Determining the best practices for complete streets in the Northern New York context

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Abstract

With today's road infrastructure focused on vehicles, about 6,000 pedestrians die from car accidents a year and 129,000 experience non-fatal injuries (Centers for Disease Control and Prevention, National Center for Injury Prevention and Control). This along with increasing physical inactivity and environmental concerns suggests that current street designs are no longer safe or effective. The solution to this problem lies within a comprehensive complete streets program. The United States Department of Transportation defines complete streets as streets that are "designed and operated to enable safe use and support mobility for all users" (US Department of Transportation). Each community is different, having specific needs, making the design of an effective complete streets program for various communities challenging. Therefore, an analysis of what methods have been implemented in the past, needs to be completed, in order to determine the degree to which traffic calming techniques worked in various locations. The Analytical Hierarchy Process (AHP) will be used to rank the features of various traffic calming measures and ascertain which practices are most applicable to the Northern New York context.

Introduction

Throughout the rapid industrialization and urban growth throughout the country, our culture and way of life has become focused on the automobile. This focus has created road designs and community layouts that revolve around cars creating several unwalkable cities and communities. This in turn has resulted in a large number of pedestrian casualties and a series of overall unsafe roads. Several attempts to solve these problems have already been made in the form of traffic calming practices and complete streets projects. Complete streets are designed to safely accommodate anyone who uses the roads through various policies, infrastructure, and by laws. The United States Department of Transportation defines complete streets as streets that are "designed and operated to enable safe use and support mobility for all users. Those include people of all ages and abilities, regardless of whether they are travelling as drivers, pedestrians, bicyclists, or public transportation riders" (US Department of Transportation). However, not all of these practices have been effective due to the various geographical and population differences of the United States which makes it nearly impossible to create one plan for every area. Creating a successful plan will require looking into previous complete streets programs and analyze the effectiveness of these programs. The goal is to find effective complete streets methods that will produce greener, safer, and more walkable communities.

This research project, in particular looks specifically at finding the best practices for complete streets that would be applicable to the Northern New York context. This location has special aspects that are important to make note of when creating a complete streets program, such as the harsh winter climate, the poor road and sidewalk connection between towns and the large Amish community. In addition, communities is the Northern New York context normally have smaller, less populated communities in which certain traffic calming methods will not be effective. These characteristics will impact which traffic calming, and other measures will be applicable to this context.

Literature Review

Several methods and techniques have been implemented as part of a complete streets program, yet most of these practices were implemented in predominantly urban areas. One challenge has been compiling previously successful methods and making them applicable to this particular context of rural Northern New York. Northern New York can be defined as the area surrounded by and North of the Adirondack Park; towns in this region have populations averaging 8,000 people and no larger than 26,000. These townships are usually few and far between connected by

While complete streets have been implemented before and are not a unique concept, there have not been many towns in northern New York adopting comprehensive complete streets policy. Larger metropolitan areas, like San Francisco, Los Angeles, and Houten (in the Netherlands), have installed complete street techniques in order to create environments conducive to pedestrians, cyclists, and motorists alike. The purpose of this study is to bring effective complete street policies to upstate New York, in which this area has different geographical, economic, and environmental conditions than the aforementioned cities.

A major aspect of complete streets is traffic calming which allows for an increased variety in modes of transportation. Extensive literature has been written about complete streets which list various types of traffic calming techniques and ways to categorize them. The four largest categories of traffic calming methods are street crossings, in-road design elements, street narrowing, and pavement markings. Street crossings include raised crosswalks, refuge islands, etc. Traffic circles, speed humps, bollards, and more make up in-road design elements. Some street narrowing techniques are chicanes, curb extensions, center islands, and so forth. Pavement markings include painted bike lanes, transverse lane markings, etc. The following is a discussion of all 31 techniques in turn, grouped in their respective categories.

Crossing the Street: One of the core principles of complete streets is allowing safe pedestrian travel, and accessibility to all parts of town. This requires those on foot to be able to cross the street safely and efficiently. Additionally, unique traffic and pedestrian conditions will need to be treated differently, which leads to various street crossing constructions.

- Raised crosswalks allow for pedestrian crossing while simultaneously reducing traffic speeds and accident frequency near the crosswalk (Monsere). However, if the crosswalk isn't installed properly, drainage issues could be dangerous for pedestrians by forming puddles which turn to ice. Additionally, emergency vehicles could be delayed 3-5 seconds when passing over the crosswalk, depending on the design (FHWA).
- Mid-block crosswalks aren't installed at intersections like traditional crosswalks, but are placed along the street in between intersections and will require extra signage to alert motorists to its presence (Broek). Speed and pedestrian collision reduction are both effects of mid-block crosswalk implementation (Hallmark, 6). With no physical displacement, all vehicles will be able to traverse the mid-block crosswalk with ease. The crosswalks are only paint, and they might not be visible in the winter time with snow on top; additional repainting will need to be done as maintenance.
- Refuge islands can be installed at crosswalks to break up the crossing into two sections; they're often used if the street is too wide for pedestrians to cross in a timely manner, and result in fewer pedestrian collisions (Monsere) An added benefit of an island is additional snow storage during the winter months, but special snow removal techniques will be needed to maneuver the island. Moreover, larger vehicles might have trouble moving around the island (Hallmark, 36).
- Signs within the crosswalk alert motorists to pedestrian crossings and are effective at reducing car speeds and collisions (Monsere) while still allowing vehicles of all sizes to easily traverse the roadway. The cons of signs are that they can be destroyed by snow plows and stolen, both of the scenarios require an additional budget for replacements (Schmitt).
- Crossing guards are placed at crossings with a high pedestrian traffic and lead to decreased pedestrian-motorist accidents. Guards are usually temporary and cannot be used year round due to weather conditions in Northern New York (anecdotal).

In-road design elements: A more permanent solution to answer to traffic calming can be found with in road design elements. When installed properly, these techniques are very effective at reducing speeds and accidents, but are generally the most expensive options to install because of their permanence.

- Roundabouts are very effective at reducing vehicle speed, accident frequency, and accident severity (Hallmark, 14). The downsides to traffic circles are the high cost of installation (Hallmark, 14), emergency vehicle delay, and maintenance. Additionally, there is a learning curve for motorists to overcome in order to properly navigate the traffic circle with correct "right of way" (Hallmark, 13).
- Transverse rumble strips are divots in roads that run perpendicular to the direction of traffic. They are effective at reducing vehicle speeds with a low price tag (Hallmark, 18), and can be used as temporary or permanent traffic calming solutions. Water can pool in the divots and cause damage to the pavement, they are possible hazards to cyclists and motorcycles (Hallmark, 18), and they will be destroyed by snow plows if the plows are not aware.
- A good way to get more cycles on the road is a protected bike lane which completely separates cyclists from motor vehicles thereby reducing bicycle accidents (NYCDOT, 50). The most notable flaw of protected bike lanes are the reduction in on-street snow storage area and difficult snow removal process (NYCDOT, 52). Also, drains cannot be placed in the bike lanes to create smooth lanes for cyclists' safety (Los Angeles, 122).
- Speed humps are great for reducing speeds and accident frequency nearby (Corkle, 13), and can be constructed with cross walks to form raised crosswalks. When constructed properly, drain flow won't be interrupted, however, drainage relocation might be a necessary step anyway. Speed humps will also delay emergency vehicles (Corkle, 79).
- To alleviate the emergency vehicle delay, speed slots offer an alternative to speed humps. With the same speed and accident reduction (Johnson), speed slots have a gap in the middle of the road where speed humps go all the way across the road. This gap allows for water flow and emergency vehicles to pass through quickly (Johnson). Special snow removal accommodations will have to be made for the slots, and drivers might cross the center lane to avoid the bumps which can cause accidents (Johnson).
- Bollards are structures that guide vehicles one way or another (Hallmark, 22) and are usually temporary fixes. They can be removed during the winter to allow for easy snow removal, and are easily replaceable (Hallmark, 23). However, if they are inserted into the pavement, they will weaken the roadbed and cause damage (anecdotal).

Street Narrowing: Similar to some of the in road design elements like roundabouts and bollards, street narrowings displace motor vehicles horizontally to reduce speeds; they also reduce the room drivers have to make error, so drivers will reduce speed so as to not cause damage to their own car (Godley).

- Center islands displace cars horizontally meaning they reduce vehicle speeds and accidents (Hallmark, 33). They are effective year round and can even have snow stored on them during the winter months. Center islands will affect street drainage and snow removal as plows will need to be careful around them (Hallmark, 35).
- Chicanes form a slalom for cars to travel through requiring them to slow down; this reduces vehicle speeds and accidents (Hallmark, 9). Special treatment will be needed for snow removal so plows do not scrape the serpentine curbs, and ponding can result from drainage issues (Hallmark, 9). Chicanes can be constructed in stages: first as painted lines, then bollards, and finally a permanent curb can be installed. This is helpful as it allows drivers to acclimate to the new road layout.

- Curb extensions or “bulb outs” are another form of street narrowing that move the curb farther into the street forcing vehicles to slow down (Hallmark, 6). Extensions increase pedestrian visibility and can add snow storage space if there is no shrubbery on them. The drawbacks of bulb outs are that larger vehicles might have a difficult time maneuvering around them (Hallmark, 7), snow removal is difficult, and on-street parking space is lost.
- Shoulder widening is similar to curb extensions except instead of a physical narrowing with a curb, there is only paint narrowing the road lanes. The benefit of this is there is no interference with emergency vehicles, large vehicles, snow removal or storage, and there is increased area for cyclists to travel on the shoulder (Hallmark, 41). However, the feature is only paint, so it is not effective year round when it gets covered by snow.
- Adding shrubbery like trees and bushes to roadways is a visually appealing way to make streets appear narrow, making motorists slow down (Hallmark, 46). Plants can be placed on the sides of roads or in medians depending on the layout of the road. There is no hindrance for emergency or large vehicles, and no need for special snow removal techniques. Nevertheless, the shrubbery will reduce snow storage area on the roadside or medians, and trees might interfere with overhead utilities such as power lines.

Pavement Markings: These techniques are typically the least expensive option to install, but require more frequent upkeep (usually repainting) than “in road design elements.” With optimal weather conditions, these markings may work just as well as their constructed counterparts, the snowy winters of Northern New York will often leave these painted lines invisible, rendering them ineffective (Hallmark, 59).

- Transverse lane markings are painted lines that cross the road perpendicular to the movement of traffic; when painted correctly, drivers believe they are increasing speed when they really are not. The lines decrease speed and do not interfere with emergency vehicles, but are not effective year round (Hallmark, 59) and a strobing effect could pose health risks to certain drivers.
- Bike boxes are painted squares at the entrances to intersections where cyclists can stay while the lights change. These boxes increase cyclist visibility and allows them to turn more safely (Los Angeles,117). Without a large cyclist population, bike boxes often go unused, they require additional maintenance, and are not always visible year round for the same reasons other painted markings are (Hallmark, 59).
- Painted bike lanes are similar to protected bike lanes, but without a physical barrier between cars and bicycles hindering emergency vehicles (Corkle, 75). While they remind motorists of a shared roadway, painted bike lanes will lose visibility during the winter months, require extra maintenance to keep smooth, and reduce snow storage as well as parking area (Corkle, 75) by seven feet.
- Sharrows are bike symbols painted on roadsides to remind motorists that they are sharing the road with cyclists. They are a very inexpensive way to increase bicycle awareness, but they have negatives: they are not always visible, require repainting, and are not effective at encouraging people to start riding bikes (Alta, 3).
- LEDs pavement markings are great ways to increase the visibility of lane lines on roadways (Hallmark, 77). However, they have a difficult implementation process, weaken the pavement which leads to cracking and potholes, and they are easily destroyed by snow plows.

Research into the Analytical Hierarchy Process (AHP) was also done to find a tool to analyze the effectiveness of the different traffic calming measures studied. The Analytical Hierarchy Process is a method that is used when there are several options available and aids in the decision making for complex environments (Vargas). AHP evaluates the given options by ranking a list of criteria based on importance. Then for each criterion, the AHP gives a score based on how well the decision maker believes that item meets the given criteria. The total score for an option is calculated by summing the weighted scores. The AHP serves as a powerful tool that is also flexible in that it produces a ranking of the options that can take input from the decision maker (Saaty).

Methodology

In order to assess which traffic calming methods would be applicable to the Northern New York area, an extensive literature review was completed to compile a list of the various traffic calming measures. This literature review helped to gather information and take notes about the numerous traffic calming measures that have been previously used. The initial list was created by reading through a report published by Iowa State University that analyzed a series of traffic calming methods used in rural communities. This list served as a starting point for researching the different methods that were compiled. The 31 items on this list, which have been explained in detail in the previous section, were chosen due to their perceived effectiveness and the amount of information that had been collected when the report was originally published. Under each option, information regarding the impact (positive and negative) of that specific traffic calming technique was recorded in the form of a pros and cons list. A pro was classified as having a positive impact, such as reducing vehicle speeds or reducing the number of accidents. A con was classified as having a negative impact, such as delaying emergency response vehicles, or interfering with snow removal, or cause drainage issues. These notes would aid in the next stage of analysis.

Once the first list was created, another list was created with further analysis of the various traffic calming measures. This analysis consisted of looking at the impact each method had on the existing road infrastructure and various motorists. From looking at the impacts of different traffic calming measures, a list of criteria was created that would be used to develop a rubric to further organize these traffic calming methods. This rubric categorized traffic calming treatment options into four main groups; crossing the street, in-road design elements, street narrowing, and pavement markings. The traffic calming methods on this rubric were chosen from the original list of 31 items based on their cost effectiveness and their ability to survive the harsh winter climate of the North Country. The full rubric with the entire list of traffic calming measures can be found in Appendix A. A screenshot of part of the rubric is shown below in Figure 1.

The list of criteria, shown in the left column in Figure 1, includes the following items: reduces vehicle speed, reduces the number of accidents, disrupts emergency vehicles, affects roadway drainage, requires maintenance, high cost, long/difficult implementation process, interferes with snow removal, effective year round, aesthetically pleasing, easily maneuverable for all vehicles, reduces room for snow storage, impacts on-street parking amenities. The items on the criteria list are on the left hand column of the rubric, and each traffic calming measure is listed in a separate column to the right.

	Crossing the Street				
	Raised Crosswalks	Mid-Block Crosswalks	Mid-Block Crosswalks + Refuge Island	Signs within crosswalk	Crossing Guards
Source	FHWA	NACTO	Iowa State University	USA Streets Blog	CDC
Reduces vehicle speeds	Yes - by up to 35%	Yes	Uncertain	Yes	Yes
Reduces number of accidents	Yes -by up to 46%	Yes - by 46%	Yes - 56%	Yes	Yes
Disrupts emergency vehicles	Minimally - 3-5 second delay	No	No	No	No
Affects roadway drainage	Yes - drains need to be placed above c	No	No	No	No
Requires maintenance	Yes	Yes - occasional repainting	Yes - repainting lines	Yes- prone to damage, occasional replac	No
Expensive	Moderate - $5,000	No - $500-$1,500	Yes - $10,000-$40,000	No - $65	No - most are volunteers
Long/Difficult implementation process	Yes	No	Yes	No	No
Interferes with snow removal	Yes	No	Yes - special accommodations	No	No
Effective year round	Yes	Yes	Yes	Yes	Yes
Aesthetically pleasing	Yes	Yes	Yes	No	N/A
Easily maneuverable for all vehicles	Yes	Yes	No	Yes	Yes
Does it reduce snow storage area?	Just at the entrance to the crosswalk	No	Just at the entrance to the crosswalk	No	No
On-Street Parking Amenities	Minimal parking space taken	No effect on parking	Minimal parking space taken	No effect on parking	No effect on parking

Figure 1: General Rubric

The general rubric that was created served as an organizational tool to gather more specific information about the selected traffic calming measures. From this rubric, a weighted decision matrix was created. This tool is part of the Analytical Hierarchy Process (AHP) and was chosen due to its ability to rank different options and produce the best option based on a scoring system. The matrix was created by ranking criteria by importance, giving each item a number one through ten. An important note to make is that the criteria list for the weighted decision matrix does not include two items from the rubric. The criteria list for the matrix left out the long/difficult implementation process and the impact on on-street parking amenities criteria due to the little effect these items had on analyzing the traffic calming measures.

The rankings that were assigned to each criterion were based off of the general goals of complete streets programs. Therefore, reducing vehicle speeds and lowering the number of accidents were viewed as the most important and given the number eight. Ensuring that the practices are maneuverable was also viewed as important and given the number seven. Interference with snow storage and effectiveness year-round were given the number six. Low cost, low impact on emergency vehicles, drainage issues, no interference with snow removal were all given the number five. Finally, requires maintenance and aesthetically pleasing were given the number four. While these weights were assigned with the broad ideas of complete streets, the specific number assigned to each criterion was somewhat arbitrary and not based on feedback from community stakeholders.

Once each criterion was ranked, each traffic calming measure was given a score (of one to three) based on how well that method met the given criteria. This score was determined based on statistics regarding the effectiveness of the method in traffic calming (reducing speeds and accidents), the price, the amount that this method impacted drainage, interference with snow removal, and impact on emergency vehicles. A score of one represented that the method met the criteria to a low extent. A score of two was the middle range and a score of three represented that the method met the criteria to a high extent.

To find the weighted score of the traffic calming method the rank was multiplied by the score given. For example, the weighted score of mid-block crosswalks in the category of aesthetically pleasing was 8, because this criterion was given the weight four, and a score of two. The total score of each traffic calming measure was calculated by summing all of the weighted scores for the traffic calming measure. Therefore, the traffic calming measure with the highest total score represents the best measure given the criteria.

Traffic Calming Measure	Aesthetically pleasing - 4		Easily maneuverable for all vehicles - 7		Does not reduce snow storage area - 6		Score
	Score (1-3)	Weighted Score (Score x 4)	Score (1-3)	Weighted Score (Score x 7)	Score (1-3)	Weighted Score (Score x 6)	Sum of Weighted Scores
Mid-Block Crosswalk	2	8	3	21	3	18	157
Roundabouts	3	12	3	21	3	18	140
Transverse Lane Markings	3	12	3	21	3	18	139
Bike Boxes	3	12	3	21	2	12	137
Transverse Rumble strips	2	8	2	14	3	18	135
Signs within crosswalks	1	4	2	14	3	18	134
Bollards	2	8	3	21	3	18	128
Shoulder Widening	2	8	3	21	3	18	128
Speed cushions	2	8	2	14	2	12	125
LED Pavement Markings	3	12	3	21	3	18	123
Crossing guards	1	4	2	14	3	18	123
Raised Crosswalks	3	12	2	14	1	6	121
Chicane	3	12	2	14	1	6	120
Speed humps	3	12	2	14	1	6	118
Mid-Block Crosswalk with refuge island	3	12	1	7	1	6	116
Speed slots	2	8	2	14	2	12	112
Protected bike lanes	3	12	3	21	1	6	111
Curb Extension	3	12	2	14	2	12	108
Painted Bike Lanes	3	12	3	21	1	6	105
Center Island	3	12	2	14	2	12	97
Landscaping- Trees and shrubs along the road	3	12	2	14	1	6	87
Landscaping- Trees and shrubs in center island	3	12	2	14	1	6	77

Traffic Calming Measure Scoreing
1=low extent
2=some extent
3=great extent

Figure 2: Weighted Decision Matrix

Results

From the analysis using the weighted decision matrix, it was determined that mid-block crosswalks are the best traffic calming measure for this area out of all the measures that were analyzed. Breaking down the matrix into the four original categories of crossing the street, in-road design elements, street narrowing and pavement markings, the best practice from each category was also determined. Mid-block crosswalks were the best traffic calming measure for crossing the street, roundabouts were the best for in-road design elements, shoulder widening for street narrowing, and transverse lane markings for pavement markings.

Conclusion

The weighted decision matrix that was created through the vast literature review will serve as an essential tool in implementing effective traffic calming measures as part of a complete streets program. This tool can be adapted and used in different contexts to help other communities assess which traffic calming measures will be applicable to their specific area.

Future Work

There a few directions this project can be taken to in the future. One would be applying this toolbox to a real context by gathering input about what criteria that specific community feels is important. From there, the weighted decision matrix can be modified to recommend the best traffic calming method for that location. This research could also be continued by looking into different areas, instead of just the Northern New York context.

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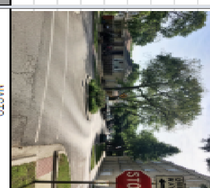
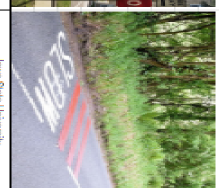
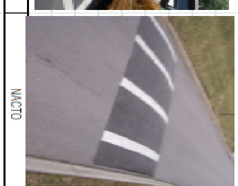
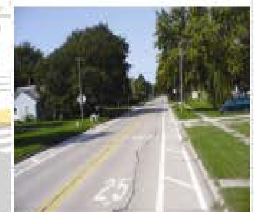
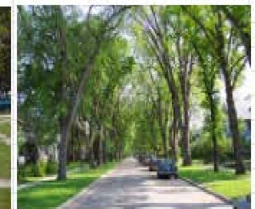
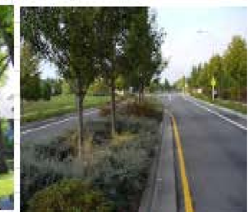
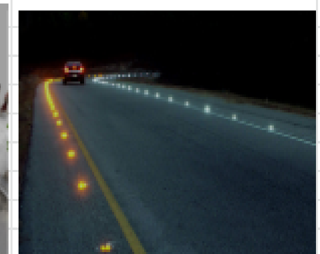
Appendix A: Full General Rubric

	In-Road Design Elements						
	Roundabouts	Transverse rumble strips	Protected Bike Lanes	Speed Hump	Speed Slots	Speed Cushions	Bollards
							
Source	NACTO	Iowa State University	Huffinton Post	NACTO	NACTO	NACTO	Smart Growth America
Reduces vehicle speeds	Yes - by 11%	Yes	No	Yes - by 22%	Yes- avg speed 20.5 mph in 25 mph zone	Yes- avg speed 10.1 mph in 25 mph zone	N/A
Reduces number of accidents	Yes - up to 71%	Yes - 51%	Yes - 38%	Yes - by up to 45%	N/A	Yes- by 40% (with 20% standard of error)	N/A
Disrupts emergency vehicles	Yes - 2-11 second delay	No	No	Minimally - 3-5 second delay	No	Minimal- avg 4.85 second delay	No
Affects roadway drainage	Yes	Yes - Pooling in divots	Yes - drains can't be placed in lanes	Yes - drains need to be placed above hump	Yes -	Yes	No
Requires maintenance	Yes -especially with trees and shrubs	Yes -simple repairs occasionally	Yes - lanes need to be smooth	No	No	No	No
Expensive	Yes - $250,000	No - $0.10 and $1.20 per linear foot (about $	Yes - $80k-$300k per mile	No - $7,000 per pair	Moderate - $3,000-$4,000	Less than $5,000	No -most expensive ones are about $200
Long/Difficult implementation process	Yes	No	No	No	No	No	No
Interferes with snow removal	Sometimes	No	Yes - needs special treatment	Few problems	Yes- requires different methods	Yes- adjusted methods and additional time	Sometimes
Effective year round	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aesthetically pleasing	Yes	Yes	Yes	Can be	Can be	Can be	Yes
Easily maneuverable for all vehicles	No	Yes	Only bicycle access	Yes	Yes	Yes	Yes
Does it reduce snow storage area?	No	No	Yes - up to 11 feet lost	Yes	Yes	Yes	Yes
On-Street Parking Amenities	Cars can't park near the intersection	No effect on parking	Buffer could supply parking for bicycles	No effect on parking	No effect on parking	Doesn't affect on street parking	Yes

A	N	O	P	Q	R	S
	Street Narrowing					
	Center Islands	Chicane	Curb Extensions	Shoulder widening	Landscaping- Trees along the road	Landscaping-Trees in Medians
						
Source	San Antonio DOT	NACTO	NACTO	Iowa State University		Iowa State University
Reduces vehicle speeds	Yes - reduced by 3-5 mph	Yes - speeds reduced by 8-12 mph	Yes - by 11%	N/A	Possible	Possible
Reduces number of accidents	No	Yes - 53%	Uncertain	Uncertain	Possible	Possible
Disrupts emergency vehicles	No	No	No	No	No	No
Affects roadway drainage	Yes - relocate catch basins, other underground	No	Yes - drain relocation	No	No	No
Requires maintenance	Yes - landscaping	Yes - landscaping	Yes - especially with landscaping	Yes - repainting lines	Yes	Yes
Expensive	$8,000-$20,000	Moderate $7,000-$11,000	$8,000-$11,000	$0.32 per linear foot	Yes - main cost comes from planting trees	Yes - costs of planting shrubs and plants
Long/Difficult implementation process	No	No	No	No	Yes	Yes
Interferes with snow removal	Yes	Yes - may need special treatment	Yes	No	No	No
Effective year round	Yes	Yes	Yes	No	No	No
Aesthetically pleasing	Yes	Yes	Yes	Yes	Yes	Yes
Easily maneuverable for all vehicles	No	Yes	Hinders larger vehicles	Yes	Yes	No
Does it reduce snow storage area?	No	Yes	Yes	No	Yes	Yes
On-Street Parking Amenities	No effects on parking	Yes	Decreases parking	No effects on parking	Yes	Yes

A	T	U	V	W	X
	Pavement Markings				Other
	Transverse Lane Markings	Bike Boxes	Painted Bike Lanes	LED's in pavement markings	Pace Car Program
					
Source	Iowa State University	NACTO	NATCO	Iowa State University	Greensboro NC Government
Reduces vehicle speeds	Yes	Yes	No	Uncertain	Yes
Reduces number of accidents	Yes	Yes - reduces by 35%	Yes - reduces by 36%	Uncertain	Yes
Disrupts emergency vehicles	No	No	No	No	No
Affects roadway drainage	No	No	Yes- Drains can't be placed in lanes	No	No
Requires maintenance	Yes	Yes -repainting symbols	Yes- Lane needs to be smooth	Yes -unclear effects of using these 24/7	No
Expensive	$2.20 per linear foot	No - average $180	No - average $160	Yes -$15,000 and $25,000 per linear mile	No
Long/Difficult implementation process	No	Yes	No	Yes	No
Interferes with snow removal	No	Yes	No	No	No
Effective year round	No	No	Yes	Yes	Yes
Aesthetically pleasing	Yes	Yes	Yes	Yes	N/A
Easily maneuverable for all vehicles	Yes	Yes	Motor vehicles might intrude	Yes	N/A
Does it reduce snow storage area?	No	Yes	Yes - up to 7 feet	No	N/A
On-Street Parking Amenities	No effect on parking	No	No effect on parking	No effect on parking	N/A

Appendix B: Weighted Matrix

Traffic Calming Measure	Criteria						
	Requires little maintenance - **4**		Low cost - **5**			Interferes with snow removal - **5**	
	Score (1-3)	Weighted Score (Score x 4)	Actual Price	Score (1-3)	Weighted Score (Score x 3)	Score (1-3)	Weighted Score (Score x 5)
Mid-Block Crosswalk	2	8	$500-$1,500	3	15	3	15
Roundabouts	1	4	$250,000	1	5	2	10
Transverse Lane Markings	1	4	$2.20 per linear foot	2	10	2	10
Bike Boxes	1	4	$180 per box	3	15	3	15
Transverse Rumble strips	2	8	$0.10 to $1.20 per linear foot (about $500 to $600	3	15	2	10
Signs within crosswalks	1	4	$65 per sign	3	15	3	15
Bollards	2	8	$100-$200	3	15	2	10
Shoulder Widening	2	8	$0.32 per linear foot	3	15	2	10
Speed cushions	1	4	$5,000	3	15	2	10
LED Pavement Markings	1	4	$15,000 and $25,000 per linear mile	1	5	3	15
Crossing guards	1	4	No cost, volunteer labor	3	15	3	15
Raised Crosswalks	1	4	$5,000	2	10	1	5
Chicane	1	4	$7,000-$11,000	2	10	2	10
Speed humps	1	4	$7,000 per hump	2	10	2	10
Mid-Block Crosswalk with refuge island	1	4	$10,000-$40,000	1	5	2	10
Speed slots	1	4	$3,000-$4,000	2	10	2	10
Protected bike lanes	1	4	$80,000-$300,000 per mile	1	5	3	15
Curb Extension	1	4	$8,000-$11,000	2	10	2	10
Painted Bike Lanes	1	4	$160	3	15	3	15
Center Island	1	4	$8,000-$20,000	1	5	2	10
Landscaping- Trees and shrubs along the road	1	4	Cost varies	1	5	2	10
Landscaping- Trees and shrubs in center island	1	4	Cost varies	1	5	1	5

Traffic Calming Measure Scoreing
1=low extent
2=some extent
3=great extent

Traffic Calming Measure	Reduces vehicle speed - **8**		Reduces number of accidents - **8**		Little Impact on emergency vehicles - **5**		No drainage issues - **5**	
	Score (1-3)	Weighted Score (Score x 8)	Score (1-3)	Weighted Score (Score x 8)	Score (1-3)	Weighted Score (Score x 5)	Score (1-3)	Weighted Score (Score x 5)
Mid-Block Crosswalk	1	8	2	16	3	15	3	15
Roundabouts	1	8	3	24	2	10	2	10
Transverse Lane Markings	1	8	1	8	3	15	3	15
Bike Boxes	1	8	1	8	3	15	3	15
Transverse Rumble strips	1	8	2	16	2	10	2	10
Signs within crosswalks	1	8	1	8	3	15	3	15
Bollards					3	15	3	15
Shoulder Widening					3	15	3	15
Speed cushions	1	8	2	16	2	10	2	10
LED Pavement Markings					3	15	3	15
Crossing guards	1	8	1	8	2	10	3	15
Raised Crosswalks	2	16	2	16	2	10	2	10
Chicane	1	8	1	8	3	15	3	15
Speed humps	1	8	2	16	2	10	2	10
Mid-Block Crosswalk with refuge island	1	8	2	16	3	15	3	15
Speed slots	1	8	1	8	2	10	2	10
Protected bike lanes	1	8	1	8	3	15	1	5
Curb Extension	1	8			3	15	1	5
Painted Bike Lanes					3	15	1	5
Center Island	1	8			3	15	1	5
Landscaping- Trees and shrubs along the road					3	15	3	15
Landscaping- Trees and shrubs in center island					2	10	3	15

Traffic Calming Measure Scoreing
1=low extent
2=some extent
3=great extent

Traffic Calming Measure	ar round - **6**	Aesthetically pleasing - **4**		Easily maneuverable for all vehicles - **7**		Does not reduce snow storage area - **6**		**Total Score**
	Weighted Score (Score x 6)	Score (1-3)	Weighted Score (Score x 4)	Score (1-3)	Weighted Score (Score x 7)	Score (1-3)	Weighted Score (Score x 6)	Sum of Weighted Scores
Transverse Lane Markings	18	3	12	3	21	3	18	139
Bike Boxes	12	3	12	3	21	2	12	137
Transverse Rumble strips	18	2	8	2	14	3	18	135
Signs within crosswalks	18	1	4	2	14	3	18	134
Bollards	18	2	8	3	21	3	18	128
Shoulder Widening	18	2	8	3	21	3	18	128
Speed cushions	18	2	8	2	14	2	12	125
LED Pavement Markings	18	3	12	3	21	3	18	123
Crossing guards	12	1	4	2	14	3	18	123
Raised Crosswalks	18	3	12	2	14	1	6	121
Chicane	18	3	12	2	14	1	6	120
Speed humps	18	3	12	2	14	1	6	118
Mid-Block Crosswalk with refuge island	18	3	12	1	7	1	6	116
Speed slots	18	2	8	2	14	2	12	112
Protected bike lanes	12	3	12	3	21	1	6	111
Curb Extension	18	3	12	2	14	2	12	108
Painted Bike Lanes	12	3	12	3	21	1	6	105
Center Island	12	3	12	2	14	2	12	97
Landscaping- Trees and shrubs along the road	6	3	12	2	14	1	6	87
Landscaping- Trees and shrubs in center island	6	3	12	2	14	1	6	77

Traffic Calming Measure Scoreing
1=low extent
2=some extent
3=great extent