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Evaluating the Feasibility of Road Diets for Advancing Urban Mobility in Newark, DE

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Abstract

Road Diets are far from a new technique for designers to apply to roadways. Yet after over 50 years of implementation and countless studies into their effectiveness, it is only relatively recently that the process is gaining widespread recognition and implementation. Each year, more states and countries are examining potential road diets and putting them into place. Still, there remains great skepticism and opposition in many corners. In addition, cities and states may be drawing from many of the same sources in how to go about the process of a road diet and evaluate them, yet their methodology, goals, and even terminology can vary from region to region. This study analyzes the implementation of a road diet along a one-way arterial road, in Newark, Delaware. The primary aim of this analysis is to evaluate the feasibility of introducing a dedicated bicycle infrastructure to enhance local accessibility and to quantify its potential impacts on traffic flow, parking availability, and loading logistics within the vicinity. While the reduction of one lane could be perceived as a constraint on traffic management, the investigation revealed that E Main Street, the roadway analyzed, for the most part, can adequately accommodate its traffic load with a single lane. Detailed findings underscore the notable enhancement in level of service and subsequent reduction in delay times across most surveyed approaches.

Keywords

Road Diets, VISSIM, Bike Lanes, Level of Service, Traffic Safety, Transportation

1. Introduction

This study aims to detail the process of implementing a road diet, the effects of this process and how to evaluate these effects, and the ways that road diets can be better integrated going forward to maximize the benefits that they offer.

Road diets proposals are filled with numerous concerns from competing stakeholders which threaten to undermine them. Finding out how to best convey the benefits of any project is essential and it is important to maximize the effectiveness of the design to both validate the viability of the project for continued and future implementations as well as to improve the lives of locals.

1.1. Case of Study

For the case study, Newark, Delaware was chosen as the location for a study to evaluate the effects of a possible introduction of a road diet. At the center of Newark resides the University of Delaware, a major public university with 24,039 enrolled students for the 2022-2023 school year [1]. While there currently exist bike lanes in the Newark area, the main corridor of the city remains inadequately set up to service bicycle traffic. As a result, a study into the feasibility of a road diet has been conducted analyzing the possibility of connecting the bicycle facilities that currently exist at the Newark and Pomeroy Rail Trail and along W Main Street to the west of the CSX at-grade railroad crossing. Such an improvement would be constructed on E Main Street, a two-lane, one-way street that flows from east to west.

1.2. Problem Statement

As road diets increasingly become a viable alternative for transportation planners to implement, it is important to continue to study their effects on a roadway and the region at large. The E Main Street in Newark provides an excellent case study as an area which is seeking to promote better bicycle and pedestrian access as part of the city's master plan. Conducting a case study as presented in this paper can provide a glimpse into the process of right-sizing a road diet for a corridor to take advantage of its strengths.

2. Methodology

The study was conducted by analyzing the existing traffic and parking situations on E Main Street and any possibilities of improvement looking at the year 2025, as described on **Table 1**. VISSIM, a software for traffic flow simulation, was used to analyze the traffic flow at each major signalized intersection based on a no build condition for the year 2025 and an alternative in which a bike lane would be constructed along the length as considered for 2025. In addition, Google Earth was used to survey the current layout of the area and to assess any changes that can be made and the capability of the region to absorb the loss of a lane or parking.

The analysis was done in late 2020 when the project was originally conducted and does not consider the roadwork that was conducted during and after this time. The study used the PM peak hour of 4:30 - 5:30 to evaluate the road with VISSIM chosen for the access to the program and for its more robust nature compared to Highway Capacity Software.

Table 1. Alternative analysis.

Alternative	Description of Alternative	Advantages	Disadvantages
1	No Build: The current layout is maintained, and no bike lane is constructed, no parking is removed, and signal timings remain unchanged.	- No loss of parking - Better flow on the major road - No cost	- Bike transit remains restricted to sharrows - Excessive delays on College Ave and Chapel Ave
2	Bike Lane: A new bike lane is constructed along the length of E Main St. connecting existing trails at the Newark and Pomeroy Rail Trail and west of the CSX at-grade railroad crossing. Parking is removed after the signalized pedestrian crossing and a lane is removed from E Main St. before the crossing.	- Increased safety for bike riders - Increases visibility for business as traffic will proceed slower through the area - Improved signal optimization and decreased delay on minor streets	- Loss of 24 parking spaces - Loss of a lane of traffic along much of E Main St - Increased delay on E Main St - Could require significant cost

Constraints

To make the project more realistic in terms of implementation, a series of constraints was selected. They are as follows:

- Sidewalk width could not be reduced to less than ten feet and if presently less than ten feet, must be maintained at that width.
- No buildings may be impacted by any improvement.
- The signalized intersections will remain signalized.
- Pedestrian and bicycle bridges are not permitted.
- Consideration must be made to the loss of parking on one side of E Main Street.

3. Data Analysis

The essential points of interest are included in **Figure 1** including the intersections considered as part of the traffic analysis.

The two College Avenue intersections are considered as one for the purposes of this analysis as their timings are tied together. Other intersections along the path were not considered as they all exist as unsignalized minor streets. There is another light between Academy Street and College Avenue that exists solely for a pedestrian crossing, but that too was not used in the analysis. The CSX rail crossing exists to the direct east of the start of an existing bike path located along W Main Street and the Newark and Pomeroy Rail Trail is a North/South bike trail located at that point.

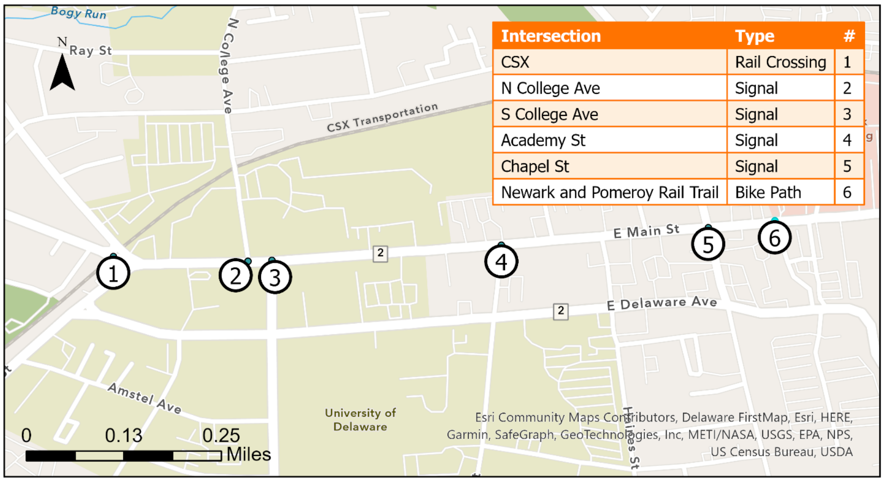

Figure 1. Study intersections and points of interest.

E Main Street is a two-lane, one-way principal arterial that flows from east to west [2]. The road passes through Downtown Newark which is filled with businesses including a few restaurants and the University of Delaware campus. Heading west, this downtown area starts shortly after the rail trail, becoming denser after Chapel Street, and continues until about two thirds of the way between Academy Street and S College Avenue as shown in **Figure 2**. The University of Delaware in turn exists for most of the way to the rail crossing. There is presently parking on both sides of the street for much of the stretch in addition to well-maintained sidewalks. The lanes are ten feet wide with seven-foot-wide parking lanes and sidewalks which vary from seven to fifteen feet in width.

3.1. 2020 Condition Analysis

3.1.1. Vehicle and Pedestrian Counts

The vehicle and pedestrian collection reports were given based on studies performed by The Traffic Group in October 2017 for the College Avenue intersections and by Tri-State Traffic Data in September 2019 for the Academy Street and Chapel Street intersections [3] [4]. The signal data was provided for September 2020 [5]. Despite these studies being conducted at various times, the data was assumed to be accurate for 2020 and was not modified from its given state. Ideally, more recent data would have been collected, particularly for the 2017 counts.

A site visit was conducted to validate the results below for 2020 and the observed conditions were similar to the results in the analysis below. Ten crosswalks were also taken into the analysis with five existing at the College Avenue intersection, two at the Academy Street intersection, and three and the Chapel Street intersection.

Due to a significant change in the noted values for traffic heading along E Main Street, the vehicle count entering the system on E Main Street was calculated by taking the sum of all the movements on that road at the College Avenue intersection and removing the traffic counts added by Academy Street and Chapel

Figure 2. Network land use [6].

Street to E Main Street. This should better reflect the true flow in the survey area. In addition, the original survey included traffic data from an unsignalized parking garage at the Academy Street intersection which no longer has an access point there. The traffic for that was discounted and removed from the study.

3.1.2. Suitability of Site

Based on a 1999 report by Burden and Lagerway, some of the following characteristics should ideally be present at any site considered for a road diet [7]:

- Moderate volumes (8 - 15,000 ADT)
- Roads with safety issues
- Transit corridors
- Popular or essential bicycle routes/links
- Commercial reinvestment areas
- Economic enterprise zones
- Historic streets
- Scenic roads
- Entertainment districts
- Main streets

For this site, at the very least, the essential bike link and main street components are met. A new bicycle facility would link up with existing facilities at the Newark and Pomeroy Rail Trail and west of the CSX at-grade railroad crossing. E Main Street is also the main street as the name implies for Newark with business and the University along its length. With a lack of daily volumes, it is unclear if the ADT for the site would fall under the maximum of 15,000 vehicles given here, the 10,000 vehicles promoted by Lyles, or the 20,000 vehicles that is typical of design. The design does exceed the one-way 1000 vehicles per hour promoted by Lyles at the intersection of E Main Street and N College Avenue where the one-way peak hour flow is 1076 vehicles per hour, but this value is close enough to not be a concern and nowhere near the 1500 vehicles per hour where delay starts to pass into unacceptable levels [8]. Based on the work of Stamatiadis [9], as shown in **Figure 3**, all three intersections (with both College Avenue intersections counted together) fall in the recommended zone for the

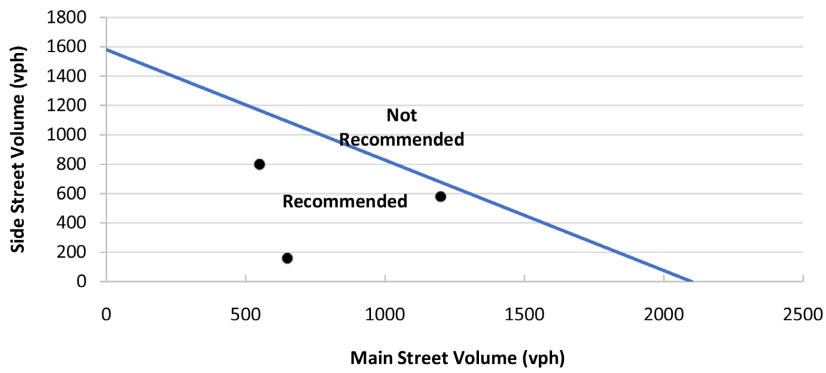

Figure 3. Guideline for operational performance at signalized intersections for Newark [9].

implementation of a road diet. The difference between this site and all those studies, however, is that the studies were conducted on a two-way roadway while E Main Street is one-way.

The number of lanes is something to keep in mind as the behavior of a one-way road is understandably different and the one-way traffic at the intersection of E Main Street and N College Avenue is likely higher than the one-way on the historically analyzed segments.

In addition, the nearby bicycle lane along W Main Street and Newark and Pomeroy Rail Trail bike path, provide the existing facilities essential for an effective improvement. This design would seek to connect them, ensuring a greater likelihood of success as well as upping the effectiveness of those existing lanes. The area features large pedestrian counts including a peak of 1333 pedestrians per hour at the intersection of E Main Street and Chapel Street. Any traffic calming or other safety benefits would therefore be very impactful on the substantial pedestrian traffic.

Based on the Delaware Department of Transportation's Bicycle Level of Traffic Stress (LTS) Model [10], the LTS for the selection of roadway, is principally a three rising to a four in certain sections west of the N College Avenue intersection. According to the 2018 Blueprint for a Bicycle-Friendly Delaware [11] an LTS 3 equates to a roadway which is "Tolerated by Riders who are enthused and confident; Heavy traffic with separated bike facility" and an LTS 4 equates to a roadway which is "Only tolerated by strong and fearless riders; cyclists must interact with high volumes or speeds of auto traffic" [11]. Neither is ideal for encouraging bicycle use and providing an environment with slower speeds or a greater degree of separation increases accessibility and comfort for more riders.

The Newark Transportation Plan from 2011 also identified the corridor as a section for pedestrian and bicycle improvements in the corridor for which a project here could expand beyond the intended implementation. The plan specifically details the use of sharrows and an increase in pedestrian bump outs. It also identifies the College Ave corridor as one which there is intended to a focus on increased safety and bicycle lanes throughout starting at the intersection with E Main Street. Decreased speeds in the corridor and having a bike lane on E

Main Street to connect to will only help both goals in the plan [12]. A road diet would almost certainly provide safety benefits, but no safety data was provided which could identify problem areas or attempt to quantify the savings.

4. Result and Analysis

4.1. VISSIM Analysis

Ten runs were conducted using VISSIM to simulate the traffic flow. Quite a few poor Levels of Service were already noted based on initial conditions. At the Chapel Street intersection, all four movements for Chapel Street were noted as being poor, especially heading southbound. The northbound movements had delays in excess of a minute while the southbound movements yielded approximately 2.5 minutes of delay with queues reaching over 1100 feet in length (which is about 0.208 miles and 55 cars long assuming 20-foot spacing). The Academy Street intersection is fine but there are serious issues at College Avenue. Both N and S College Avenue generated a level of service F and the left turn lane for E Main Street was also at capacity. The average delays for N College Avenue exceeded seven minutes.

The traffic flow and approaches on E Main Street are mostly handled well, but the minor roads all run into issues as their queues gradually build up. While these issues could be fixed with changes in signal patterns at the expense of some of the flow on E Main Street, they do cause pause for thought when considering any improvements. It was decided here that a goal of level of service D was sought as the desired minimum for approaches and intersections, with a level of service C the ideal minimum.

Errors were noted in the model for N College Avenue not being able to ever complete its run as vehicles remained in each simulation while both approaches for Chapel Street were unable to be completed about half the time. The Chapel Street errors are considered minor while the N College Avenue errors were more concerning from a modeling standpoint. Still, the existence of so many errors is not considered an issue as they can be chalked up to not simulating the downstream signals for either road. Even so, these errors may be partially responsible for the unusually lengthy delays.

There are currently no numbers for bike traffic, but the number is not expected to be high considering the high rate of flow on E Main Street and the lack of a dedicated bike lane. The lack of numbers for bicycle traffic is a limitation, but it is an expected one. There are currently a sizable number of pedestrians in the survey area, but they are mostly a consideration for safety concerns. Any improvement must take that into consideration. The presence of a dedicated pedestrian signal during the College Avenue intersection, however, is a major factor in the congestion that occurs there.

4.2. 2025 Future Conditions

The primary point of comparison for the alternatives is between the No Build condition and the alternative where a new bicycle facility is constructed. Both were done for the year 2025 and as a result, future volumes needed to be calculated for each movement. The future volume was calculated by using the equation below.

$$\text{Future Volume} = \text{Present Volume} * (1 + \text{Growth Rate})^{\text{\# of Years}} \quad (1)$$

The years' value for both intersections was assumed to be five as the traffic data given was taken to be identical to the initial value for 2020. The growth rate was calculated by using the below equation where the number of years refers to the number of years progressing in the projection.

$$\text{Annual Growth Rate} = \frac{\text{2030 Population} - \text{2020 Population}}{\text{2020 Population} * \text{\# of Years}} \quad (2)$$

The 2020 and 2030 populations were determined using the Wilmington Area Planning Council's Traffic Analysis Zone projections for each year in the Greater Newark Area [12]. The 2020 population was given as 70,888 while the 2030 population was given as 72,882. As a result, the annual growth rate was calculated to be 0.281% and was applied to each movement including pedestrians using the first formula as shown in **Table 2**.

The impact of the growth rate over five years was minimal. The individual vehicle and pedestrian counts were only increased by a few over that span, but these still are the values used going forward. **Table 3** shows the increase in flow for each approach from 2020 to 2025.

4.3. 2025 Alternative 1—No Build Condition Analysis

Minimal change was noted from the existing conditions. The only change in level of service was the Chapel Street intersection dropping a letter grade to E and now be operating at capacity. Queue lengths also remained similar over time as the maximum queue only increased by two car lengths at most and in some cases,

Table 2. Population growth in newark, DE.

Region	2020	2030	Average Annual Growth	Growth from 2020-2025
Greater Newark Area	70.888	72.882	0.281%	1.41%

Table 3. Growth for each approach.

Region	2020	2025	Average Annual Growth
E Main Street	1057	1072	1.41%
Chapel Street Northbound	476	483	1.41%
Chapel Street Southbound	335	340	1.41%
Academy Street	160	162	1.41%
N College Avenue	239	242	1.41%

particularly on the E Main Street movements, it decreased. The error count also remained similar though the count of vehicles that could not get through the system was slightly higher. The changes being so minor in comparison to the existing conditions make sense as the annual growth rate was so small, and which yielded a total growth rate of 1.41%.

4.4. 2025 Alternative 2—Build Analysis

4.4.1. Alternative Selection

Considering the constraints, the decision was made that the primary goal would be the creation of a new bicycle lane. Based on American Association of State Highway and Transportation Officials (AASHTO) standards, it was determined that this lane should be at a minimum of four-feet-wide, with a five-feet minimum where there is on-street parking, and with a six-foot-wide lane desired [13]. The main ways to get this extra room are to decrease the width of the sidewalk, reduce the travel to one lane, and remove parking.

To determine the possibility of reducing sidewalk width, the width of the sidewalk presently was measured along E Main Street using Google Earth. Since the minimum sidewalk width was established as ten feet by the constraints, the existing sidewalk would need to be fifteen feet wide if parking spots were present and fourteen feet if they were not. While portions of the sidewalk met this minimum, the areas that did were occasionally broken up by outdoor seating and foliage. It was therefore decided to try and pick a different method unless deemed necessary by any restrictions.

4.4.2. Initial VISSIM Tests

In evaluating the possibility of reducing the travel to one lane, a quick and dirty model was constructed in VISSIM. This model maintained the signal timings and was merely constructed to be able to run. The results were promising, showing that for the Chapel Street and Academy Street intersections, the level of service would be decreased but still good enough. A greater issue arose at the College Avenue intersection, however. The delays there were already substantial on the Existing and No Build models and this analysis only made it worse. In addition, the S College Avenue approach, which already had issues when it was two lanes, would have to be reduced to one lane as well to fix the geometry since it would be turning onto a road which now only had one lane. Since this change to one lane for S College Avenue and for E Main Street would have so harshly affected the intersection, the decision was made to try and maintain two lanes for the area surrounding it.

This analysis led to the final decision to propose an alternative with a mix of single and double lanes on E Main Street. The location of the road would expand from one lane was determined by analyzing the map. It was also decided to try and maintain as much parking as possible was made for the area which represented more of a downtown corridor since it is likely that the businesses there would be less open to losing their parking. It would also be counterproductive to the goal of encouraging greater usage of these businesses if vehicles were forced to park further away. This consideration was determined to be not as much of a concern after the downtown area, as the land use changed to the University. The exact location for the switchover from a single to two lanes was picked as the pedestrian crossing only signal which is located between the Academy Street and College Avenue intersections. This spot was chosen for both its convenience in limiting the modification of the existing crossing there as well as its location just outside the terminus of the downtown corridor and is depicted in **Figure 4**.

4.4.3. VISSIM Analysis

The model was redesigned in VISSIM to account for this new layout and a further ten runs were conducted for a preliminary analysis for this alternative. While there was a definite dip in level of service, the results were considered reasonable and so it was decided to try to better optimize the signals. The biggest targets were the Chapel Street and College Avenue intersections which were respectively at and over capacity.

Ten seconds were added to the Northbound through traffic while five seconds were added to both the northbound left and southbound through at Chapel St. To compensate, ten seconds were taken away from the E Main Street approach. As a result, the Chapel Street intersection improved noticeably to the desired minimum level of service D for each approach as well as the overall intersection.

At College Avenue, it was determined that the flashing don't walk time was already at its minimum required, so four of the five walk cycles, which are all on the same separate pedestrian timer, were shortened to the minimum walk time of seven seconds [14].

The five seconds saved here were used to increase the length of the signal for N College Avenue. Next the overlap was removed from the E Main Street approach at the College Ave intersection with the left turn allowed to run the same time as the through. This yielded the least errors overall, but a further five seconds were taken away from the E Main Street approach and given to N College Avenue.

Figure 4. Lane Switchover projection [6].

All these changes had the effect of making the minimum level of service for all approaches a level D apart from the one at N College Avenue which had been significantly reduced from a delay of 658 seconds to one of only 112 seconds. While there is concern that the E Main Street through at that intersection dropped to a level D at that intersection, it stayed at C at the other two. In addition, the reduction of errors was seen to be a sign that the system could better handle the typical flows. Any further timing changes risked ruining the progress made, however the possibility exists for changes in timing to be made at the College Avenue intersection to maintain a C level of service for all the major approaches at the expense of the minor street approaches.

4.4.4. Curb Extensions

An added consideration also needs to be made for the existence of a few curb extensions. They currently exist at Chapel Street, College Avenue, and the pedestrian only intersections. While the possibility is there for these short stretches to become sharrows, this solution would defeat the purpose of a continuous bike lane. As a result, these would need to be removed in part or in whole on the right side of the road in the College Avenue case to make room for the new bike lanes. As much of the College Ave curb extension should be preserved, especially considering their status in the Newark Transportation Plan, with the recommendation made to decrease the bike lane to four feet for that short stretch. A short, protected bike path which would be cut into the curb extension was considered, but instead it was decided to just remove four feet from the edge of the extension. The other two curb extensions exist before the changeover to two vehicle lanes and will have the required space.

4.4.5. Bicycle Lane Width

Otherwise, there is plenty of room to add a full six-foot-wide bike lane along the entire length of E Main Street with the removal of a lane or parking spots. In the sections of the design where the parking spaces are to be removed, seven feet of space will be made available. Six feet will be used in the construction of the bike lane while the other foot can be used to create a buffered lane. Where the lane is to be removed, ten feet of space will be made available. Six feet of that will be used for the bike lane while the other four feet can be used for the expansion of the parking spaces from the current minimum of seven feet on each side to nine feet or partially in the creation of buffered bike lanes. None of that expanded space should be used on the lane width as the current ten-foot width is effective for traffic calming [15].

A two-way bike path was considered for the downtown corridor as it would provide noticeably improved accessibility for that essential area and the ten feet of removed lane width is enough to construct such a facility with five feet needed for each direction. There would not be enough room to place a two-lane path where parking is being replaced as only seven feet is being removed. This is still an option for construction, but a one-way path was decided on to maintain continuity across the entire path and because there would be no existing entrance location for eastbound bicycle traffic after that bike lane switches from one-way to two-way traffic.

4.4.6. Expanding Curb Width

Curbs could also be widened, especially where the width is presently only seven feet, providing two feet additional to each side. If desired, an extra foot can be removed from the bike path for use in expanding this area. This would allow for a larger space for restaurants to have outside seating as well as greater pedestrian comfort. It would however require both a greater monetary investment as well as the possibility of shutting down portions of the street for construction, which would be considered an unpopular decision by businesses. Changes in markings are instead advised since they are quicker and cheaper to make. A greater width of bike lane was also considered, but they are discouraged by guides as they make the lanes look like another traffic lane.

4.5. Parking and Loading Analysis

4.5.1. Vehicle Parking

As part of the Build Alternative, there will be parking spaces removed over a stretch of E Main Street between the end of the downtown area and the railroad crossing. According to Google Street View, that total consists of a loss of 24 parking spaces that seem to be well used based on the satellite images of the area.

More exact figures on usage were not able to be obtained because of the pandemic. Accounting for these lost spots will be difficult because of an apparent number of free parking spaces. The best option for rerouting those parking on the street is to have them park in the nearby parking garage.

The walking distance from the furthest car to the entrance of the garage is 1000 ft (0.189 miles). Assuming a walking speed of 3 mph, that would be an average of 3.79 minutes, with an assumption that the total time including leaving the garage is around 5 minutes. Using the distance most people are willing to travel to access transit of 0.25 miles or five minutes, this is considered acceptable assuming that the people who street park also have access to the garage [16].

4.5.2. Loading and Rideshares

The changes to the stretch of road should not impact deliveries or rideshares too much when considering the region being affected, but it should still be considered especially since accommodating this traffic that does exist will be difficult. College Avenue lacks any on-street parking and there is no parking on the opposite side of Main Street. The Trabant University Center already has its own place for deliveries, but the buildings on the north side of Main Street do not have that luxury and a survey would need to be conducted assessing their need for deliveries. Rideshares however could be accessed various full lots surrounding the area as well as the parking remaining on E Main St as seen below. If necessary, one or two of the spaces on E Main Street could be set aside as dedicated pick up and drop off points.

Table 4. Level of service comparisons.

Intersection	Movement	Existing Level of Service	No Build Level of Service	Build Level of Service
E Main St and Chapel St	E Main St Through	B	B	C
E Main St and Chapel St	E Main St Right Turn	B	B	B
E Main St and Chapel St	E Main St Left Turn	C	C	D
E Main St and Chapel St	Chapel St NB Through	E	E	C
E Main St and Chapel St	Chapel St NB Left Turn	E	E	C
E Main St and Chapel St	Chapel St SB Through	F	F	D
E Main St and Chapel St	Chapel St SB Right Turn	F	F	D
E Main St and Chapel St	Overall Intersection	D	E	D
E Main St and Academy St	E Main St Through	A	A	A
E Main St and Academy St	E Main St Left Turn	A	A	C
E Main St and Academy St	Academy St Left Turn	D	D	D
E Main St and Academy St	Overall Intersection	B	B	B
E Main St and College Ave	E Main St Through	C	C	D
E Main St and College Ave	E Main St Right Turn	C	C	D
E Main St and College Ave	E Main St Left Turn	E	E	C
E Main St and College Ave	S College Ave Left Turn	F	F	D
E Main St and College Ave	N College Ave Right Turn	F	F	F
E Main St and College Ave	Overall Intersection	F	F	D

Table 5. Level of service comparisons.

Intersection	Movement	Existing Average Queue (ft)	Approx# of Cars	No Build Average Queue (ft)	Approx# of Cars	Build Average Queue (ft)	Approx# of Cars
E Main St and Chapel St	E Main St Through	23.91	1	22.64	1	299.77	15
E Main St and Chapel St	E Main St Right Turn	26.67	1	25.31	1	278.90	14
E Main St and Chapel St	E Main St Left Turn	15.04	1	14.96	1	120.65	6
E Main St and Chapel St	Chapel St SB Through	742.68	37	764.16	38	132.50	7
E Main St and Chapel St	Chapel St SB Right Turn	718.40	36	739.40	37	132.50	7
E Main St and Chapel St	Overall Intersection	225.65	11	234.06	12	136.08	7
E Main St and Academy St	Overall Intersection	15.20	1	14.98	1	23.57	1
E Main St and College Ave	N College Ave Right Turn	561.78	28	562.24	28	206.94	10
E Main St and College Ave	Overall Intersection	196.09	10	200.79	10	87.78	4

4.5.3. Bicycle Parking

There exists a small amount of bike parking such as at the corner of Orchard Rd and Main Street and just past N College Avenue, but more would need to be added to service the increased traffic the dedicated bike lane hopes to bring in. There currently exists several single bike racks located in the downtown's vicinity. Increasing the quantity of those would encourage the use of bicycles as a means of transportation to the shops. There is also a greater opportunity to place larger bike racks near the University since the existing ones seem to be well used and the University is a logical destination point for much of the area's bike traffic.

Bike share locations are also a possibility though the coverage area is likely not dense enough nor big enough to warrant their cost and implementation. If one is desired, the existing use of bike parking in the area indicates that placing a bike share station near to the campus would be ideal since it would be both a common departure and arrival point. Placing another near the restaurants and shops would complement the initial location well, though there exists an issue of space in the downtown area. The extra four feet added in that area by removing a lane could be put instead to use in places for the construction of either or both bike shares and racks for public bike use. These could be added directly to the streets in places too small for a car to park or at the expense of a parking spot. They would work best as an addition to newly constructed sidewalks for reasons of safety, but the 25 MPH speed limit ensures that this should not be a necessity [17].

4.6. Level of Service Analysis

As shown in **Table 4**, the level of service and consequently the delay time improved across most of the surveyed approaches. The ones that decreased on E Main Street are significant, but they all still meet the acceptable level of service D and most meet or exceed the desired level of service C. Concern exists over the level of service D for the intersection of E Main Street and College Ave, but a change in timing could fix that at the expense of the minor streets particularly since they already fail in the existing condition. In addition to the decrease in delays, the amount of queuing should decrease significantly throughout the study area. Aside from E Main Street at the Chapel Street intersection, every change in queue saw less or equal numbers of the average number of cars (assuming 20 ft spacing per car) with some significant improvements. **Table 5** shows these comparisons for movements featuring the most noticeable changes as well as each overall intersection.

5. Conclusions and Recommendations

5.1. Conclusions

After analyzing the choice between maintaining the current layout for E Main Street in Newark and the build alternative, the latter was decided as the recommendation. While the change would be a significant one, the losses in traffic flow and parking are considered manageable. While the loss of a lane would affect the ability of the town to handle traffic, most E Main Street can handle its traffic with only one lane.

An added benefit of decreased flow on E Main Street should be safer for the bike traffic being added in. This added layer of safety alongside an implemented bike lane should encourage more bicycle use and help to justify the expense of these changes. Slowing the main street down could also benefit businesses located downtown. As it stands, it is quite easy to blow through the downtown corridor quickly and slower travel should allow for increased visibility of the shops and restaurants. All the desired changes can be implemented though without affecting the important spots in the downtown area, which would also be the hardest to employ any mitigation.

The implementation of a bike lane is the most important change of the build alternative and would do much to improve bicycle accessibility for the region. The lane will link up two existing and extensive bicycle facilities as well as servicing the heart of Newark. It could also help in crafting a more modern downtown Newark along with the increased flexibility in space from removing a lane. This space, though proposed for expanding the width of parking spots, could also be made into wider sidewalks or for the implementation of bike storage facilities.

As it stands now, there is a substantial opportunity to improve the alternative transportation options for downtown Newark. There should also be ample flexibility regarding the modification of the existing design of E Main Street while still being able to handle the current vehicle traffic in the area.

By analyzing the existing and future conditions, several important conclusions were reached:

- At present, the only bike accommodation on E Main Street exists in the form of a sharrow in the right lane.
- E Main Street services two major land uses along the survey area in the University of Delaware and a downtown corridor, which should have different demands.
- The flow on the major street, E Main Street, is currently good, but there exist major delays for the minor roads, specifically College Avenue and Chapel Street.
- Projected growth over the next five years is expected to be minimal and should have a negligible effect on traffic conditions.
- There should be many opportunities to construct a bike lane using the given road layout while hopefully maintaining quality traffic flow.

5.2. Recommendations

While this analysis was not performed with the intent that the road diet would be applied to E Main Street, arguably the most crucial step would be to reach out to the public before heading any further. Public involvement is essential in any project, but especially in one that can be controversial and counterintuitive to the typical thought process when it comes to fixing roads. By engaging the public early and keeping them up to date, the project can better identify potential issues early on that regular users would be more attuned to and help build a greater trust in the project. Research repeatedly shows that the lack of public support can kill a road diet regardless of level of success. Public support can be increased by a successful project, but too much opposition makes that task impossible.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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