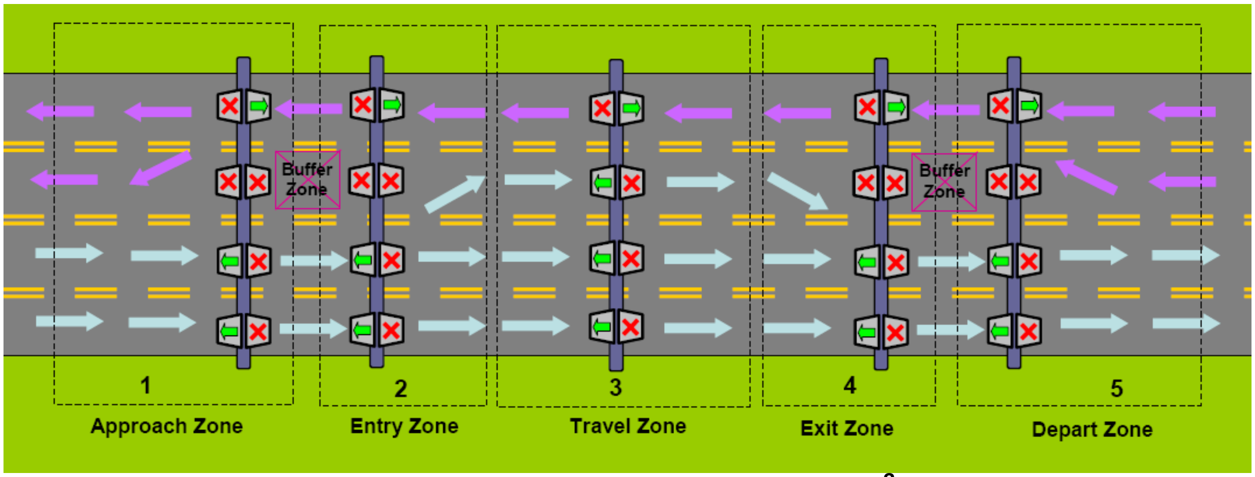


Figure 6 – Spatial Transition Zones[3]

Sample RLS Projects

RLS projects are not unique to Canada or the United States. Many systems exist throughout the world. The following figures (7-11) show some examples of these systems.

Figure 7 – Birmingham, England

(Source: http://flickr.com/photos/mattii70/811794271/ Accessed in February 2009)

Figure 8 – Centre Street – Calgary AB

(Photo by the City of Calgary, 2008)

Figure 9 – Jacques Cartier Bridge - Montreal, QC
(Source: http://www.flickr.com/photos/danirenno/3055698721/sizes/l/ - Accessed in November 2008)

Figure 10 – Grant Road - Tucson, AZ
(source: http://wc.arizona.edu/papers/97/138/03_4.html - accessed November 2008)

Figure 11 - Tyvola Road, Charlotte, NC
(source: http://books.google.com/books?id=eXhhK07i6VwC&pg=PA27 access May 10 2010)

The 5400 South (SR 173) RLS Project

Project Background

State Route 173, otherwise known as 5400 South in the County of Salt Lake, Utah, is an east-west urban arterial roadway that connects residential communities with businesses. As such, it is a major commuter route for many travelers every week day. Congestion occurs regularly during peak hours within the three kilometer section between the Bangerter Highway and Redwood Road.

This section of roadway consists of a 7 lane cross-section with sidewalks on both sides, as illustrated in Figure 12. There is a 70 Km/hr (45 mph) posted speed limit with average daily traffic reaching 46,000 vehicles. Week day traffic has a 73/27 split in the morning peak hour and a 39/61 split in the afternoon peak.

The goal of this project was to increase east/west mobility for western Salt Lake County. This corridor had restricted right-of-way availability, and there was a need from businesses along the arterial to maintain access. Reversible lanes were selected as the solution to reduce commute times and congestion on SR-173 without the need to construct additional lanes. Note, the term “Flex Lanes” was used by the state instead of Reversible Lanes to more clearly communicate the project to the public. Particularly to distinguish this RLS application for an urban arterial from the RLS applications for freeway systems that the local driving public generally think of when they hear “reversible lanes.

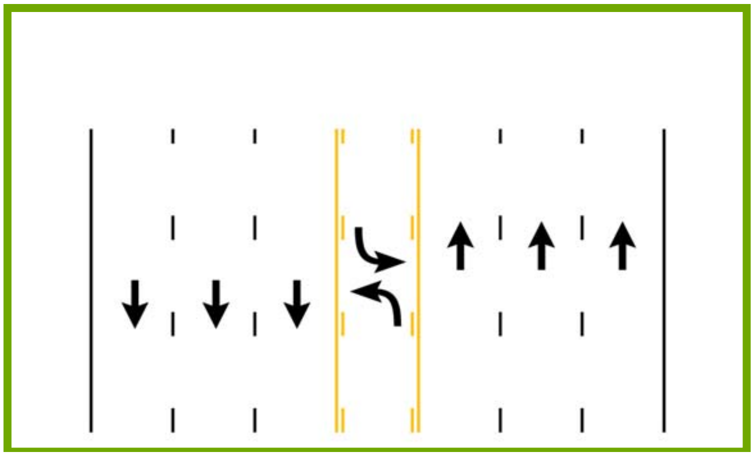
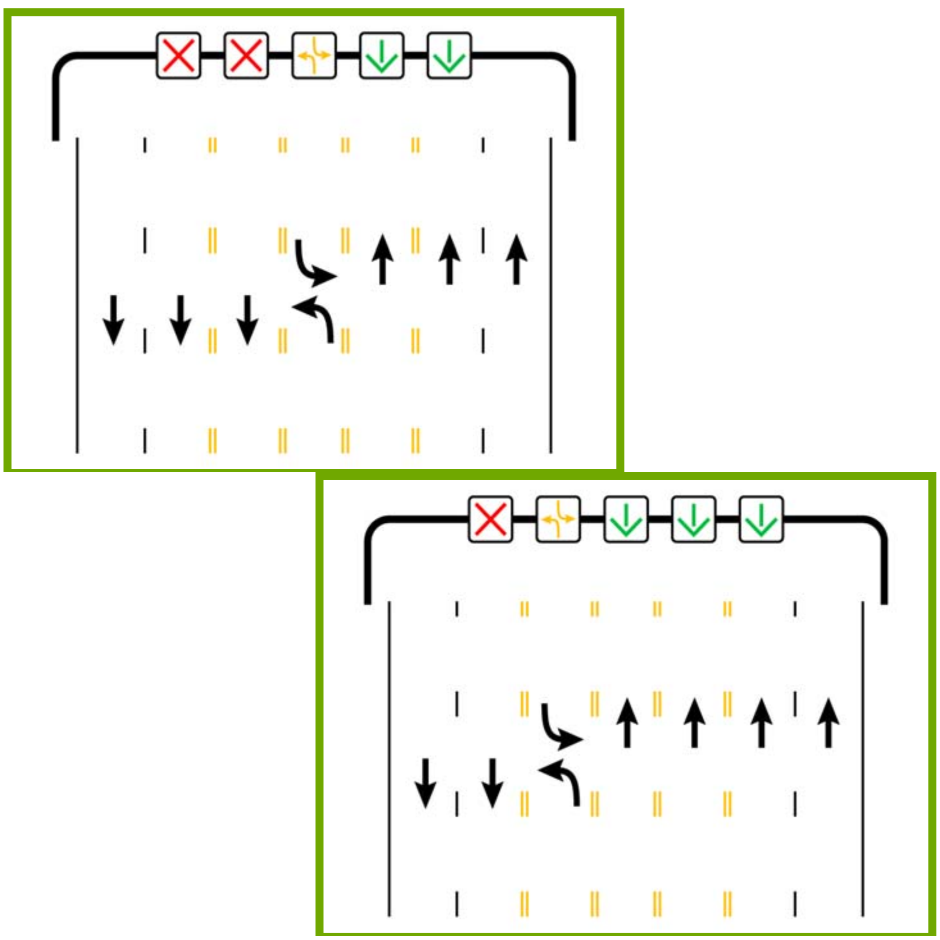


Figure 12 – Existing Roadway Configuration

Flex Lane Design Configuration

With the need to maintain business access, the recommended solution was to implement a reversible lane system that could shift the two-way left turn lane to accommodate the varying lane configuration at different times of the day. Figure 13 shows the lane configuration changes for the different peak periods.



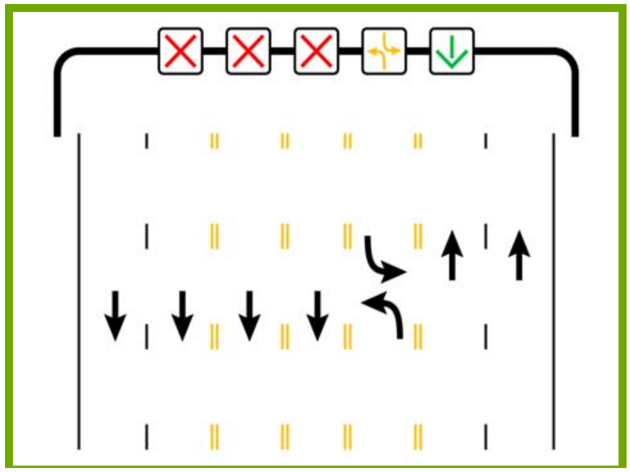


Figure 13 – Flex Lane Configurations (off peak, AM peak, PM peak)

Flex Lane Transitions

Transitioning into and out of the flex lane corridor required detailed planning at each end of the corridor. The spatial transition at the west end terminus (Bangerter Highway) needed special consideration for both the westbound exit and the eastbound entry to the flex lane corridor.

For the westbound vehicles in the PM peak, the left lane becomes a trap lane (vehicles must turn left) at the next intersection, so the lane control signals needed to be designed to show that restriction to approaching drivers. For the eastbound traffic in the AM peak, there is an added lane available once they are past the median barrier at the Bangerter intersection. In the PM peak, there is a left lane drop once they are past the median barrier. Lane control signals along this transition were designed to display this information to the drivers.

The spatial transition at the east end terminus (Redwood Road) also needed special design considerations. For the eastbound (exit) traffic in the AM peak, a lane was dropped prior to the intersection at Redwood Road to accommodate a new lane configuration at the intersection. This decision was driven by safety concerns (introducing 2 new concepts to drivers at the same time) and verified through traffic analysis not to create a bottleneck. For westbound (entry) traffic in the AM peak, a lane was dropped just past the median barrier of the intersection, while for the PM peak a lane was added after the median barrier.

Lane control gantries were spaced closer together (site-specific) at the terminus points to provide better information to the drivers and shorten spatial transition lengths where left turn movements are restricted. Throughout the rest of the corridor, the gantry spacing was typically based on drivers' line of sight and a requirement that the drivers should be able to see at least two gantries at any time (to provide confirmation of lane designation). Identifying gantry locations also required field inspections to determine the best locations based on sidewalk, utilities and driveway accesses. Typically, this resulted in a spacing of 150-200 metres (500-700 feet).

To avoid confusion as drivers approached a signalized intersection (there are 5 of these within the corridor), the lane control gantries were not placed closer than approximately 100 metres (300 feet). This provided an adequate separation of the lane control signals and the traffic signals.

The other aspect of flex lane transitioning is the temporal transition periods. This is the specific times needed to allow drivers to shift lanes safely when the system is transitioning from one lane configuration to another. As noted above, this includes a “warning” clearance interval (yellow “X”); an “all red” clearance interval (solid red “X”) and then opening the lane for travel (green arrow) in the opposing direction.

The timing of these intervals is based on the posted speed, the length of the corridor (or in this case the distance between signalized intersections) and the cycle length of the traffic signal system on the corridor. Cameras at strategic points along the corridor also provide the operators in the traffic management centre with a visual confirmation that the lanes are clear for transition.

Traffic Signal Interaction

The interaction of the flex lane system with the traffic signal system is critical in the successful operations of the system. With the changing lane configuration, the left turn lanes at the signalized intersections also change, so providing positive guidance to drivers approaching these intersections is a necessity.

When drivers are turning left across four lanes of oncoming traffic, the signal phasing should be set up as protected-only left turns. However, during off-peak and opposing peak periods, the left turn phase can be set up as protected-permitted.

When the flex lane system shifts the lanes for the different periods of the day, the left turn lanes at signalized intersections also must shift. There is a need to clear the left turn lanes before transition so that the drivers are not trapped in a lane that has oncoming traffic.

The signal layout at these intersections must now have a signal head over each of the five lanes that approaching drivers could be in. This requires the use of occasionally “dark” signal heads and a complex signal controller operation. Special blank-out lane designation signs are also provided next to each signal head to reinforce direction of travel and use for every lane. Figure 14 below illustrates how the lane control signals and the traffic control signals operate together.

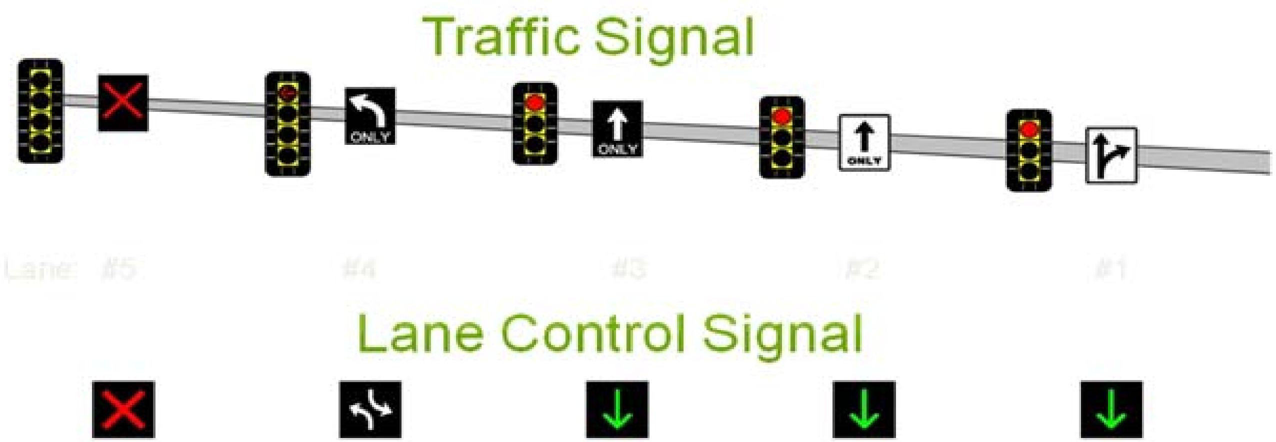


Figure 14 – Typical Traffic Signal / Lane Control Signal Interaction

The Flex Lane system is designed to provide an on-site master controller that will monitor the local programmable logic controllers (PLC's) at each gantry and communicate with the traffic signals even if the connection to the Traffic Operations Centre is lost. The traffic signal system uses standard NEMA traffic signal controllers supplemented with a unique, custom-designed relay board to control the changeable left turn signal heads.

Public Consultation

Because reversible lanes were new to both UDOT and the local driving public, the project required extensive stakeholder coordination and public outreach. AECOM worked closely with the UDOT TOC (the state-wide traffic management center), UDOT Region 2 Traffic and Safety Division, the City of Taylorsville, and other key stakeholders to meet operational, safety, and functional requirements. In-house experience with this type of project also allowed AECOM to anticipate and effectively address public comments and concerns.

Conclusions – Next Steps

The flex lane system design is complete and the Utah DOT is in the process of installing the system, to be completed by the fall of 2010.

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[1] Transportation Association of Canada, *Guidelines for the Planning, Design, Operation and Evaluation of Reversible Lane Systems*, Ottawa ON, 2009, pp 6

[2] Transportation Association of Canada, *Guidelines for the Planning, Design, Operation and Evaluation of Reversible Lane Systems*, Ottawa ON, 2009, pp 44

[3] Transportation Association of Canada, *Guidelines for the Planning, Design, Operation and Evaluation of Reversible Lane Systems*, Ottawa ON, 2009, pp 12