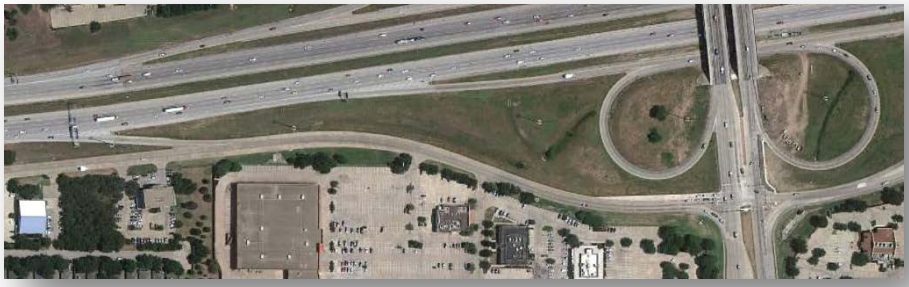
LOOP RAMPS REDUCING LEFT TURNS

Description

Localized bottlenecks can be created when large volumes exiting a freeway are destined to turn left at the intersecting cross street. Retiming the signal at the intersection to address the left-turn congestion may worsen congestion for the crossing arterial street. One solution to reduce delay and queuing is to keep the left-turning traffic on a collector-distributor road past the cross street and then have the traffic use a loop ramp to access the cross street.



Aerial photograph is of Westbound IH 20 to Southbound FM 157/Cooper Street (initial exit) or Northbound FM 157/Cooper Street (second exit to collector-distributor road and then loop ramp) in Arlington, TX. Source: Google Earth ™ Mapping Service.

The loop ramp configuration is a viable alternative when sufficient right-of-way is available to accommodate the loop roadway. The loop design converts a stop or signal-controlled left-turn movement at the ramp terminal into a merge or yield-controlled movement on a loop ramp. Collector-distributor roads can be used in conjunction with loop ramps to provide a speed change area for vehicles traveling between the intersecting streets.

Target Market

The provision of loop ramps for left-turning movements should be considered at locations where high left-turn volumes exist and sufficient right-of-way exists (or can be acquired) for the construction of the ramp. Two locations where loop ramps are considered include signalized freeway service interchanges and arterial intersections with heavy left-turn volumes.

Signalized Freeway Service Interchanges

The accommodation of high-volume left-turn movements can significantly affect the operations of a signalized intersection. These movements can be removed from the signalized ramp terminal if a loop ramp is provided. At freeway facilities without frontage roads, providing a loop ramp allows the left-turn phase at the ramp terminal to be eliminated entirely.

Cost:	●●●●○
Time:	**Medium / Long**
Impact:	**Spot / Corridor**
Who:	**City / State**
Hurdles:	**Right-of-Way**

For freeway facilities with frontage roads, left-turn phases must still be provided at the signalized ramp terminals for vehicles originating from or destined to locations along the frontage road, but the left-turn phase durations may be significantly reduced.

Arterial Intersections with Heavy Left-Turn Volumes

Loop ramps can improve traffic operations at arterial intersections that have heavy left-turn volumes. In this case, the loop ramps would be installed as part of a grade-separation project. This type of application is sometimes used as part of a highway-rail grade separation project, in which case additional benefits are realized through the removal of the highway-rail grade crossing.

How Will This Help?

- Increase safety by reducing the number of conflict points. An intersection between a one-way frontage road and a two-way arterial street has 13 conflict points. Providing a loop ramp for one of the left-turn movements results in the elimination of three conflict points.

For more information, please refer to: http://mobility.tamu.edu/mip/strategies.php.

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Providing a loop ramp for two of the left-turn movements results in the elimination of five conflict points. Safety is also improved by eliminating left-turn vehicle queuing.

- Improve efficiency of turning movements. When a free-flow loop ramp is provided, left-turning drivers no longer have to stop at a signal or stop sign, and may not even have to stop when merging onto the arterial cross street if they are provided with an exclusive receiving lane. When a non-free-flow loop is provided, the movement is accomplished with a right turn instead of a left turn. Efficiency is also improved by eliminating the need to store queued left-turning vehicles on the link between the two ramp terminals.
- Reduce delay, improve capacity through shorter cycle lengths, and simplify signal timing. At an isolated signalized intersection, eliminating a protected left-turn phase increases capacity by reducing lost time, and may even allow the cycle length to be decreased. At a signalized diamond interchange, if left-turning movements are removed through the provision of a loop ramp, it becomes easier to implement the three-phase or two-phase diamond interchange timing sequences, which lend themselves better to providing progressed traffic flow through the interchange and to adjacent signals on the arterial street. Capacity is also increased through the elimination of spillback that could occur due to left-turn vehicle queuing.

Chapter 22 of the *Highway Capacity Manual* was used to produce estimates of delay for a signalized diamond interchange before and after installation of loop ramps to accommodate left-turning entering or exiting vehicles. The delay estimates were for an arterial street with an AADT of 40,000 vehicles per day and a combined frontage road AADT of 20,000 vehicles per day. The results of this comparison are shown in the following table. The comparison shows that if loop ramps are provided for the entering or exiting left-turn movements at a signalized freeway service interchange, delay reductions in the range of 7 to 37 percent can be obtained, depending on what percentage of left turn movements are originating from or destined to

Example of Loop Ramp Delay Savings

Interchange Type	Left-turn Vehicles Served by Loop Ramp	Frontage Roads Present?	Delay (s/veh)	Level of Service
Conventional Diamond	None	N/A	42.0	D
Hybrid Diamond / Parclo A	Entering vehicles (10% of left turns)	Yes	38.9	D
Hybrid Diamond / Parclo B	Exiting vehicles (10% of left turns)	Yes	38.8	D
Hybrid Diamond / Parclo A	Entering vehicles (90% of left turns)	Yes	29.1	C
Hybrid Diamond / Parclo B	Exiting vehicles (90% of left turns)	Yes	26.6	C
Parclo A	Entering vehicles	No	18.0	B
Parclo B	Exiting vehicles	No	14.0	B

Table 1. Hypothetical example of delay savings from adding loop ramp when arterial street AADT is 40,000 veh/day and combined frontage road AADT is 20,000 veh/day.

For more information, please refer to: http://mobility.tamu.edu/mip/strategies.php.

the frontage roads. If frontage roads are not present (or left turns to or from the frontage roads are forbidden), the delay reduction increases to the 57 to 67 percent range.

Implementation Examples

The Washington State Department of Transportation completed an upgrade to the interchange of IH 5 and SR 531 in Arlington, Washington in July 2010.[1] Traffic studies revealed that more than 40,000 vehicles used this interchange daily, and that the heaviest movement was the west-to-south entrance movement. A loop ramp was added to the interchange to serve this movement, and the rest of the interchange's ramps were realigned and widened. A park-and-ride lot was also built near the interchange. The construction cost for the entire project (including right-of-way acquisition) was $23.5 million, and the project took 16 months to complete.

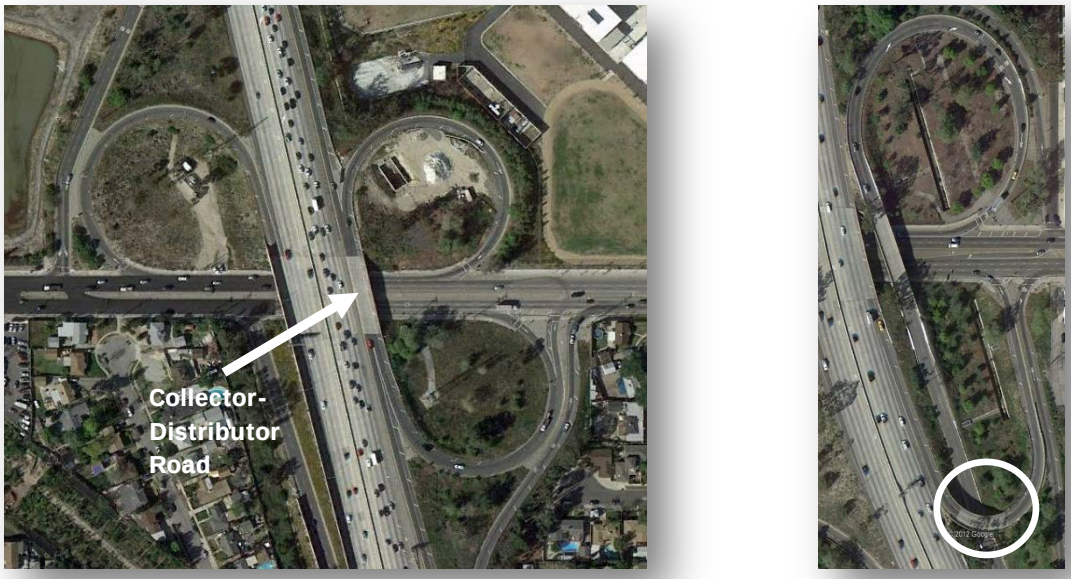
A similar project was implemented by the Colorado Department of Transportation at the interchange of IH 225 and Iliff Road in 2001.[2] This project involved adding one loop ramp and widening and realigning another ramp. Right-of-way acquisition was not required. This project cost $3.1 million to build.

The Indiana Department of Transportation added two loop ramps to the interchange of IH 465 and Keystone Avenue in Indianapolis in 2011.[3] This project costs $18.2 million and took approximately one year to complete.

Application Techniques and Principles

Loop ramps may be installed to accommodate one or both of the left-turns at a signalized freeway interchange ramp terminal. These two options are shown below. On the western side of the interchange, a loop is provided for the west-to-south movement. The south-to-east movement is still routed through a signalized intersection, but this signal does not need a protected left-turn phase for vehicles entering the freeway. A signalized intersection on the eastern side of the interchange is eliminated entirely because loop ramps are provided for the north-to-west and east-to-north movements.

The decision to install loop ramps is based on operational considerations like left-turn volumes and queue length, and geometric considerations like the availability of right-of-way. In the left portion of the figure below, right-of-way was available in only three of the four quadrants of the interchange, so three loop ramps were constructed.



Partial Cloverleaf Interchange at State Route 170 and Roscoe Boulevard; Braided Loop Ramps at State Route 170 and Victory Boulevard. Aerial Photographs from Los Angeles, California. Source: Google Earth ™

For more information, please refer to: http://mobility.tamu.edu/mip/strategies.php.

When two loop ramps are provided along one side of the freeway interchange, a weaving area will be created where exiting and entering vehicles cross paths. The provision of a collector-distributor road allows the weaving activity to be removed from the freeway mainline. This option is shown in the left portion of the figure above. Another design option is to braid the loop ramps, as shown in the right portion of the figure above, to eliminate the weaving movement entirely.

For freeway facilities with frontage roads, loop ramps can be provided for left-turn movements entering or exiting the freeway mainline, but at-grade intersections must still be provided for left-turning vehicles destined to or originating from locations along the frontage road. In this case, it is not possible to eliminate the signalized intersection unless the frontage-road volumes are very light.

Issues

The additional right-of-way and paved surfaces required to construct collector-distributor roads and loop ramps will have a substantial influence on cost. The right-of-way requirements are influenced by the radii of the loop ramps, which in turn are based on design speed. The *Green Book* suggests curve radii of 150 to 540 feet for design speeds of 25 to 40 mph, and states that design speeds on the higher end of this range should be chosen for freeway exit ramps. Hence, the cost of right-of-way acquisition increases rapidly with increasing design speed.

Adequate signing for road users is important to the operational success of a loop ramp. Proper signing is especially important for freeway entrance loop ramps, as these ramps require drivers to access the ramp from the right side of the crossing arterial street. Since these drivers are making a left-turn movement, their expectation is to access the entrance ramp from the left side of the arterial street. Signs for freeway exit loop ramps must specify both the name of the arterial street and the direction of travel served by the ramp.

The use of collector-distributor roads can add complexity to exiting and entering decisions, and the lack of signing and marking can negatively affect driver's decisions. The anticipated speeds, along with available sight distance on the approach to and within the weaving section, should be considered during design.

Delay benefits obtained through the provision of a loop ramp are partially offset by the increased travel time associated with the traversal of the loop ramp. The increased travel time is quantified as "geometric delay" in the *Highway Capacity Manual*.

Who Is Responsible?

TxDOT officials are responsible for ramp construction projects on state-maintained highways. City officials are responsible for projects on city streets. In the case of an intersection between a state highway and a city street, coordination between state and city officials would be required in all stages of the project—planning, design, and construction—as well as in operations if the signalized intersections at the interchange are to be coordinated with the adjacent signals along the arterial street.

Project Timeframe

The timeframe for the addition of a loop ramp depends on the scope of the project and the need for right-of-way acquisition. The previously-listed implementation examples suggest that the addition of loop ramps, along with realignment and widening of other ramps at the interchange, can be completed in one to two years. The timeframe would be longer if a collector-distributor road or braided ramps were included in the project.

Cost

Project cost may vary significantly, depending on the necessity of acquiring right-of-way, the number of loop ramps to be added, and the decision of whether to include a collector-distributor road or braided ramps in the project.

The previously-listed implementation examples suggest that the addition of a single loop ramp costs in the range of $2 to 4 million. If right-of-way acquisition is required, costs can increase to the $15 to 25 million range.

Data Needs

To assess the potential operational benefit for installing a loop ramp, traffic operations data would need to be collected. These include turning movement counts, lane counts and assignments, and signal phasing information like cycle length, phase durations, and offsets for signals in a coordinated system. An origin-destination study would be required, to determine the number of vehicles making each left-turn movement. To quantify benefits following installation, delay studies would need to be conducted both before and after the installation. A methodology for evaluating the operational performance of a signalized interchange ramp terminal is provided in Chapter 22 of the *Highway Capacity Manual*.

To assess the potential safety benefit for installing a loop ramp, crash counts would need to be collected at the intersection and along the two crossing roads in the vicinity of the interchange. A loop ramp may be beneficial if many crashes involving left-turning vehicles occur at the intersection, or if many rear-end crashes with queued left-turning vehicles occur on one or both of the crossing roads. Methodologies for evaluating the safety performance of freeway, interchange ramp, and ramp terminal facilities are currently under development, and will be included in a future edition of the *Highway Safety Manual*.

Loop Ramps Best Practice

- Type of Location: Freeway service interchanges, especially if the ramp terminals are signalized and one or more of the left-turn movement volumes entering or exiting the freeway are heavy, or if left-turn vehicle queuing is excessive.
- Agency Practices: Coordination between design and operations, and between state and local agencies responsible for signal timing.
- Frequency of Reanalysis: After substantial land use changes or development; as travel increases or trips change in the area; at time of roadway widening or reconstruction.
- Supporting Policies or Actions Needed: Capability to fund improvements, multi-agency agreements, and policies where roadways cross jurisdictional boundaries.
- Complementary Strategies: Grade separation.

For More Information

American Association of State Highway and Transportation Officials. *A Policy on Geometric Design of Highways and Streets*. AASHTO, Washington, D.C., 2011.

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Transportation Research Board of the National Academies. *Highway Capacity Manual.* TRB. Washington, D.C., 2010.

References

1. WSDOT – Project – I-5 – 172nd Street NE (SR 531 Smokey Point) Interchange Improvements. http://www.wsdot.wa.gov/projects/sr531/i5loopramp. Accessed March 20, 2012.

2. Interstate 225 – CDOT. http://www.coloradodot.info/about/50th-anniversary/interstate-225.html. Accessed March 20, 2012.

3. New Loop Ramps at I 465 & Keystone Ave. on the Northside. http://blogs.wishtv.com/2011/07/20/new-loop-ramps-at-i-465-keystone-ave-on-the-northside/. Accessed March 20, 2012.