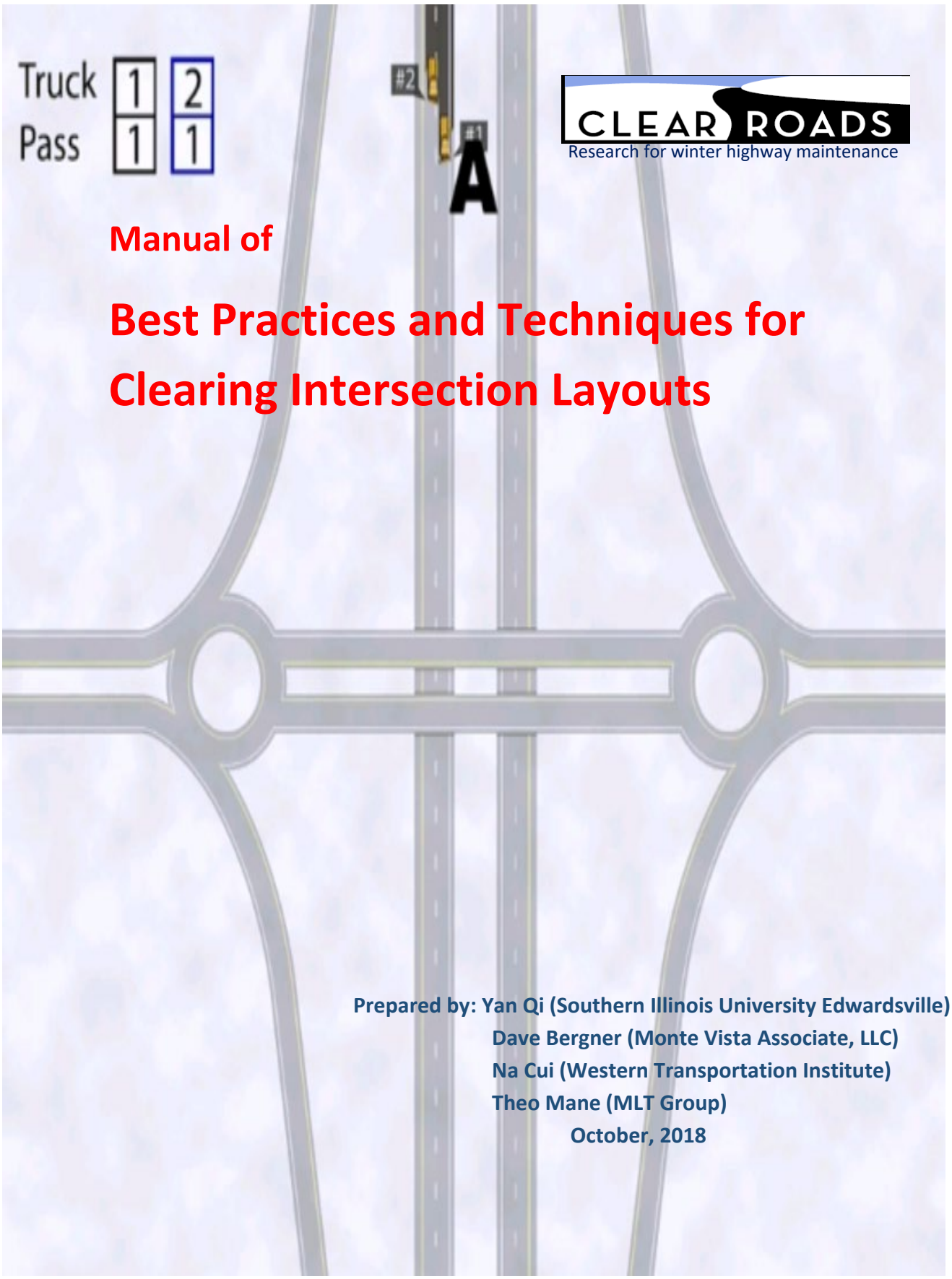

CLEAR ROADS
Research for winter highway maintenance

Manual of

Best Practices and Techniques for Clearing Intersection Layouts

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CHAPTER 1
INTRODUCTION

Overview

The purpose of this manual is to present best practices and techniques for snow plowing various intersection layouts in a format that is easy to use and access. While it is understood that different agencies have different vehicles and equipment and their experience of clearing certain type of layout varies, this compilation represents the best practices as determined from a nationwide survey with responses and inputs from a wide group of state agencies, municipal public works, federal agency, tribal and territorial agencies, and metropolitan airport agency. Accompanying with the manual, a training video with animations and a set of reference cards were also developed. Using the snapshots of training video animations, the manual will show the key vehicle maneuver and plowing pattern of the best practice for clearing various layouts.

The manual has been developed to tackle challenges faced by transportation agencies for removing snow from complex intersection/interchange layouts. It is known that our surface transportation system handles increasing volume of vehicle traffic, and to meet this demand, engineers utilize traditional and innovative intersection and interchange configurations to keep traffic moving more efficiently and safely through high volume locations with multiple merging and turning points. However, these configurations can create quite a challenge for removing snow. The best practices presented in the manual will provide insights and guidance for agencies in selecting plow configuration and plowing pattern when clearing various layouts.

This manual will demonstrate the recommended methods for clearing snow from the following ten complex interchange and intersection layouts. All the supporting information in the manual will be available from Clear Roads (www.clearroads.org), along with the training video and reference cards.

1. Roundabout Intersection
2. Four-Leg Intersection
3. Displaced Left-Turn Intersection
4. Median U-turn Intersection
5. Double Roundabout Interchange
6. Diamond Interchange
7. Cloverleaf Interchange with C/D Lanes
8. Single-Point Interchange
9. Diverging Diamond Interchange and
10. Directional T Interchange.

Additional Considerations

Each transportation agency has unique situations and conditions, including

- Roadway geometrics due to topography
- Traffic volumes
- Density of surrounding area
- Climate
- Total lane-miles
- Types and number of plow vehicles
- Plow configurations
- Workforce composition
- Levels of service

Figure 1.1: Snow plowing an intersection

Many operators develop their own plowing techniques based on experience and equipment. **The best practices presented in the Manual provide suggested best setup and plowing patterns for clearing each layout, but they are not the only approaches. If agencies have different number of trucks and different plow configurations, the number of passes and plowing patterns will be altered to clear those configurations**.

The best practices in this manual focus on efficiency and productivity, while ensuring safety and mobility for the public. **There will be additional cleanup in areas, such as gores and shoulders, and these areas must eventually be cleared**. The focus of these best practice examples is on the driving lanes with the intent of removing snow as much as possible and keep or getting the traffic moving as quickly and efficiently as practical.

Equipment Options

Transportation agencies effectively use different types of vehicles and equipment for snow plowing. Single-axle and tandem-axle dump trucks fitted with front plows are commonly used for winter operations. Many agencies also equip their trucks with wing plows on the right side of the truck. Wing plows are used for extended snow plowing operations.

Figure 1.2: Tandem-axle dump truck

Other common equipment for snow plowing includes:

- Tow plow
- Underbody plow
- Both left and right-wing plows
- Single axle and tandem axle dump trucks
- Grit truck
- Loader truck

Figure 1.3: Tow Plow in operation

Figure 1.4: Underbody plow in operation

Figure 1.5: Both left and right wing plows

Figure 1.6: Single axle and tandem axle dump

Figure 1.7: Grit Truck in snow plowing

Figure 1.8: Loader Truck in snow plowing

How to Read Clearing Diagrams

To distinctly show multiple passes and trucks in the best practice examples, the diagrams use individual truck numbers, pass numbers, and plow configurations as depicted in Figure 1.9 (a). Figure 1.9 (b) presents the width of two typical passes, with 11′ clear width for a front plow only and 14′ for a front plow and a wing plow. The starting point of a pass is indicated by "▲" and a U-turn is depicted by "↰" in the diagram.

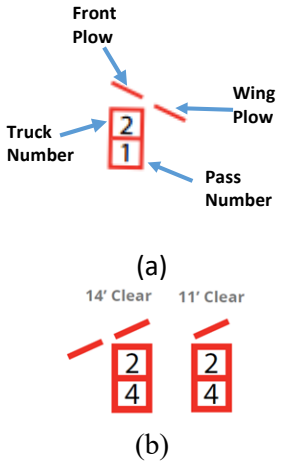


Figure 1.9: Truck and pass number indication and snow plowing widths

Safety Considerations

Safety is always the top priority. An operator must stay constantly aware of weather, pavement, and traffic conditions; the positions of plows; the presence of roadside structures, obstructions or other hazards. The operator must also continually monitor material applications and a two-way radio. Other considerations include:

- Do not use cell phone which can distract the operation procedure.
- Adjust speed to avoid casting snow over bridges or overpasses or too far onto sidewalks.
- Push snow away from traffic lanes whenever possible to make sure there is no impede of the traffic flow.
- Be aware of the pavement cross slope, wind conditions and other considerations for the route.
- Flatten out plows through intersections and over-bridge decks.
- Adjust the plow angle when crossing bridge joints and rail crossings.
- Be alert for the seal plates, rough pavement, and high manholes or valve-box covers.
- When using a wing plow, watch the roadside obstructions such as guard rail, sign posts, fire hydrants, and mail boxes.
- Along curves, push snow to the inside or low side, unless that is the high side of the road profile or if there is no storage to the inside.

CHAPTER 2
ROUNDABOUT INTERSECTION

Overview

Roundabouts are becoming more common for controlling traffic at grade intersections. They allow traffic to flow more effectively and safely than traditional four-way intersections controlled by traffic signs or signals. However, they do pose unique problems for snow plow operators because of tight turning movements and lack of adequate space to store plowed snow.

Figure 2.1: Roundabout intersection

Equipment and General Considerations

In the best practice example, a single truck equipped with a front-plow and dual wing plows is employed. Using a left-wing plow to clear inside shoulders provides a faster and safer approach. Only the front plow is used when circling the roundabout, as it is generally not acceptable to deploy a wing plow into a live traffic lane.

Several notes and considerations for plowing roundabouts are:

- Don't use wing plow when circling the roundabouts;
- At certain merging and turning spots, "square" the front plow and lift or tuck-in the wing plow(s) to avoid pushing snow into lanes that have been cleared on previous passes; and
- Push snow away from roundabouts to avoid piled snow on the center island restricting visibility and minimize melt-water running across the roundabout lanes and refreezing.

As mentioned earlier, the best practice example provides a suggested best setup and plowing patterns for clearing roundabouts. If the truck doesn't have a reversible front plow or double wings, additional passes will be required to clear this configuration.

Plowing Pattern

Figure 2.2 presents the plowing pattern to clear a typical roundabout intersection. Only one truck is utilized, the circle is cleared first before the legs are cleared.

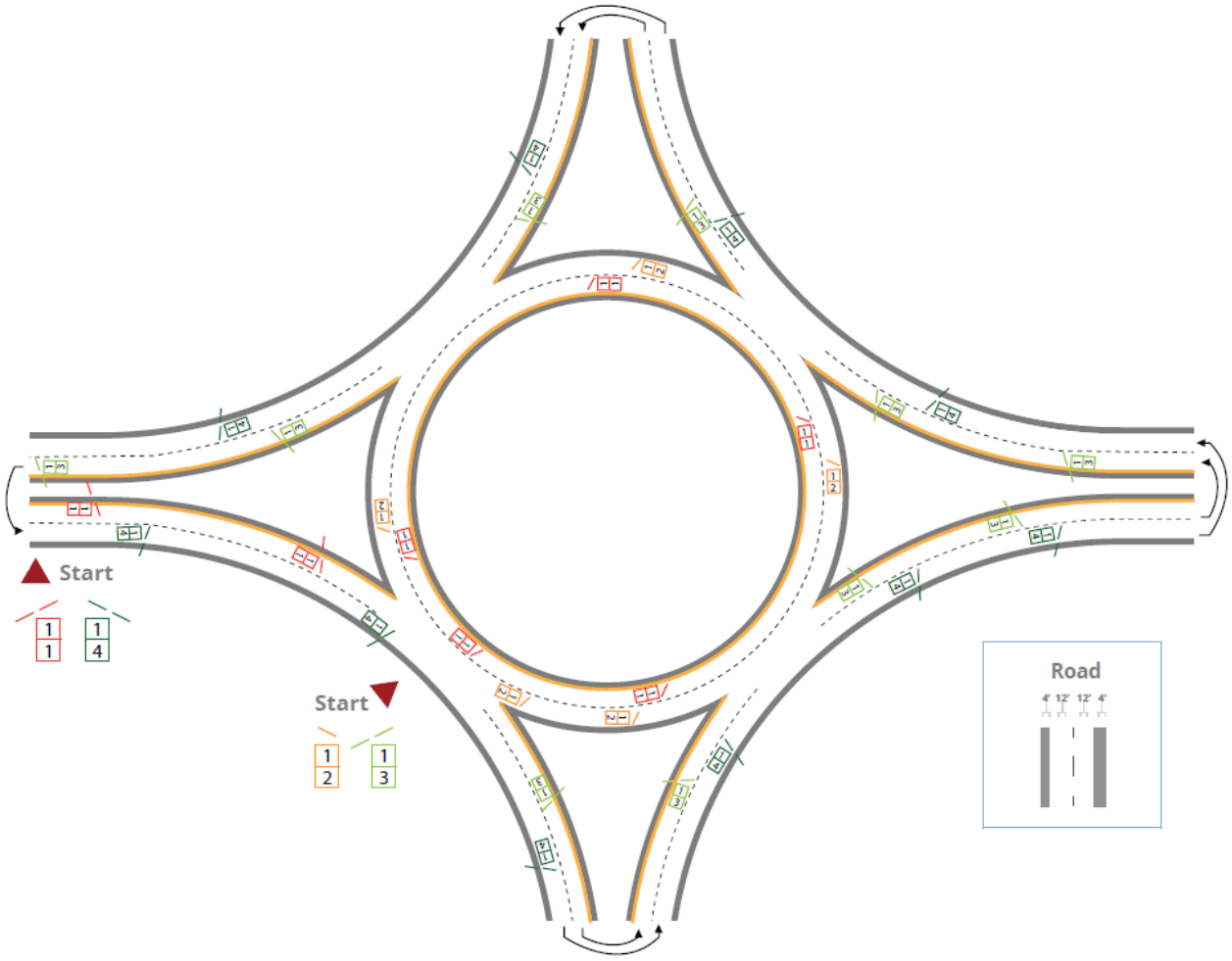


Figure 2.2: Plowing pattern for clearing a roundabout intersection

Step 1:  Truck 1 clears one entrance approach of the roundabout intersection by pushing snow to the left side. As the truck enters the intersection, it 'tucks in' the left-wing plow and stays in the inside lane, but reverses the front plow angle to move snow to the outer or right-hand lane. **This is done to avoid depositing plowed snow on the roundabout itself. It also keeps piled snow from restricting visibility and minimizes melt-water running across the lanes and refreezing.**

Step 2:  The truck continues completely around until arriving at the same point where it enters the intersection, then it moves over to the outer lane and begins Pass 1/2. Pass 1/2 continues completely around again but is now plowing the accumulated snow from both the inside and outside lanes away from the roundabout. Figure 2.3 illustrates the snow plowing pattern in Passes 1/1 and 1/2.

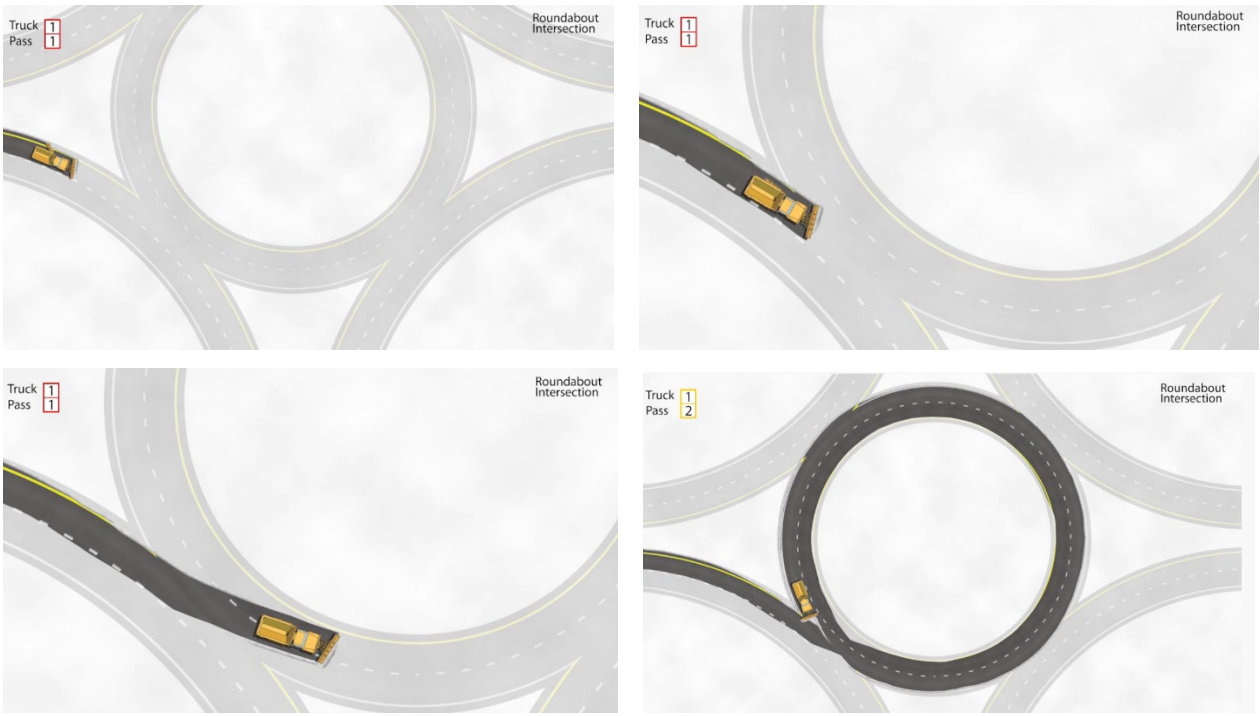


Figure 2.3: Snow plowing pattern in Passes 1/1 and 1/2

Step 3: After completing the snow plowing in the roundabout intersection, the truck exits the intersection at the same point where it enters the intersection and starts plowing snow from the roundabout intersection approaching legs. The truck re-angles the front plow to the left and stretches out the left wing. The Pass 1/3 continues plowing until the point where it makes a U-turn. It proceeds the opposite direction but does not re-enter the roundabout. Insteat, it continues snow plowing on the inside lane by pushing snow to the left. Before entering the intersection, the truck "tucks in" the left-wing plow and angles the front plow to dump the snow. While passing through the intersection, "square" the front plow to avoid drag snow onto cleared outer lane of the roundabout. The left-wing plow is deployed after passing the intersections. The same maneuver applies to all four intersection points. The truck makes a U-turn and proceeds snow plowing on the inside lane by pushing snow to the left for all the remaining legs. Figure 2.4 illustrate the truck maneuver at intersection points in Pass 1/3.

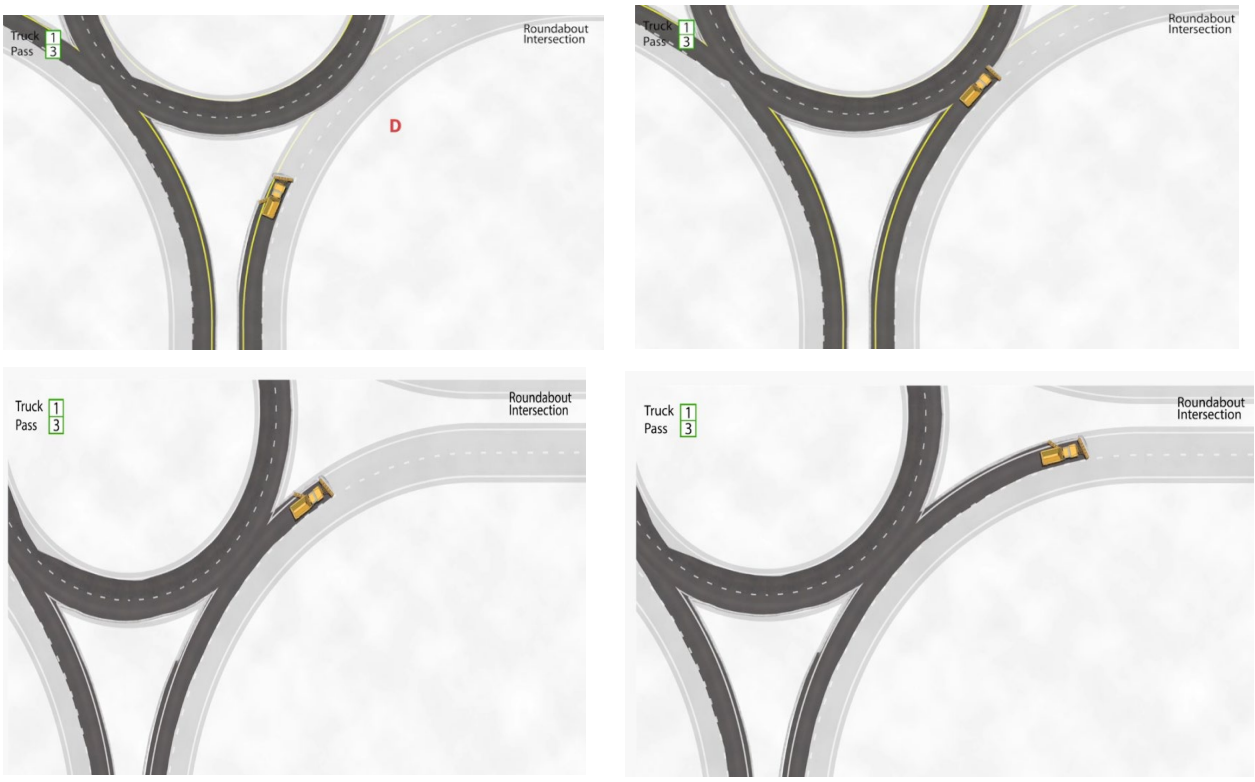


Figure 2.4: Truck maneuver at intersection points in Pass 1/3

Step 4: 

After completing the snow plowing of all the inside approaching lanes of the roundabout intersection, the truck makes a U-turn, shifts to the outside lane, and reserves the plow angle to the right, "truck in" the left-wing plow, stretches out the right-wing plow and begins Pass 1/4. It repeats the same pattern as in Pass 1/3 while staying in the outside lane.

Note: After the truck finishing Passes 1/1 and 1/2, there is still snow left at the entrance and exit of the roundabout. This is bound to happen when using only one truck to plow roundabout intersections. As mentioned earlier, the goal here is to remove as much snow as possible and keep traffic moving. To clear those 'left over' areas, additional passes will be needed.

CHAPTER 3
FOUR–LEG INTERSECTION

Overview

The best practice example depicts a typical four-way intersection with dedicated left-turn lanes and paved shoulders on all right sides. These intersections could be signalized or Stop/Yield sign controlled.

Figure 3.1: Four-leg Intersection

Equipment and General Considerations

Plow truck operators should be alert when approaching this type of intersections and always anticipate other drivers who may ignore them. At the intersection area, operators need to "square" the front plow and lift or tuck-in the wing plow(s) to avoid pushing snow into lanes that have been cleared on previous passes. In the best practice example, a single truck with front and right-side wing plows has been used. Many agencies deploy two trucks in echelon to clear snow for this configuration.

Plowing Pattern

Figure 3.2 presents the plowing pattern of clearing a typical four-leg intersection. Using one single truck, nine passes are needed to clear the intersection in the best practice example.

Step 1: 

The truck proceeds towards the intersection along one main road approach in the left turn (inside) lane with both plows angled to the right. Not completing a left turn, it proceeds straight through the intersection and shifts to plow the inside through lane, pushing snow to right.

Step 2: 

The truck turns around and begins Pass 1/2 heading the opposite direction on the main road in the left turn (inside) lane. The plows are still angled to the right. Again, not completing a left turn, it proceeds straight through the intersection continuing in the inside through lane.

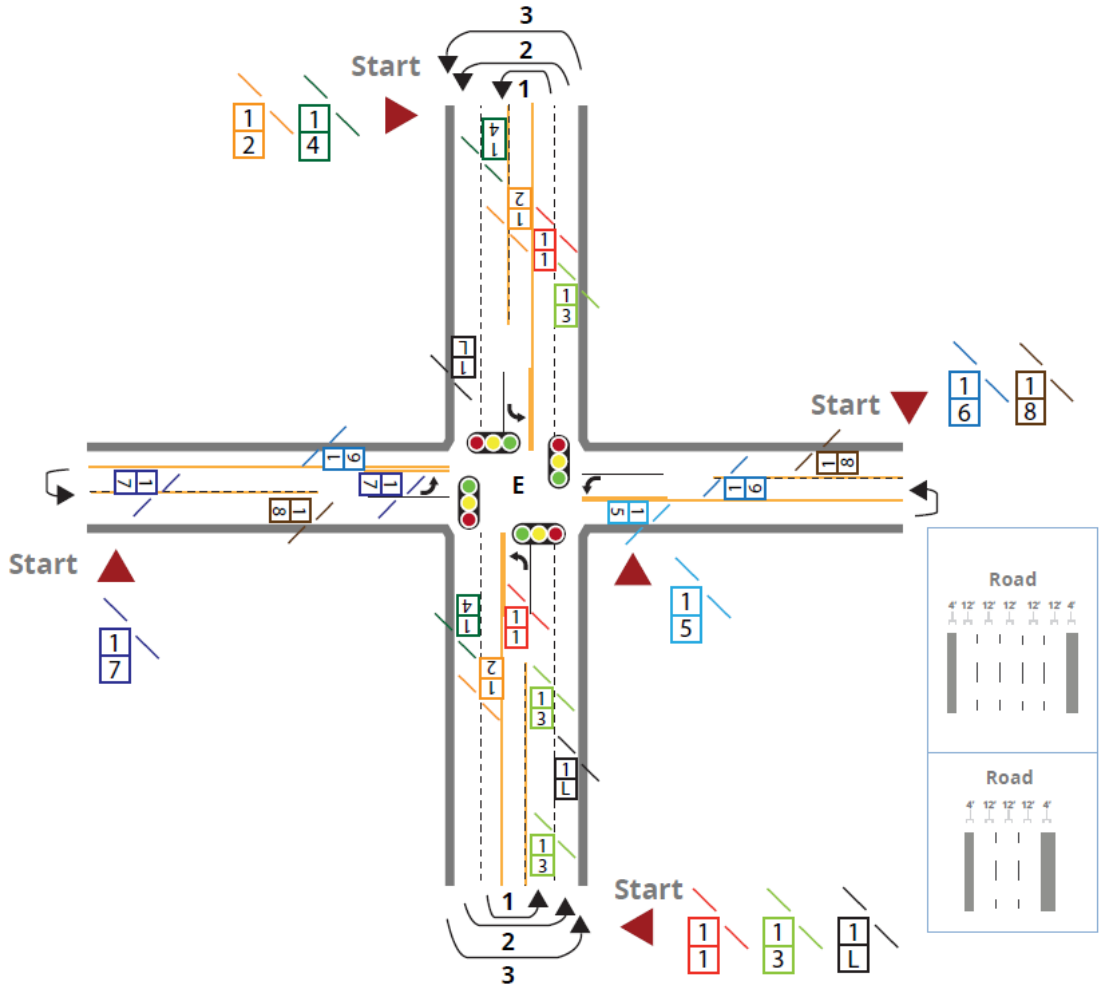


Figure 3.2: Plowing pattern for clearing a four-leg intersection

Step 3: The truck turns around and begins Pass 1/3 by shifting to the left through lane, with plows still angled to the right. The wing plow is extended to clear part of the right (outside) lane. It continues through the intersection to clear the right through lane.

Step 4: The truck truns around and shifts to clear the opposite direction left through lane and begins Pass 1/4. Again, the wing plow is extended to clear part of the right (outside) lane. It continues through the intersection to clear the right through lane.

Step 5: The truck turns around and starts Pass 1/L to proceed in the main road outside lane through the intersection and turns around to proceed in the opposite direction outside lane through

the intersection. This pass clears the snow left on the right lane and right shoulder on the main road approaches (legs).

Note: Though the right lanes on the main road at the directions going away from the intersection have already been plowed in Pass 1/3, operators may keep their plows down to cleanup, especially on the shoulder.

Step 6: The truck turns right at the intersection onto the minor road and begins Pass 1/5. It clears the one lane road with the wing plow clearing the shoulder, pushing snow to right.

Step 7: The truck turns around and begins Pass 1/6. It proceeds in the left lane, which turns into a dedicated left-turn lane when approaching the intersection. The truck does not complete a left-turn; instead, as it crosses the intersection it shifts into the one lane road and continues Pass 1/6.

Step 8: The truck turns around and heads the opposite direction beginning Pass 1/7. It proceeds in the left lane, which turns into a left turn bay when approaching the intersection. Again, when the truck reaches the intersection, the truck does not complete a left turn, instead, as it crosses the intersection it shifts to the right to the already plowed (Pass 1/5) one lane.

Step 9: The truck turns around and begins Pass 1/8 to proceed in the right lane heading the opposite direction. It continues through the intersection over the completed lane (Pass 1/6) at the other end. There, it turns around and proceeds in the opposite direction right lane to the intersection.

Note: For Passes 1/6, 1/7, and 1/8, square the plow when approaching intersection to avoid dragging snow onto the already cleared lanes.

CHAPTER 4
DISPLACED LEFT-TURN INTERSECTION

Overview

A displaced left-turn interchange is similar to a typical four-way intersection except that the left -turn lanes cross to the opposite side of the roadway before reaching the intersection. In the best practice example, right-turn only lanes are also present.

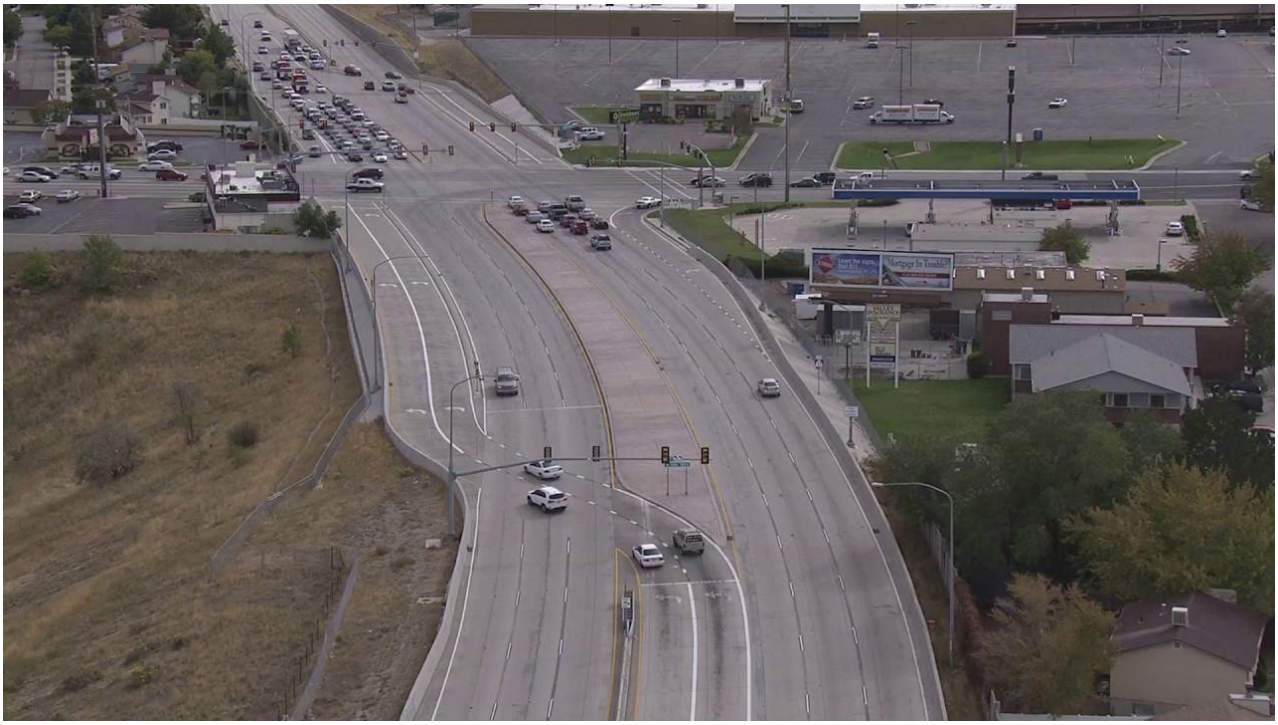


Figure 4.1: Displaced left-turn intersection

Equipment and General Considerations

Two trucks have been used in the best practice example; each has a front plow and a right -wing plow. All lanes of the two at-grade roadways are 12′ wide with 4′ wide shoulders. Note that both roadways are essentially three lanes in each direction with dedicated right-turn lanes. Approaching the signalized intersection, the inside left through lanes become exclusive left-turn lanes but downstream of the intersection they revert to through lanes.

Plowing Pattern

Figures 4.2 -4.5 present the plowing pattern of clearing a displaced left-turn intersection.

Step 1: 

Truck 1 starts Pass 1/1 in center lane on one approach of the main road; front plow angled right and right-wing plow extended over part of right lane. Proceeding through intersection, then it shifts to the left-through lane. Continuing to far end-point, it turns around and continues Pass 1/1 in center lane of opposite direction. Proceeding into the intersection, it then turns right onto the crossroad left lane and continues to the crossroad near end-point.

Following Truck 1 in a formation, Truck 2 starts Pass 2/1 in the right lane with front plow angled right and right wing-plow extended. Proceeding through the intersection, it shifts to the center-through lane and continues to the far end-point. The truck turns around and continues Pass 2/1 in the right-through lane of the opposite direction. Approaching the intersection, it shifts to the right-turn lane. Turning right onto the crossroad *center* lane, the truck continues to the crossroad near end-point.

Step 2: 

Both trucks turn around and continue Passes 1/1 and 2/1 on the crossroad, keeping in the formation, with truck 1 in the center lane and truck 2 in the right lane. Crossing the intersection, truck 1 shifts to the left lane and truck 2 shifts to the center lane.

Both trucks turn around at the cross road far end-point and resume Passes 1/1 and 2/1 in the opposite direction, with truck 1 in the center lane and truck 2 in the right lane. Entering the intersection, both trucks turn left on the main road. Truck 1 shifts to left lane, truck 2 shifts to center lane, and both trucks continue to the main road near end-point. This completes Passes 1/1 and 2/1.

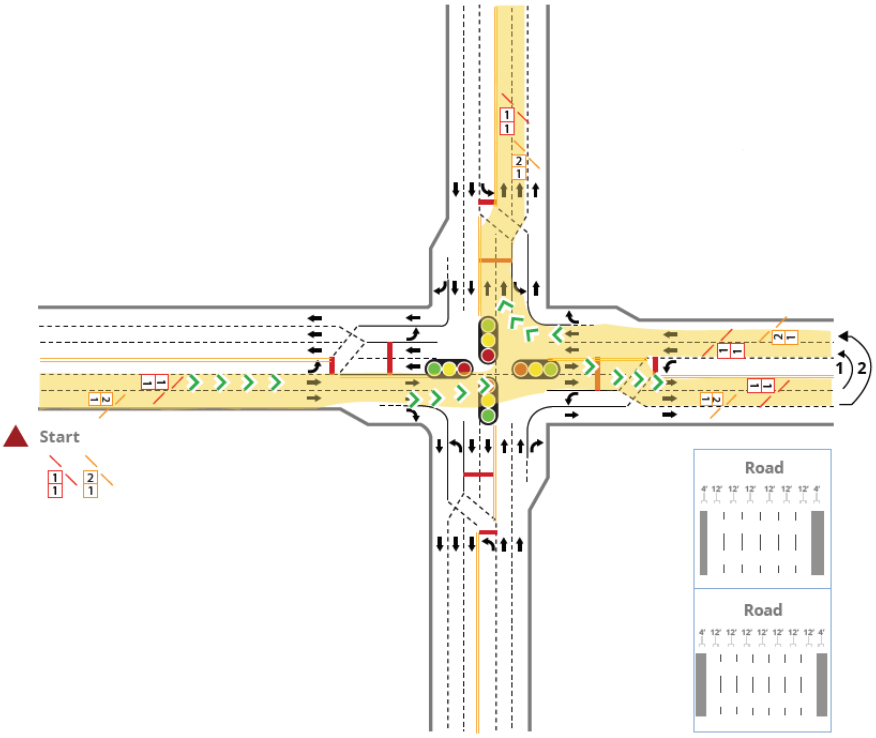


Figure 4.2: Snow plowing pattern for clearing a displaced left turn intersection (1/4)

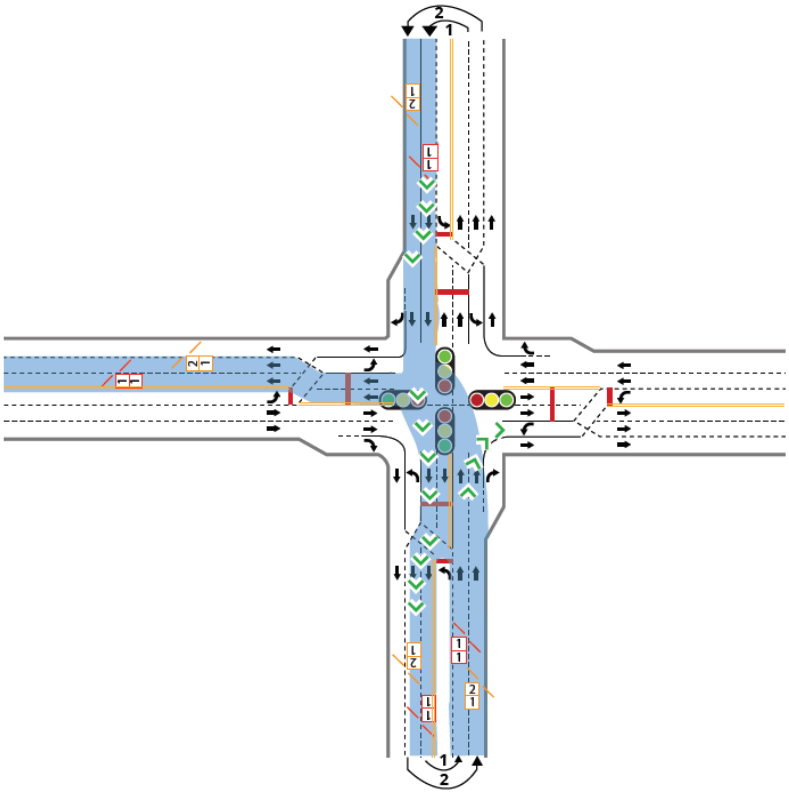


Figure 4.3: Snow plowing pattern for clearing a displaced left turn intersection (2/4)

Step 3: 

Truck 1 turns around and begins Pass 1/2 in the main road left lane using only front-plow angled right. When approaching the intersection, the left lane turns into a dedicated left turn lane. Truck 1 enters the left turn lane and turns left onto the crossroad *center* lane and continues to far end-point. It turns around and continues Pass 1/2 in the left lane on opposite direction of the main road. Similarly, approaching the intersection, truck 1 enters the left-turn lane, turns left onto the main road *center* lane and continues to the near end-point.

Truck 2 turns around and begins Pass 2/2 in the main road right-turn lane using only front-plow angled right. The truck turns right onto the right lane of the cross road. It turns around at the end-point and continues Pass 2/2 in the opposite direction. Entering the right-turn lane, truck 2 turns right at the intersection and continues in the main road right lane to the near end-point. This completes Passes 1/ 2 and 2/2.

Step 4: 

Truck 1 turns around at near end-point and begins Pass 1/ 3 in the main road left lane (which turns into a dedicated left turn lane when approaching intersection) using only front-plow angled right. It turns left into the center lane on the crossroad and continues with right-wing plow extended. At the cross road near end-point, the truck turns around and clears the left lane (which turns into a dedicated left turn lane when approaching intersection). It turns left into the main road *center* lane, extend right-wing plow and continues in the *center* lane to the far end-point.

Truck 2 turns around at near end-point and begins Pass 2/3 in the right-turn lane on the main road using only front-plow angled right. At the intersection, it turns right and continues Pass2/3 in the right lane of the cross road. At the cross road near end-point, the truck turns around and continues Pass 2/3 in the right turn lane on the opposite direction. At the intersection, it turns right and continues Pass 2/3 in the right lane of the main road to the far end-point. This completes all passes.

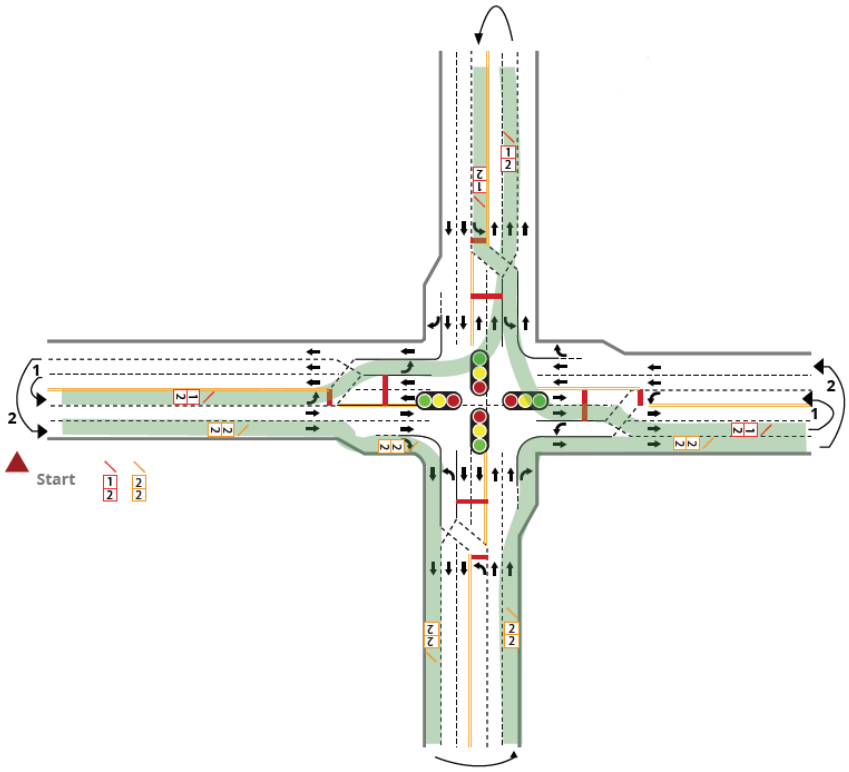


Figure 4.4: Snow plowing pattern for clearing a displaced left turn intersection (3/4)

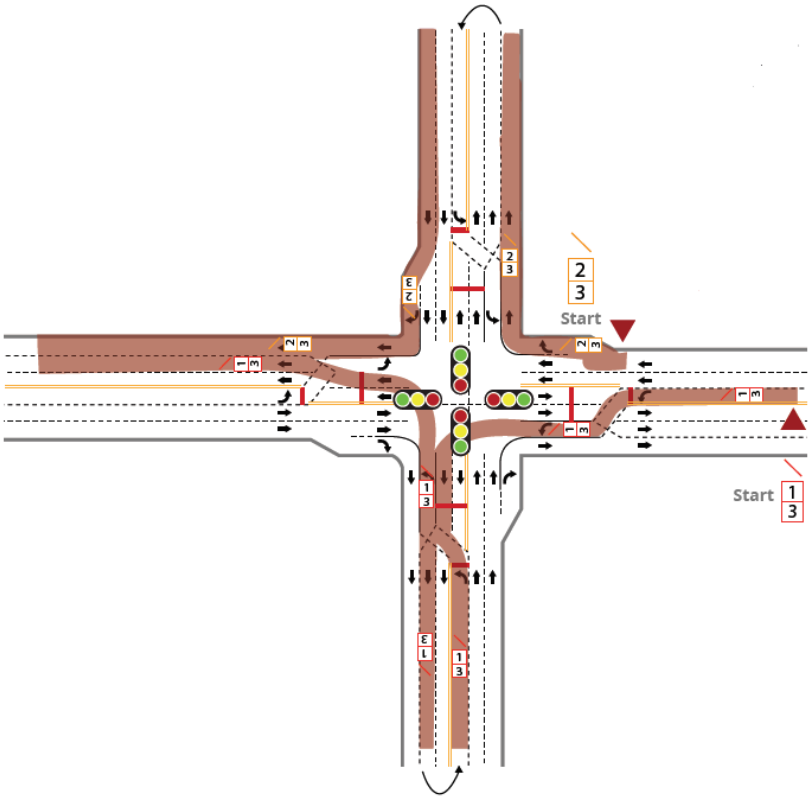


Figure 4.5: Snow plowing pattern for clearing a displaced left turn intersection (4/4)

CHAPTER 5
MEDIAN U-TURN INTERSECTION

Overview

A median U-turn intersection is an at grade intersection where direct left turn movements are replaced with indirect left turns across a wide median. This provides a much safer and more efficient flow of traffic. Dedicated right-turn lanes on the main road also improve safety and mobility.

Figure 5.1: Median U-turn intersection

Equipment and General Considerations

In the best practice example, two trucks have been used; one for the four-lane main highway and the other for the two-lane cross road. Each has a front plow and a right -wing plow. The through lanes are 12′ wide on both the highway and the cross road. The highway has 4′ wide left shoulders and 8′ wide right shoulders. The cross road has 4′ wide shoulders on both sides. The U-turn ramps are 16′ wide with 4′ wide left shoulders and 8′ wide right shoulders.

Plowing Pattern

Figure 5.5 presents the plowing pattern of clearing a typical median U-turn intersection.

Major Road -Truck 1

Step 1: 

Truck 1 starts snow plowing from any terminus on the main road. It clears outside lane of the main road, pushing snow to right. It proceeds opposite bound using the front plow angled right and wing-plow extended to the opposite terminus. Turning around, the truck continues Pass 1/1 in the right (outer) through lane of the opposite direction. It proceeds through the intersection, still in the right lane.

Step 2: 

At the near end-point, truck 1 turns around and begins Pass 1/2 in the dedicated right-turn-only lane; at the intersection, it moves into the outside through lane and continues to the far end-point. The truck turns around and clears the dedicated right-turn lane in the opposite direction. At the intersection, it moves into the outer through lane and continues to the near end-point.

Step 3: 

Truck 1 turns around and begins Pass 1/3 in the left (inside) through lane with front plow angled left and wing-plow tucked in. It continues through the intersection and proceeds to the far end-point. It turns around and continues Pass 1/3 in the left through lane of the opposite direction. The truck turns around and proceeds forward in the left lane through the intersection.

Step 4: 

Truck 1 turns around and begins Pass 1/4 at the U-turn ramp, shifting slightly left to clear the gore at the U-turn. As the gore ends, the truck proceeds along the left shoulder to the far end-point with the front plow angled left. It turns around and continues Pass 1/4 in the left through lane of the opposite direction. Crossing the intersection, the truck shifts left to clear the gore area by the U-turn, then it proceeds straight along the left shoulder to the near end-point.

Step 5: 

The truck turns again and begins Pass 1/5 at the U-turn ramp. It enters the U-turn ramp and stays to the right as ramp curves, still using only the front plow angled left. The truck completes the turn, merges onto the left-through lane of the opposite direction. It proceeds through the

intersections, then enters the other U-turn ramp. The truck resumes on Pass 1/5, staying to the right with front plow angled left. It completes the turn and merges into the left-through lane. Figures 5.2, 5.3 and 5.4 show the snow plowing pattern for the Pass 1/5.

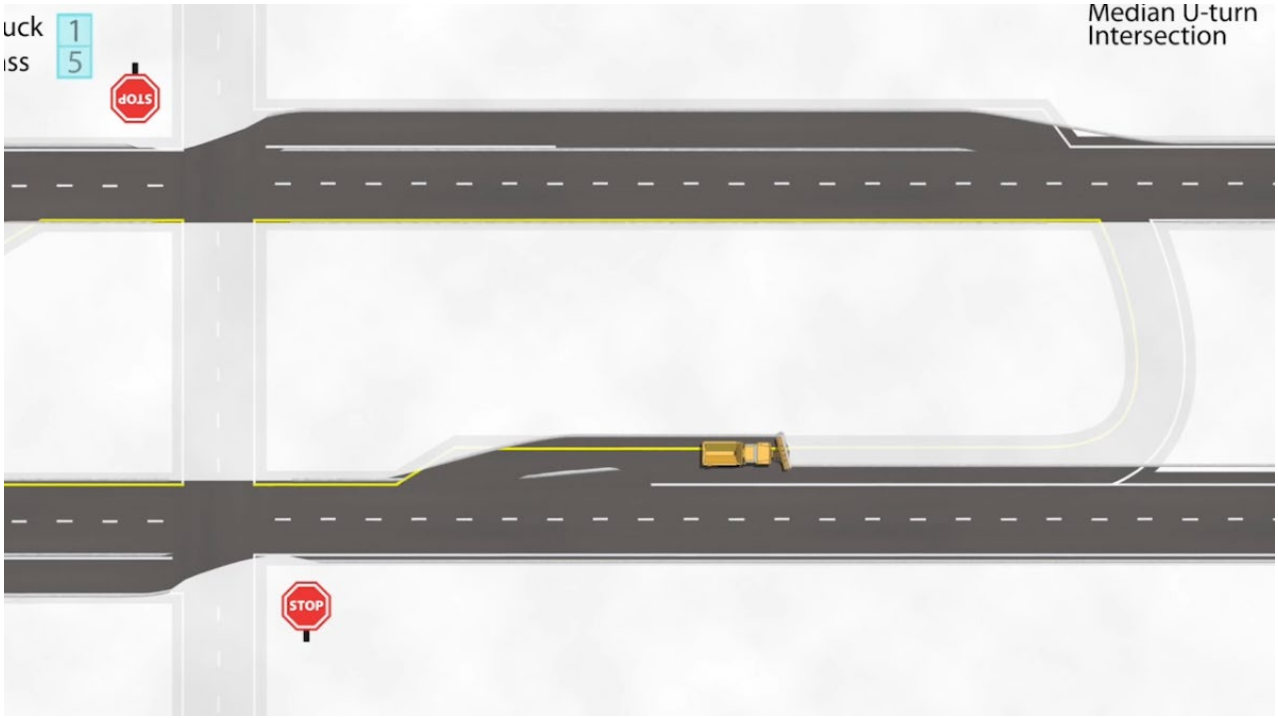


Figure 5.2: Snow plowing pattern for the pass 1/5 (a)

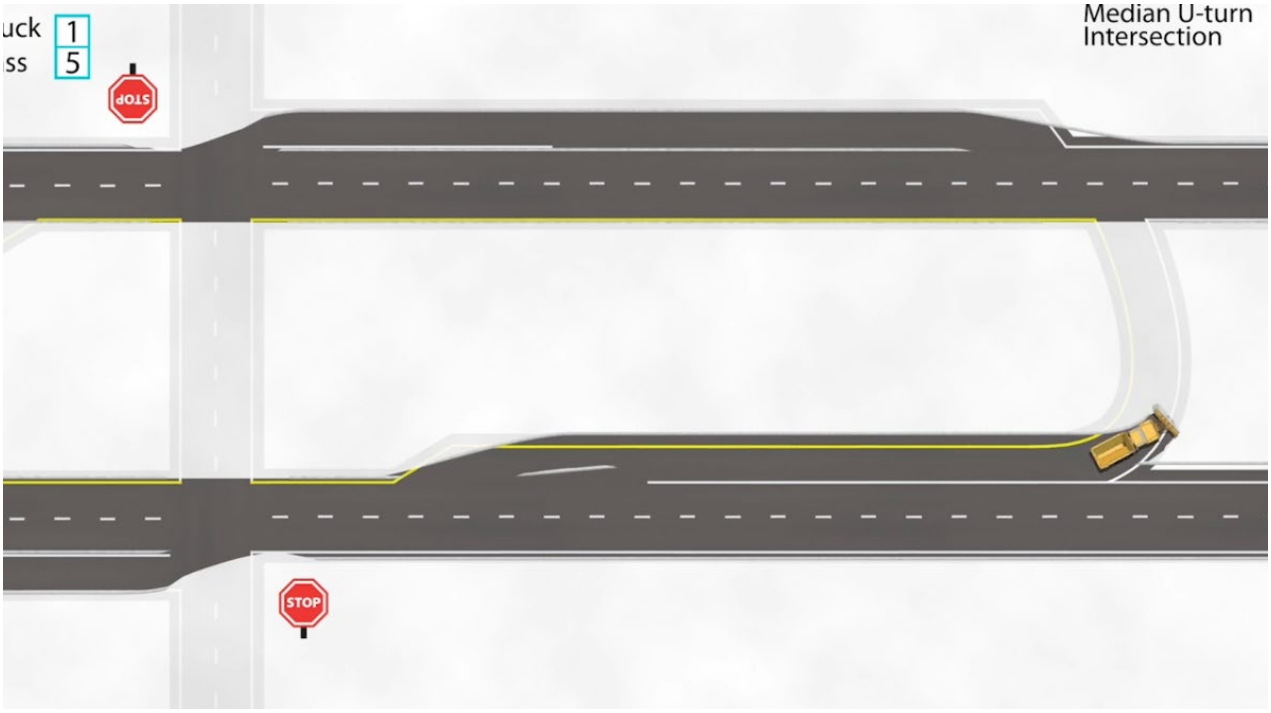


Figure 5.3: Snow plowing pattern for the pass 1/5 (b)

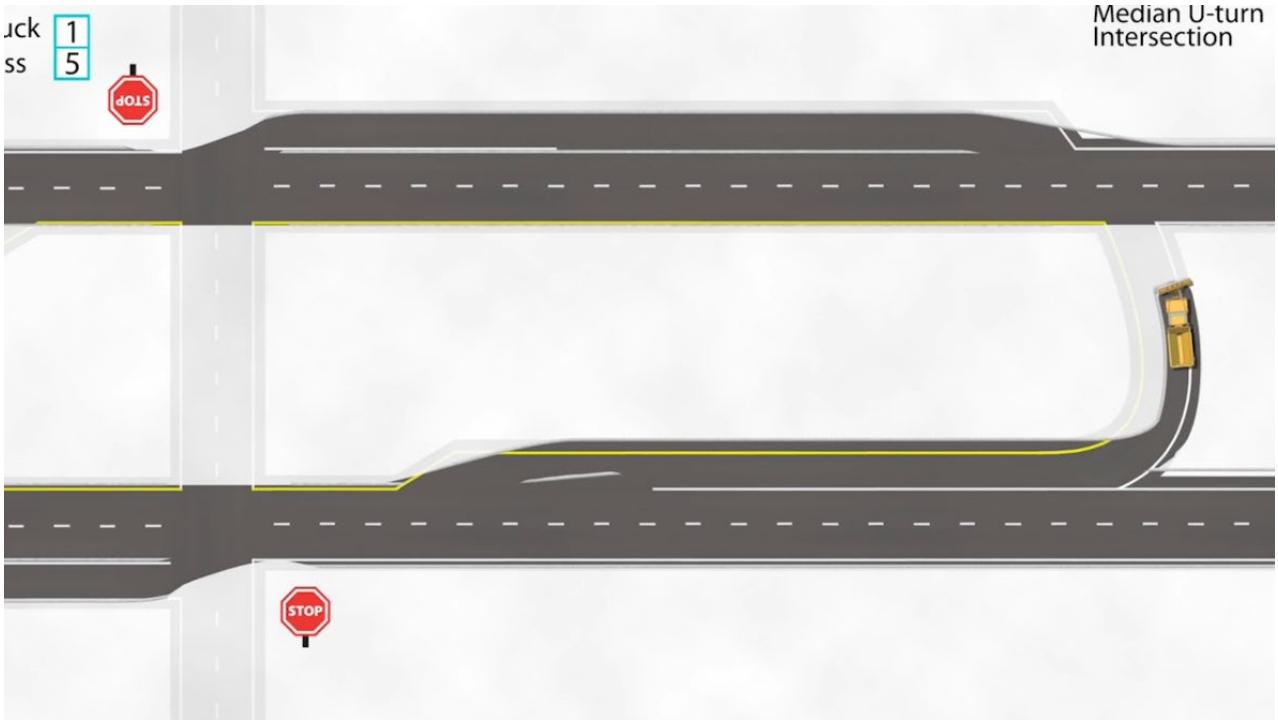


Figure 5.4: Snow plowing pattern for the pass 1/5 (c)

Step 6: The truck reenters the U-turn ramp and begins Pass 1/6. It stays to the left using front plow angled to left only. It completes the turn and merges into the left-through lane of the opposite direction. Crossing the intersection, the truck enters the other U-turn ramp, continuing Pass 1/6 staying left. After completing the turn, it merges into the left-through lane.

Note: Depending on the location and where the snow is pushed, Pass 1/2 for the exclusive right-turn lanes on the major road could clear after all the through lanes and the U-turn lanes (Passes 1/5 and 1/6) are completed.

Minor Road-Truck 2

Step 1: Truck 2 begins Pass 2/1 at the near end-point of the minor road. It proceeds in one direction with the front plow angled right and the right wing extended. The truck crosses the intersection when traffic clears and continues to the far end-point.

Step 2: The truck turns around and begins Pass 2/2 in the opposite direction. It proceeds with the front plow angled right and the right wing extended. The truck crosses the intersection when traffic clears and resumes Pass 2/2 to completion.

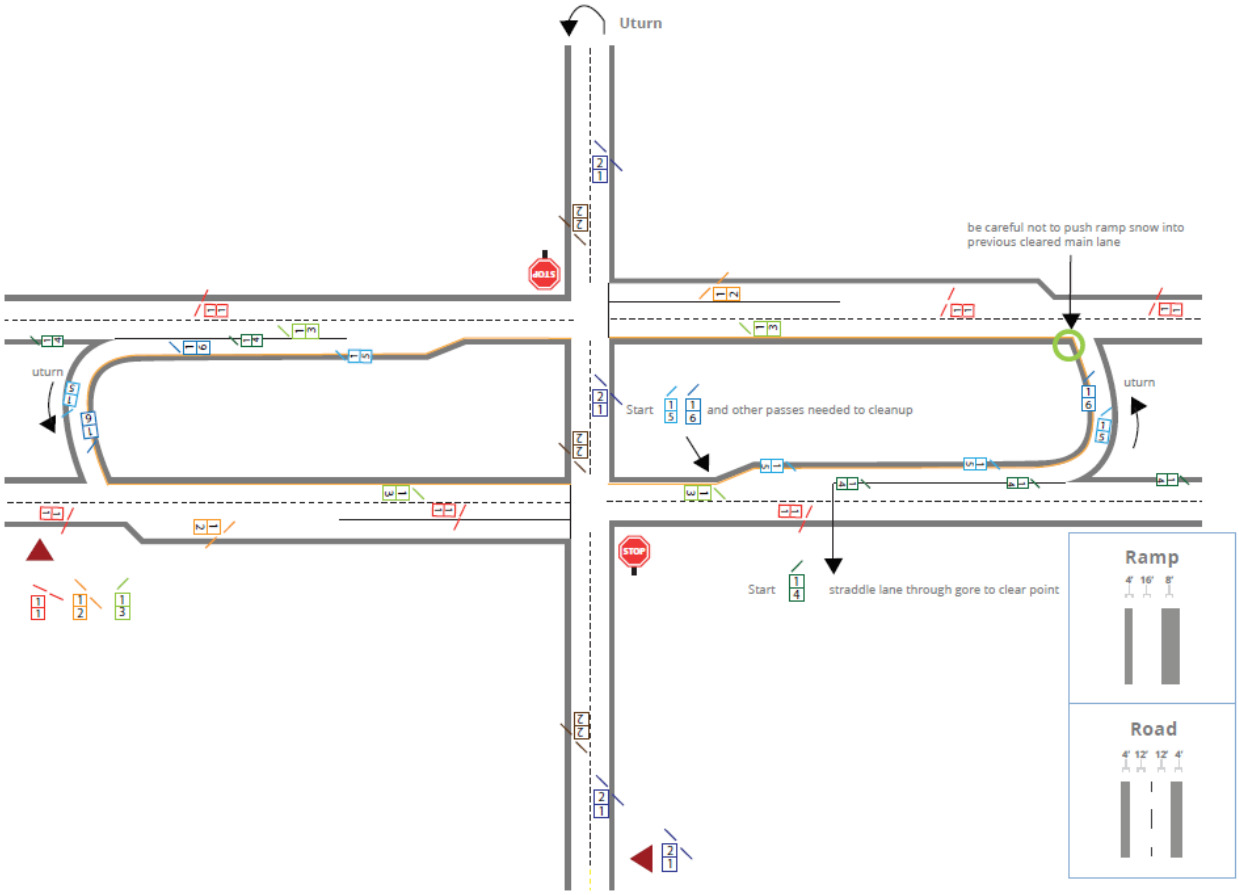


Figure 5.5: Plowing pattern for clearing a median U-turn intersection

CHAPTER 6
DOUBLE ROUNDABOUT INTERCHANGE

Overview

A Double-Roundabout interchange provides continuous traffic flow of vehicles entering and exiting the main highway using separated grades for the main highway and the cross road. YIELD signs are used at each entry into the roundabout. In addition, plow operators are required to obey all traffic controls.

Figure 6.1: Double roundabout interchange

Equipment and General Considerations

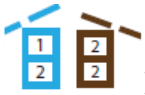
In the best practice example, two trucks have been used on the main highway; each has a front plow and a right-wing plow. The through lanes are 12′ wide on both the highway and the intersecting local road. The highway has 4′ wide left shoulders and 8′ wide right shoulders. The two-lane local road has 4′ wide shoulders on both sides. The off and on -ramps are 16′ wide with 4′ wide left shoulders and 8′ wide right shoulders. Here, small islands or medians are located at the local road approaches.

Plowing Pattern

Figure 6.6 presents the plowing pattern of clearing a typical double roundabout interchange.

Step 1: 

Trucks 1 and 2 begin at near end-point of the main four-lane divided highway. Truck 1 starts Pass 1/1 in the left (inside) lane with front-plow angled left and the left-wing plow extended. Truck 2 starts Pass 2/1 in the right (outer) lane with front plow angled right and right-wing plow extended. Both trucks proceed in echelon to the far end-point and turn around.

Step 2: 

Both trucks begin Passes 1/2 and 2/2 in the opposite direction to the near end-point and turn around

Step 3: Truck 1 turns around and begins Pass 1/3 on the near off-ramp with the front plow angled right and right wing extended. It continues and enters the first roundabout, tucks-in the wing plow. The truck circles the roundabout in the left (inner) lane; staying to the left, across the local road overpass. It circles the opposite roundabout and staying to the left (inner) part; the front plow is angled right. No wing plow is used.

Truck 1 proceeds back across the overpass staying left; front plow angled right. It partially circles the first roundabout, enters the on-ramp and merges with main road traffic. Figures 6.2- 6.5 illustrate the snow plowing pattern for the Pass 1/3.

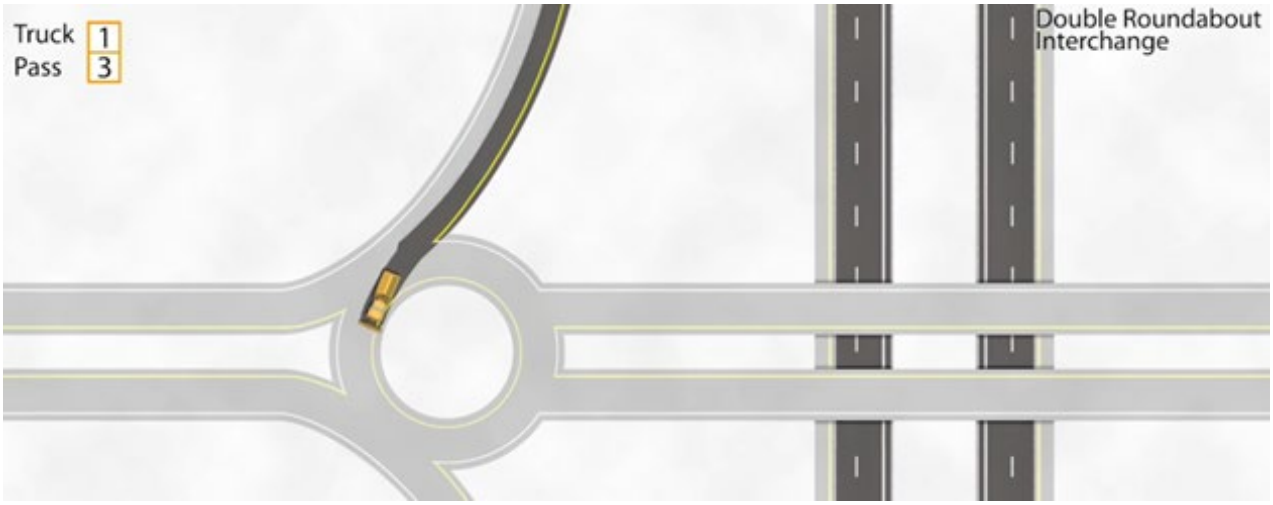


Figure 6.2: snow plowing pattern for the Pass 1/3 (a)

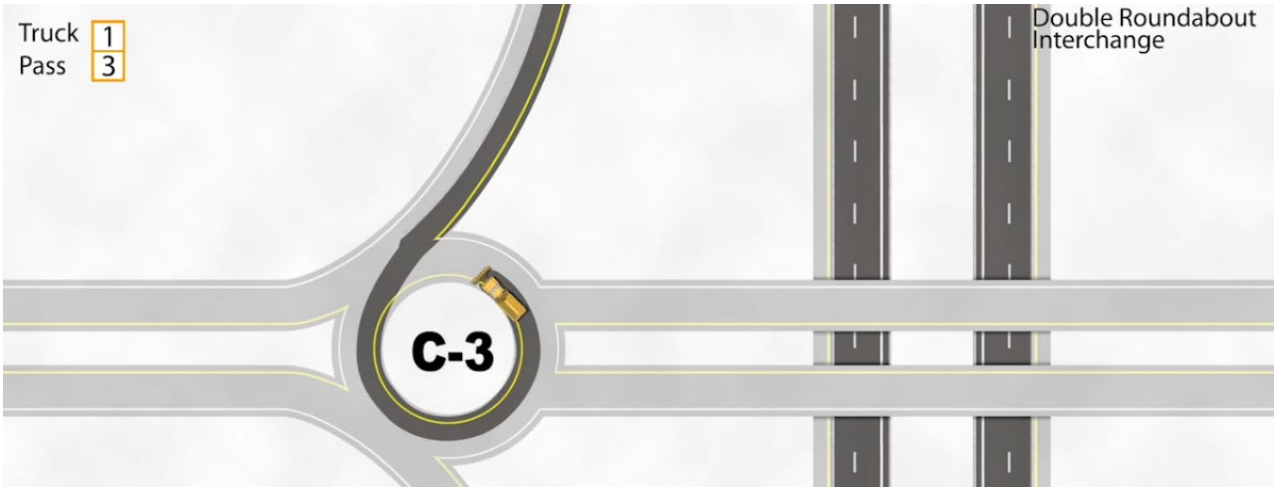


Figure 6.3: Snow plowing pattern for the Pass 1/3 (b)

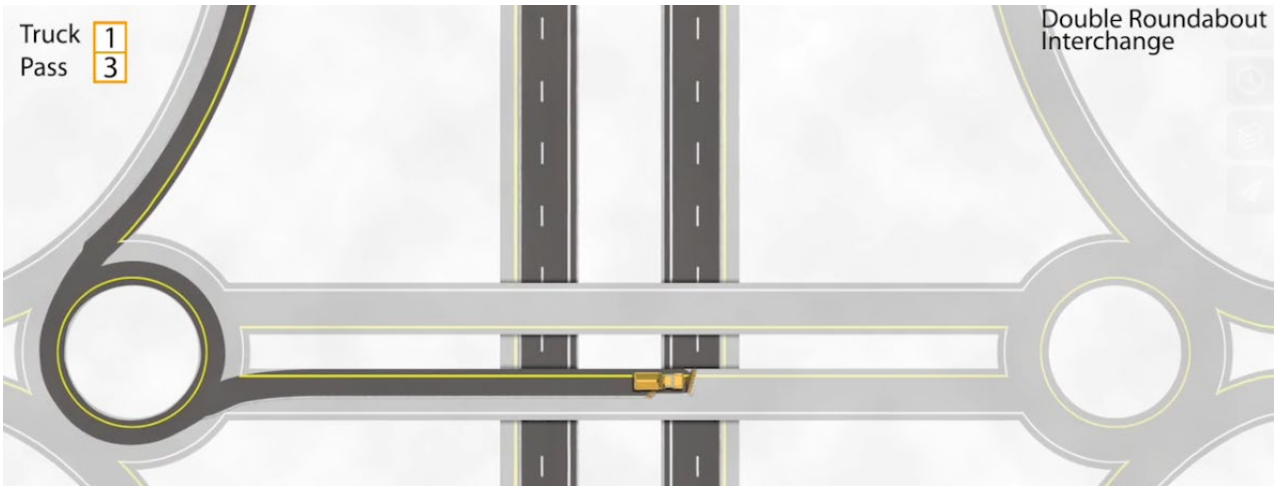


Figure 6.4: Snow plowing pattern for the Pass 1/3 (c)

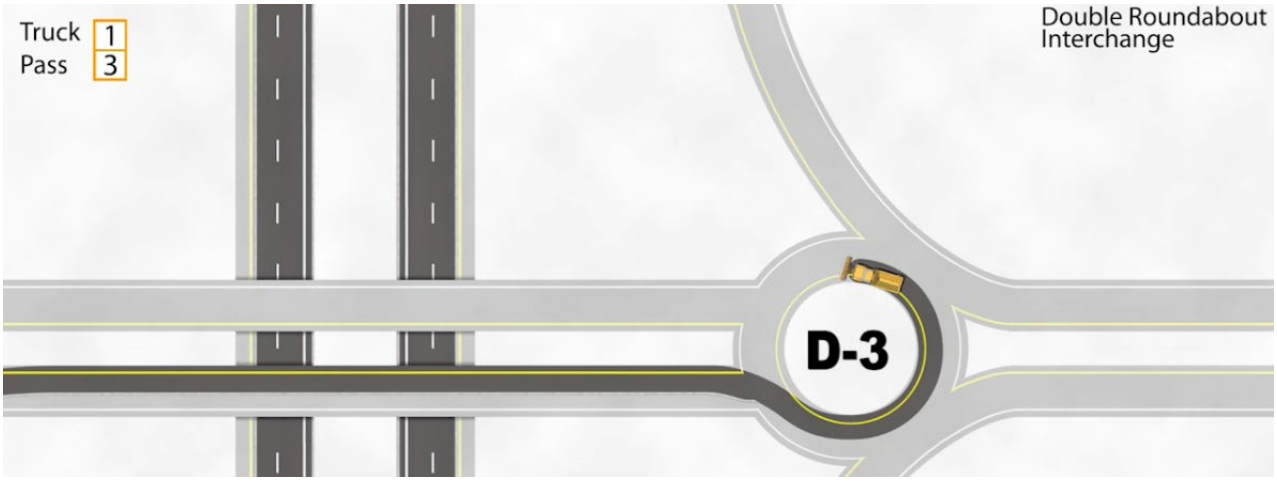


Figure 6.5: snow plowing pattern for the Pass 1/3 (d)

Meanwhile, Truck 2 begins Pass 2/L, clearing the freeway right shoulder using front and wing plows. It turns around and clears the opposite side of the freeway right shoulder using front and wing plows.

Step 4 Truck 2 starts Pass 2/4 on the off-ramp, with front-plow angled right and right-wing plow deployed. It clears the roundabout circle and crosses the local road overpass. The truck circles the opposite roundabout and proceeds back to the initial roundabout, staying on the right lane while crossing the local road overpass. The truck circles and enters the on-ramp, staying to the right lane with front-plow angled right and right-wing plow out. Later, it merges with the through lanes on the main roadway.

Step 5: Truck 1 begins Pass 1/L, clearing the off-ramp right shoulder using the front-plow angled right and right-wing out. It continues the snow plowing on the local road right side, then turns around and continues the snow plowing along the right shoulder. Later, truck 1 merges with the through lanes. Truck 1 completes when it reaches the nearest entrance of the freeway.

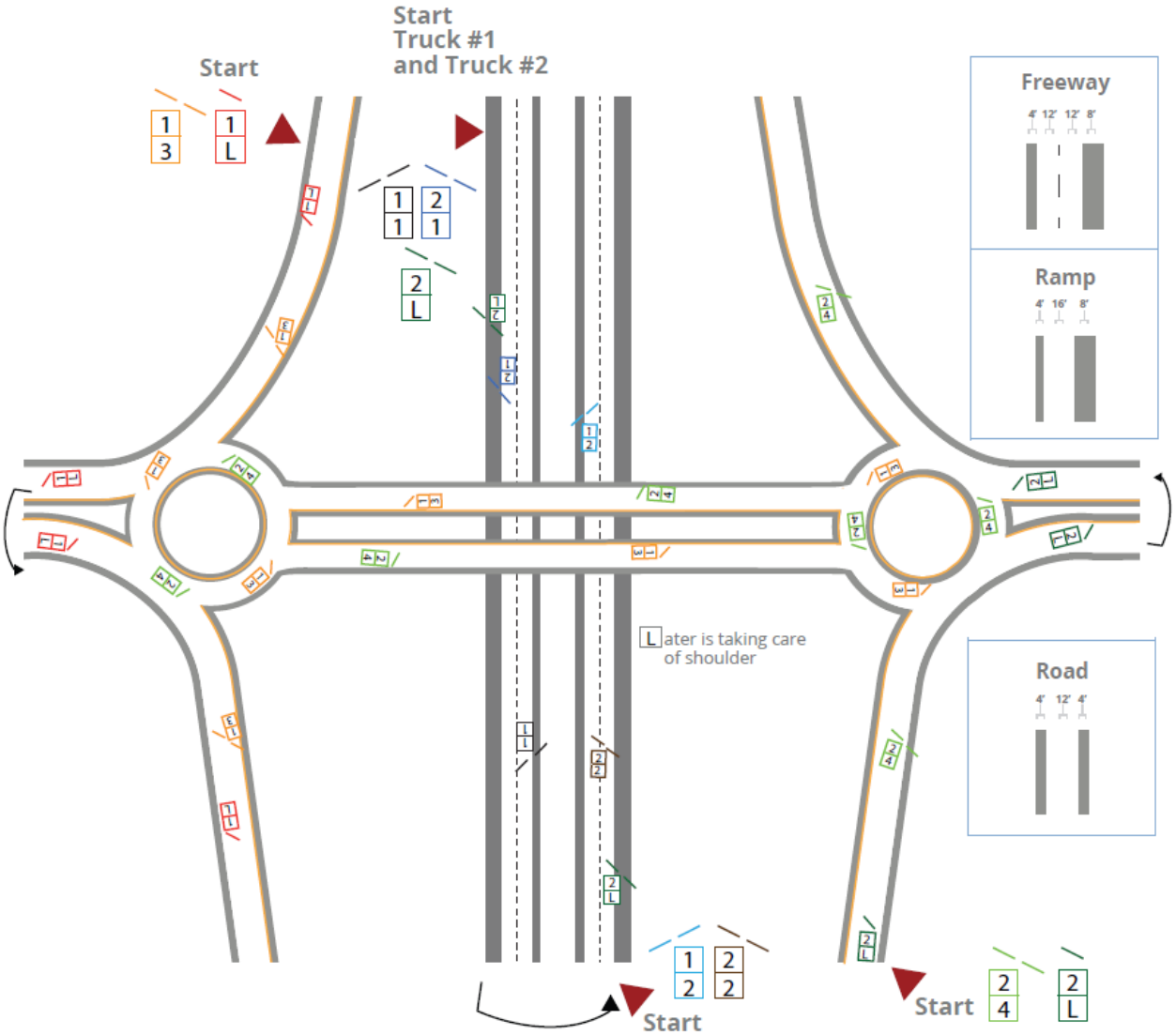


Figure 6.6: Plowing Pattern for clearing a double roundabout interchange

Step 6: Returning to the initial position, truck 2 turns and then exits and starts clearing the off-ramp to resume Pass 2/L. The truck turns onto the local road and enters the on-ramp still clearing the right shoulder. After clearing the on-ramp, it merges with the through lanes. Then Truck 2 completes snow plowing.

CHAPTER 7
DIAMOND INTERCHANGE

Overview

The familiar Diamond interchange provides continuous traffic flow of vehicles entering and exiting the main highway using separated grades for the main highway and the cross road. This interchange has been widely used for decades. Due to its simple configuration, diamond interchange is comparatively easy to plow. Depending upon the topography, density, traffic volumes, and other factors, the main highway may be above or below the cross road. Traffic control at where the ramps meet the cross road may be just STOP and YIELD signs, or traffic signals.

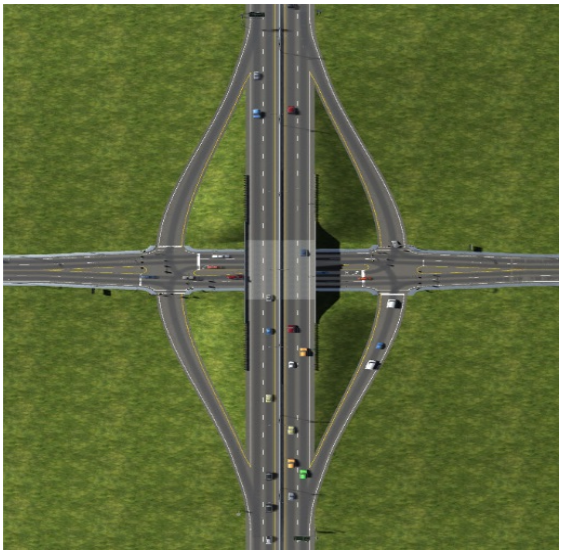


Figure 7.1: Diamond Interchange

Equipment and General Considerations

In the best practice example, two trucks have been used on the major highway; each has a front plow and a right-wing plow. The through lanes are 12′ wide on both the highway and the intersecting lower road. The highway has 4′ wide left shoulders and 8′ wide right shoulders. The two-lane local road has 4′ wide shoulders on both sides. The lanes on the off and on ramps are 16′ wide with 4′ wide left shoulders and 8′ wide right shoulders. A third truck handles the local road. Small islands or medians are commonly placed where the ramps intersect the cross road.

Plowing Pattern

Figure 7.2 presents the plowing pattern to clear a diamond interchange. Truck 1 and Truck 2 clear the main lane first and then clear the ramps. Truck 3 clears the cross route.

Truck #1 and Truck #2

Step 1: 

Trucks 1 and 2 begin in one direction on the main four-lane, divided highway, pushing snow to right.

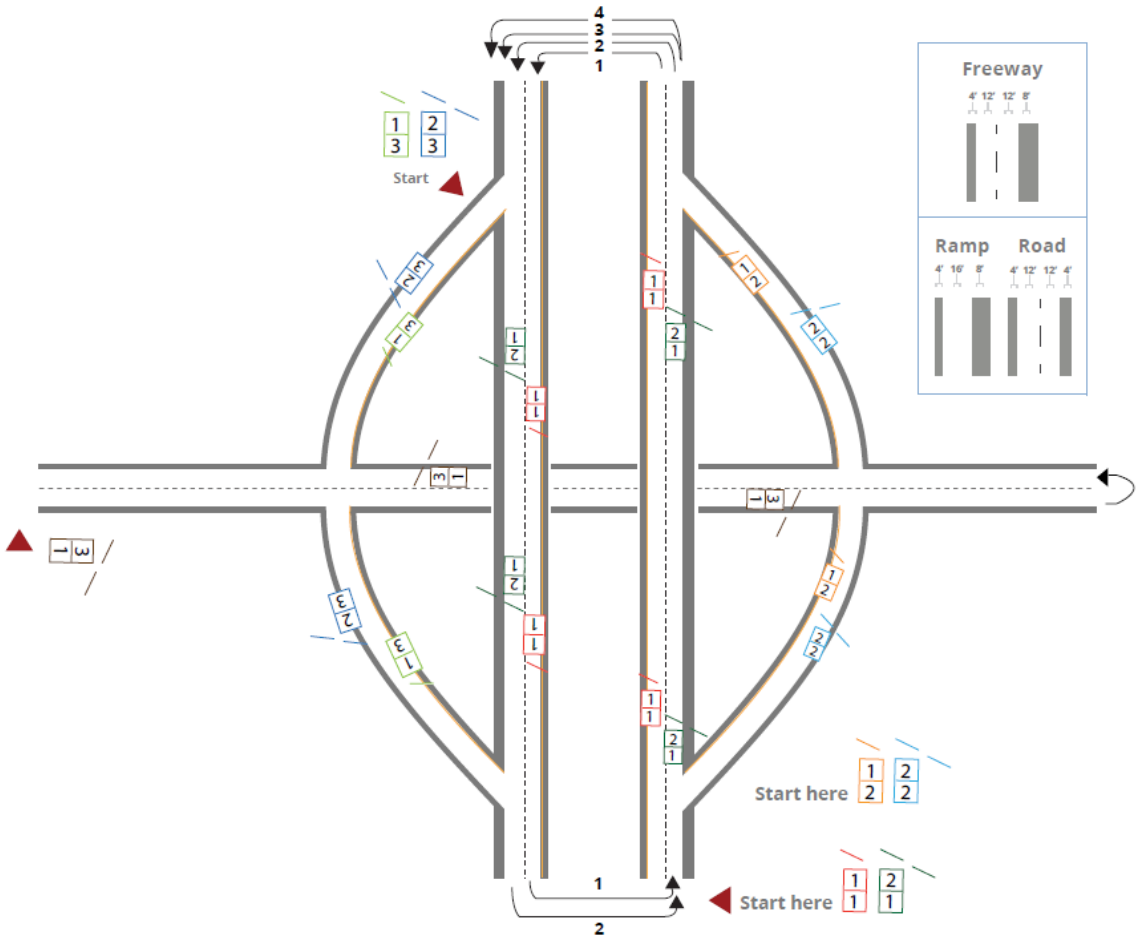


Figure 7.2: Snow plowing pattern of clearing a diamond interchange

Truck 1 begins Pass 1/1 in the left (inside) lane of freeway with front plow angled right.

Truck 2 begins Pass 2/1 in the right (outer) lane; the front plow is angled right and the right-wing plow is extended out and slightly behind truck 1.

Step 2 At turn-around point both trucks cross-over and continue in opposite direction pushing snow to the right:

Truck 1 clears opposite direction inside lane, pushing snow to right.

Truck 2 clears outside lane of freeway, pushing snow to right (trailing truck 1).

Figure 7.3 illustrates the snow plowing for the step 1 and step 2.

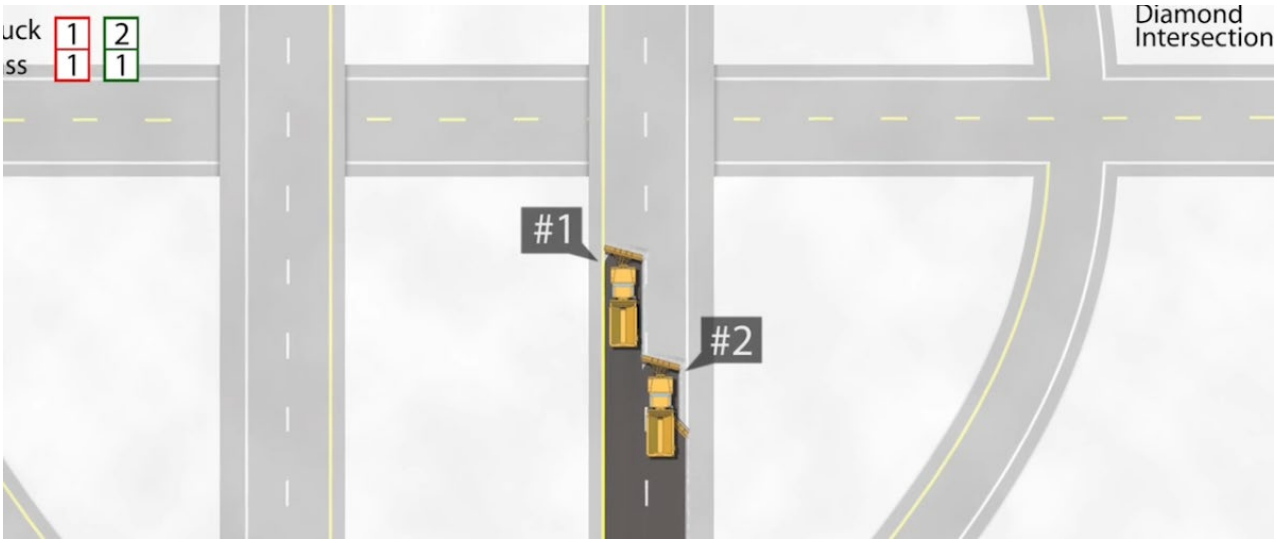


Figure 7.3: Snow plowing for the step 1 and step 2

Step 3 At turn-around point, both trucks cross-over to clear exit-entrance ramps on one side of highway, pushing snow to right:

Truck 1 clears exit and entrance ramps, staying on inside and pushing snow to right.

Following truck 1, truck 2 clears exist and entrance ramps, staying on outside and pushing snow to right.

Figure 7.4 illustrates the snow plowing for the step 3.

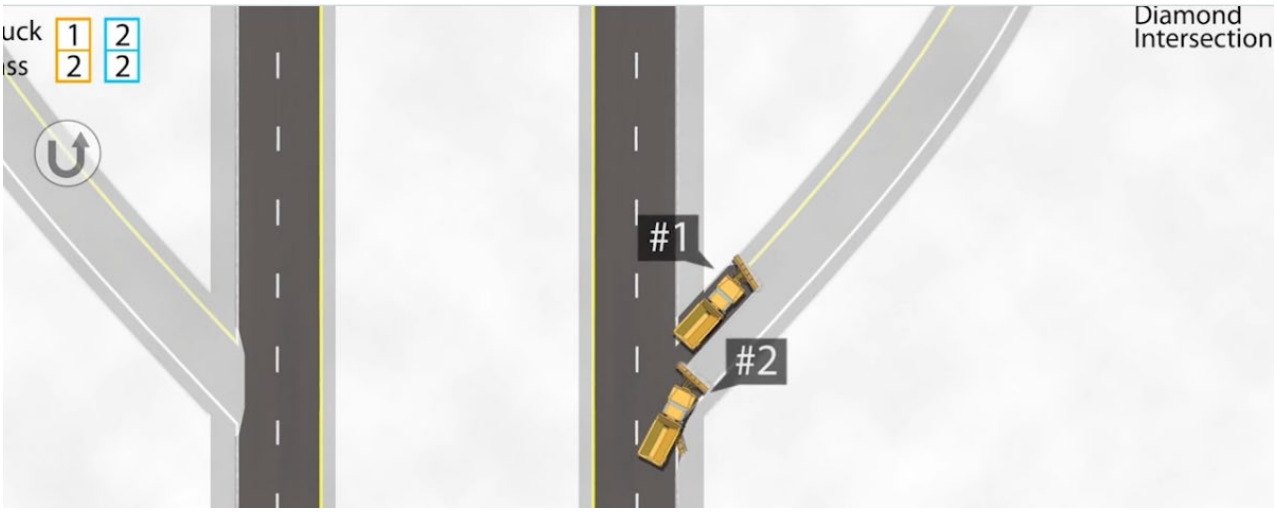


Figure 7.4: Snow plowing for the step 3

Step 4 At turn-around point, both trucks cross-over to exit- entrance ramps on opposite side of highway, pushing snow to right:

Truck 1 clears opposite exit and entrance ramps, staying on inside and pushing snow to right.

Following truck 1, truck 2 clears opposite exist and entrance ramps, staying on outside and pushing snow to right.

Note: Both trucks proceed in formation while clearing the main line freeway and the exit-entrance ramps.

Truck #3

Step 1: Truck 3 begins Pass 3/1 in one direction on two-lane cross road, with front plow angled to the right and right wing plow extended.

Step 2: Truck 3 turns around and continues Pass 3/1 to clear in opposite direction, pushing snow to right.

Figure 7.5 illustrates the snow plowing for the trcuk 3 step 1.

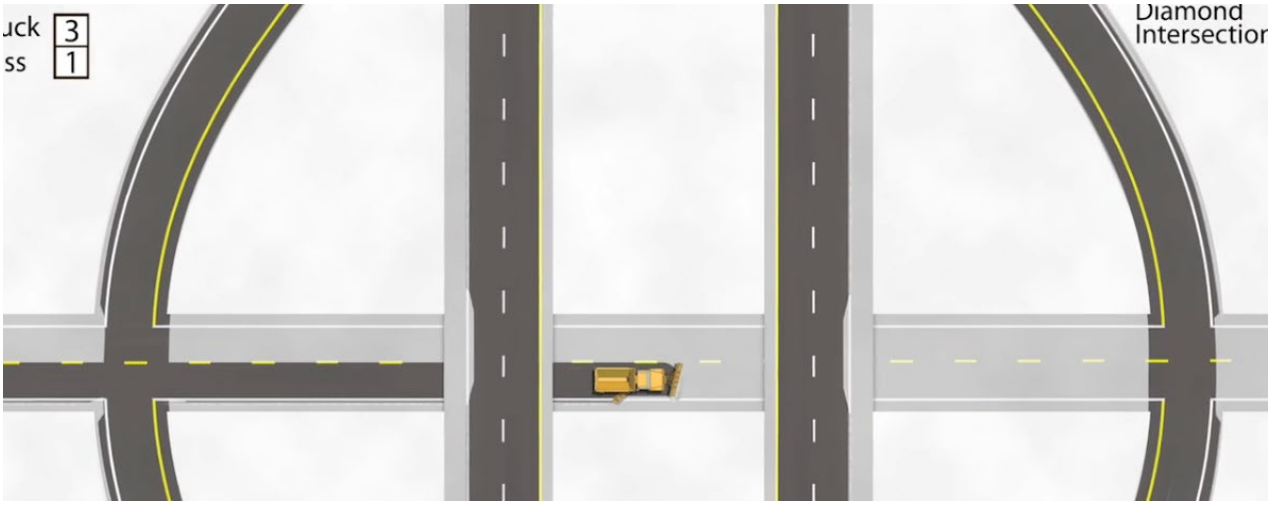


Figure 7.5: Snow plowing for the truck 3 step 1

CHAPTER 8
CLOVERLEAF INTERCHANGE WITH C/D LANES

Overview

The cloverleaf interchange is very common due to its capability of safely and efficiently moving traffic on and off two intersecting roads on separate grades without use of STOP signs or signals. The principal feature is either two or four inner circular ramps set within outer "diamond" ramps. The approximate loop ramps allow traffic that would normally have to make a left-turn from one road to another to do so without crossing opposing traffic. Right turn movements are handled by the outer "diamond" ramps. Another significant feature of our example is the use of Collector-Distributor (C/D) lanes, or ramps, that parallel the main roads' through lanes. The C-D lanes provide safer, more efficient flow of traffic. Plowing concepts discussed for a full cloverleaf with C-D lanes can also be used for partial cloverleaf interchanges.

Figure 8.1: Cloverleaf interchange

Though the cloverleaf can handle a lot of traffic, it does have a few significant drawbacks that can be problems for snow plows:

- Smaller loops of the ramps have "tighter" turning radii; this requires a sharp drop in speed to avoid tipping or road runoff.
- The distance between traffic entering from the right from the on-ramp and traffic exiting to the right for the off-ramp is relatively short. At periods of heavy traffic there is much weaving of vehicles trying to merge left onto the roadway while others in the through lanes are slowing down while attempting to move far right to the exit.

Equipment and General Considerations

In the best practice example, a full cloverleaf interchange with C/D lanes has been considered. Five trucks are employed in the example: trucks 1 and 2 for the four-lane divided main highway, trucks 3 and 4 for the four-lane lower cross road, and truck 5 for the loop and outer ramps as well as C/D lanes. Trucks 1, 3, and 5 have a front plow and a right-wing plow, while trucks 2 and 4 only have a front plow. The through lanes are 12′ wide on both the highway and the cross road with 4′ wide left shoulders and 8′ wide right shoulders. The lanes on the ramps are 16′ wide with 4′ wide left shoulders and 8′ wide right shoulders.

Note that the main road overpass lanes are separated by an open space; each time the truck plows across the overpass it must slow down and "square the plow" to avoid casting snow off the overpass to the roadway below.

Plowing Pattern

Figure 8.2 illustrates the snow plowing pattern for clearing a typical cloverleaf interchange with C/D lanes.

Trucks 1 and 2

Step 1: 

Trucks 1 and 2 start from the main road near end-point. Truck 1 begins Pass 1/1 in the right-through lane with front-plow angled right and right wing extended. Truck 2 begins Pass 2/1 in the left through lane with only front plow angled left, slightly behind Truck 1. They proceed across the overpass, carefully to not propel plowed snow over the railing. The trucks continue across the overpass to the far end-point. They turn around, resume Passes 1/1 and 2/1, keep in formation. The truck proceed across the overpass in the opposite direction to the near end-point.

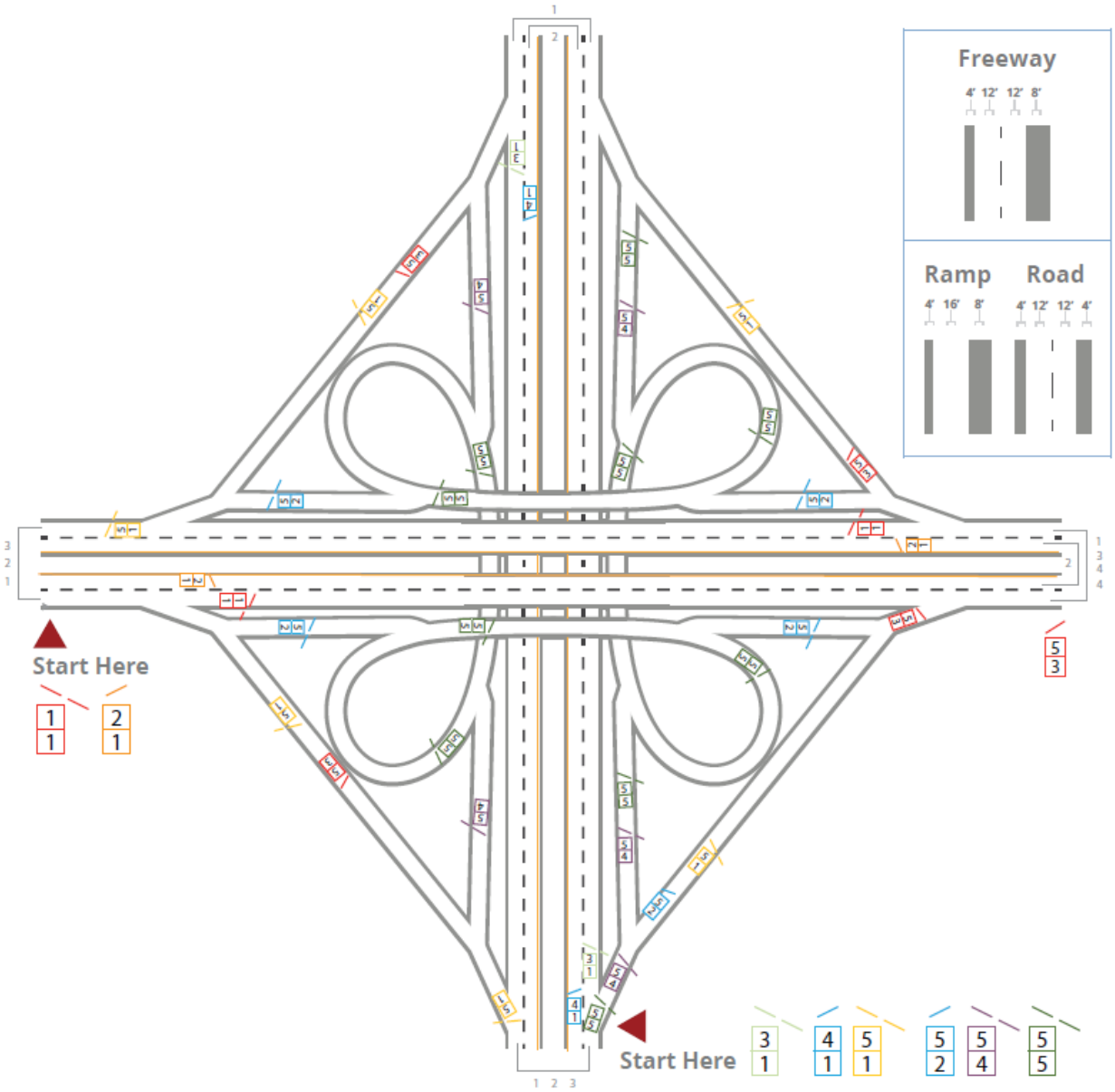


Figure 8.2: Snow plowing pattern for clearing a cloverleaf interchange with C/D lanes

Truck 3 and 4:

Step 1: Trucks 3 and 4 start at the near end-point of the lower cross road. Truck 3 begins Pass 3/1 in the right- through lane of the lower road, front -plow angled right and right-wing plow extended. Truck 4 begins Pass 4/1 in the left-through lane, front-plow only angled left, slightly behind Truck 3. They proceed to the far end-point and turn around. The trucks resume Passes 3/1 and 4/1 in the opposite direction to the near end-point.

Note that when plowing the right shoulders, the truck should square the plow to carry snow across the merge of the on-ramps with the through lane and the entrance to the off-ramps.

Truck 5

Step 1:

Truck 5 begins Pass 5/1 on the outer-ramp at the near end-point of the lower cross road. It proceeds along the right shoulder with front-plow angled right and right-wing extended. It merges with main road through lanes and proceeds to end-point.

The truck turns around, shifts right, exits onto the outer-ramp. It resumes Pass 5/1 along the right shoulder, with front-plow angled right and right-wing plow out. It merges with lower cross road through lanes and proceeds to end-point. Truck 5 turns around, repeats the same steps to clear all the outer ramps and proceeds back to the near end-point of the lower cross road.

Step 2: 

Truck 5 begins Pass 5/2 on the outer-ramp at the near end-point of the lower cross road. It proceeds along the left shoulder with only front plow angled left. It merges with main road through lanes and proceeds to end-point. The truck turns around, exits onto the main road C-D ramp and continues Pass 5/2 on the connector, with front-plow angled right and right-wing extended. It continues across the overpass, merges with through lanes and proceeds to main road near end-point.

The truck turns around, shifts right and exits onto the C-D ramp of the opposite direction. It resumes Pass 5/2 with front-plow angled right and right wing extended. The truck continues across the overpass and merges with main road through lanes. It proceeds to main road far end-point.

Note that as the truck approaches the merges with the "loop" ramps it aligns plows to carry the snow across the openings.

Step 3: 

Truck 5 turns around and begins Pass 5/3 *by repeating the same pattern as Pass 5/1* plowing the remaining outer ramps in the same sequence but now along the left shoulder, with only front-plow angled left. Pass 5/3 completes when the truck arrives at lower road near end-point.

Step 4: 

The truck turns around, exits onto the lower cross road C-D ramp and starts Pass 5/4 on the connector, with front-plow angled right and right-wing extended. It merges with through lanes and proceeds to lower cross road far end-point.

The truck turns around, shifts right and exits onto the C-D ramp of the opposite direction. It resumes Pass 5/4 with front-plow angled right and right wing extended. The truck merges with main road through lanes and proceeds to lower cross road near end-point.

Step 5: 

Truck 5 turns around, shifts right, exits onto the lower road C-D connector. It proceeds under the overpass and begins Pass 5/5 at the loop-ramp. It proceeds with front-plow angled right and right plow extended. The truck merges onto the main road C-D connector, proceeds across the overpass and enters opposite side loop-ramp. It merges onto the lower C-D connector, proceeds under the overpass then enters the loop-ramp. It then merges onto the main road C-D connector and proceeds across the overpass. The truck enters the loop-ramp and merges onto the lower road C-D connector, proceeds under the overpass to the far end of the lower cross road. This completes all passes.

CHAPTER 9
SINGLE-POINT INTERCHANGE

Overview

In a single point interchange, on and off ramps converge at a central, signalized location, and can accommodate higher volumes of traffic within tighter right-of-way limits. This allows traffic to operate safer and more efficiently.

Figure 9.1: Single point interchange

Equipment and General Considerations

In the best practice examaple, two trucks have been used; each has a front and right-wing plow capable of a clearing a 14′ span. The plows of both trucks are angled to push snow to the right. The travel lanes on the freeway and the road are 12′ wide, but 16′ wide on the ramps; shoulders vary in width from 4′ to 8′.

Plowing Pattern

Figure 9.2 illustrates the snow plowing pattern for clearing a typical single point interchange.

Step 1: Truck 1 begins Pass 1/1 in the left lane or inside lane of the four-lane divided main road; truck 2 begins Pass 2/1 in the right lane or outside lane, slightly behind and to the right of truck 1. At the far end-point, both trucks turn around and continue Passes 1/ 1 and 2/ 1 in the opposite direction.

Step 2: Both trucks turn around at the near end-point and begin Passes 1/2 and 2/2 on the near off- ramp. They turn left at the intersection and continue plowing both through lanes of the minor road. At the next end-point, both trucks turn around and clear the two left-turn lanes. They proceed across the intersection, plow the on-ramps then merge onto the major road.

Step 3: Both trucks turn around at the far end-point of the major road, then begin Passes 1/3 and 2/3 on the off-ramp. They turn left at the intersection and continue plowing both through lanes of the minor road. They turn around at the minor road end-point and continue Passes 1/3 and 2/3 in the opposite direction left turn lanes. They proceed across the overpass on the green signal and turn left in formation and enter the on-ramp. Merging onto the highway, they continue to the far end point of the highway. Both trucks turn around, then they shift right to the off ramp. Staying in formation, they proceed up the off ramp to the traffic signal at intersection, with wing plow tucked in and front plow lifted (since on-ramp is already cleared). On the green signal, they turn left and continue on the two through lanes to the far end point of the minor road.

Step 3: The trucks turn around and begin Passes 1/4 and 2/4 with front plow lowed and wing plow extended. They plow the two through lanes, proceed across the overpass on the green signal, and continue to reach the near end point of the minor road. The trucks turn around and continue Passes 1/4 and 2/4 in the two through lanes. They proceed across the overpass on the green signal and continue to reach far end point of the minor road.

Step 5:  Truck 2 is dismissed. Truck 1 turns around at the minor road end-point. It begins Pass 1/5 enters the on-ramp right lane, then merges onto the main road. It turns around at the end-point and enters the right lane of the off-ramp. It proceeds up the ramp merging with the minor road through lane.

When it reaches the end-point, it turns around, shifts to the far-right lane, enters the on-ramp and plows the lane and shoulder until merging onto the main road. It turns around at the end point and enters the off-ramp. The truck proceeds to turn right onto the minor road right lane. This completes all passes.

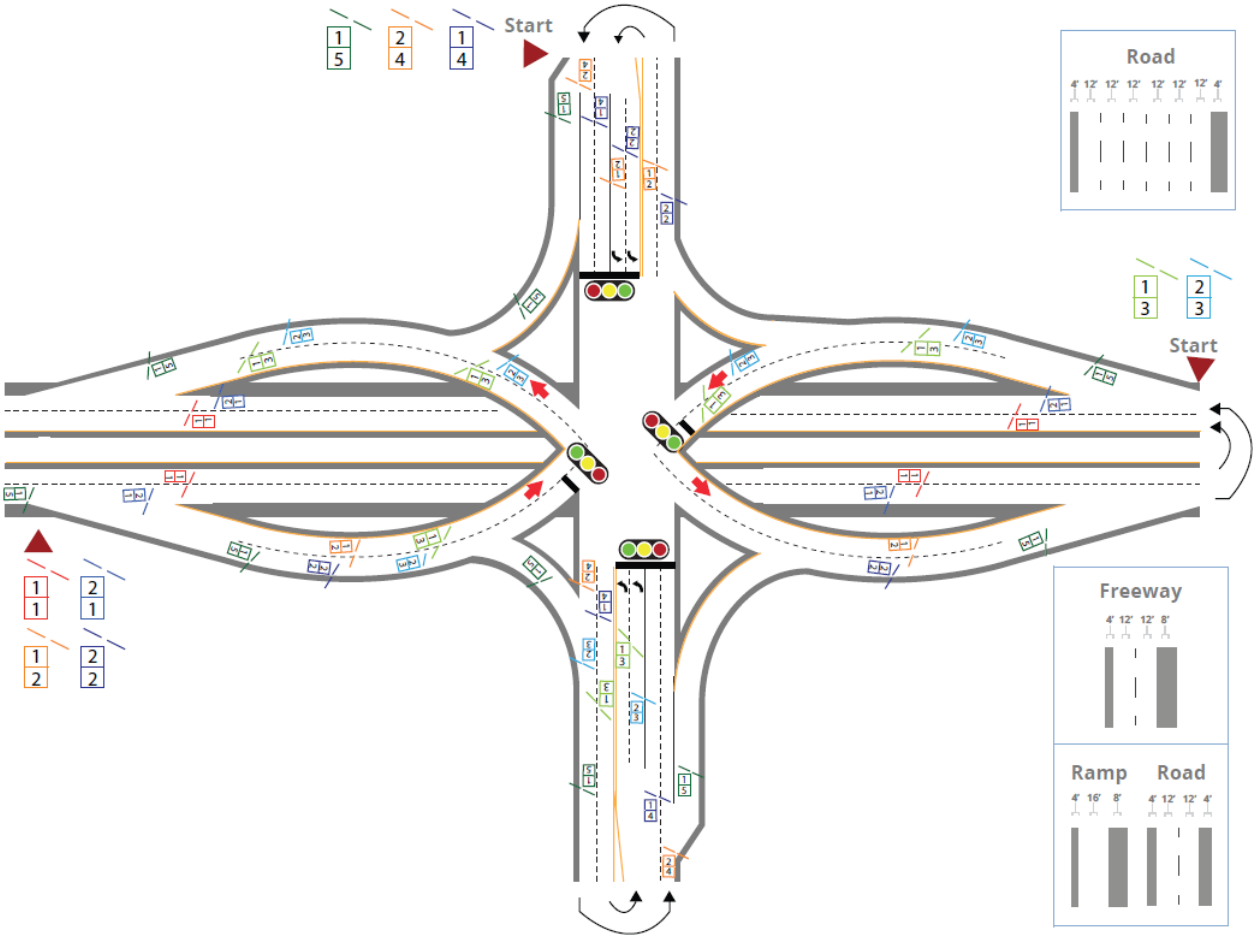


Figure 9.2: Snow plowing pattern on Single Point Interchange

CHAPTER 10
DIVERGING-DIAMOND INTERCHANGE

Overview

A diverging-diamond interchange is similar to a standard diamond interchange but with one noticeable and important difference; the through lanes on the overpass are reversed. This eliminates conflicts of left-turn movements with opposing traffic and the need for exclusive left-turn traffic signal phases. Traffic flows more efficiently and safely through the two signalized intersections.

Figure 10.1: Diverging diamond interchange

Equipment and General Considerations

In the best practice example, three trucks have been used; Truck 1 and truck 2 have a front-reversible plow and a right-wing plow capable of a clearing a 14′ span, while truck 3 has a front-reversible plow and dual wings. Two trucks handle the freeway and the third truck the local road above. Both the freeway and the local road are four-lane divided; the through lanes on both are 12′ wide; the ramp lanes are 16′ wide. The shoulders on the freeway and ramps are 4′ wide on the left and 8′ right; road shoulders are 4′ wide on both sides.

Note that when plowing on the overpass, trucks should reduce speed to prevent projecting snow over the railings to the road below.

Plowing Pattern

Figures 10.2 and10.3 illustrate the snow plowing pattern for clearing a typical diverging diamond interchange.

Freeway -Trucks 1 and 2

Step 1: 

Both trucks start at the near end-point in echelon (truck 2 slightly trailing truck 1). Truck 1 begins Pass 1/1 in the left-through lane, with front-plow angled left and left wing extended. Truck 2 begins Pass 2/1 in the right-through lane; with front-plow angled right and right-wing plow extended onto the shoulder. Both trucks continue to the far end-point, turn around, and continue Passes 1/1 and 1/ 2 in the opposite direction back to the near end-point.

Ramp-Truck 3

Step 1: 

Truck 3 starts at the near end-point of the freeway, proceeds to the off- ramp to begin Pass 3/1. It stays to the left with front-plow angled left and left wing extended. It continues operation to the left even after the ramp splits.

At the end of the ramp, the truck turns left onto the local road left-through lane, reverses the front-plow to angle right and extends the right -wing. It continues across the overpass and enters the on-ramp. The truck reverses the front-plow to angle left, extends the left wing and stays to the left on the ramp. It merges with freeway through lanes and proceeds to the end-point.

Step 2: 

Truck 3 turns around and proceeds to the off-ramp to begin Pass 3/2. It stays to the right with front-plow angled right and right-wing plow extended. At the split, the truck stays right and then merges with the left lane. The front-plow stays angled right and the right-wing plow is extended out.

The truck proceeds to the end-point, turns around and continues Pass 3/2 in the left-through lane. Nearing the overpass, it moves to the right and enters the on-ramp. The truck stays right on the ramp, merges onto the freeway and proceeds to the far end-point.

Step 3: Truck 3 turns around and proceeds to the off-ramp to begin Pass 3/3. The front-plow is angled left and left wing is extended. It stays left past the split. At the end of the ramp, it turns onto the left-through lane. Keeping the front-plow angled left, the truck crosses the overpass and enters the on-ramp. Continuing along the left of the ramp, it merges onto the freeway through lanes and proceeds to the end-point.

Step 4: Truck 3 turns around and proceeds to the off-ramp to begin Pass 3/4. The front-plow is angled right and the right-wing plow is extended as the truck stays to the right along the ramp. At the split, it stays right. At the end of the ramp it merges onto the left-through lane. Proceeding to the end-point, the truck turns around and resumes Pass 3/ 4 in the left-through lane. Approaching the overpass, it shifts right and enters the on-ramp. The truck stays to the right, merges onto the freeway through lanes and proceeds to the end-point.

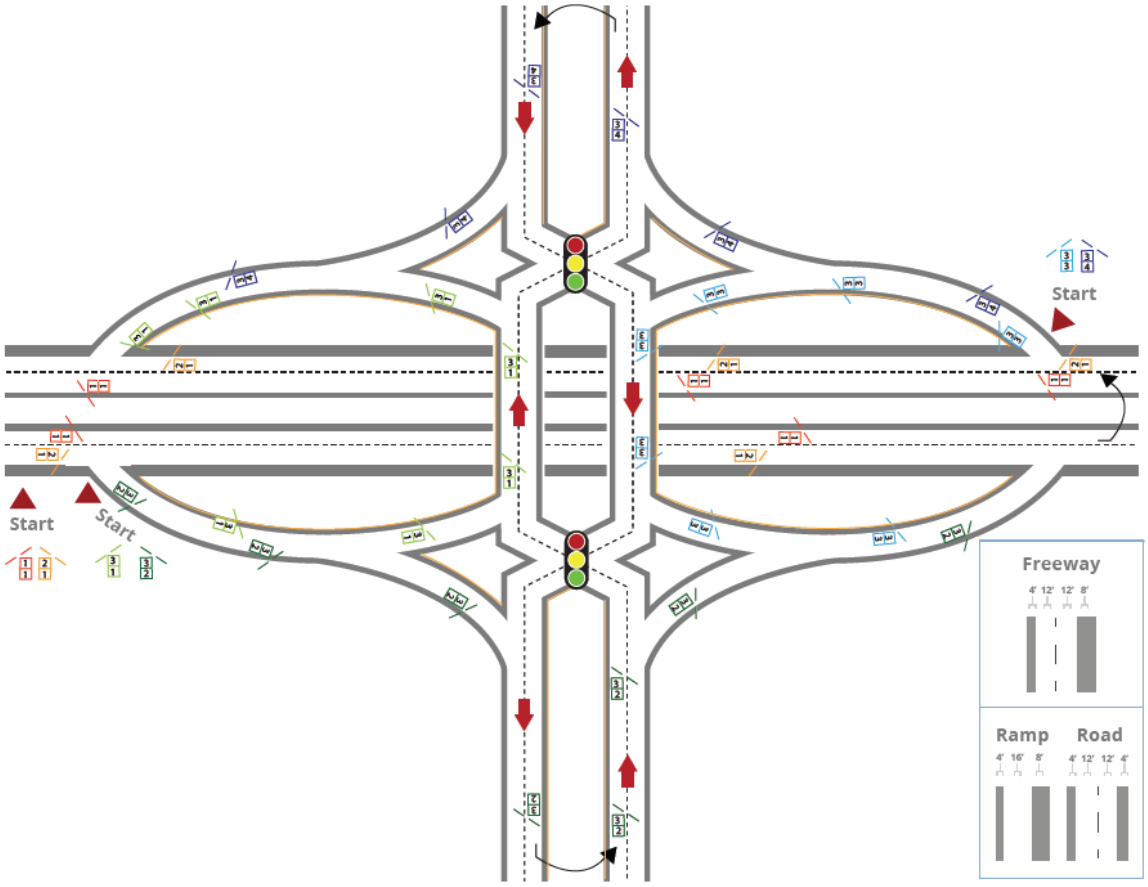


Figure 10.2: Snow plowing pattern for clearing a diverging diamond interchange 1/2

Step 5: 

Truck 3 turns around and exits onto the freeway off-ramp. Approaching the right side of the divider island, it reverses front-plow to the left, extends left wing, and begins Pass 3/5 along the island's left shoulder. At the end of the ramp, it reverses the front-plow to the right, extends the right-wing plow and merges with the right-through lane of the local road. The truck plows this lane and shoulder to the end-point. It turns around and resumes Pass 3/5 in the opposite direction right-through lane. The truck shifts into the left-through lane at the near-side traffic signal. It proceeds on the signal across the intersection and shifts into the right-through lane. At the traffic signal at the other end of the overpass, it shifts to the left-through lane. Truck 3 proceeds on the signal across the intersection and then shifts to the right-through lane. It continues Pass 3/ 5 to the end-point.

Step 6: 

Truck 3 turns around and begins Pass 3/6 in the right-through lane. Approaching the near side traffic signal, it shifts to the left-through lane then reverses the front-plow to left-angle and extends left wing. Proceeding on the signal across the intersection, it shifts to the right-through lane, reverses the front-plow to the right and extends right-wing. Approaching the far side traffic signal, the truck shifts to the left-through lane. It proceeds on the signal across the intersection, stays in the left-through lane and continues Pass 3/6 to the end-point.

Step 7: 

Truck 3 turns around and begins Pass 3/7 in the right-through lane, with front plow angled to the right and right-wing extended. It crosses the near intersection on the signal and continues in the right-through lane of the overpass. The truck proceeds through the far intersection on the signal and continues in the right-through lane to the end-point.

Step 8: 

Truck 3 turns around and begins Pass 3/8 in the right-through lane of the opposite direction. It crosses both intersections at the overpass on the signal, stays in the right-through lane to the end-point.

Step 9: 

Truck 3 turns around and begins Pass 3/9 entering the first on-ramp. It clears the right side of the island, with front-plow angled left and left wing extended. The truck proceeds down the on-ramp, merges with freeway and proceeds to the end-point. It turns around and exits onto the off-

ramp of the opposite direction. At the split, it stays left, reverses the front plow to the right and clears along the island. The truck merges onto the local road left-through lane, then it enters the next on-ramp, with the front-plow angled right and right wing extended and clears along the island. The truck merges onto freeway and proceeds to end-point**.**

The truck turns around and again exits onto the off-ramp. At the split it stays right, reverses front-plow to left, extends left wing and clears along the island. The truck merges with local road through lanes and proceeds to the end-point.

Step 10 

Truck 3 turns around and enters the next on-ramp. It stays to the left, with front-plow angled left, left wing extended, and clears along the island. The truck proceeds down the ramp, merges onto freeway to the end-point.

The truck turns around and then exits onto the off-ramp. At the split, it stays left, reverses the front plow to the right, extends right wing, and clears along the island. At the end of the ramp, the truck turns left onto the local road through lanes. It crosses the overpass then enters the on-ramp, clearing the remaining side of the island. The truck continues down the ramp and merges with the freeway. This completes all passes.

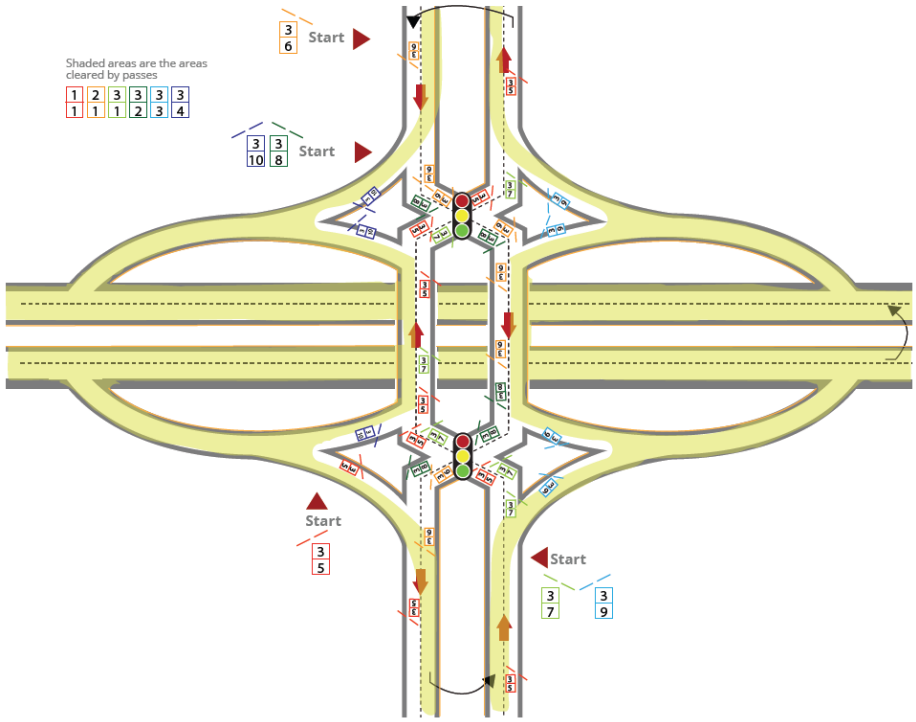


Figure 10.3: Snow plowing pattern for clearing a diverging diamond interchange 2/2

CHAPTER 11
DIRECTIONAL T INTERCHANGE

Overview

A Directional T interchange differs from a traditional T intersection in that it provides continuous traffic flow of vehicles entering and exiting the main highway. Potential for right-angle collisions is eliminated by separated grades using elevated ramps and overpasses. No traffic control signs or signals are needed.

Figure 11.1: Directional T interchange

Equipment and General Considerations

In the best practice example, two trucks have been used: one has a front plow and a right -wing plow, the other has a front and reversible wing plow. The through lanes are 12′ wide on both the highway and the intersecting road. The highway has 4′ wide left shoulders and 8′ wide right shoulders. The local road above has 4′ wide shoulders on both sides. The lanes on the off and on ramps are 16′ wide with 4′ wide left shoulders and 8′ wide right shoulders.

Plowing Pattern

Figure 11.2 illustrates the snow plowing pattern for clearing a typical directional T interchange.

Truck 1

Step 1: Truck 1 begins Pass 1/1 in the left (inside) through lane in one direction of the major road. It uses front-plow only angled to the right. At the far end-point it turns around and continues Pass 1/1 in left-through lane of the opposite direction.

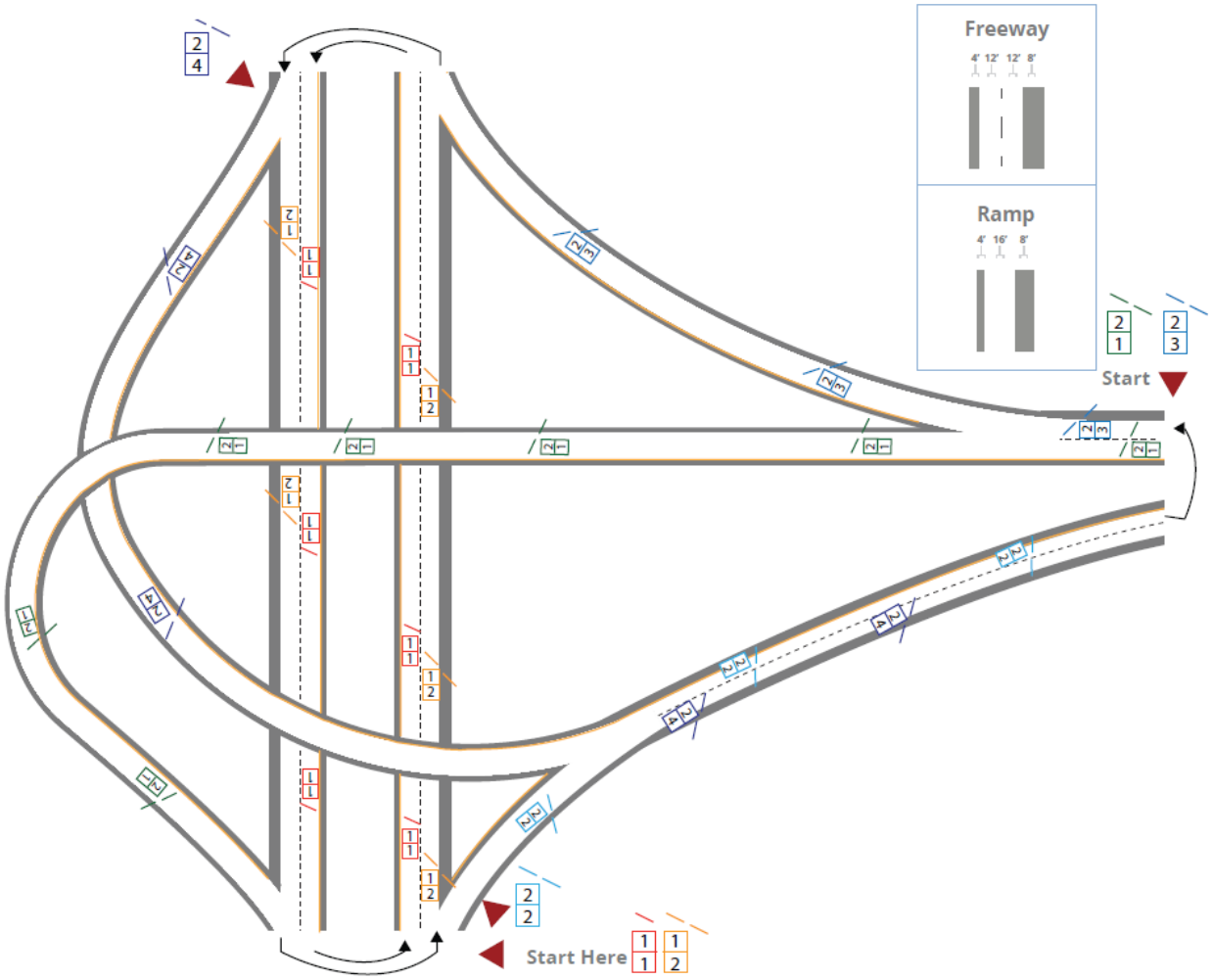


Figure 11.1: Snow Plowing Pattern for clearing a directional T interchange

Step 2: 

Truck 1 turns around at the near end-point onto the right- through lane and begins Pass 1/ 2 with the right-wing plow fully extended. At the far end-point it turns and continues Pass 1/ 2 in the right lane to the end-point.

Truck 2

Step 1: 

Truck 2 begins Pass 2/1 at near end-point of minor road. The right-wing plow is fully extended and the front plow angled to the right. It proceeds across the overpass; as it enters the banked curve of the ramp it reverses the angle of the front plow to the left and extends the left-wing plow.

As the curve straighten, it re-angles the front plow to the right and extends the right-wing plow out. It merges onto the major road and turns around at the designated point.

Step 2: 

Truck 2 enters the near off-ramp and begins Pass 2/2 with front plow angled right and right-wing plows extended. At the merge with another ramp it shifts to the left lane, retracts the right-wing plow and continues with the front plow only angled right. When the ramp ends, the truck continues to the minor road end-point and turns around.

Step 3: 

Truck 2 heads back toward the overpass in the right lane, both plows angled to the right. It enters the on-ramp to begin Pass 2/3. The truck proceeds down the ramp, merges onto the major road and continues to the far end-point. It turns around and exits onto the off-ramp.

Step 4: 

It starts Pass 2/4 with both plows angled to the right but at the beginning of the banked curve, the front plow is angled left and the left wing is extended. As the curve straightens the truck reverses the front plow angle to the right. Where the overpass merges with the other ramp, truck 2 shifts to the right (outside) lane and continues to the end-point.

The Directional T interchange is now complete except for additional cleanup along some shoulders and at gore areas.

CHAPTER 12
SUMMARY AND CONCLUSIONS

In the preceding sections, best practices for clearing snow from ten different interchanges and intersections were presented. These can be very complex and challenging, especially during intense snow storms. Of course, how operators will handle these will depend upon various factors such as:

- vehicles and equipment,
- agency standards and protocols,
- roadway geometrics,
- topography,
- traffic volumes, and
- weather conditions.

Most critical, though, is how to apply the experience, training, and good judgment to provide safety and mobility to drivers in a reasonable time with the resources operators have.

Nearly all agencies conduct pre-season "dry runs" so that the operators become familiar with their routes and work out solutions to more difficult layouts. Operators should note any locations or situations, such as major construction work, that might require modifying a route. If an operator will be working with one or more partners, review the patterns before running the route each storm. Ideally, a practice run would also be held at night as plowing operations often occur during hours of darkness.

Some key points covered in the practice manual are listed below:

- Always remember to make safety…yours, your co-workers and the public…the top priority. Do a thorough check on your truck before leaving the yard at the beginning of the shift and each time you return for fuel or material.
- Stay alert. Operating a plow truck requires your full concentration and constant attention to traffic, pavement and weather conditions. Long hours behind the wheel cause fatigue and tedium but a moment's distraction can result in a serious crash. And though you may feel urgency in completing your assigned route, driving too fast is dangerous.
- Do not use a cell phone while driving.
- Lower speed to avoid casting snow over bridges or overpasses or too far onto sidewalks.

- Push snow away from traffic lanes whenever possible to avoid obstructing the traffic flow.
- Be aware of the pavement cross slope, wind conditions and other considerations for the route.
- Straighten plow angle through intersections and on bridge and overpass decks.
- Increase the plow angle when crossing bridge joints and rail crossings to avoid "tripping the plow."
- Be alert for steel plates, rough pavement, and manholes or valve-box covers that may trip the plow.
- When using a wing plow, watch for roadside obstructions such as guard rails, sign posts, fire hydrants and mail boxes.
- Along curves, push snow to the low side whenever possible.
- Watch for pedestrians in the roadway and stalled vehicles.

By following these pointers and the techniques shown for clearing snow from complex interchanges, operators will be able to handle your route efficiently, effectively, and safely.

On behalf of the Clear Roads Consortium, thanks for reading this manual. We hope that you gained useful knowledge and practical tips that will help you out on the road. Keep on plowing. We depend on you.

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