BOOSTING THE BUS:
BETTER TRANSIT INTEGRATION ALONG WEST CHESTER PIKE

JUNE 2011

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REGIONAL
PLANNING COMMISSION

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The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals, and the public with a common vision of making a great region even greater. Shaping the way we live, work, and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment, and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region — leading the way to a better future.

The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey Departments of Transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for the findings and conclusions herein, which may not represent the official views or policies of the funding agencies.

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Executive Summary

The purpose of this study was two-fold:

- First, to develop a set of best practices to improve the quality of transit service in the West Chester Pike corridor (with a focus on SEPTA Route 104) as well as its integration with corridor development;
- Second, to use VISSIM microsimulation to test the impacts of various operational improvement strategies on the speed and running times of Route 104 buses.

This project draws on the findings of several prior efforts by the Delaware Valley Regional Planning Commission (DVRPC) and its planning partners for enhancements to transit service in the West Chester Pike (PA-3) corridor. These include a 2007 DVRPC feasibility study for a dedicated median busway between 69th Street Transportation Center and I-476 (*Feasibility Analysis of West Chester Pike Busway*, pub. no. 07001) as well as a Transportation Management Association of Chester County (TMACC) study from the same year that considered the feasibility of Transit Signal Priority (TSP) in the Chester County portion of the corridor (*Transit Advantage: Transit Signal Priority on PA Route 3*). Drawing on the generally favorable findings of the latter study, DVRPC's 2008 *Speeding Up SEPTA* report (pub. no. 08066) included a case study on SEPTA Route 104 in a chapter that addressed strategies to improve the effectiveness of suburban bus service.

Following stakeholder discussions, staff developed a series of three enhancement scenarios for Route 104: a) a corridor-length implementation of TSP; b) TSP plus a relocation of many near-side stops to the far side of their intersections; and c) TSP plus a new limited-stop operating pattern (the West Chester RapidBus). DVRPC's simulations of these enhancement scenarios suggest that they would result in travel time savings, with the most meaningful benefits naturally being observed under the RapidBus proposal (which was simulated to cut the time competitiveness gap between auto and transit by about 32 percent in the westbound direction, and 66 percent eastbound). The time savings estimated for the TSP-only and TSP plus far-side stop scenarios are much more modest, with only a negligible additional benefit being observed for the addition of far-side stops to TSP.

For West Chester Pike, the next steps toward improving bus service are to pursue implementation strategies (either incrementally or as a single project). The Delaware County TMA (DCTMA) is presently managing a feasibility and outreach project on implementing TSP and land use access improvements, which are expected to be consistent with the recommendations of this report. The experiences of other cities and regions that have pursued bus enhancement or Bus Rapid Transit (BRT)-lite projects like the proposed RapidBus, from major cities to suburban corridors, suggest that when it comes to the effectiveness of improvements, perception is reality. Whichever improvement strategies are pursued – from simple TSP to the full RapidBus vision – they should be promoted and branded rather than made quietly.

CHAPTER 1

Introduction and Background

A vision for transit service in the West Chester Pike corridor

Over the coming years, **West Chester Pike will become a much more multimodal corridor, with new sidewalks and crosswalks providing safe and comfortable pedestrian access** to, along, and across the Pike. Supported by this improved passenger accessibility, the quality of SEPTA Route 104 bus service will be enhanced by additional investments including **TSP** at intersections, **rethought stop locations**, and **new and enhanced bus shelters** with more passenger information and amenities. The West Chester RapidBus, a new and specially branded express version of Route 104 service, will provide a **convenient, comfortable, and fast** connection between West Chester Borough and 69th Street Transportation Center, with travel times that are competitive with the automobile. This high quality of service will **help make bus service a mode of choice rather than last resort** for Chester County and Delaware County residents and workers for many trips along West Chester Pike. This higher demand for bus service will in turn take some cars off the road, freeing capacity and improving overall corridor mobility.

Purpose and project approach

Improving the quality and effectiveness of bus service in the PA-3 / West Chester Pike corridor has been the subject of several recent planning efforts. These include a 2007 DVRPC feasibility study for a dedicated median busway between 69th Street Transportation Center and I-476 (*Feasibility Analysis of West Chester Pike Busway*, pub. no. 07001), as well as a TMACC study from the same year that considered the feasibility of TSP in the Chester County portion of the corridor (*Transit Advantage: Transit Signal Priority on PA Route 3*). Drawing on the generally favorable findings of the latter study, DVRPC's 2008 *Speeding Up SEPTA* report (pub. no. 08066) included a case study on SEPTA Route 104 in a chapter that addressed strategies to improve the effectiveness of suburban bus service.

The purpose of this study is two-fold:

- First, to develop a set of “best practices” to improve the quality of transit service in the West Chester Pike corridor (with a focus on SEPTA Route 104) as well as its integration with corridor development;
- Second, to use VISSIM microsimulation to test the impacts of various operational improvement strategies on the speed and running times of Route 104 buses.

Summary of current SEPTA service along West Chester Pike

There are a number of SEPTA bus routes that operate on at least a portion of West Chester Pike, generally sharing an eastern terminus at 69th Street Transportation Center and running along West Chester Pike before deviating to various western termini. The lone end-to-end service (from 69th Street Transportation Center to West Chester Borough) is Route 104. Table 1 below summarizes the operating characteristics of each of the SEPTA routes that serve a portion of the West Chester Pike corridor (in descending order by weekday passenger volume).

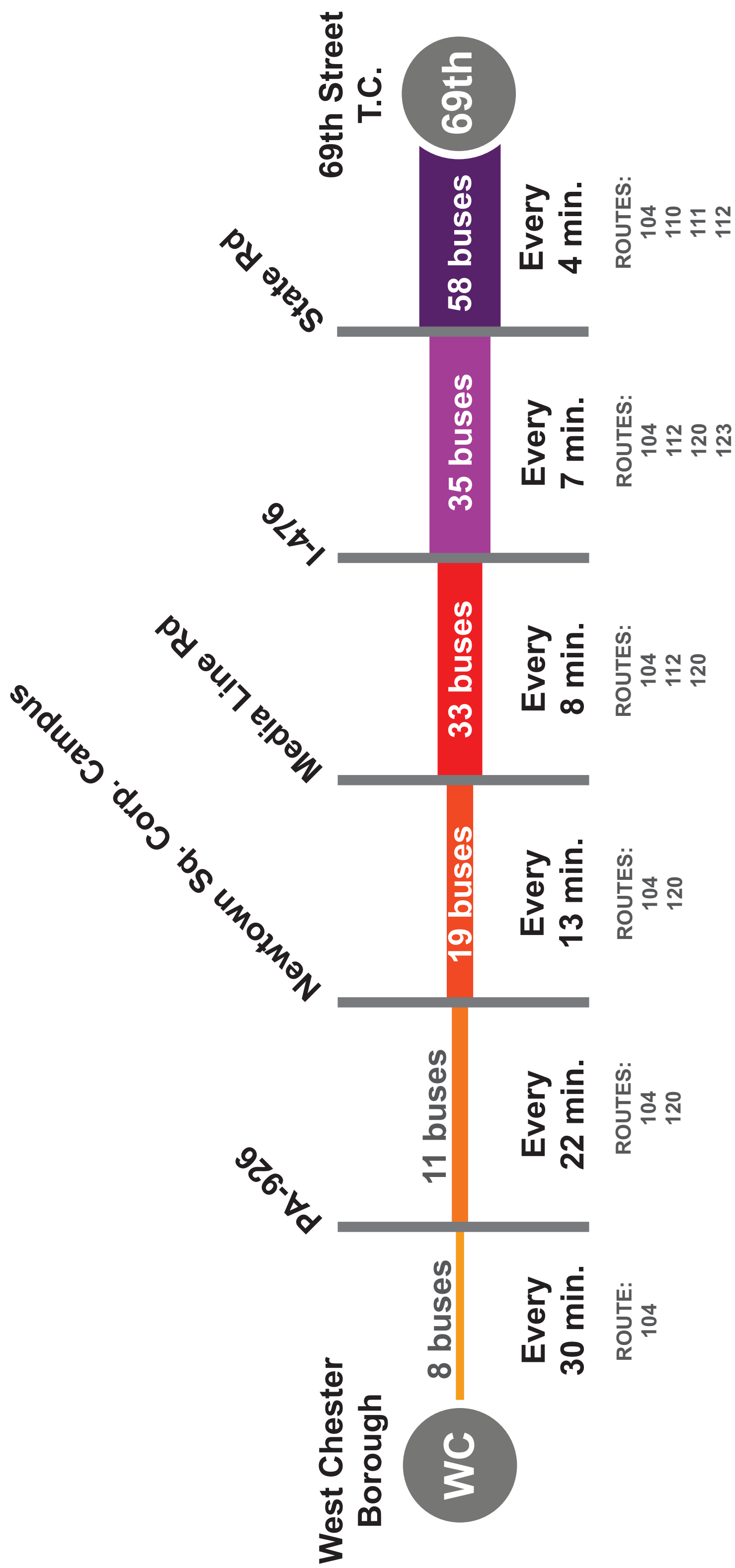
Table 1: Characteristics of West Chester Pike bus services

Route	Peak Vehicles	Weekday Passengers	Annual Passengers	Passenger Revenue	Operating Ratio
104	13	3,082	913,680	$1,065,351	20%
110	6	1,635	484,650	$565,102	22%
112	9	1,605	455,790	$531,451	23%
111	6	1,445	410,340	$478,456	18%
123	4	1,188	367,090	$428,027	20%
120	2	468	138,890	$161,946	18%

Source: SEPTA FY2011 Annual Service Plan

As noted above, bus service along West Chester Pike is concentrated in the eastern end of the corridor near 69th Street, where routes with various western termini converge on West Chester Pike before reaching 69th Street Transportation Center. This means that for a passenger in the eastern portion of the corridor heading towards 69th Street Transportation Center and taking the next bus available regardless of route, **service levels are very high during peak periods, approaching the higher range of peak service levels in Center City Philadelphia**. Figure 1 illustrates this, summarizing levels of service for various segments along the corridor.

Figure 1: West Chester Pike SEPTA bus service summary, AM peak, 7 a.m. – 9 a.m.



NOTE:
Numbers of buses above refer to total segment volumes (both directions); frequencies are each way.

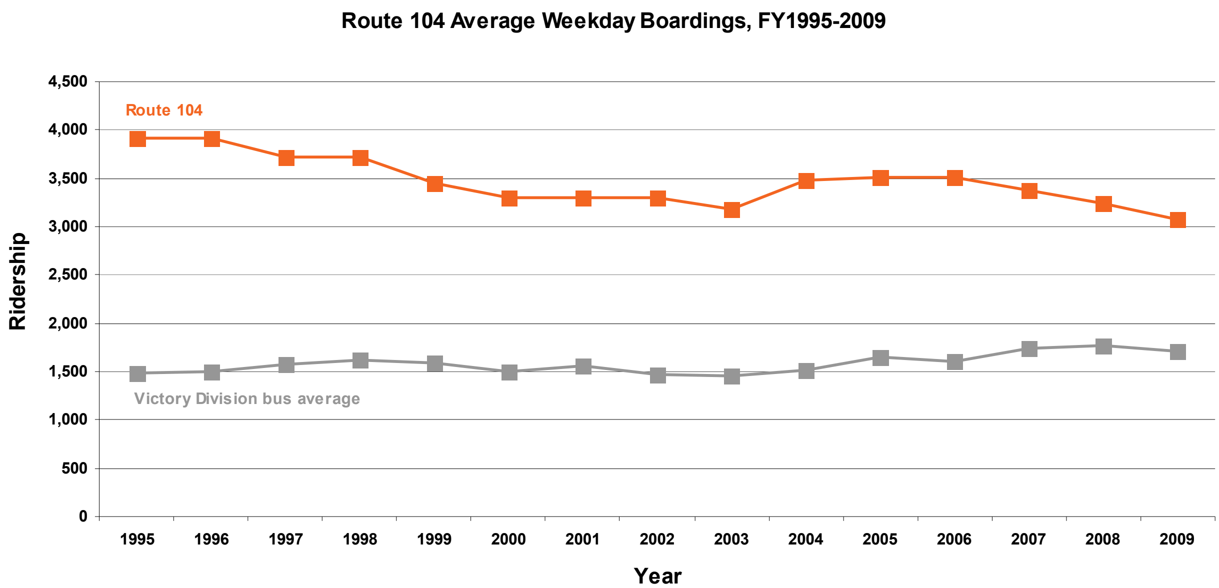
Source: SEPTA schedules, March 2011

SEPTA Route 104 Service Summary

As Route 104 is the only route with end-to-end service between West Chester and 69th Street – and the route on the PA-3 corridor with the highest daily ridership – this is the route that is the focus of the present study.

During the AM and PM peak periods, half of Route 104's trips in both directions run express between 69th Street Transportation Center and Eagle Road. The remaining peak trips (again, in both directions) are local runs that serve all stops but terminate at the Newtown Square Corporate Campus. After the PM peak (beginning at 7:00 p.m.), Route 104 service also deviates into the Edgmont Square Shopping Center in Newtown Square. Figure 2 summarizes Route 104 daily ridership over time in comparison with the average ridership on Victory Division bus routes.

Figure 2: Summary of Route 104 passenger activity over time

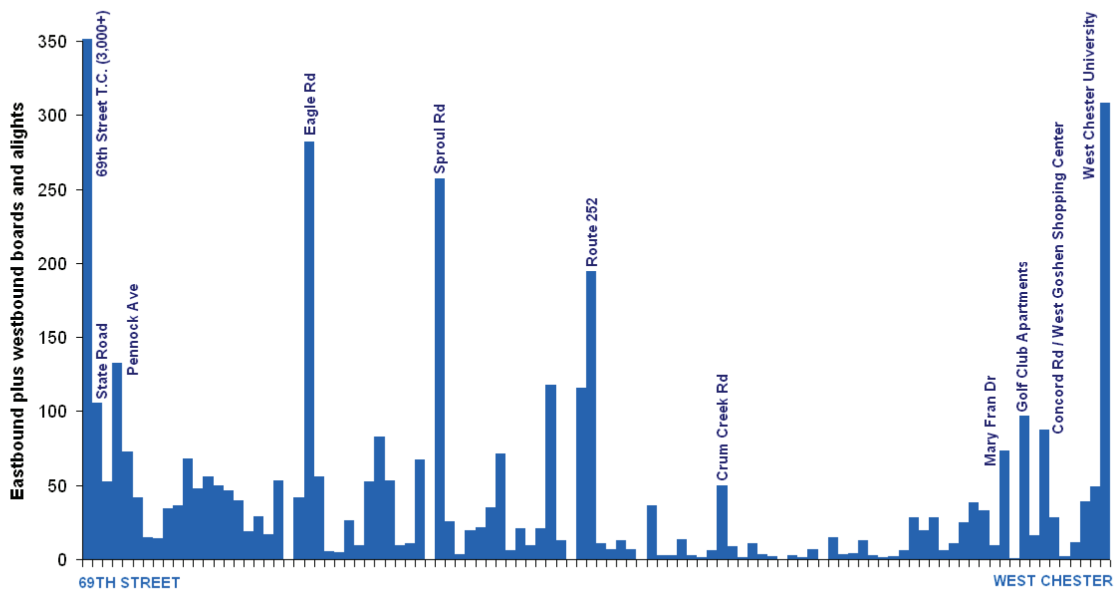


Source: SEPTA Route Operating Ratio reports, FY1995-FY2009

As Figure 2 indicates, Route 104 ridership continues to be high relative to the average ridership of its peer routes (and indeed most suburban routes in the entire SEPTA system). However, its historical ridership trend is generally downward over the last 15 years, declining overall by just over 20%. As an experiment to generate new ridership, Route 104 was one of the suburban routes selected for increased frequencies as part of SEPTA's FY2009 Added Service Initiative (with peak frequencies to West Chester improving to every 20 minutes). Despite this investment, ridership did not respond, and frequencies to West Chester were restored in 2010 to the prior 30 minutes. Notably, Route 104's weekday ridership remains above the 3,000 threshold established by the Federal Transit Administration (FTA) as part of the evaluation criteria for Very Small Starts (VSS) funding, used nationally to fund relatively low-capital (less than $75 million) BRT and "BRT-lite" investments in bus corridors with high levels of existing ridership. When the combined ridership among all the routes that share the eastern portion of the PA-3 is considered (see Figure 1), the case for corridor transit improvements is strengthened still further.

Figure 3 summarizes Route 104 passenger activity by location along the West Chester Pike corridor. As this figure indicates, the majority of Route 104's passenger activity is concentrated in the eastern portion of the corridor and the far western terminus (in and around West Chester). Additionally, there are a handful of stops with significantly more passenger activity than the typical stop which may warrant special planning consideration; several of these are also identified in Figure 3.

Figure 3: Route 104 total daily passenger activity by stop



Source: SEPTA ride check passenger counts, winter and fall 2009

It bears noting that according to the passenger count data available, 69th Street Transportation Center has nearly as much daily passenger activity (just over 3,000 combined boards and alights per day) as the combined total of every other stop along Route 104 (about 3,700 per day). This means that nearly half of all passenger trips on Route 104 either begin or end at 69th Street Transportation Center (and most involve a transfer there to services such as the Market-Frankford Line into Philadelphia, Route 108 towards Philadelphia International Airport, or Route 113 towards Darby Transportation Center). On the other hand, more than half of Route 104 passenger trips *do not* involve 69th Street Transportation Center, instead both beginning and ending at West Chester or intermediate locations along the corridor. This indicates that **Route 104 is not simply a suburb to city (or reverse) commuter service; it serves a much more complex array of trip patterns and purposes**.

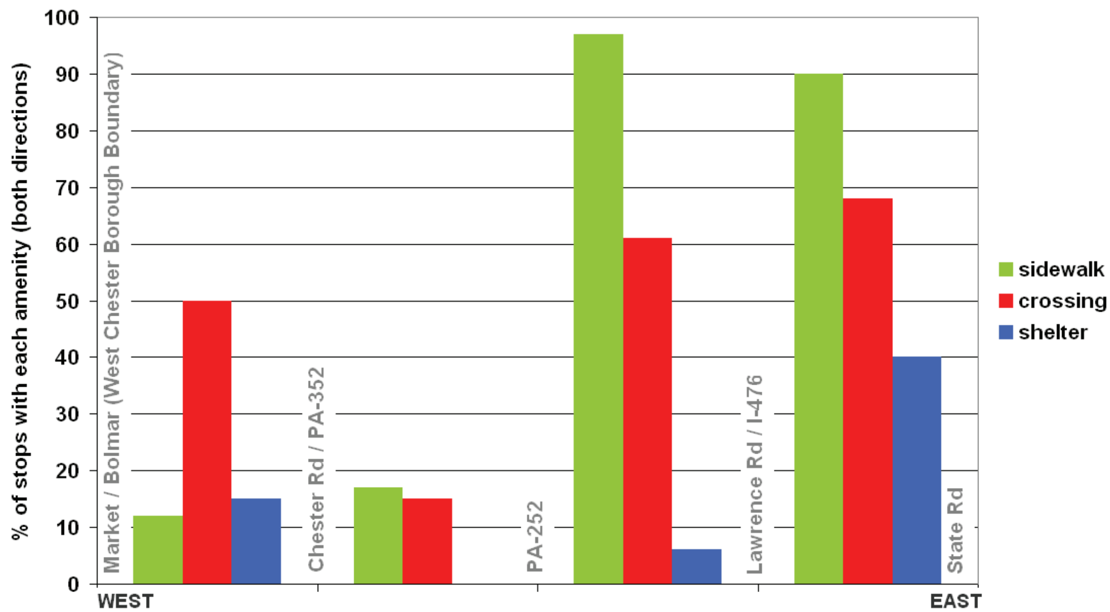
Stop conditions and context along West Chester Pike

Like any transit line, Route 104 does not operate in a vacuum, but rather is a creature of its operating context and surrounding land uses. The ability of passengers to safely, comfortably, and conveniently access the Route 104 bus at both ends of their trip, particularly by foot, has a significant impact on whether, how, and how often they use the service. In this regard, **Route 104 passes through nearly the entire cross-section of suburban land uses in the DVRPC region**, from the relatively urban, mixed-use, and walkable (Upper Darby, West Chester) to highway-oriented commercial development where bus passenger access is often a secondary consideration.

As part of this study, DVRPC staff undertook a summary inventory of passenger amenities and access along the corridor using aerial photography and Google Street View imagery, with a focus on this project's study area: State Road in Upper Darby to the West Chester Borough boundary (this project does not directly address conditions at Route 104's termini – the immediate vicinity of 69th Street Transportation Center and West Chester Borough – since conditions in these locations are uniquely complex and may warrant special consideration in future studies). Figure 4 summarizes the relative presence of three key passenger amenities within four corridor subsegments (State Road to I-476; I-476 to PA-252; PA-252 to PA-352; and PA-352 to the West Chester Borough boundary):

- sidewalks in the immediate stop vicinity;
- marked crosswalks at the stop or nearest intersection; and
- the presence of a bus shelter.

Figure 4: Percentage of stop/access amenities by corridor segment



Source: DVRPC 2005 orthophotography, bing.com pictometry 2010, google.com Streetview 2010

For the most part, the presence or absence of a bus shelter is an issue of comfort, weather protection, and the desirability of transit. **The absence of sidewalks or crosswalks, however, presents real safety concerns**. As Figure 4 indicates, each of these three key passenger access amenities is more widely present in the eastern portion of the study area corridor than in the western portion. In addition to this broad observation, two more specific conclusions are worth noting:

- The presence of crosswalks accommodating safe passenger street crossings is relatively consistent throughout the corridor, with the exception of the segment between PA-352 and PA-252, which has markedly fewer safe and permitted crossings.
- Sidewalks accommodating stop access are much more prevalent east of PA-252 than west of PA-252.

Figure 5 illustrates examples of passenger and pedestrian access challenges along the West Chester Pike corridor. As the 2007 TMACC study found, at some intersections along West Chester Pike crosswalks are not only absent, but crossings themselves are prohibited.

Figure 5: Illustrations of passenger access gaps along West Chester Pike

ABOVE and BELOW: Pedestrians crossing West Chester Pike toward the Golf Club Apartments despite the lack of a crosswalk on the eastern side of the intersection. There is a crosswalk on the western side of the intersection.

ABOVE: Bus stop area without sidewalk or shelter, but well-worn by waiting passengers (West Goshen Shopping Center).

Source: Chester County Planning Commission 2010

In contrast, a number of locations have relatively good passenger amenities, particularly in the eastern portion of the corridor where stops are shared by multiple routes. Figure 6 illustrates one such example in Haverford Township (a crosswalk is also present, but not pictured).

Figure 6: Route 104 stop location with shelter and sidewalk

Source: Delaware County Planning Department 2010

Relationship between access amenities and ridership

Given the extreme variation in passenger amenities and access conditions along the corridor, one question that emerges is the impact that the presence or absence of such amenities has on passenger activity and ridership. In other words, are access amenities concentrated where ridership is concentrated?

This is a “chicken and egg” question: will people ride transit where access is safe and comfortable, or are amenities installed where passenger activity is naturally generated (because of land use context, for example). In reality, the answer to both questions is a qualified “yes,” and the correlation of each type of amenity with passenger activity (boards and alights) can be instructive.

Staff conducted a correlation analysis for this project’s core West Chester Pike study area (State Road to the West Chester Borough boundary), comparing stop-level boards and alights to the presence or absence of the three passenger/access amenities previously discussed: bus shelters, sidewalks, and marked crosswalks that permit relatively safe crossing of West Chester Pike.

Of these, crosswalks were the amenity most highly correlated with passenger activity, with a correlation of 0.49. For the Route 104 study area, about 70% of total passenger activity occurred at stops with marked crosswalks, despite only about 45% of all stops having crosswalks. The next most highly correlated amenity was sidewalks, with a correlation of 0.39, followed by shelters with a correlation of 0.25. A follow-up regression analysis found that both crosswalks and sidewalks were statistically significant predictors of ridership, but the presence of a shelter was not. **The high ridership correlation for crosswalks in particular suggests that they should be a key strategy for passenger access improvement**.

Boosting the bus: improvement strategies

In February 2010, DVRPC staff held a project stakeholder workshop on improvement strategies for Route 104 and West Chester Pike. At this workshop, representatives of Chester County, Delaware County, the TMACC, the DCTMA, and SEPTA came together to review bus operations, discuss corridor conditions, and consider a host of potential strategies to improve the quality of transit service along West Chester Pike. The remainder of this report details the results of analysis undertaken as a result of this workshop, focusing on two broad categories of improvement:

- **Route 104 operational enhancements:** these are strategies to improve the speed and efficiency of bus operations, helping to make the bus more time competitive with the automobile.
- **Route 104 design enhancements:** these are examples of strategies to improve the quality of the passenger experience on Route 104 through stop design improvements, access improvements, and passenger information improvements.

Route 104 Operational Enhancements

One of this project's objectives is to improve the quality of Route 104 service as measured by travel time, particularly in comparison to the automobile. Improved travel times would have immediate mobility benefits for current riders and also make the service more attractive for new riders, helping to improve overall mobility in the corridor. During data collection for the current project, DVRPC staff made a series of "floating car" trips along West Chester Pike at various times of the day in order to obtain point-to-point automobile running times for modeling purposes. Based on this data collection and SEPTA's most recent Route 104 schedule, a current peak period travel time comparison for the trip between 69th Street Transportation Center and downtown West Chester is as follows:

- **AM peak eastbound:** automobile 38 minutes, bus 53 minutes (+15 minutes or 39%)
- **AM peak westbound:** automobile 44 minutes, bus 56 minutes (+12 minutes or 27%)
- **PM peak eastbound:** automobile 47 minutes, bus 60 minutes (+13 minutes or 28%)
- **PM peak westbound:** automobile 42 minutes, bus 57 minutes (+15 minutes or 32%)

During initial discussions with project stakeholders, including a February 2010 workshop, a variety of operational enhancements for Route 104 were considered. These included a menu of strategies that are typically considered for Transit First projects in the City of Philadelphia and for "Rapid Bus" or BRT-lite projects nationally:

- **Transit Signal Priority (TSP)** along the corridor, granting buses extended green signal phases (or shortened red phases). TSP could be simple (where the bus is always granted signal priority upon detection, provided another bus has not been granted priority too recently) or conditional (where the bus is only granted priority when it is behind schedule, for example). Conditional TSP can improve reliability, but not necessarily travel time.
- **Stop consolidation or limited-stop operations**. Stopping less frequently saves braking and acceleration time, and can also save dwell time depending on how passenger activity is affected.
- **Stop relocation from the near side of the intersection to the far side**. This strategy helps to speed up transit service by reducing the number of times a transit vehicle misses a signal cycle when stopping at the near-side of the intersection for boarding and alighting passengers. Far-side stops are usually a particularly effective strategy when combined with TSP, which helps to prevent circumstances where a bus stops twice at an intersection: once on red, and once more at the far-side stop. In the context of a TSP strategy, far-side stops

also help mitigate conflicts with right-turning traffic and make the time taken to clear the intersection more predictable for timing green phase extensions.

- **Exclusive rights of way** to allow buses to bypass key traffic choke points. These could include targeted shoulder operating segments and/or queue-jumping lanes with special transit signal phases that would grant buses an early green signal to get around traffic queues.

Following stakeholder discussions, staff developed a series of three enhancement scenarios for Route 104. The consensus was to rule out interventions that would require right-of-way changes over the near term, and so strategies such as queue-jumping lanes were not included in the enhancement scenarios. The three enhancement scenarios are as follows:

SCENARIO 1:
Corridor-length TSP; optical implementation similar to City of Philadelphia Transit First routes[1]

SCENARIO 2:
TSP plus **relocation of all near-side corridor stops to far side**, wherever it is technically feasible to do so

SCENARIO 3:
TSP plus **far-side stops** plus **stop consolidation**

Microsimulation evaluation of Route 104 operational improvement scenarios

The central element of this study is a microsimulation analysis of a base case (present day) operating scenario for Route 104, plus each of the three improvement scenarios using VISSIM software. Each scenario is modeled during the **weekday PM peak** for this project's core **West Chester Pike study area: State Road in Upper Darby to the West Chester Borough boundary** (Bolmar Street / Montgomery Avenue). Comparing the resulting travel times from scenario to scenario (by segment and end-to-end) provides detailed information on the impacts of each strategy on bus travel times and general traffic flow. The impact on cross-street traffic will also be estimated at select locations.

Scenario 1 details (corridor-length TSP):

The first build scenario reflects the installation of an optical TSP system at every signalized intersection in the study area. This TSP functionality is equivalent to the technology used in City of Philadelphia Transit First projects in recent years. When a bus is detected by a signal's optical receiver (which has a line of sight range of about 1,000 feet) during a green signal phase, that

[1] Philadelphia Transit First projects incorporating TSP include Trolley Routes 10 and 15 as well as Bus Route 52. For more details, see DVRPC publication no. 08066.

green signal phase is extended by 10 seconds. This is automatic; the emitter is always on, with no ability for the bus driver to manually activate or deactivate. It is worth noting that the extended green is only provided if the bus needs it – if the bus "checks out" (passes the signal) before the end of the normal green phase, the phase extension is canceled. Once the transit priority has been actuated, an extended green will not be granted to another bus until 4 minutes have passed. After the extension has been granted, the signal begins to recover the extension time by spreading it out over subsequent phases (individual signals can be programmed to recover time according to traffic demand).

Scenario 2 details (TSP plus relocation of near-side stops to far side):

This scenario includes the TSP from scenario 1, as well as the relocation of as many near-side stops to the far side of intersections as feasible. As noted previously, TSP can be particularly effective when combined with far-side stops. The stops in Table 2 were selected for relocation by first identifying:

- All stops at signalized intersections;
- Of these, all near-side stops;
- Of these, all locations where there is no physical constraint that would make relocation impossible, such as a steep slope or existing structure. In order to explore the maximum potential benefits of stop relocation, staff erred on the side of relocation.

Table 2: Stops proposed for relocation in scenario 2

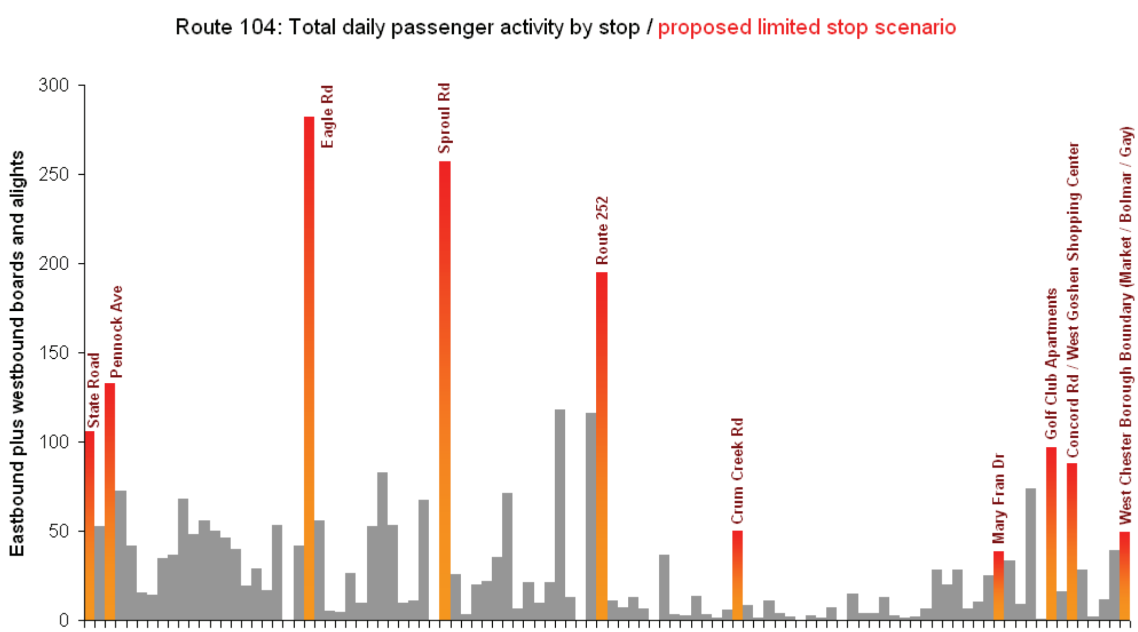
Eastbound from West Chester Signalized stops: 52 Proposed to be moved NS→FS: 26 (50%)	**Westbound from 69th Street** Signalized stops: 47 Proposed to be moved NS→FS: 20 (43%)
Bolmar St at Market St	Carol Blvd
Turner Ln	Linden Ave
Concord Rd / West Goshen Shopping Center	Glen Gary Rd
5 Points Rd	Old West Chester Pike
Spring Ln / Golf Club Apartments	Ann Rd
Glen Ave	Media Line Rd / Line Rd
Falcon Ln	Radnor Dr
Mary Fran Dr	Valley View Ln
Manley Rd	Clover Ln
Stoneham Dr	St Albans Ave
Street Rd	PA-252
Delchester Rd	Clyde Ln
Rock Ridge Rd	Delchester Rd
Crum Creek Rd	Manley Rd
Boot Rd B (opposite SAP entrance)	Chester Hollow Rd
Bishop Hollow Ln / Clyde Rd	Westtown Way
Bryn Mawr Ave	Strasburg Rd
Valley View Ln	Paoli Pike at Concord Rd (West Goshen Shopping Center)
Media Line Rd / Line Rd	Paoli Pike at Turner Ln
Malin Rd	Gay St / Montgomery Ave / Bolmar St
New Ardmore Ave	
Glen Gary Rd	
Glendale Ave	
Lynn Blvd	
Park Ave	
Pennock Ave	

Source: Google Streetview 2010, SEPTA 2010, DVRPC 2010

Scenario 3 / RapidBus details (TSP plus stop relocations plus stop consolidation):

This scenario includes the corridor-length TSP from scenario 1 and the stop relocations from scenario 2, but focuses on a high level of stop consolidation (or, rather, an end-to-end limited stop operation). The proposal is for a true end-to-end limited stop (express) service, which would be overlaid on local service (similar to BRT-lite services elsewhere in the United States: LA MetroRapid, New York SelectBus, NJ TRANSIT GoBus). **This scenario would reflect the best-case operating pattern for bus service along West Chester Pike that can be achieved with limited capital and no exclusive rights of way**. Ten stops are proposed for this scenario (in each direction), plus termini at 69th Street and downtown West Chester (which are outside the simulation area for the modeling analysis). These stops, which are indicated by the orange bars in Figure 7, have been selected based on existing ridership relative to other nearby stops as well as stop spacing. These 10 stops would result in an average stop/station spacing of roughly two miles, and local service would continue operating in parallel with the new limited-stop service.

Figure 7: Stop selections for scenario 3 - RapidBus scenario



Source: SEPTA spring 2009 ride-check data; 53 days over three months

Taken together, the improvements proposed under scenario 3 comprise a BRT-lite level of service enhancements, particularly when combined with other improvements to the passenger experience such as enhanced stops, additional passenger information, and specially branded vehicles. These types of improvements would not impact operations nor the operations modeling in this chapter, but are detailed in Chapter 4.

Model description and procedures

This section briefly describes the software system, model elements, and computational procedures used to model traffic and transit operations along West Chester Pike (PA-3) for this study. A step-by-step description of model development procedures can be found in Appendix A. **This model simulates traffic conditions and signal operations on an average day during the PM peak hours, from 3:00 p.m. to 6:00 p.m**. The simulated portion of PA-3 extends from State Road in Upper Darby Township to Bolmar Street in West Chester Borough, including a short section of Paoli Pike (following the SEPTA Route 104 operating pattern).

Software system

DVRPC employs a suite of modeling software developed by PTV Vision; this suite consists of two components: a macro-scale travel demand forecasting package (VISUM) and a micro-scale operations analysis simulator (VISSIM). PTV Vision originally developed this software for the dense transit systems found in many European cities, where it is the industry standard, and is equipped to accurately represent the complex travel decisions enabled by the Delaware Valley's multimodal transportation infrastructure. The DVRPC regional travel demand model (TIM 1.0) was recently converted to the VISUM platform and provided the basis for many of the inputs to this project's VISSIM microsimulation model, including background traffic density, traffic routing, prevailing speeds, and basic intersection geometry.

Model elements

The basic intersection and roadway characteristics from TIM 1.0 (including road network, traffic volume, and route choice data) were reviewed and given an initial calibration. The study area was then "cut-out" to create a smaller focused area model for enhancement with greater detail and exported to VISSIM for final calibration. The elements of geometry, vehicle traffic density, vehicle travel speeds, transit vehicle stop behavior and dwell time, and signal control are discussed below.

Geometry

TIM 1.0 includes some roadway characteristics necessary for microsimulation modeling, such as the number of lanes, capacity, and a rough approximation of roadway geometry (nodes and links). After giving the study area a thorough review, it was clipped from the regional model for more detailed attention. This smaller rudimentary model was enhanced using the VISUM software to include all signalized intersections in the corridor as well as detailed roadway geometry (lane movements, etc.). Finally, this focused network was exported to VISSIM where roadway geometry was again enhanced at the intersection level, paying specific attention to the number and width of lanes, length of turn pockets, and channelized turns. Intersection engineering diagrams were provided by PennDOT for the majority of study area intersections.

Traffic volume and routes

Estimating the level of background traffic was critical to accurately modeling transit operations along the PA-3 corridor. DVRPC collected travel data along the corridor during the month of January 2010, and supplemented this data with historic counts from DVRPC's traffic count database as well as those conducted for other studies. The data include a combination of automatic traffic recorder (ATR) counts and manual turning-movement counts. These counts are routinely processed by DVRPC's Office of Travel Monitoring, adjusted for consistency, and synthesized to accurately reflect travel conditions on an average day. Final hourly volumes were extracted from the daily counts to show the "peaking" nature of PM traffic density by selecting representative "control counts." Historic turning-movement counts were obtained from the *Technical Appendices for the Newtown Square Master Plan Traffic Study* (March 2007, McMahon Associates, Inc. project no. 806129.11) at Newtown Street Road and Bishop Hollow Road / Clyde Lane to accurately reflect the delay experienced by vehicles approaching PA-3 on perpendicular facilities and to estimate the impact TSP would have on travelers using those facilities.

Auto and transit vehicle travel speeds

Automobile travel speed on PA-3 was measured using the "floating car" method. Collecting this data involves driving a car several times through the corridor while measuring travel times and prevailing speed on short segments of roadway in both directions. The data collection vehicle is carefully driven so as to only pass as many vehicles as are passing it. In this way, it obtains a median travel time. These data are routinely processed by DVRPC's Office of Travel Monitoring for accuracy and consistency.

Transit vehicles were assumed to travel at a **desired speed of 35-mph in urban and suburban sections of the corridor and 50-mph in the rural sections**. In other words, these are the maximum speeds that the simulated buses desired to travel at, if permitted by traffic signals, passenger activity, acceleration and deceleration rates, etc. All transit vehicles were set to use these same desired speeds such that any differences in travel times among the modeling scenarios would result from the alternative improvement treatments (rather than transit vehicle speed differences).

Transit vehicle departures, stop frequency, and dwell time

The automatic vehicle locator (AVL) data provided by SEPTA includes raw transit vehicle travel and location data as well as passenger boardings and alightings for each stop made by the transit vehicle. Using this data, DVRPC developed three stop frequency and dwell time distributions (for high, medium, and low volume stops). Dwell time was calculated by using the boarding and alighting service times (seconds per passenger) found in the Transportation Research Board's 2000 *Highway Capacity Manual*, Chapter 27. Transit vehicle departures and service patterns were taken from SEPTA's spring 2010 schedules. Where a simulation run had no passengers for a given stop, stop skipping was allowed.

Signal control

Signal timing plans were provided by PennDOT for a majority of the signalized intersections in the study area. The signals are generally ring barrier type controllers on a 110-second cycle, partially actuated (side streets and left turns), and part of a coordinated signal system (there are several different systems in the corridor). Each unique signal timing plan is implemented in the VISSIM software using the ring barrier controller signal type.

Drawing from experience with optical TSP implementations in the City of Philadelphia, TSP was simulated using a 1,000 ft optical detector range or line-of-sight to the signal mast arm (the nearer of the two). In other words, transit vehicles checked-in with the signal when they were within 1,000 ft of the intersection, or as soon as the vehicle had a clear line-of-sight to the signal head. Transit vehicles checked out when they passed through the intersection and lost optical contact with the detector. The appropriate green phase was programmed to last up to 10 seconds longer if a transit vehicle was checked in when the signal would normally change to yellow. The signal changed as normal when the transit vehicle checked out, even if the 10-second extension had not yet been completed. In this way, signals would grant only as much extended green time for buses as required, up to 10 seconds.

For the purposes of this study, this simplified TSP treatment was applied to all signals in the corridor regardless of each signal's unique context. A more effective real-world TSP implementation would ideally include a customized implementation (the number of seconds for a green phase extension, for example) based on the individual signal context, as well as a revised coordination of all signals in the corridor. **Given these constraints, this model is likely to underestimate the impact of TSP for this project to some extent.**

Procedure

Each scenario was run a minimum of 10 times in VISSIM for five simulated hours during each run. The first hour of simulation time is used for model testing purposes. The second hour of simulation time "primes" the network with afternoon levels of traffic density and allows the buses to enter the network before collecting data from the model. The model then runs for an additional three hours, reflecting PM peak-period traffic volumes, during which time the model collects output data and stores it in a Microsoft Access database. Each scenario was run in 10-iteration batches, and output data averaged across all iterations.

Model results

For calibration purposes, DVRPC staff identified three major travel time segments along the corridor:

- **Segment 1:** State Road (Upper Darby Township) to PA-252 (Newtown Township)
- **Segment 2:** PA-252 (Newtown Township) to Delchester Road (Willistown Township)
- **Segment 3:** Delchester Road (Willistown Township) to Bolmar Street / Montgomery Avenue (West Chester Borough)

These segments overlap slightly to allow the simulated transit vehicles time to serve and clear the stop associated with each intersection. **For this reason, segment-level results do not precisely sum to the corridor totals**.

Validation

Before a computer model can be used to evaluate transportation alternatives, it must first demonstrate the capacity to reasonably reproduce current conditions. This process is known as model validation. Validation is achieved when a model reasonably reproduces measured data not used in the development of the model. For example, a microsimulation model should be able to successfully reproduce travel times, even though this data is not used to develop any of the model inputs. For this study, DVRPC chose vehicle travel time to validate the model. Validation statistics are shown in Table 3 for private vehicles and Table 4 for transit vehicles. It is important to note that both the observed data and the modeled data contain some level of error.

Table 3: Auto travel time validation (PM peak)

	Average Vehicle Travel Time [min]			
Westbound	**Observed**	**Model**	**Difference (M-O)**	
Overall study corridor: State Rd to Bolmar St	38.9	38.0	-0.9	-2.4%
Segment 1: State Rd to PA-252	19.3	21.0	1.7	+8.1%
Segment 2: PA-252 to Delchester Rd	7.2	7.1	-0.1	-1.4%
Segment 3: Delchester to Bolmar St	12.9	12.5	-0.4	-3.2%
Eastbound				
Overall study corridor: Bolmar St to State Rd	42.4	38.9	-3.5	-9.0%
Segment 1: PA-252 to State Rd	23.7	22.0	-1.7	-7.7%
Segment 2: Delchester Rd to PA-252	7.4	7.2	-0.2	-2.8%
Segment 3: Bolmar St to Delchester Rd	12.6	10.8	-1.8	-16.7%

Source: DVRPC 2011

Table 4: Transit travel time validation (PM peak)

Operating Pattern: Express to Eagle Road	Average Vehicle Travel Time [min]			
Westbound	**Observed**	**Model**	**Difference (M-O)**	
Overall study corridor: State Rd to Bolmar St	51.3	51.6	0.3	+0.6%
Segment 1: State Rd to PA-252	25.5	23.9	-1.6	-6.7%
Segment 2: PA-252 to Delchester Rd	8.2	8.6	0.4	+4.7%
Segment 3: Delchester Rd to Bolmar St	17.6	16.5	-1.1	-6.7%
Eastbound				
Overall study corridor: Bolmar St to State Rd	48.9	52.0	3.1	+6.0%
Segment 1: PA-252 to State Rd	19.9	24.3	4.4	+18.1%
Segment 2: Delchester Rd to PA-252	7.7	9.9	2.2	+22.2%
Segment 3: Bolmar St to Delchester Rd	16.9	16.5	-0.4	-2.4%

Source: DVRPC 2011

These tables show that the model reasonably reproduced observed data. Looking at the entire study corridor by direction, the modeled travel times were within 10 percent of observed data; however, the model shows less accuracy at the segment level. Both auto and transit travel times in the westbound direction very closely match the observed data: most differ by less than a minute. The eastbound direction does not fit the observed data as well.

Taken as a whole, the model was well validated against the observed travel time data in the westbound direction and reasonably validated against the observed travel time data in the eastbound direction. The direction of major traffic flow for this corridor is westbound during the PM peak hours; consequently, it is more important that the model be able to replicate these outputs.

Summary of simulation results for each transit improvement scenario

Table 5 and Figure 8 summarize the simulated transit vehicle travel times for each scenario. Travel times for Route 104's Express to Eagle Road operating pattern are summarized in all cases except the RapidBus scenario, where travel times for that proposal's limited-stop operation are shown. Table 5 and Figure 8 summarize the expected successive improvement in transit travel times, as each scenario overlays an additional transit improving treatment on the last.

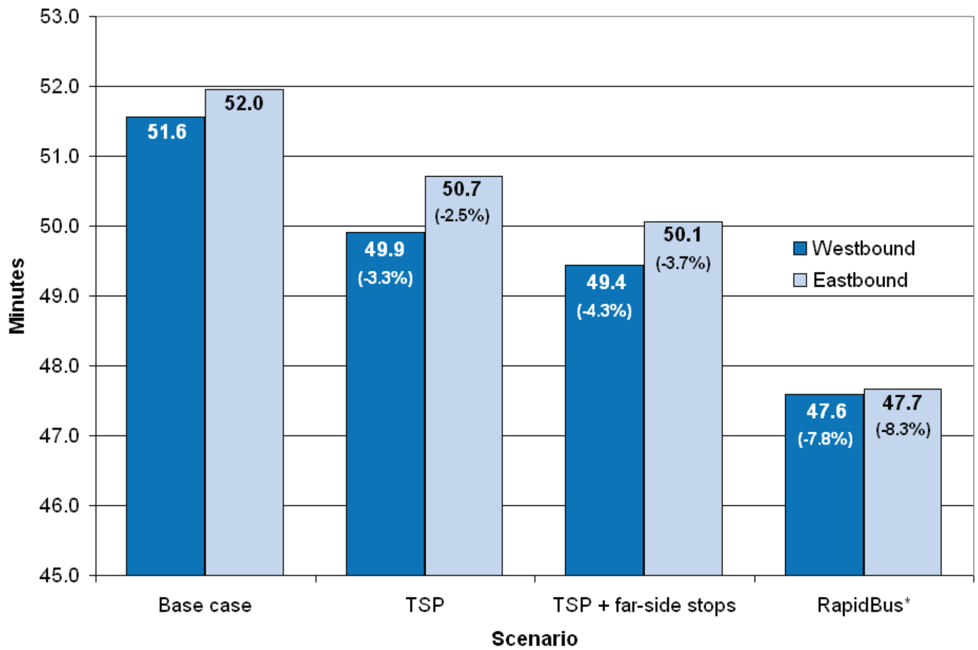
Table 5: Transit travel time results (PM peak)

	Average Vehicle Travel Time [min]			
Westbound	**Base Case**	**TSP**	**TSP + Far Side**	**RapidBus**
Overall study corridor: State Rd to Bolmar St	51.6	49.9	49.4	47.6
Segment 1: State Rd to PA-252	23.9	23.6	23.4	22.1
Segment 2: PA-252 to Delchester Rd	8.6	8.3	8.5	8.4
Segment 3: Delchester Rd to Bolmar St	16.5	15.8	15.8	16.2
Eastbound				
Overall study corridor: Bolmar St to State Rd	52.0	50.7	50.1	47.7
Segment 1: PA-252 to State Rd	24.3	24.0	23.3	22.3
Segment 2: Delchester Rd to PA-252	9.9	9.7	9.6	8.8
Segment 3: Bolmar St to Delchester Rd	16.5	16.1	16.3	15.8

Source: DVRPC 2011

At first glance, the TSP-only and TSP plus far-side stop scenarios yielded fairly weak transit travel time savings given the number of signals in the study area. For context, DVRPC's *Speeding Up SEPTA* report (pub. no. 08066) estimated an average time savings of 6.8 percent for other cities that implemented TSP, and also noted an industry rule-of-thumb estimate of five seconds saved per signalized intersection, which would yield an expected savings of 5.08 minutes for the 61 study area traffic signals that Route 104 traverses in each direction. The smaller-than-expected results that were simulated (1.7 and 1.3 minutes eastbound and westbound, respectively) could be due to the previously described simple ("one size fits all") TSP implementation, or a function of the density of transit vehicles in the corridor. After a transit vehicle actuates the green phase extension, the signal enters a recovery period and will not grant another extension for four minutes. As a result, closely packed buses will spoil the extension for the following vehicle. This may spread the TSP time savings out over many individual buses, diffusing the cumulative benefit.[2]

Figure 8: Transit vehicle travel times by scenario (PM peak)



*In all cases except the RapidBus, end-to-end travel times reflect Route 104's Express to Eagle Road operating pattern. For the RapidBus scenario, the consolidated stop operating pattern is used.

Source: DVRPC 2011

While Table 5 and Figure 8 summarize total transit vehicle travel times, Table 6 and Figure 9 summarize net time savings by scenario. The TSP treatment alone was observed to save an average of 1.7 minutes over the base case scenario in the westbound direction and an average of 1.2 minutes in the eastbound direction. Taken together, the TSP scenario resulted in an average savings of about three minutes for a round trip.

The TSP plus far-side stop scenario saved an average of 2.1 minutes over the base case scenario in the westbound direction and 1.9 minutes in the eastbound direction. Taken together, this represents an average savings of four minutes for a round trip – a marginal additional improvement over TSP alone. The RapidBus scenario saved an average of 4.0 minutes over the base case scenario in the westbound direction and an average of 4.3 minutes in the eastbound direction. This represents a combined average savings of 8.3 minutes for a round trip.

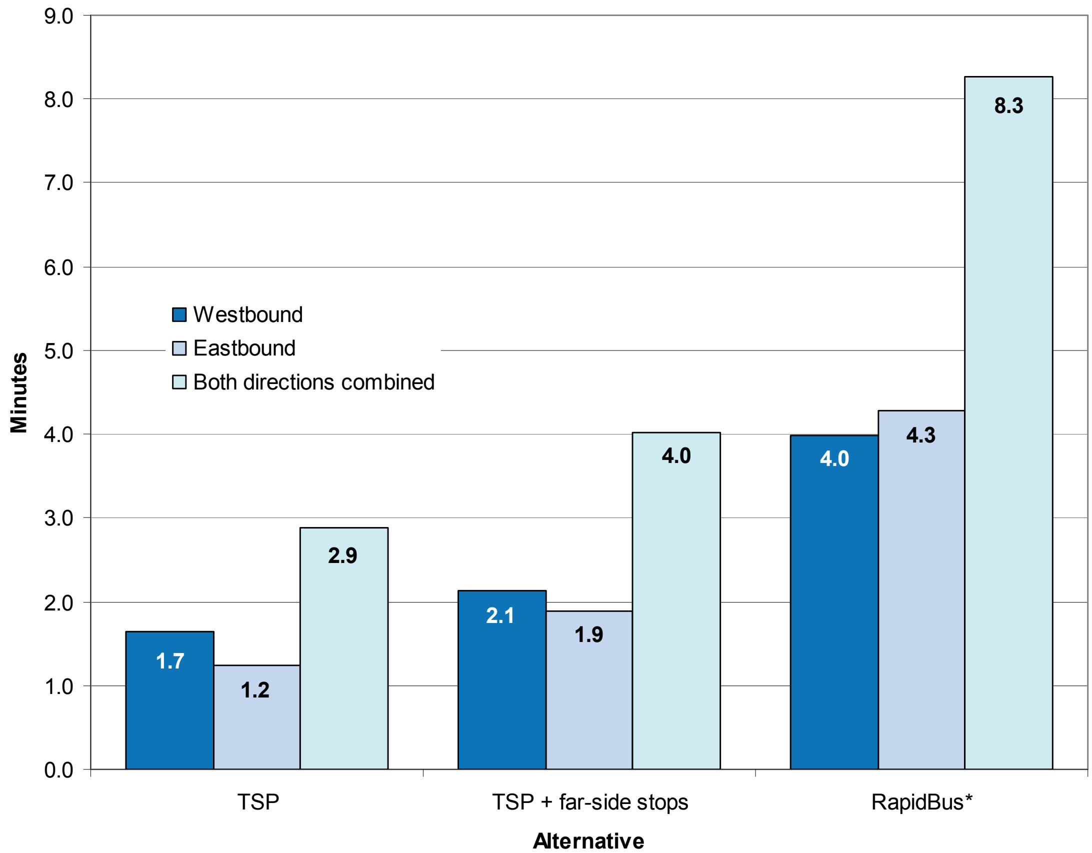
[2]Staff performed an additional sketch-level exercise where only RapidBus vehicles operated in the corridor to estimate the best-case TSP benefit. Relative to the results in Table 5 and Figures 8 & 9, this exercise resulted in additional time savings of 1.6 minutes westbound and 0.9 minutes eastbound. This exercise was not given the rigor of a full planning scenario.

Table 6: Transit vehicle time savings summary (PM peak)

Direction	Transit Vehicle Time Savings [min]		
	TSP	TSP + Far-Side Stops	RapidBus
Westbound	1.7	2.1	4.0
Eastbound	1.2	1.9	4.3
Both directions combined	2.9	4.0	8.3

Source: DVRPC 2011

Figure 9: Transit vehicle travel time savings by scenario (PM peak)



*In all cases except the RapidBus, end-to-end travel times reflect Route 104's Express to Eagle Road operating pattern. For the RapidBus scenario, the consolidated stop operating pattern is used.

Source: DVRPC 2011

It is useful to consider the travel time savings in Table 6 in the context of the total potential for bus travel time improvements, that is, the difference between observed bus and auto travel times in the study area for the PM peak period. From Tables 3 and 4, this difference is 12.4 minutes in the westbound direction, and 6.5 minutes in the eastbound direction. In this context, the estimated performance gains in Table 6 appear fairly significant: **the RapidBus scenario cuts the transit-auto travel time gap by about 32 percent in the westbound direction, and fully 66 percent eastbound.**

Transit vehicle intersection delay

In addition to simple end-to-end travel times, transit operational enhancements are often evaluated based on their impact on delay at an intersection level. Intersection delay is the portion of transit vehicle travel time spent slowing down, waiting, and finally accelerating back to travel speed as part of responding to a traffic signal. For this study, DVRPC estimated that the average intersection delay was reduced by about one second under both the TSP scenario and TSP plus far-side stop scenarios. Table 7 summarizes average transit vehicle delay per intersection under each scenario.

Table 7: Transit vehicle intersection delay summary (PM Peak)

	Average Delay Per Intersection [sec]			TSP Compared to Base	TSP + Far Side Stops Compared to Base
Both Directions	Base Case	TSP	TSP + Far Side		
All corridor signals	19.3	18.2	18.2	-1.1	-1.1
Segment 1 signals	19.9	18.8	19.0	-1.1	-0.9
Segment 2 signals	17.3	16.3	16.2	-1.0	-1.1
Segment 3 signals	19.0	17.8	17.2	-1.2	-1.8

Source: DVRPC 2011

Impact on intersecting facilities

Because a TSP implementation can change the amount of green time allocated to crossing traffic, local officals are naturally concerned about the potential negative impacts on vehicles using intersecting roadways, particularly where demand is heavy or problems already exist. For this study, DVRPC was able to perform a detailed evaluation of cross-street delay on two facilities: one high-volume arterial (Newtown Street Road / PA-252) and one pair of lower-volume collectors (Bishop Hollow Road and Clyde Lane). Table 8 summarizes vehicle delay time on these intersecting facilities by direction and hour, with delay improvements being highlighted in green and additional delays in red.

For this study, DVRPC's simulations showed a negligible impact during the 3:00 p.m. hour; however, as traffic volume builds during the simulation, two impacts can be clearly seen. First, on southbound PA-252, vehicle delay increases over time to 10 seconds in the 5:00 p.m. hour. Comparatively, there is very little impact on traffic traveling in the northbound direction, with the simulations actually showing a negligible improvement. This is likely due to the much heavier traffic volumes southbound. During simulation testing, the volume on this leg (particularly the southbound left) was found to be too heavy for the signal timing plan. The second impact can be seen on Bishop Hollow Road / Clyde Lane. At this location, the TSP scenario was found to reduce vehicle delay on the northbound approach to a fairly significant degree (9.5 seconds). This is likely due to high traffic volumes making the northbound right, and the close proximity of PA-252 (just 500 feet to the east). This circumstance leads to general traffic vehicles making the northbound right to join the queue for PA-3 eastbound being able to “piggy back” on the TSP received by transit vehicles headed in the same direction.

Table 8: Intersecting facility vehicle delay summary (PM peak)

Hour	Vehicle Delay [sec]					
	Newtown Street Rd. (PA-252)			Bishop Hollow Rd./Clyde Ln.		
	Base Case	TSP	Difference	Base Case	TSP	Difference
	Southbound					
3:00 p.m.	52.6	52.2	-0.4	40.4	41.3	+0.9
4:00 p.m.	74.0	78.2	+4.2	41.2	41.0	-0.2
5:00 p.m.	100.8	110.8	+10.0	40.4	39.7	-0.7
Hour	Northbound					
3:00 p.m.	35.5	35.5	0.0	31.9	31.2	-0.7
4:00 p.m.	36.2	36.0	-0.2	51.5	49.2	-2.3
5:00 p.m.	36.5	36.0	-0.5	59.1	49.6	-9.5

Source: DVRPC 2011

Summary of findings

DVRPC’s simulations of the operational enhancements proposed for Route 104 suggest that they would result in travel time savings, with the most meaningful benefits naturally being observed under the RapidBus BRT-lite proposal (which was simulated to cut the transit-auto travel time gap by about 32 percent in the westbound direction, and 66 percent eastbound). The time savings estimated for the TSP-only and TSP plus far-side stop scenarios are much more modest, with only a negligible additional benefit being observed for the addition of far-side stops to TSP.

As previously noted, it is likely that a more precisely engineered TSP design than the one simulated here would result in some additional travel time benefits, particularly if supplemented with corridor signal optimization. That said, it is important to have realistic expectations about the level of additional benefit that can be expected. This project’s PA-3 study area is a long corridor, and most of its transit running time is due to this simple fact (as well as Route 104’s relatively frequent stops). To achieve significant time savings without exclusive rights of way, significant stop consolidation (or a very limited stop operation) such as that simulated for the RapidBus scenario will be required.

It also bears noting that even the most aggressive operational enhancement strategies will be limited in their ability to attract new ridership if passenger access to stops is poor, or if new passengers are not made aware of service improvements through effective messaging and branding. Chapter 4 details study findings and recommendations for these topics.

Route 104 Design Enhancements

There are two roles for design enhancements to Route 104 and its context along the West Chester Pike corridor. First, basic improvements to passenger safety or comfort, and second, specific strategies to enhance passenger amenities at specific high-priority stop locations. Together with enhanced branding and the operational improvements modeled in Chapter 3, these specific design enhancements would make Route 104 into a true BRT-lite type of service: the first of its kind in the DVRPC region.

Basic safety or comfort improvements

As detailed in Chapter 2, there are significant impediments to safe passenger bus stop access along the West Chester Pike corridor. Many stops have no sidewalk access, no crosswalks permitting safe pedestrian crossings of West Chester Pike, or both. In addition, bus shelters offering basic weather protection are comparatively rare. Given unlimited resources, each of these amenities would be provided at every stop. Reasonably, however, some level of prioritization is required. Both sidewalks and shelters can be expensive to install and maintain, and crosswalks can interfere with traffic signal optimization and impair travel times.

One approach is to prioritize improvements based on existing passenger activity. Where ridership is high despite missing amenities, those current riders would benefit immediately. Further, these riders may be reflective of additional latent demand that would lead to new ridership if amenities were provided. As a starting point, Figure 10 and Table 9 summarize the top 30 study area stops by total weekday passenger activity (boards plus alights in both directions, where a given intersection has stops in both directions), and notes access gaps by direction at those stop locations. Mary Fran Drive, the 31st-ranked stop for overall passenger activity, is also included because of its selection for this project's RapidBus operating scenario. Note that Figure 10 and Table 9 refer only to the presence or absence of these amenities, and not their quality or condition.

Figure 10: Graphical summary of rider facilities and gaps for top-volume stops

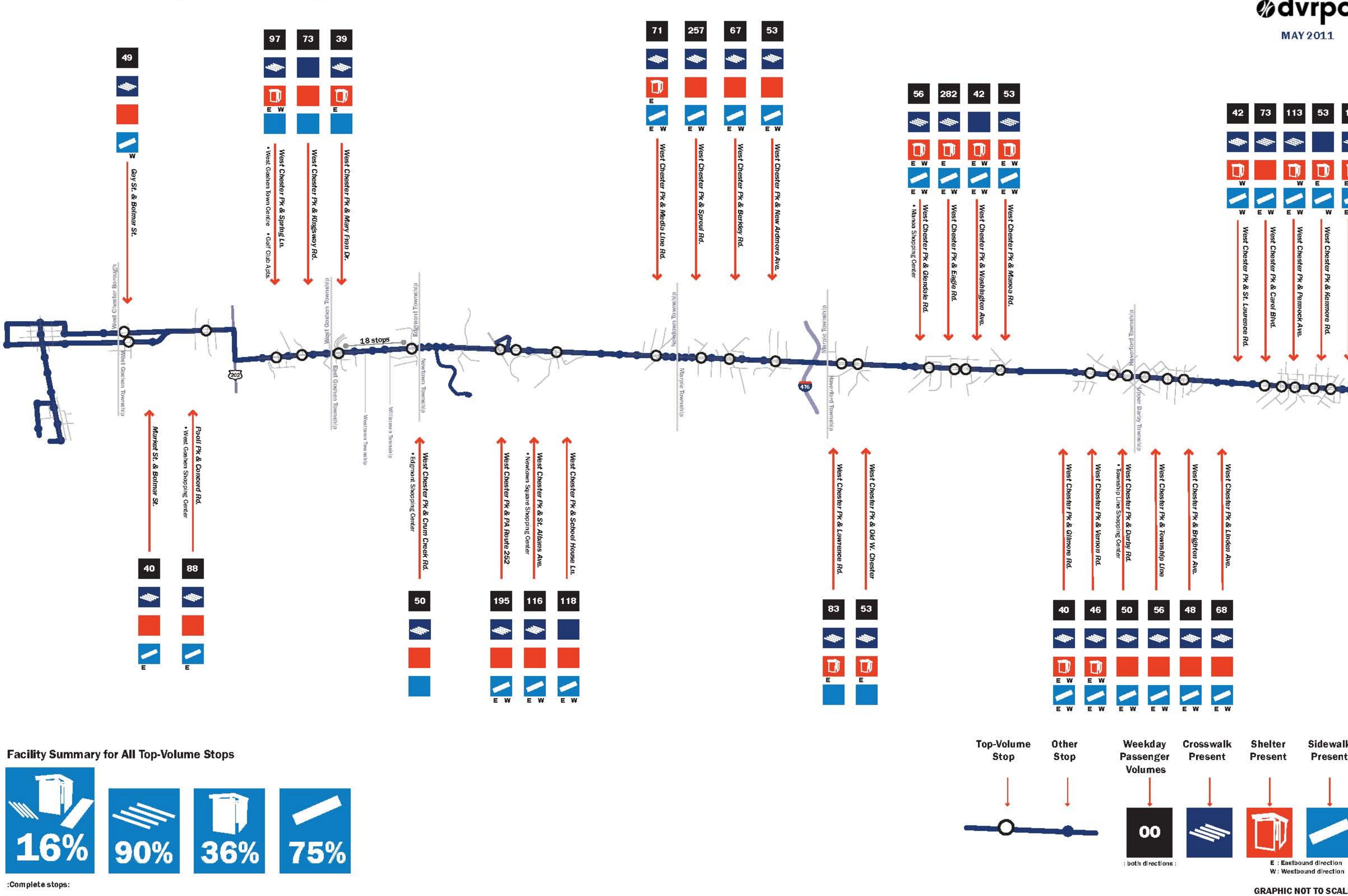


Table 9: Passenger amenities for top study area stops by passenger volume, ordered from east to west

	Estimated Avg. Weekday Boards Plus Alights	Marked Crosswalk	EB Sidewalk	WB Sidewalk	EB Shelter	WB Shelter
State Rd	106	Yes	Yes	Yes	Yes	No
Kenmore Rd	53	No	No	Yes	Yes	No
Pennock Ave	133	Yes	Yes	Yes	No	Yes
Carol Blvd	73	Yes	Yes	Yes	No	No
St Laurence Rd	42	Yes	n/a	Yes	n/a	Yes
Linden Ave	68	Yes	Yes	Yes	No	No
Brighton Ave	48	Yes	Yes	Yes	No	No
Township Line Rd	56	Yes	Yes	Yes	No	No
Darby Rd	50	Yes	Yes	Yes	No	No
Vernon Rd / Kohl's	46	Yes	Yes	Yes	Yes	Yes
Gilmore Rd	40	Yes	Yes	Yes	Yes	Yes
Manoa Rd	53	Yes	Yes	Yes	Yes	Yes
Washington Ave	42	No	Yes	Yes	Yes	Yes
Eagle Rd	282	Yes	Yes	Yes	Yes	No
Glendale Ave	56	Yes	Yes	Yes	Yes	Yes
Old W. Chester Pike	53	Yes	No	No	Yes	No
Lawrence Rd	83	Yes	No	No	Yes	No
New Ardmore Ave	53	Yes	Yes	Yes	No	No
Church Rd / Berkley Rd	67	Yes	Yes	Yes	No	No
Sproul Rd	257	Yes	Yes	Yes	No	No
Media Line Rd	71	Yes	Yes	Yes	Yes	No
School House Ln / Dunwoody Dr	118	No	Yes	Yes	No	No
St. Albans Ave/Cir	116	Yes	Yes	Yes	No	No
PA-252	195	Yes	Yes	Yes	No	No
Crum Creek Rd	50	Yes	No	No	No	No
Mary Fran Dr	39	Yes	No	No	Yes	No
Kingsway Rd	73	No	No	No	No	No
Golf Club Apartments	97	Yes	No	No	Yes	Yes

Table 9 (continued): Passenger amenities for top study area stops by passenger volume, ordered from east to west

	Estimated Avg. Weekday Boards Plus Alights	Marked Crosswalk	EB Sidewalk	WB Sidewalk	EB Shelter	WB Shelter
Concord Rd / West Goshen Shopping Center	88	Yes	Yes	No	No	No
Gay St / Montgomery Ave / Bolmar St	49	Yes	n/a	Yes	n/a	No
Market St / Bolmar St	40	Yes	Yes	n/a	No	n/a

Source: SEPTA spring 2009 ride-check data; DVRPC 2010

Each of the gaps identified in Table 9 warrant attention. Based on the correlations between amenities and ridership that were previously calculated, the first and second priorities should be the pursuit of new marked crosswalks and sidewalks, respectively, where they do not exist. The crosswalk and sidewalk gaps identified in Table 9 are explored and summarized below.

Safety gap: missing crosswalks at high-volume stops

Since none of the four missing crosswalks are located at signalized intersections, installing a marked crosswalk in any of these cases is problematic. A 2002 FHWA report (*Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations*) determined that for multi-lane roadways with traffic volumes greater than 12,000 vehicles per day and/or posted speed limits of at least 40 mph, installing marked crosswalks can exacerbate safety problems and lead to additional pedestrian crashes, unless additional treatments are also employed. West Chester Pike meets both criteria in each of these four cases. For each location, a more detailed evaluation of passenger and pedestrian activity is warranted in order to develop an appropriate treatment (which could include crosswalk installation, stop relocation, stop consolidation, or sidewalk connections to nearby crossings).

- **School House Lane / Dunwoody Drive, Newtown Township** – the nearest crosswalk is located approximately 900 feet to the west at Bryn Mawr Avenue. Traffic volumes in this portion of PA-3 are about 40,000 vehicles per day, with a 40-mph speed limit.

- **Kingsway Road, West Goshen Township** – the nearest crosswalks are located roughly one-quarter mile

LEGEND FOR THE FOLLOWING GRAPHICS

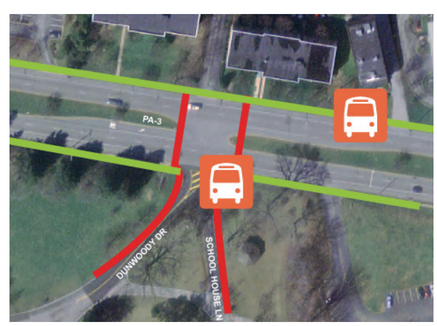
Crosswalk / sidewalk present

Crosswalk / sidewalk absent

Stop location

NOTE:
PA-3 runs left to right in each graphic; the street in the caption is the main cross street shown.

GRAPHICS NOT TO SCALE



School House Lane

to the west and one-third mile to the east, making it likely that anyone crossing at this location will do so illegally. Kingsway Road is illustrated in the next section.

- **Kenmore Road, Upper Darby Township** – the nearest crosswalk is located roughly 500 feet to the east at State Road. Since pedestrian crossings are not prohibited by a posted sign and sidewalks are present on both sides of Kenmore Road where it intersects West Chester Pike, an "implied crosswalk" may be legally present even though it is unmarked. Since this is a T-intersection (Kenmore Road does not continue through), there is some question as to the legal status of this crosswalk. West Chester Pike traffic volumes here are about 25,000 vehicles per day, and the posted speed limit is 35 mph.

Kenmore Road

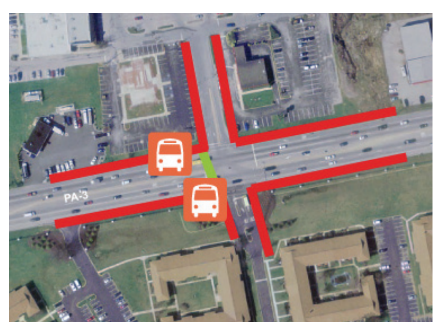
- **Washington Avenue, Haverford Township** – in this case, the nearest crosswalk is located 500 feet to the west at Eagle Road. Since pedestrian crossings are not prohibited by a posted sign and sidewalks are present on both sides of Washington Avenue where it intersects West Chester Pike, an "implied crosswalk" may be legally present even though it is unmarked. Since this is a T-intersection (Washington Avenue does not continue through), there is some question as to the legal status of this crosswalk. West Chester Pike traffic volumes here are about 35,000 vehicles per day, and the posted speed limit is 40 mph. A detailed evaluation of passenger and pedestrian activity in this area may be warranted in order to develop an appropriate treatment.

Washington Avenue

Safety gap: missing sidewalks at high-volume stops

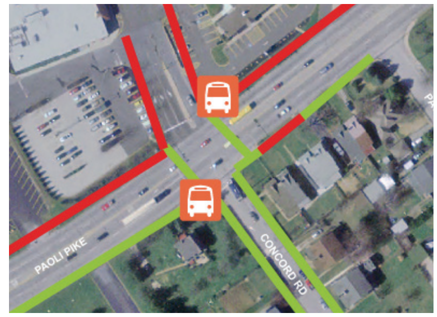
The sidewalk gap information summarized in Table 9 can be a bit misleading, since it refers only to sidewalks in the immediate vicinity of each stop and not to sidewalks along connecting roadways, which are also critical to pedestrian accessibility and comfort. This section takes a closer look at each of the gaps identified in descending order by passenger volume.

- **Golf Club Apartments, West Goshen Township** – in this location, the Golf Club Apartment complex is located opposite the West Goshen Town Centre shopping center. While there is a walkway network throughout the apartment complex and bus shelters on concrete pads accommodating both eastbound and westbound passengers, there is no walkway connecting the apartment complex to the eastbound shelter or the shopping center to the westbound shelter; the shelters exist as concrete islands, requiring passengers to walk across grass or landscaping.



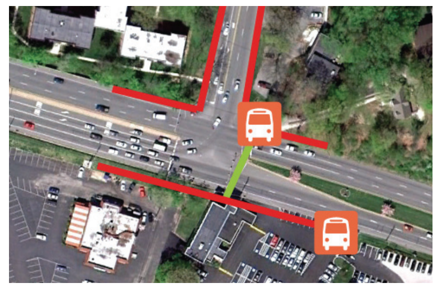
Golf Club Apartments

- **Concord Road / West Goshen Shopping Center, West Goshen Township** – There is a sidewalk gap in the westbound direction at this location, with no sidewalk along the Paoli Pike frontage of the West Goshen Shopping Center, and no direct sidewalk connection to the westbound Route 104 stop, although a short sidewalk stub makes a partial connection. This location is pictured in Figure 5 on page 11.

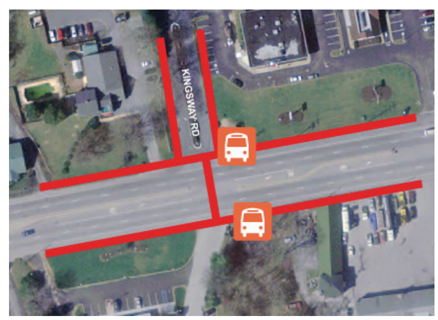


Concord Road

- **Lawrence Road, Haverford Township** – This stop pair serves the Waterford Apartment complex on the north side of West Chester Pike as well as a medical center on the south side. There are no sidewalks on either West Chester Pike frontage, nor along Lawrence Road, which provides access to the Waterford Apartments as well as other residential streets to the north of West Chester Pike.


Lawrence Road

- **Kingsway Road, West Goshen Township** – This stop serves various small-scale commercial uses on the south side of West Chester Pike, as well as the Goshen Terrace apartment complex on the north side (Kingsway Road serves as the access road to those apartments). There are no sidewalks on either West Chester Pike frontage, nor along Kingsway Road.

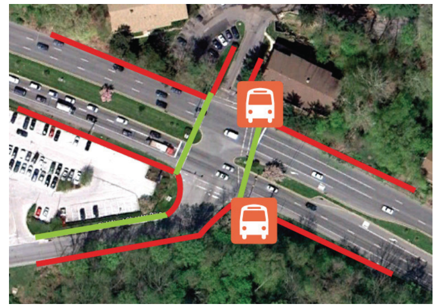


Kingsway Road

- **Kenmore Road, Upper Darby Township** – This stop serves various small-scale commercial uses on the south side of West Chester Pike as well as residences along Kenmore and Englewood Roads to the north. The surrounding sidewalk network is generally complete with the exception of a gap along the southern frontage of West Chester Pike in this location, including the site of the eastbound bus shelter. While a concrete sidewalk is not present, this gap is surfaced with asphalt.

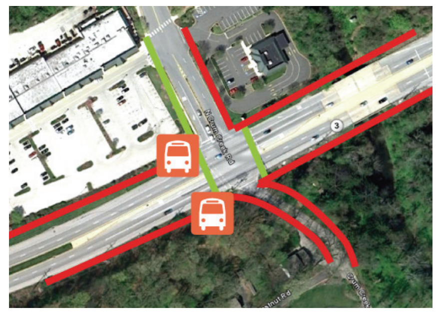

Kenmore Road

- **Old West Chester Pike, Haverford Township** – This stop is located just to the east of Lawrence Road (page 36), and serves the same medical/wellness center on the south side of West Chester Pike as well as the Hollow Run apartments on the north side. Neither frontage of West Chester Pike has sidewalks in this vicinity, nor does the Hollow Run apartments' access drive or Old West Chester Pike.



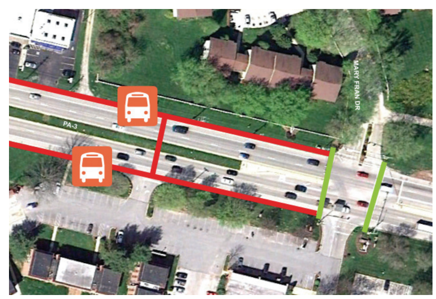
Old West Chester Pike

- **Crum Creek Road, Edgmont Township** – This stop serves the Edgemont Shopping Center on the north side of West Chester Pike, as well as various residential streets on the south side via Crum Creek Road. Neither West Chester Pike frontage has sidewalks, nor does Crum Creek Road, but there is a sidewalk connection into Edgemont Shopping Center via its access road.



Crum Creek Road

- **Mary Fran Drive, East Goshen Township** – This stop serves the Rose Hill Apartments on the south side of West Chester Pike and the Goshen Meadows apartment complex on the north side. Neither access driveway, nor either West Chester Pike frontage, has sidewalks. The eastbound stop has a shelter connected by a walkway to the Rose Hill Apartments parking lot. The shelter and walkway were installed and are maintained by Rose Hill Apartments.



Mary Fran Drive

Comfort gap: missing shelters at high-volume stops

As Figure 10 indicates, only 36 percent of the identified high-volume stop locations have bus shelters. SEPTA service standards provide for shelters where stops are located on SEPTA property ("Terminals, Transportation Centers, Loops, and Stations") and have at least 500 daily boardings. However, with the exception of 69th Street Transportation Center, this standard does not apply to the PA-3 corridor. National standards for passenger thresholds that warrant shelters vary significantly, but would typically include stops with passenger volumes comparable to or lower than the Route 104 volumes summarized in Table 9 and Figure 10. The State of Florida's standard, for example, is 25 passengers per day.[3]

In the case of SEPTA's suburban bus operations, shelters and related stop amenities are typically provided and maintained by municipalities, private parties, or (most commonly) an advertising firm such as Clear Channel. Shelter installation by Clear Channel requires mutual interest by a municipality and the advertising firm, as well as the willingness of a property owner if the shelter is to be located outside the public right of way. Upon agreement with a municipality and property owner (if applicable), Clear Channel is responsible for installation of the shelter and concrete pad (as well as ongoing maintenance) in exchange for advertising revenue. Typically, the firm will also share a portion of the advertising revenue with the municipality; rates vary based on traffic, but average roughly $100 per month per shelter. Where a TMA acts as an intermediary between the municipality and advertising firm, they collect a commission from that monthly municipal share.

This arrangement is attractive to all parties – Clear Channel gets advertising in a visible location, and the municipality and SEPTA passengers get a basic transit amenity at no upfront or ongoing cost. However, the present status quo has two key shortcomings. First, it depends on Clear Channel continuing to find it profitable. Second, it is not always rational. Clear Channel is interested at least as much in visibility by auto drivers as visibility by transit passengers, and so shelters are not always located in the locations with the highest levels of bus passenger demand. Additionally, consideration is not always given to the presence of sidewalks or walkways accommodating safe and accessible shelter access, leading to the somewhat common condition of a shelter isolated on a concrete pad, occasionally even inaccessible by passengers. This condition presents an image of poor planning and coordination by all parties.

For these reasons, **a new local framework for suburban shelter installation and maintenance may be warranted, but would bring with it significant challenges**. Barriers to improvement include municipal policies and ordinances, and a mechanism to meet installation and ongoing maintenance costs. This is a topic to be considered in future planning efforts. In the meantime, the shelter gaps identified in Table 9 should be used to prioritize shelter locations in the study area where possible.

Other opportunities to improve basic passenger amenities

In addition to addressing the specific priority access gaps detailed above, as a general rule, sidewalks, crosswalks, and shelters accommodating safe and comfortable transit access should always be pursued as opportunities occur. There are also a number of other improvements to basic passenger amenities that could be pursued at all stops to enhance the attractiveness of service, and at a comparatively minor expense.

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[3] *Accessing Transit: Design Guidelines for Florida Bus Passenger Facilities*. Florida State University and Florida Department of Transportation, 2004.

For example, King County Metro stops in and around Seattle have a streamlined version of a current bus schedule posted at every bus stop, even where there are no shelters (see Figure 11).

Figure 11: Schedule information posted as part of bus stop signage in Seattle

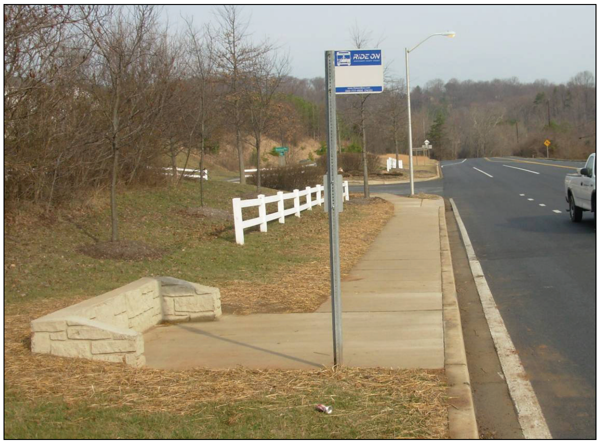
Source: DVRPC 2010

Such enhancements to passenger information would help to make service more attractive to occasional riders, but would generate ongoing maintenance expenses. A compromise solution might be to have basic information on frequencies posted in a similar way (i.e., *7 a.m.-9 a.m.: every 20 minutes*, etc.). Such summary information may actually be more legible for riders, and would likely not require updating as frequently.

As an alternative, the proliferation of mobile devices such as smart phones makes it possible for some passengers to access real-time stop-level information electronically. Entering a stop ID number on a mobile website, for example, could allow a passenger to access not only schedule information but also real-time bus location information. The provision of such electronic stop-level data, which SEPTA is currently exploring, would be a significant enhancement to the passenger experience, but only for passengers who can afford mobile internet access (and in locations where it is available).

Some transit agencies have also explored other innovative ways to enhance the physical presence of bus stops in suburban corridors at relatively minor upfront and ongoing expense, and Figure 12 illustrates two such examples. Link Transit in Wenatchee, Washington, has used a soil and gravel stabilizing product called Envirotac, originally used for military applications, to quickly create inexpensive (about $400 per stop), semi-permanent concrete-like pads at unimproved bus stops. This strategy was combined with other improvements, such as similar passenger information signage to that shown in Figure 11, to make waiting more convenient and less stressful. A human-scale, clearly delineated, and flat place to wait is a simple thing, but can make a big difference. It is noteworthy that this stop improvement concept does not trigger the full set of ADA requirements because the improvements are not technically permanent.

Figure 12: Examples of improvement treatments for bus stops without shelters



Knee wall and concrete pad at bus stop (Source: Montgomery County, MD 2011)

Envirotac bus stop pad (Source: Link Transit 2011)

At a higher level of investment, Montgomery County, Maryland, has installed "knee walls" at many stops that do not have enough passenger activity to warrant shelters. These knee walls have multiple functions: rear retaining walls to mitigate slope debris, knee-high enclosures that give the stops a sense of permanence, wheelchair backstops, and benches. In some cases, they are decorated by community residents.

Implementation strategies and possible funding sources for safety and comfort improvements

Enhancing passenger safety and comfort as suggested above is not free – as detailed with regard to shelters, there are upfront and ongoing costs that can be considerable. An incremental improvement strategy to provide sidewalks, crosswalks, and transit amenities is to require them as new development and redevelopment occurs. Municipalities should ensure that such improvements are required by their development ordinances, particularly where transit access is involved.

One possible source of funding for improving the safety of access to bus stops is the FTA New Freedom program, which provides for improvements to transit access for the disabled (including, for example, accessible sidewalks connecting with transit facilities). This federal funding is formula-based, and further analysis would be needed to determine and document that identified improvements are eligible for the New Freedom program. New federal “livability” funding programs could provide other opportunities to fund shelters and improvements to bus stop access, and should be explored in the context of other priorities.

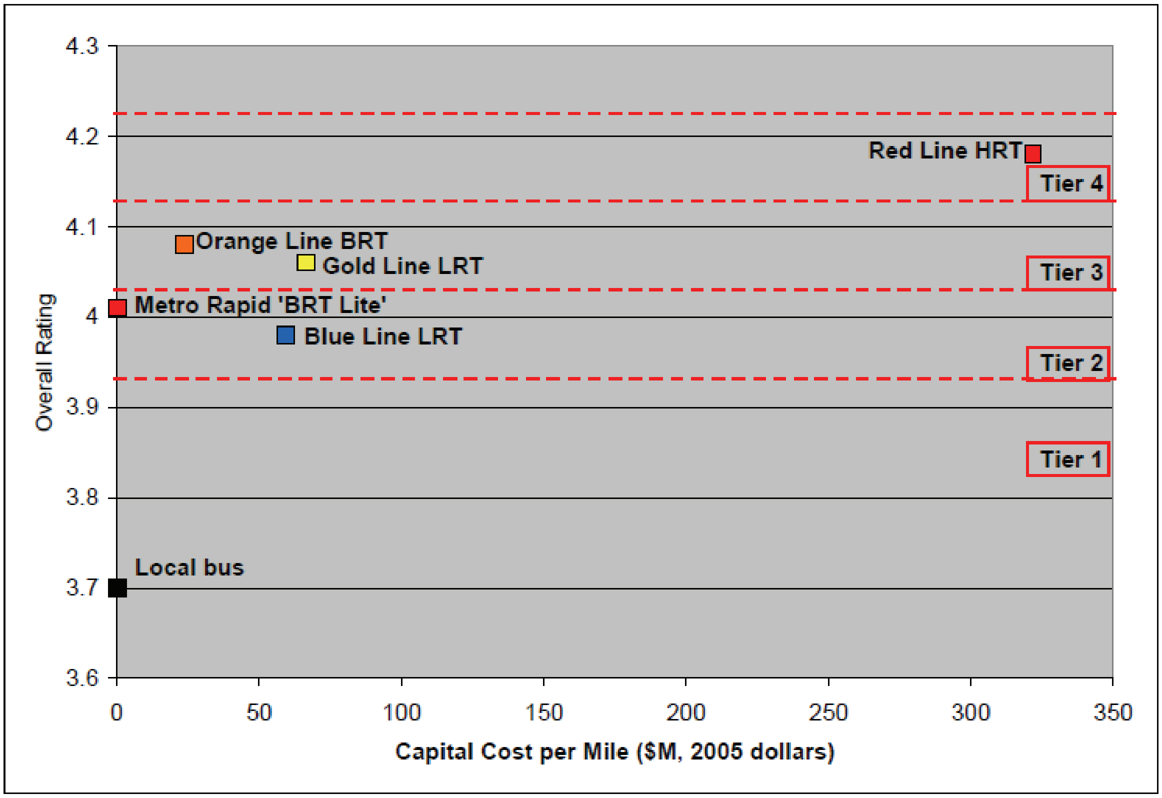
Boosting the bus: the West Chester RapidBus

As described in the prior chapter, the third operational improvement scenario that was simulated for this project combines transit signal priority, stop relocations, and a limited stop version of end-to-end Route 104 service (overlaid on continuing local service). In addition to the core West Chester Pike study area modeled for this project, this limited stop service would also serve 69th Street Transportation Center and downtown West Chester. This improvement scenario, which does not include exclusive rights of way, amounts to a "BRT-lite" type of service, as has been successfully implemented elsewhere in the United States (with one local example being NJ TRANSIT's GoBus in Newark).

For such services, operational improvements such as these are typically viewed to be only half of the project – with the other half being branding and facility design. As one NJ TRANSIT planner remarked, "customer perception is half the battle." Branding is held to be key to successful projects: both "premium service branding" and "significant transit stations" are required project elements for FTA Very Small Starts project funding where exclusive rights-of-way are not present.

Recent surveys in Los Angeles suggest that among a cross-section of riders and non-riders, the improvements that differentiate Metro Rapid service from standard local buses – which are essentially the same package of changes proposed under the RapidBus modeling scenario for Route 104, plus branding and enhanced stops – were sufficient for a Metro Rapid favorability rating that met or exceeded those of various rail services in the area. This survey result, summarized in Figure 12, suggests tremendous "bang for the buck" for BRT-lite investments.

Figure 13: Ratings by riders and non-riders of LA MTA transit services by capital cost



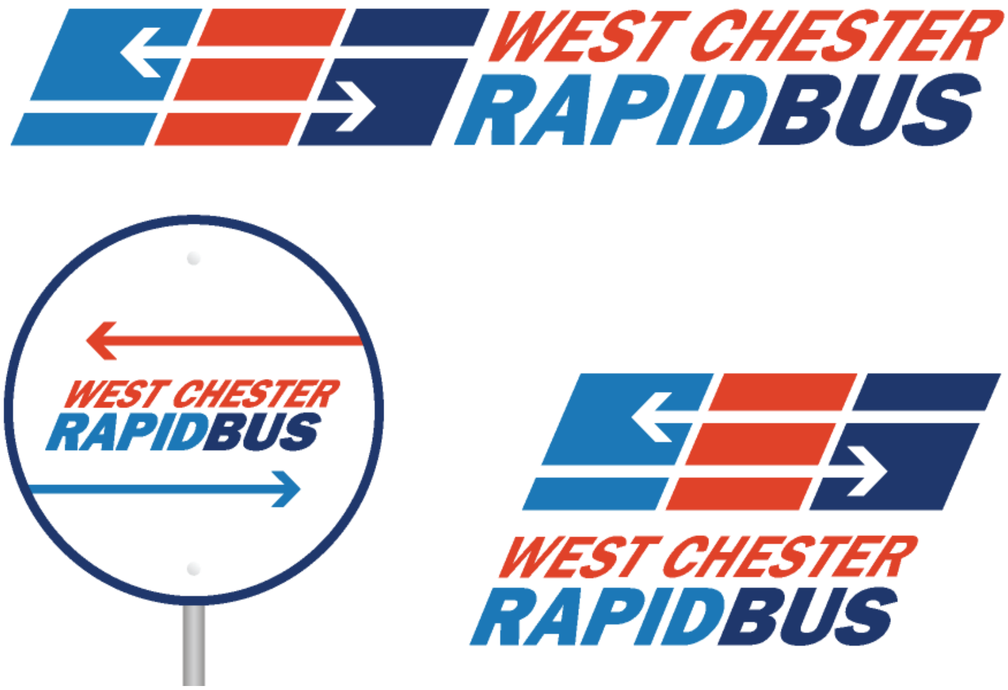
Source: NBRTI, *Quantifying the Importance of Image and Perception to Bus Rapid Transit*, 2009

In order to convey what these types of improvements would look like in the context of Route 104 and West Chester Pike, DVRPC staff developed a conceptual branding package for premium Route 104 service, as well as two conceptual designs for upgrading current bus stops into more substantial stations for the RapidBus operation modeled as part of scenario 3.

West Chester RapidBus

Figure 13 illustrates a conceptual branding package that was developed based on service branding applied elsewhere for similar projects. This branding draws on SEPTA's color scheme, but is intended to differentiate the newly improved service from local operations through new fonts and design elements. This conceptual branding incorporates the line's West Chester destination, consistent with SEPTA's new standard for rapid transit lines, and also bi-directional arrows that reflect the line's bi-directional ridership patterns.

Figure 14: Conceptual logos and branding for West Chester RapidBus service



Source: DVRPC 2010

In developing conceptual stop/station designs for the West Chester RapidBus, staff sought to incorporate the passenger access enhancements detailed previously (including both high quality crosswalks and a complete set of sidewalks in the stop vicinity), as well as other enhancements such as specialized shelters, specialized signage, and electronic passenger information signs similar to those employed for BRT-lite projects elsewhere. One resource that was consulted for emerging best practices in quality bus stop design was the report *Rethinking the Suburban Bus Stop*, published by the Airport Corridor Transportation Association (in Pittsburgh) in 2009. This report includes a set of typologies for bus stop designs for a variety of operational contexts.

Figure 14 illustrates a *before* and *after* photosimulation of a new westbound stop at Pennock Avenue in Upper Darby Township. In addition to the West Chester RapidBus branding and signage, the improvements depicted include:

- Enhanced passenger information, including a digital “next bus” display and a simplified and stylized route map graphic.
- A bumpout with a widened sidewalk to create additional waiting space and ease boardings and alightings. Note that the in-line bus stopping that would be enabled by such a bumpout was not part of the RapidBus operational simulation in Chapter 3.
- A stylized and distinctive shelter.
- Fencing and landscaping to separate the stop area from the adjacent surface parking lot.

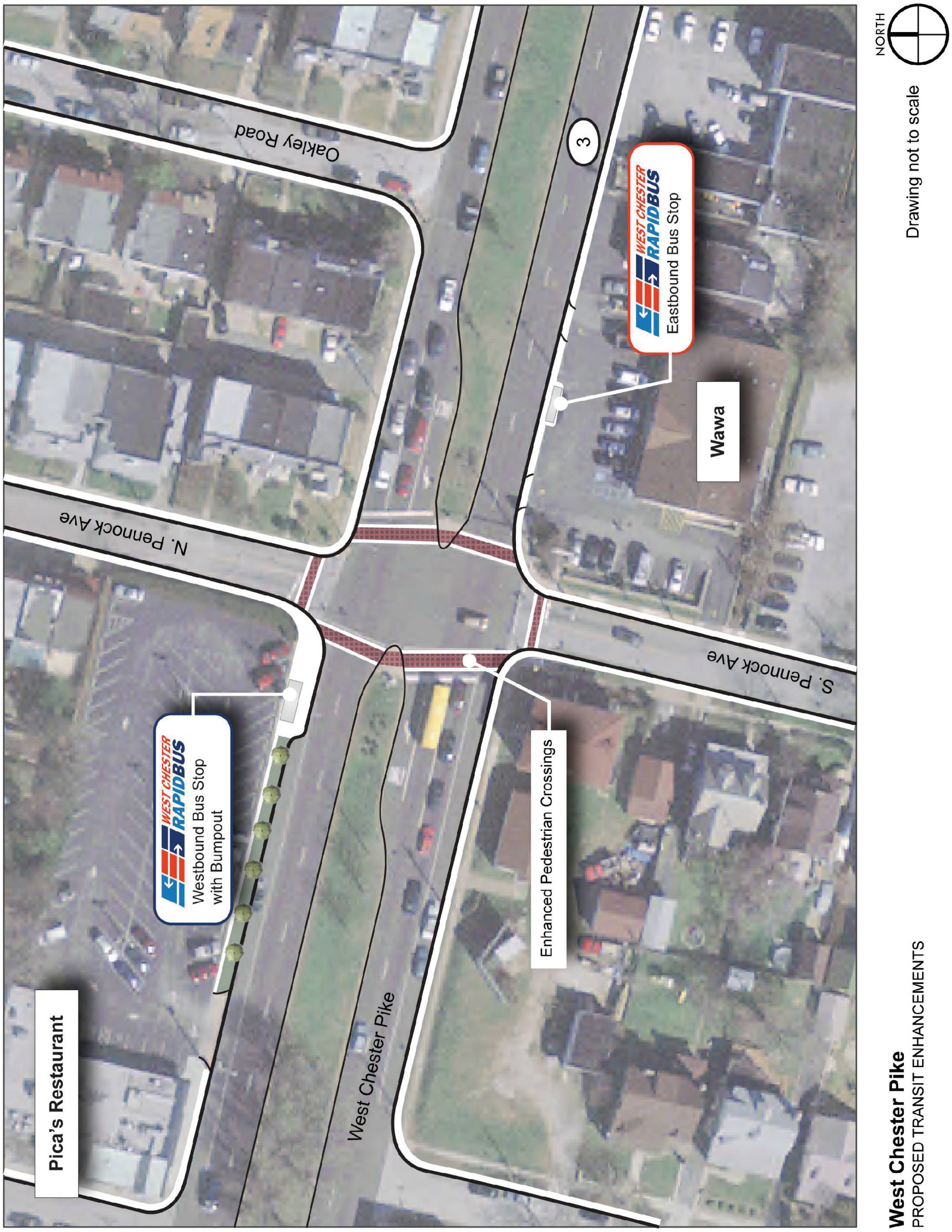
Figure 15: Illustration of conceptual improvements at Pennock Avenue

This particular set of improvements is conceptual and illustrative, and could be phased-in or otherwise implemented in a variety of ways. For example, the depicted brick-surfaced bumpout would permit the bus to stop in the traffic lane rather than curbing and having to re-enter traffic. However, the other improvements could also be implemented in whole or in part without the bumpout.

Source: DVRPC 2010

Figure 16 is a conceptual plan view illustrating the context of the proposed stop improvements and highlighting other desirable access amenities (such as enhanced crosswalks).

Figure 16: Pennock Avenue intersection context



Source: DVRPC 2010

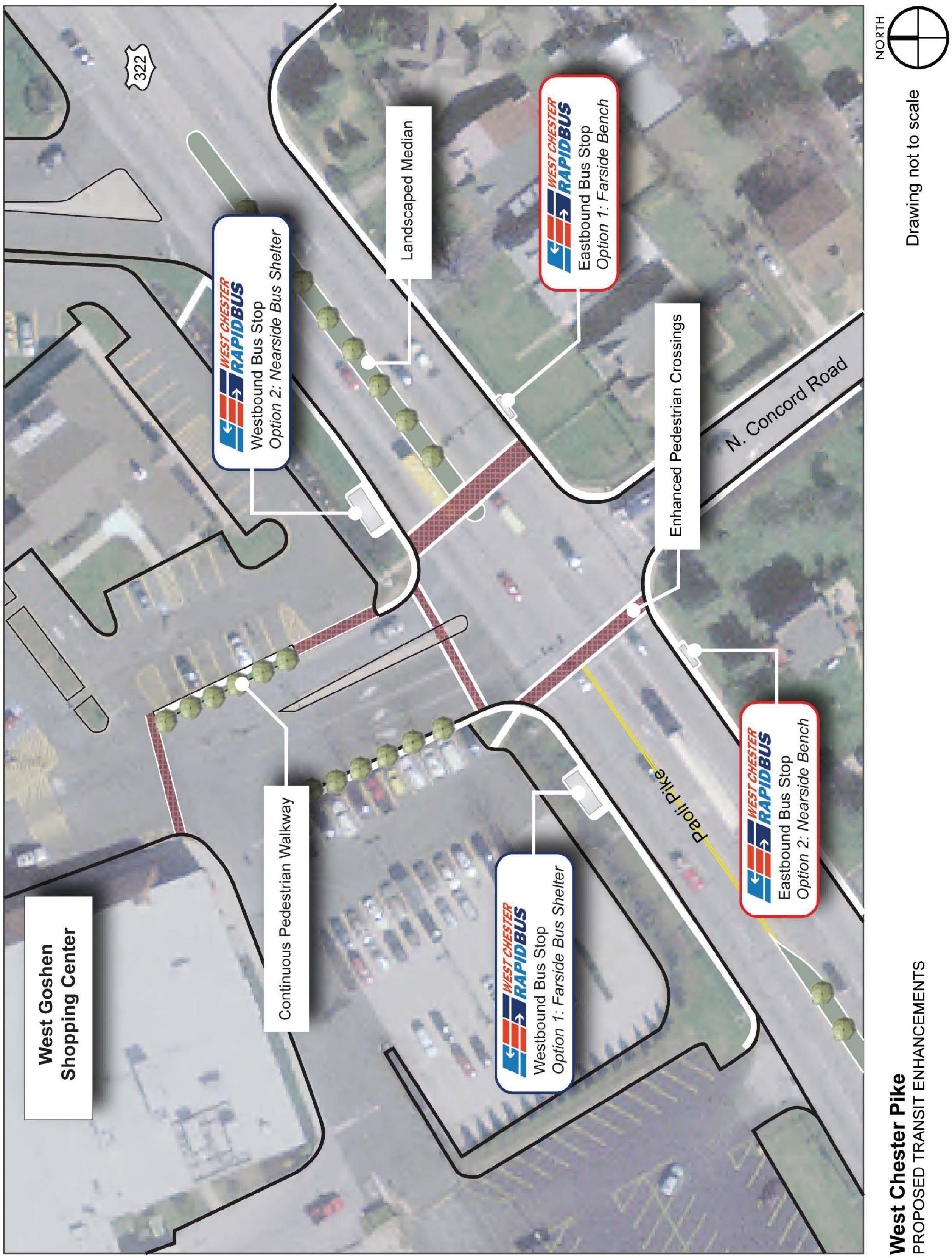
A *before* and *after* photosimulation was also prepared for a new westbound stop at West Goshen Shopping Center in West Goshen Township (Figure 17). While the simulated operational improvements for this project anticipate relocating this stop to the far side of the intersection, the photosimulation shows a near-side alternative in order to highlight the additional amenity opportunities presented where more space is available (namely, a larger shelter enclosure and additional landscaping). Also pictured is a new landscaped median and brick crosswalk for Paoli Pike, as well as a West Chester RapidBus wrap applied to a SEPTA bus. The plan view for this location (Figure 18) shows both near- and far-side shelter location alternatives in both directions, as well as enhanced crosswalks and improved walkway connections into the shopping center.

Figure 17: Illustration of conceptual improvements at West Goshen Shopping Center

The bus in the illustration below depicts one possible application of the suggested West Chester RapidBus branding as a wrap on a standard SEPTA bus. The bus shown is one of SEPTA's newest hybrid vehicles. Other project elements could advance independently of the proposed branded service, but branding for service-differentiation is a required project element for some funding programs, such as Very Small Starts.

Source: DVRPC 2010

Figure 18: Intersection context for West Goshen Shopping Center entrance



Source: DVRPC 2010

Getting there from here: capital costs for implementation

As with most transportation improvements, the biggest impediment to achieving the vision for West Chester Pike bus service in this report is cost. As with any transit project, project cost for the West Chester Pike RapidBus would have two components: the initial upfront capital cost, and the ongoing annual operations and maintenance costs, or operating costs.

Capital costs

Table 10 summarizes order-of-magnitude capital cost estimates for each of the component elements of the RapidBus project vision, drawn from available sources. These costs are for the RapidBus project itself, and do not include the costs of broader corridor-length access enhancements, such as crosswalks (except at RapidBus station locations) and connecting sidewalks. They also do not include the costs for optional landscaping elements such as the landscaped medians depicted in Figures 16 and 17, which would also lead to additional maintenance responsibilities and costs. It is assumed that stop relocation costs (for near-side to far-side relocations) would be minimal, and generally limited to labor costs.

Operating costs

Operating costs for this particular project could vary widely depending on the type of implementation that is pursued. A project that stops short of the full RapidBus proposal could be operated at only marginal additional expense, since using standard SEPTA buses in a limited stop operating pattern would require a reshuffling of existing fleet resources rather than significant fleet expansion. However, improved and faster service can be expected to attract increased ridership, which could require additional peak vehicles and thereby raise operating costs.

In contrast, wrapping buses with the RapidBus branding would have low upfront capital costs, but would create new maintenance challenges. This is because SEPTA typically rotates vehicles among all routes in the Victory District, and the wrapped RapidBus vehicles would be limited to Route 104 service (unless RapidBus services were also implemented for other routes). SEPTA estimates that the implementation of RapidBus branding would require at least five additional peak vehicles in order to maintain 30-minute headways, in addition to as many as 10 rotational spares to address maintenance issues.

In addition, a program for maintenance should always be included when considering an implementation program. Shelters must be maintained, and TSP equipment replaced as it becomes damaged. Since shelter maintenance falls outside SEPTA’s jurisdiction, a shelter management program for RapidBus facilities would need to be developed with one or more stakeholder agencies willing to accept responsibility for upkeep.

Table 10: Estimated capital costs for RapidBus implementation

Item	Unit Cost	Quantity	Total Cost	Note	Cost Source
Optical TSP equipment at signals	$5,000	13	$65,000	13 corridor signals need optical receivers per TMACC and DCTMA studies (5 in Chester County and 8 in Delaware County). Other signals have emergency preemption equipment that can also accommodate TSP. This cost assumes that no signal controllers will need to be replaced for TSP equipment to be added.	USDOT ITS Cost Database
Signal retiming plans	$3,500	61	$213,500	Development of new signal timing plans that incorporate TSP for all signalized intersections in the corridor (State Road in Upper Darby to the West Chester Borough boundary).	DVRPC *Transportation Operations Master Plan*, July 2009, pub. no. 09049
TSP emitters on buses	$2,000	20	$40,000	Assumes emitters for Route 104's 11 peak vehicles plus 9 additional buses to permit vehicle rotation. Depending on the operating mix of RapidBus and local vehicles, additional buses may also require emitters.	USDOT ITS Cost Database
RapidBus stations with "next bus" digital displays	$35,000	22	$770,000	Assumes two enhanced shelters (stations) at each corridor RapidBus stop location (one in each direction) plus one each at 69th Street and West Chester University.	Characteristics of Bus Rapid Transit for Decision-Making (FTA, 2004)
Enhanced crosswalks at intersections with RapidBus stations (duratherm street print)	$40,000	10	$400,000*	$17 per square foot; roughly 2,300 s.f. per intersection for 10-foot crosswalks across four legs; treatment applied at ten RapidBus station locations. This is a recent PennDOT-approved treatment for a local streetscape project.	DVRPC 2010
Estimated total cost for full RapidBus implementation					$1,488,500

*As a low-cost alternative, basic continental crosswalks of the same dimensions would cost about $1,000 per intersection, for a total cost of roughly $10,000. Duratherm street print adds considerable expense, but also considerable visibility and the potential for reduced maintenance costs.

Source: DVRPC 2010

Summary and next steps

This project represents an opportunity to rethink the role and potential of suburban bus service, as envisioned by DVRPC's *Long-Range Vision for Transit* (pub. no. 08068). The strategies and issues described here are specific to West Chester Pike and SEPTA Route 104, but are similarly applicable to other suburban bus corridors throughout the DVRPC region. Any significant enhancement to transit service will be challenging in the present funding climate, but funding opportunities are available where transit service providers and local government stakeholders demonstrate a shared commitment to coordinated planning. Potential sources of capital funding include FTA Very Small Starts funding as well as new and emerging “livability”-related funding programs.

For West Chester Pike, the next steps toward improving bus service are to pursue implementation strategies (either incrementally or as a single project). The DCTMA is presently managing a feasibility and outreach project on implementing TSP and land use access improvements, which are expected to be consistent with the recommendations of this report. **The experiences of other cities and regions that have pursued “BRT-lite” projects, from major cities to suburban corridors, suggest that when it comes to the effectiveness of improvements, perception is reality**. New York has SelectBus; New Jersey has GoBus; Los Angeles has MetroRapid – even where improvements are invisible to the rider and have benefits measured in seconds rather than minutes, effective branding tells the story. Passengers don't necessarily feel the TSP working or the far-side stops benefiting them, but they see the new logo, colors, and amenities. **In other words, whichever improvement strategies are pursued – from simple TSP to the full RapidBus vision – they should be promoted and branded rather than made quietly.**

APPENDIX A

Model Construction

The PTV Vision software package, consisting of VISUM (macro-level demand modeling) and VISSIM (micro-level operations simulator), was used to model the transit scenarios in this study. Initial network editing and demand calibration was done using the VISUM software to develop a focused model. The remaining work was completed in the VISSIM software. This is the first DVRPC project to utilize the VISUM-to-VISSIM connected functionality. This method allows the user to export a skeleton network from VISUM, complete with vehicle inputs and routing decisions. The two models retain a connection, such that the user can export different demand assumptions without losing the network enhancements that have been made to a VISSIM network. This appendix details the specific software procedures that were used in the conduct of simulations for this project.

Modeling procedure

Network preparation in VISUM

1. The 2005 DVRPC PM Peak period model (full VISUM implementation) was used as the base model for this study. The network geometry and attributes were reviewed for coding errors and the assigned volumes vetted against the surveyed count data for general network assignment reasonability.

Develop focused subarea model

2. The study area was “clipped” out of the regional model to create a smaller, more manageable version file that will serve as the basis for the VISSIM network and demand inputs. The subarea model includes the portion of PA-3 from 69th Street in Upper Darby Township to High Street in West Chester Borough, with a short section of Paoli Pike in West Goshen Township approaching West Chester Borough (following SEPTA’s Route 104 operating pattern onto the US-202 Bypass northbound, exiting at Paoli Pike). However, since we are not concerned with through traffic on the US-202 Bypass, only the ramps are included in the VISUM subarea model; the links connecting the PA-3 interchange with the Paoli Pike interchange were added as part of the transit routes (see step 18).

3. The raw subarea network was enhanced using aerial photography to rectify the roadway geometry. Cross streets with signal control were added where necessary (up to, but not including, the next signalized intersection). In some cases, it was necessary to disconnect links that create a triangle with one leg formed by PA-3 and the other two legs formed by cross streets which also intersect with each other a short distance from the

main corridor (e.g., Darby Road and Township Line Road in Upper Darby). We were able to avoid a difficult assignment problem by excluding the intersection of the cross streets.

4. Zones were split based on adjacent land uses, and connectors were added such that every cross street link terminates in a connector-zone pair (a zone will never be connected to a link at a midpoint).

5. VISUM transit routes in the study area were deleted. More precise transit routes were later added manually in VISSIM during steps 15 - 18.

Calibrate focused demand model

6. Five hour (PM peak) traffic volume and turn counts were input into the model at all available locations. The smaller trip matrix (generated during step 2) was refined by splitting zones and calibrated using the TFlowFuzzy algorithm.

7. Vehicle routes and turns were reviewed for soundness. Re-ran TFlowFuzzy as needed.

Export to VISSIM

8. The calibrated and focused subarea model was exported to VISSIM. The network was exported in the .ANM file, while the vehicle routes were exported in the .ANMROUTES file. Two additional files were created with the “P” prefix (.PANM and .PANMROUTES) to connect the VISSIM model back the VISUM version file. This allows the modeler to return to the VISUM network and export a new demand scheme without losing any enhancements made to the VISSIM network.

9. The .ANM and .ANMROUTES files were read into VISSIM and reviewed for errors or export/import process issues. At this point, the routes and vehicle inputs were deleted in order to make network editing less cumbersome in VISSIM. The vehicle routes were later re-imported after the VISSIM network editing was complete.

Clean and enhance VISSIM network

10. The raw network imported from VISUM required a good deal of editing before a simulation could be successfully run. The network geometry was again rectified against the aerial photography. Several passes were made over the entire network, working east to west (in the direction of major flow) and paying special attention to a different feature with each pass:

    a. **Roadway geometry:** clean the network between intersections, focus on shape and number of lanes.

    b. **Intersection geometry:** review lane turns (the path a vehicle takes through the intersection), correct spline (the arc of the turn), define channelized turns, delete illegal movements (these movements are turned off in VISUM but the export process creates the lane turn anyway).

c. **Intersection control:** add signal heads, vehicle detectors, and program signal controller (RBC) using signal timing plans, add right-on-red where allowed, review and edit conflict zones (right-of-way between conflicting movements within each intersection).

Refine VISSIM network and calibrate automobile traffic

11. Re-imported vehicle generators and routes. Edited desired speed distributions based on floating car data. Defaults were used for vehicle mix (no classification counts were taken) and the acceleration/deceleration profiles of both private and transit vehicles.

12. Ran test simulation and reviewed traffic flow for bottlenecks, signal control errors, weaving problems, and failing left turns. Several areas presented unique challenges due to the high volumes experienced during the PM peak:

    a. "Partial routes" were used where necessary to capture traffic making difficult movements across several lanes of high volume through traffic to reduce weaving issues. For instance, traffic approaching PA-3 on South Lawrence Road may turn right onto PA-3 and continue eastbound, or turn right onto PA-3 and make an immediate left onto North Lawrence Road. Partial routes allow traffic bound for North Lawrence Road to cut across the first two lanes and finish the initial turn in far left lane, preventing two difficult lane changes across one of the most heavily traveled segments of PA-3.

    b. "Priority rules"' were used to prevent a downstream queue from overflowing into the upstream intersection and "blocking the box."

13. Lane change behavior was edited to emulate the very aggressive lane change behaviors common during PM commute hours (safety distance reduction factor = 0.2; minimum headway = 1 ft) as recommended by PTV Vision.

14. Added the data collection elements, defined travel time segments, and established the output connection with MS Access database to store simulation performance data.

Add transit operations and calibrate

15. Added transit stops; defined dwell time distributions based on the AVL boarding and alighting analysis. Transit vehicle clearance time (five seconds), passenger boarding time (two seconds), and alighting time (1.5 seconds) were all based on the 2000 *Highway Capacity Manual*, Chapter 27. Transit vehicle clearance time was reduced to four seconds in calibration. Stop skipping was allowed for all stops (where no boarding/alighting passengers were present for a given simulated run). Three dwell time distributions were defined for each category of transit stop by service frequency:

a. **High frequency:** Transit vehicle services a stop 60 percent of the time; the dwell time is distributed between 4 - 18 seconds with a 2 percent chance to dwell up to 27.5 seconds.

b. **Medium frequency:** Transit vehicle services stop about 45 percent of the time; the dwell time is distributed between 4 - 14 seconds with a 1 percent chance to dwell up to 20 seconds.

c. **Low frequency:** Transit vehicle services stop about 15 percent of the time; the dwell time is distributed between 4 - 10 seconds with a 1 percent chance to dwell up to 25.5 seconds.

16. Added transit lines; defined transit vehicle class and type by operating pattern, defined transit headways based on SEPTA schedules. Four operating patterns were defined for Route 104:

    a. **Express route:** express from 69th Street Transportation Center to Eagle Road; local to West Chester.

    b. **Local route:** local from 69th Street Transportation Center to West Chester.

    c. **Campus route:** local from 69th Street Transportation Center to Campus Blvd.

    d. **BRT route (RapidBus):** limited service from 69th Street Transportation Center to West Chester.

17. Defined and added desired speed points for transit lines: 35 mph in urban and suburban areas; 50 mph in rural areas. All transit vehicles were set to use these desired speeds such that any differences in travel time would result from the alternative treatments, and not from variation in transit vehicle speed.

18. Added the links connecting the US-202 / PA-3 interchange with the Paoli Pike interchange and edited transit line routing to follow actual operations across these links.

19. Ran simulation, performed final review of transit operations and automobile behavior, checking for interaction between transit and auto traffic. Reviewed network performance and made final adjustments (QA/QC).

Validate base case scenario

20. Ran full simulation to validate the existing case against travel time data (floating car data for auto, AVL data for transit).

21. Established a Base Case folder and duplicated VISSIM files from the validated existing case. Ran Base Case scenario; recorded data and summarized.

Develop TSP scenario

22. The Base Case scenario folder was copied and renamed to use as a template for the TSP scenario. The signal control files were edited to allow TSP (10-second green phase extension only, four-minute recovery phase) and transit vehicle detectors were added to emulate the optical sensor technology. “Check-in” detectors were added 1,000 ft away from the signal head or consistent with line-of-sight restrictions (the nearer of the two) and “check-out” detectors were added under the signal mast arm. The scenario was tested and debugged to make sure transit vehicles triggered the green extension as expected.

23. Ran TSP scenario; recorded data and summarized.

Develop TSP plus far-side stop scenario

24. The transit signal priority folder was copied and renamed to use as a template for the TSP plus far-side stop scenario. New transit stops were added to the far side of the locations identified in Table 2 and the transit lines were rerouted from the old near-side stop.

25. Ran TSP plus far-side stop scenario, recorded data and summarized.

Develop BRT / RapidBus scenario

26. The far-side stop folder was copied and renamed to use as a template for the RapidBus scenario. A new transit line was added and routed through the stops identified in Table 7.

27. A new dwell time distribution was defined for the RapidBus route using the high-volume dwell time distribution calculated in step 15. Skipping stops was not allowed.

    a. RapidBus dwell: Transit vehicle serves stop 100 percent of the time; the dwell time is distributed between 4 - 18 seconds with a 2 percent chance to dwell up to 27.5 seconds.

28. Ran RapidBus scenario; recorded data and summarized.

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Key Words: SEPTA, transit, bus, BRT, RapidBus, pedestrian, bus shelter

Abstract: The purpose of this project was first to develop a set of best practices to improve transit service in the West Chester Pike corridor as well as its integration with corridor development; and second to use VISSIM microsimulation to test the impacts of various operational improvement strategies on the speed and running times of SEPTA Route 104 buses. The results of this analysis suggest that these improvements would result in travel time savings, with the most meaningful benefits naturally being observed under the RapidBus BRT-lite proposal (which was simulated to cut the time competitiveness gap between auto and transit by about 32-percent in the westbound direction, and 66 percent eastbound). The time savings estimated for the TSP-only and TSP plus far-side stop scenarios are much more modest, with only a negligible additional benefit being observed for the addition of far-side stops to TSP.

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