Harrisonburg Transit Study
Final Report
(Task 4 Memo)

By Renaissance Planning Group on behalf of
Central Shenandoah Planning District Commission and
Harrisonburg Department of Public Transportation

June 23, 2014

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Background

This report documents the major steps undertaken during the Harrisonburg Transit Study 2013-2014 (HTS), which defines the preferred alignment for a prospective new bus route and accompanying adjustments to existing bus routes serving the City of Harrisonburg. The report compiles and summarizes information on the current route structure and its performance, limitations, issues and opportunities. It then describes the guiding principles used to develop the proposed alignment for a new bus route and changes to the alignments of two existing bus routes. The new network is then described in detail and an analysis of the impacts of the improved service follows. The report combines analytical findings based on data provided by the Harrisonburg Department of Public Transportation (HDPT) with stakeholder input obtained throughout the HTS process.

Existing Conditions

HDPT provides fixed route bus service to the City of Harrisonburg and its major institutions, including James Madison University (JMU) and Eastern Mennonite University (EMU), each of which provides supplemental funding to support campus-oriented transit service. While the majority of transit service in the city is directed to these universities and most riders are students, the City of Harrisonburg also operates five routes (the "City Routes") that enable the city's residents, workers, and visitors to reach other major destinations around town. They provide an especially valuable service to the city's non-student population, including persons with limited or no access to an automobile such as low-income, elderly, and youth populations. A map of the City Routes is presented in Figure 1.

The City Routes operate year-round between the hours of 6:30 AM and 7:00 PM on weekdays and 8:30 AM to 6:00 PM on Saturdays. The City Routes currently do not operate on Sundays. In FY2010, the City Routes operated over 200,000 revenue vehicle miles and over 17,000 revenue vehicle hours. They carried over 200,000 passengers, or about 12 passengers per hour of revenue service. This represented about 11 percent of the total ridership for the entire HDPT system, including JMU routes.[1] Since that time, ridership has continued to increase system wide on an annual basis, while the configuration of and level of service provided by the City Routes has not changed significantly.[2]

During discussions with drivers, dispatchers, supervisors, and other HDPT professionals held in October, 2013, we learned that the steady increase in ridership has contributed to some capacity strains and schedule lapses on City Routes during peak travel times. Most of the riders boarding City Routes were reported to be a diverse mix of the city's non-student population, including low income individuals and families, high and middle school students, and senior citizens.

The five City Routes serve over 200 bus stop locations throughout the city. All routes except for route 4 operate as one-way loops. Route 4 is primarily a two-way linear route, but includes lariat routing in the vicinity of JMU. Several opportunities to transfer between routes are available in central Harrisonburg, notably at the transfer hub (Roses) and the Cloverleaf shopping center (except route 5). Routes 2 and 3 also meet at the Godwin Hall transfer hub where riders can transfer to or from JMU routes.

[1] City of Harrisonburg (Department of Public Transportation), Transit Development Plan, 2011
[2] City of Harrisonburg (Department of Public Transportation), TDP update, 2013

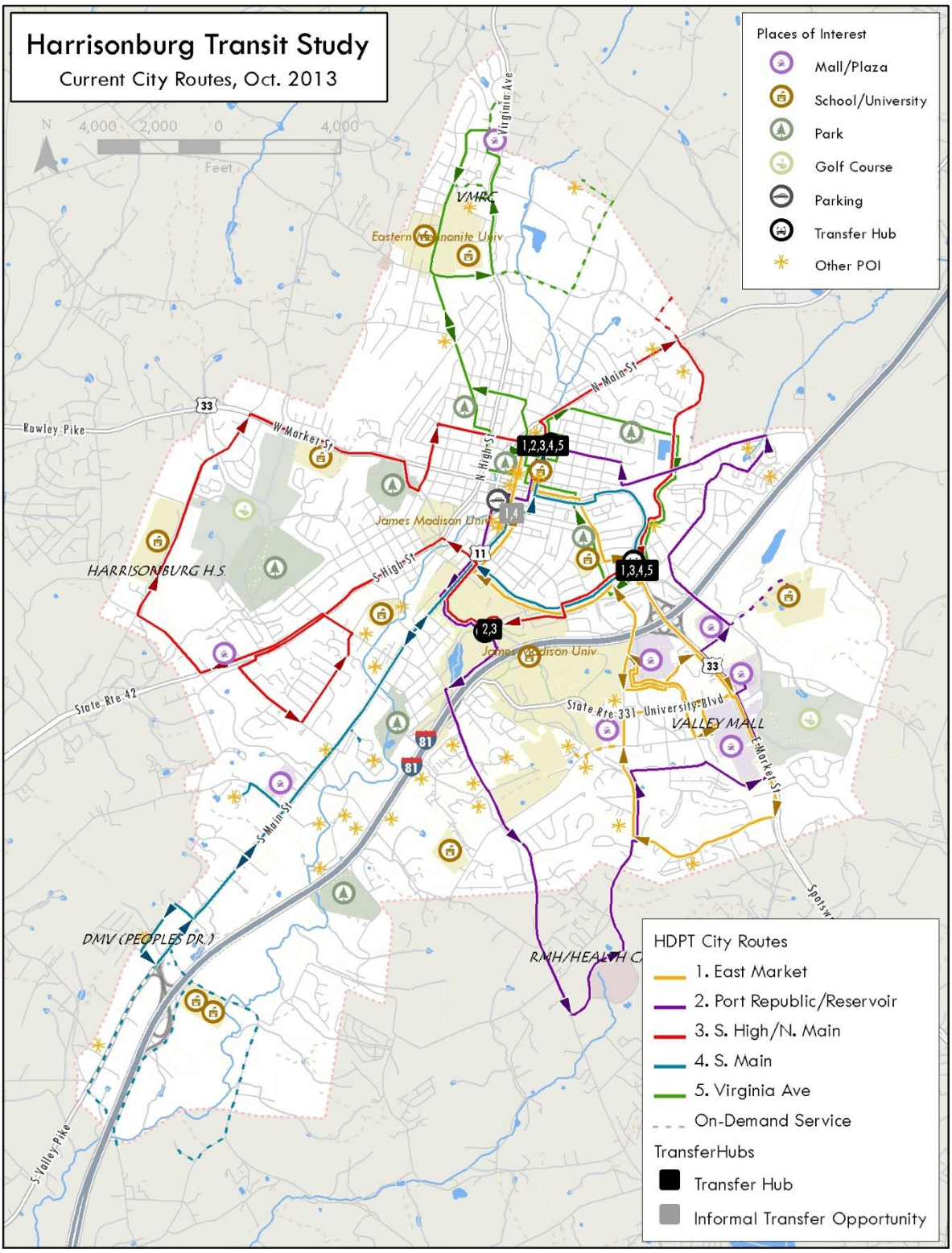


Figure 1 – Map of Current City Routes

Performance

Coverage

The existing HDPT City Routes cover a large portion of the City of Harrisonburg (see Table 1), serving roughly 81 percent of the City's population and almost 84 percent of jobs within the City within a quarter-mile (roughly a 5-minute walk). Many of the riders of HDPT's City Routes are residents and workers who have limited or no access to a car due to income and/or age constraints. An analysis of the locations of transit dependent populations - including low income households, senior citizens (65 years or older), and youth (5 years to 17 years) - indicates that the current City Routes serve a large proportion (80 percent or more) of these potential riders. The system also connects to 78.5 percent of the City's low-wage jobs, allowing low wage worker residents to reach their places of employment without an automobile.

Table 1 – Share of Activities and Transit-Dependent Groups within a Quarter-Mile of a Transit Stop[3]

Transit-Dependent Groups	Citywide	Within 1/4 mile of transit stop	Percent Transit-Accessible
Population	48,914	39,658	81.1%
Seniors (65+)	4,033	3,297	81.8%
Youth (5-17 years)	4,923	4,142	84.1%
Low-wage worker residents	4,582	3,698	80.7%
Jobs	32,165	26,996	83.9%
Low-wage jobs	9,635	7,564	78.5%

Additional analysis, including maps illustrating the locations of transit-dependent populations, can be found in Appendix A.

Accessibility

While the coverage statistics demonstrate the near-comprehensive geographic scope of the City Routes network, they do not describe the ease with which a person can travel from one location to reach destinations scattered throughout the City. Having seen the general distribution of activities within stop areas and the locations of transit dependent populations, an analysis of transit schedule data reveals the level of accessibility provided by the City Routes. In this analysis, jobs are taken as a proxy indicator of activities to which riders would generally want to travel. The accessibility analysis examines travel times

[3] Total population and jobs numbers based on census block centroid location. Seniors, youth, low wage residents, and low wage jobs based on overlap of census block groups with a quarter-mile buffer area drawn around HDPT City Routes transit stops (including those served by on-demand portions of routes). The share of each block group overlapping the buffer area was assumed to reflect the share of that block group's total transit-dependent group numbers. For example, if a block group has 100 seniors, and 50 percent of the block group overlaps the transit stop buffer area, 50 seniors in that block group are assumed to have access to transit.

between stops based on general transit feed specification (GTFS) files to find the shortest transit itineraries between a given origin-destination pair.

The analysis reveals high levels of transit accessibility in central Harrisonburg and extending along Chicago Avenue/Park Road, Market Street, and Main Street. Fringe areas generally have lower levels of accessibility due to relatively long travel times and transfer requirements when compared to the highly accessible central areas, which lie at the heart of the HDPT network. Additional key findings include:

- Areas with high activity density, especially employment density, are highly accessible locations within the current routing scheme. **Some areas with high population densities, however, appear to have fairly low accessibility to job centers.** Examples include the population concentrations in east Harrisonburg (Old Furnace Road and vicinity) and portions of Port Republic road south of I-81.
- The block groups with the highest **concentrations of low wage workers have good transit accessibility to jobs**. However, more direct connections between these areas and locations rich with low wage jobs may be possible, reducing travel times and minimizing the need for transfers.
- **HDPT provides generally high levels of accessibility to the city's households with limited auto access.** Most of these are located in the core or around the Virginia Mennonite Retirement Community (VMRC), and these areas are well-served by the current City Routes.
- **Youth and senior populations are fairly well served**, as the City Routes serve the VMRC area well and connect to most schools in the city. Some longer distance connections that may be desirable for these groups - such as VMRC residents accessing Rockingham Memorial Hospital - or students on the east side of town accessing Harrisonburg High School - currently require a transfer.

Figure 2 displays the average accessibility from block groups served by each of the City Routes. The chart shows both access to population and access to jobs. All routes exhibit a well-balanced ratio of population to jobs accessibility. Routes 1 and 5 provide the highest absolute levels of accessibility to jobs, while routes 2 and 3 provide relatively low levels of jobs accessibility.

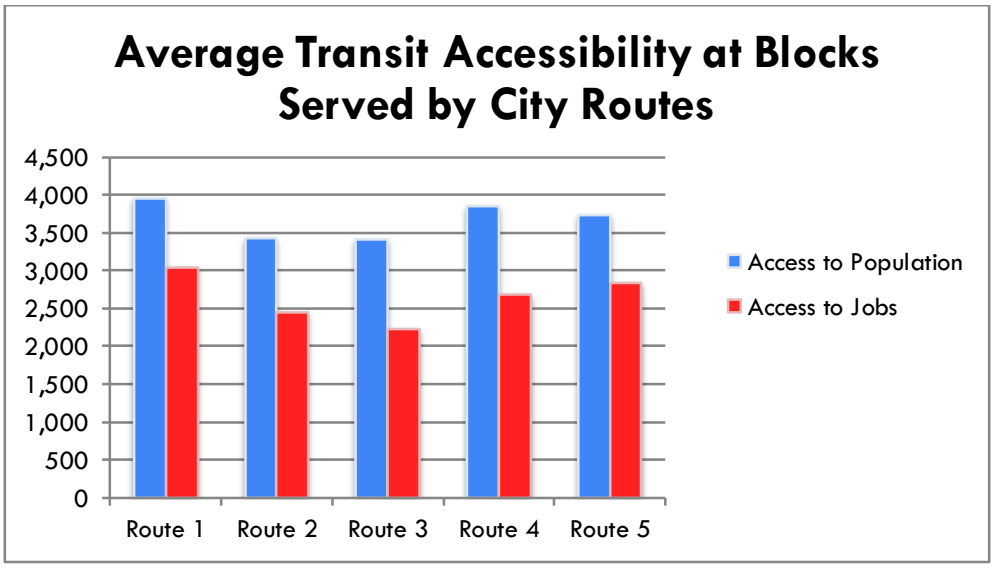


Figure 2 – Average Transit Accessibility at Blocks Served by City Routes

Additional details on the existing conditions accessibility analysis can be found in Appendix A.

Reliability

The accessibility figures provided above assume adherence to the schedule provided in the GTFS files. However, discussions with HDPT drivers and support staff revealed that the City Routes frequently fall behind schedule, for various reasons discussed later in this section. Figure 3 displays a map of on-time performance at time points throughout the system. The pie charts show the percentage of arrivals at each time point (regardless of route) that are on-time (white), early (blue), or late (red).[4] The map shows a trend of late arrivals, especially in the latter stages of routes. This finding is intuitive, as delays would tend to be cumulative. However, it suggests that routes regularly fall behind schedule, with some stops experiencing late arrivals more than 50 percent of the time. Most of these do not show a high number of boardings (reflected by the size of the pie in the map in Figure 3), but some stops with heavy boarding activity, such as Valley Mall, Chestnut Ridge Drive, West Market Street, and others, experience lateness more than a quarter to a third of the time. There are several possible explanations for the high numbers of late arrivals:

Transfers: Many transit itineraries in Harrisonburg require riders to transfer between routes at select transfer locations where two or more routes meet at a scheduled time. Drivers noted that managing transfer times is a large obstacle in managing delays. Multiple routes may have to wait on one route if that route is delayed, creating a domino effect of delays that affects on-time performance throughout the system.

Circuitousness: To cover the entire city of Harrisonburg with just five routes is a substantial challenge, and it requires routes to meander and loop in ways that can create scheduling challenges. Opportunities to provide more direct, simplified routing should be explored to address delays associated with circuitousness.

On-Demand Calls: Each of the City Routes includes at least one "on- demand" leg of the route, which is not part of the route's regular run but provides service to low ridership areas at the request of patrons who arrange for pickup or drop off at these locations. (These legs are displayed as dashed lines on the system maps.) The on-demand portions of the route add travel time to the run when customers request this service. Discussions with HDPT staff revealed that on-demand calls can create especially severe delays on routes 4 and 5, probably because the on-demand legs of these routes are lengthier than other routes. While the on-demand option provides a valuable service to customers, they can also substantially undermine the predictability of the schedule, which can have system wide impacts when attempting to accommodate transfer requests by holding other routes at transfer locations.

Stop Spacing: Finally, in some locations, stops may be spaced too frequently, reducing average operating speeds along portions of a route. Generally, stop spacing of one-quarter to one-half mile in high ridership areas is appropriate; with stops along lower volume segments spaced more widely and located at safe, convenient sites.

[4] Vehicles arriving at a time point more than five minutes after the scheduled time are considered late, while vehicles arriving more than one minute before the scheduled time are considered early.

Additional details on the on-time performance analysis are available in Appendix A.

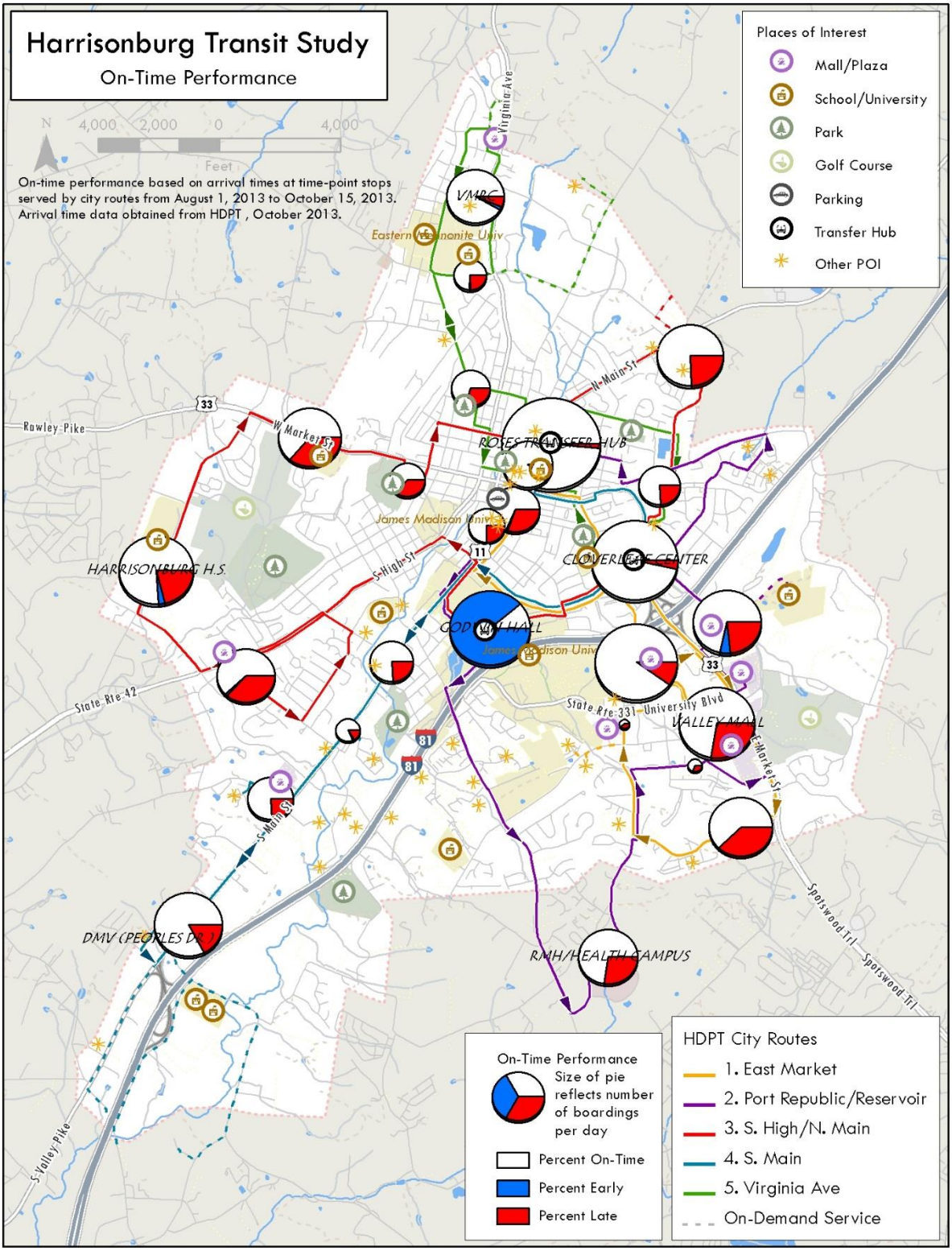


Figure 3 – Map of On-Time Performance on City Routes

Ridership

Ridership throughout Harrisonburg has grown steadily for many years. The City Routes make up only a small portion of the total HDPT system, but they carry a substantial number of non-student passengers. Figure 4 displays average daily boardings and alightings by stop location, regardless of route. The major transfer points - Roses transit hub, Cloverleaf Center, and Godwin Hall - have the largest numbers of boarding and alighting activity, an intuitive finding. Other stops with high levels of on/off activity include the Harrisonburg Crossing and Valley Mall stops, Peoples Drive (DMV), Harrisonburg High School and Harrison Middle School, the VMRC, and stops near the university campuses. These locations generally correspond with the locations of high activity density, high concentrations of transit dependent populations, and high levels of transit accessibility.

At the route level, route 1 carries the greatest number of passengers of any City Route, both in terms of absolute ridership and riders per unit (hours or miles) of service. Route 5 carries the lowest overall number of riders, but is comparable to other routes when analyzed on a per mile basis. Figure 5 summarizes daily boardings and alightings for each City Route on a per mile and per hour basis. A major item of concern is the high levels of ridership on route 1, which serves the areas with some of the richest transit potential in the city, and the delays experienced along the route (described in the previous section). As ridership continues to grow, delays along the route are likely to increase over time.

Additional details on the performance of the existing system, including additional maps and analysis, are available in Appendix A.

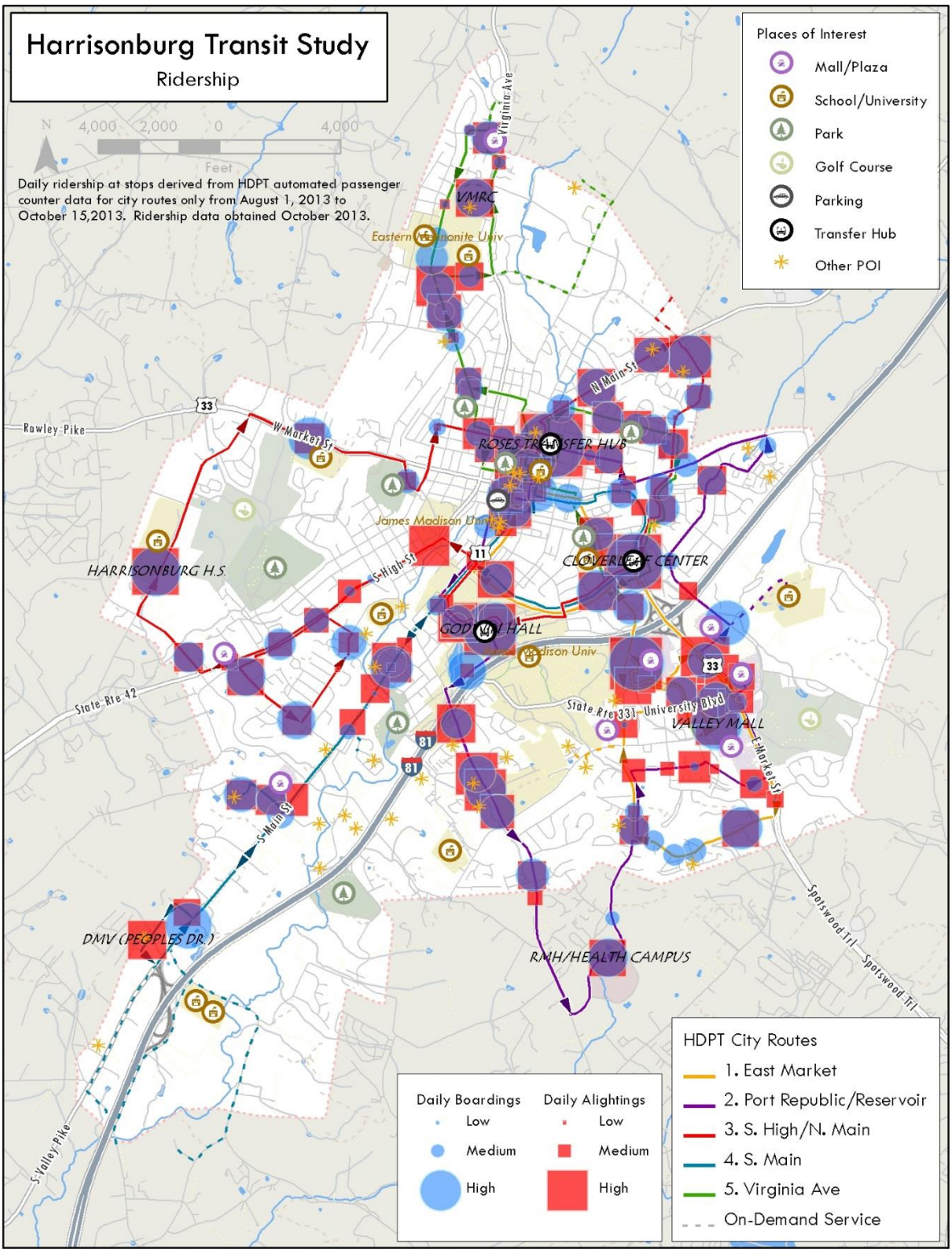
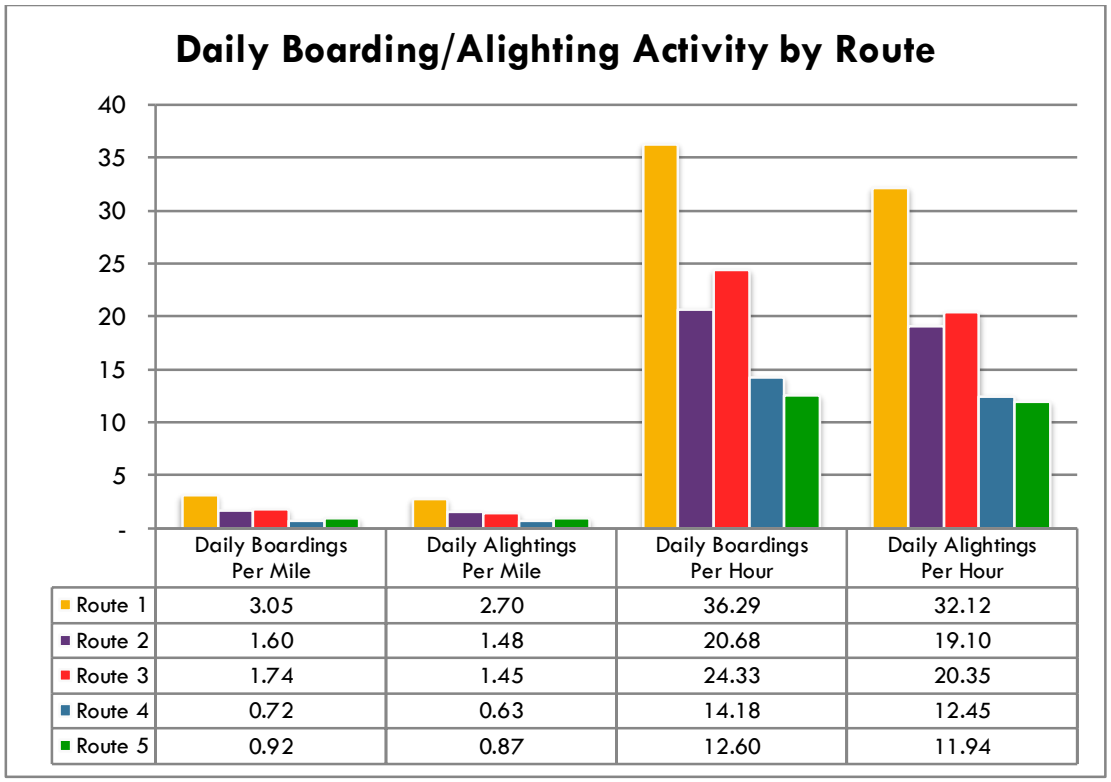


Figure 4 – Map of Boarding and Alighting Activity at Stops Served by City Routes



	Daily Boardings Per Mile	Daily Alightings Per Mile	Daily Boardings Per Hour	Daily Alightings Per Hour
Route 1	3.05	2.70	36.29	32.12
Route 2	1.60	1.48	20.68	19.10
Route 3	1.74	1.45	24.33	20.35
Route 4	0.72	0.63	14.18	12.45
Route 5	0.92	0.87	12.60	11.94

Figure 5 – Daily Boarding and Alighting Activity by Route

Limitations

HDPT faces a few notable limitations that affect some of the performance metrics outlined above, and these also influence the proposed expansions and revisions to the existing City Routes network as well as their projected performance levels. These limitations are described briefly below to provide context for interpretation of the performance indicators noted above and the development of a new routing scheme:

The City Routes network represents a small share of Harrisonburg's overall transit service. Most transit service in Harrisonburg is focused on JMU and its students, and the University provides funding to support those routes. The City Routes network is small by comparison, limited to five existing routes and carrying only about 11 percent of total transit ridership in the City. However, the City Routes are the primary transit service used by Harrisonburg's permanent, non-student population.

Serving the vast majority of the City with only a handful of routes contributes to the circuitous routing and on-time performance issues cited above. It also **makes bi-directional routing difficult** - in many cases impossible - which often undermines the intuitiveness of transit travel and limits general accessibility by transit, especially in a comparative sense. For example, a destination only minutes "upstream" along a route by car may require the route to complete its loop before allowing transit access to that same destination location. This means that "downstream" origins require long travel times to reach "upstream" destinations, whereas with bi-directional routing the travel times more closely resemble auto travel times.

The above limitations are a reflection of the fact that **Harrisonburg is primarily an auto-oriented city**, meaning that the typical urban design and activity density characteristics of the city favor automotive travel over other modes. As a result, **choice ridership is limited**, regardless of how well the City Routes network is designed. Thus, the City Routes currently function largely as a social service to youth, seniors, and low-income residents and workers.

Finally, **Rockingham County does not contribute funding to support transit services**. While HDPT's routes provide extensive coverage of the City of Harrisonburg, there has been much growth and development occurring in surrounding Rockingham County, and this trend is expected to continue especially on the Eastern side of the City. Without participation from the County, HDPT's services are generally constrained to service within the City, and this limits opportunities for providing access to emerging neighborhoods and jobs centers in nearby Rockingham County.

Issues and Opportunities

The performance indicators and general limitations of the City Routes network noted above provide a rich frame of reference for developing service enhancement concepts. The summary findings of the above sections can be outlined as *issues* confronting the existing City Routes network and *opportunities* for enhancing transit service in Harrisonburg through the addition of a new route and modifications to existing routes. An itemized list of these major issues and opportunities is presented below:

ISSUES:

- **On-time performance**: all existing City Routes struggle to stay on schedule for the duration of the route.
- **Directness:** due to the need to cover the entire City of Harrisonburg with only a few routes, the existing City Routes network is largely made up of circuitous loop or lariat routes. For the average traveler, these routings are difficult to interpret on a map and this contributes to a feeling of uncertainty about the convenience of reaching one's destination and - perhaps more so - making a return trip.
- **Transfers**: As is common in transit service, HDPT relies on transferring between transit vehicles to fulfill many trip itineraries. However, transfers are available at only a few select locations - most notably the Roses downtown hub and the Cloverleaf shopping center - and infrequently, as buses converge at each of these points once an hour. As such, buses are often left waiting at one of these locations to allow passengers to transfer to or from another route that may be behind schedule. This contributes to system wide delays.
- **Hours of Service**: Though not directly related to the design of service enhancements, a common theme heard during the course of this study was that HDPT patrons would like for buses to run later into the evening. This issue should be the subject of another study to assess the feasibility of expanding the general span of service for the City Routes network.

OPPORTUNITIES:

- **Extensive Coverage**: The City Routes network already provides near comprehensive coverage throughout the City of Harrisonburg. This means the proposed service enhancements can focus largely on addressing some of the issues described above, especially by enhancing directness in

route design, increasing transfer opportunities, and making it easier for all routes to stay on schedule.

- **Transfer Location Options:** Increasing transfer opportunities entails establishing transfer sites, which often need to be off-street locations with room to accommodate at least two buses. Several potential transfer locations - beyond those already used by the City Routes - may be natural places to open up new transfer opportunities. In the heart of HDPT's existing service area, these include Rockingham Memorial Hospital (RMH), Valley Mall, and the Wal Mart in the Harrisonburg Crossing shopping center. At the fringes of the existing service area, locations along Peoples Drive or South Main Street may be found suitable, as may the Wal Mart location near the intersection of High Street and Erickson Avenue. These fringe locations currently are unserved or served by only a single route, but they may allow a future east-west crosstown route to connect to the City Routes system at various points.
- **Destination-Rich Centers**: Harrisonburg has a few major off-campus destination centers. These include downtown, the shopping area in southeast Harrisonburg between Reservoir and Market Streets, and the South Main Street corridor. HPTD serves all of these areas currently, though the service in southeast Harrisonburg must meander to adequately cover all of the destinations in the area. There is an opportunity to enhance connectivity among these major destination areas with the advent of a new route.
- **Emerging East-West Travel Options**: East-west travel in Harrisonburg is limited to those streets that cross Interstate 81. East-west travel has historically been limited in the southern portions of the City. However, a new path for east-west travel in this area has been created through improvements to Stone Spring Road and the Erikson Avenue extension. This may open up opportunities for a future crosstown route to better connect the City's major destination areas and to serve future growth and development that will occur along these roads.

These issues and opportunities set the stage for the discussion of proposed changes and additions to the City Routes network and provide a useful backdrop for summarizing their impacts. They also support a set of general recommendations and considerations for future service enhancements at the end of this report.

Development of Alternatives

Guiding Principles

The prospective addition of an additional City Route will help HDPT address current system issues and enhance system wide performance, especially for transit dependent populations throughout the City of Harrisonburg. To inform the development of a preferred alignment for the future route, several guiding principles and general service improvement concepts were developed*:*

- Maintain a focus on covering as much of the City as possible;
- Enhance the overall directness provided by routes to reduce general travel times and rider convenience;
- Enhance system reliability (improve on-time performance) and maintain reasonable scheduled travel speeds;

- Promote efficiency by serving areas with highest ridership potential. Discussions with HDPT staff indicated that special emphasis should be placed on alleviating loads and delays on the existing route 1, which served high ridership areas in southeast Harrisonburg.

Proposed New Route and Adjustments to Existing Routes

Guided by the principles listed above, a preferred alignment for a new City Route and adjusted alignments for two existing City Routes were identified during the process of this study. Figure 6 illustrates the proposed changes and how they fit into the context of the existing City Routes network. The proposed new route and modifications to the existing routes are described in detail below.

Proposed New Route 6

Route 6 will be a new route, resulting from splitting the existing route 2 into two routes, as proposed in HDPT's 2010 TDP update. The new route will begin at the Roses transfer hub (interfacing with all other city routes); serve JMU via South Liberty Street and South Main Street; continue to Godwin Hall via Bluestone Drive (interface with route 3); follow Carrier Drive, University Blvd, and Port Republic Road to reach Rockingham Memorial Hospital (interface with route 2); return to Port Republic Road and travel north to Neff Avenue; proceed east on Neff Avenue to Reservoir Street; turn north on Reservoir Street to return to downtown Harrisonburg, deviating to serve the shopping areas along University Boulevard and Evelyn Byrd Avenue (interface with route 1 at Walmart). Route 6 may be able to serve all or part of the on-demand locations currently served by the existing route 1 as part of its standard service or as an on-demand extension of the route.

The Route 6 is expected to take about 52 minutes to complete the circuit described above, leaving eight minutes of break time at the Roses hub or make-up time in the schedule for the driver. The timing of its arrival at transfer locations is convenient for facilitating transfers to or from other routes at various locations[5]:

- Roses: interfaces with all other routes shortly after the half-hour
- Godwin Hall: interfaces with route 3 around 43 minutes past the hour
- RMH: interfaces with route 2 around 58 minutes past the hour
- Walmart: interfaces with route 1 around 14 minutes past the hour
- Returns to roses around 22 minutes past the hour.

The new Route 6 will increase transfer opportunities throughout the southern portions of the City and enhance transit connectivity between Downtown Harrisonburg, JMU, RMH, and the Valley Mall shopping area. It will alleviate loads and delays on route 1 by providing redundant routing from the mall

[5] All transfer times are approximate. Depending on arrival times of route 6 or connecting routes, some delays associated with transfers may occur. However, these should generally be alleviated by softness built into the schedule, redundant transfer opportunities, and redundant potential transit itineraries for traveling between the major ridership generators of downtown Harrisonburg, JMU, RMH, and the shopping/employment areas surrounding Valley Mall.

area to downtown and - potentially - serving the multifamily housing on Neff Avenue currently served by route 1's on-demand leg.

Route 1 Modifications

The modified route 1 will be very similar to the existing route 1, serving the high ridership area of Valley Mall and the Harrisonburg Crossing shopping area. It will depart the Roses hub (interfacing with all other city routes); travel along Mason Street, Market Street, Reservoir Street and Carlton Street to the Cloverleaf transfer center (interfacing with all other city routes, except the new route 6); continue on East Market Street to University Blvd to Reservoir Street; proceed north on Reservoir Street and turn right into Walmart; exit Walmart on Evelyn Byrd Avenue and proceed to the south side of Valley Mall (interface with route 6); exit the mall on to Evelyn Byrd Ave (via Neff Avenue) and travel to East Market Street; turn to serve multifamily housing along Chestnut Ridge Dr; proceed north on Reservoir Street, turning on University Blvd and again on Evelyn Byrd to again serve Walmart (interface with route 6); and return to the Roses hub via Reservoir/MLK Pkwy/S Main St. The modified route will only continue to serve the on-demand stops on Neff Ave west of Reservoir Street if it is deemed infeasible to have these locations served by the new route 6.

The total time to complete the route 1 circuit will be similar to the time allotted to the existing route 1, though the revised alignment shortens the route to enable it to stay on schedule more reliably. The route is expected to take about 50 minutes to run, leaving drivers a 10 minute break at the hub or 10 minutes of extra time to complete on-demand runs (which may ultimately be served by route 6), wait on transfers, or make up for other delays. Route 1 will interface with other new routes as follows:

- Roses: interfaces with all other routes shortly after the half-hour
- Cloverleaf: interfaces with all other routes except the new route 6 at about 40 minutes past the hour
- Valley Mall: interfaces with the modified route 2 at around 52 minutes past the hour
- Walmart: interfaces with the route 6 around 14 minutes past the hour

The modified route 1 shortens and streamlines the alignment of the existing route, making the routing more intuitive for patrons and helping to improve travel time reliability on the busiest route in the City Routes network. It also opens up opportunities to transfer to route 6 and route 2 at high ridership locations outside of downtown (Walmart and Valley Mall, respectively), substantially increasing the number of single-seat ride options to and from these major generator locations and augmenting system wide accessibility benefits.

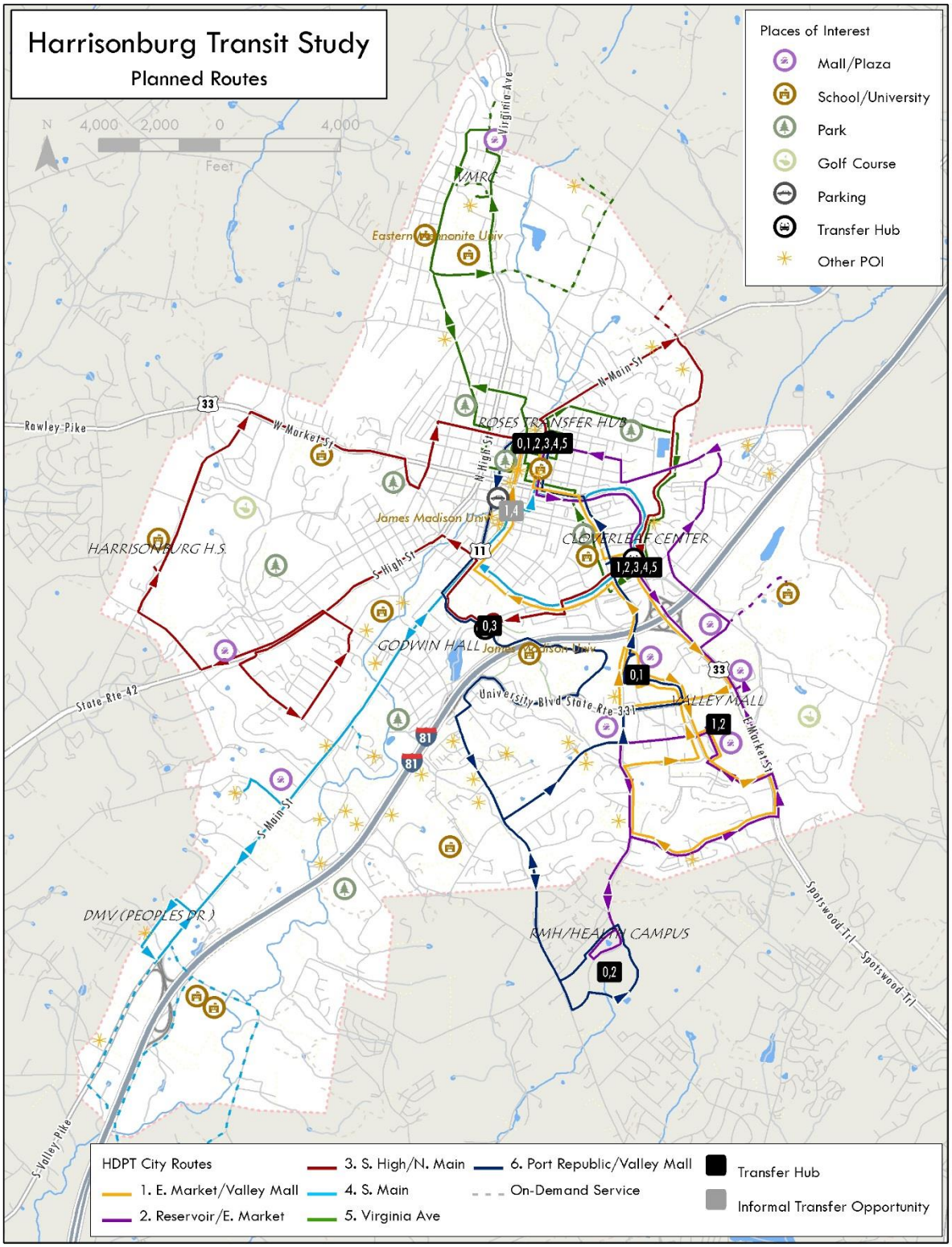


Figure 6 – Map of Proposed Future Routes

Route 2 Modifications

The modified route 2 will, in many ways, resemble the eastern portions of the existing route 2 and provide service along East Market Street, Chestnut Ridge Drive, and Neff Ave/Evelyn Byrd Ave to complement and alleviate routes 0 and 1. Starting at the Roses hub (interfacing with all City Routes), route 2 travels along Gay Street to Mason Street, then south to East Market Street, serving the Cloverleaf transfer center (interface with all city routes except route 6); continues on East Market Street to Evelyn Byrd Avenue and serves the Valley Mall (interfacing with route 1); exits the mall on Evelyn Byrd, continuing west on Neff Avenue; turns south on Reservoir Street to RMH (interface with route 6); returns north on Reservoir Street and east on Chestnut Ridge Drive; turns north on East Market Street; east on Linda Lane to Country Club; north to Blue Ridge Drive and west on Old Furnace Road; returning to Roses hub along Old Furnace and East Gay Street. The modified route 2 will continue to serve the on-demand stops on Linda Lane east of Country Club.

Route 2 is expected to require about 50 minutes of travel time, leaving a roughly 10 minute break for the driver at the Roses hub. The route also includes five minutes of wait time at Valley Mall to allow for interaction with route 1 and to provide additional time in the schedule to bolster on-time performance. Transfer opportunities for route 2 are described below:

- Roses: interfaces with all other routes shortly after the half-hour
- Cloverleaf: interfaces with all other routes except route 6 at about 40 minutes past the hour
- Valley Mall: interfaces with route 1 around 52 minutes past the hour
- RMH: interfaces with route 6 around 58 minutes past the hour

The modified route 2 will complement routes 0 and 1 to enhance the number of available transit itineraries for traveling between places in Downtown Harrisonburg and the Valley Mall area, serving the major generators at RMH and the multifamily housing along Old Furnace Road. With route 1, it provides bi-directional transit service to the multifamily housing complexes on Chestnut Ridge Drive, significantly increasing travel options and accessibility to and from this major generator.

Analysis of Proposed Service Changes

Operating Characteristics

Revenue vehicle miles: Estimates of revenue miles of service were developed by first measuring the route miles (including on-demand portions) of the City Routes shapes (obtained from GTFS and modified to reflect new/modified routing). For each shape, this number was then multiplied by the number of trips made on a typical weekday and a typical weekend day to obtain daily revenue miles of service estimates. Finally, the respective daily numbers were multiplied by the expected number of weekday and weekend service days in a typical year. We assumed 252 weekday days of service and 52 weekend days of service. These estimates of service days per year were based on the 'calendar' and 'calendar dates' files in the GTFS dataset.

Revenue vehicle hours: Estimates of revenue hours of service were developed by approximating the total time between the start of a route's operations at the beginning of the day to the ending of its operations at the end of the day. In all cases, this was roughly 12 hours per weekday and roughly 9

hours per weekend day of service. These daily values were then multiplied by the assumed number of weekday and weekend days of service in a typical year (see explanation above on this topic) to obtain rough annualized totals.

Table 2 shows the estimated annual revenue miles and revenue hours of service for the existing and proposed systems as well as subtotals for the new and modified routes.

The addition of route 6 will increase the system revenue hours of service by about 20 percent, which is intuitive given that one new route is being added to five existing routes. System revenue vehicle miles, however, will only increase by about 14 percent, a product of the fact that the new route partly serves to alleviate delay on existing routes by making them shorter and more direct.

Table 2 – Approximate Revenue Vehicle Miles and Hours of Service: Existing and Proposed

	Revenue Miles of Service	Revenue Hours of Service
System wide - Existing	255,000	17,500
System wide - Proposed	290,000	20,900
Route 6 - Proposed	39,100	3,500
Route 1 - Proposed	40,500	3,500
Route 2 - Proposed	42,600	3,500

The modified route 1 will decrease in route miles by 2 to 3 percent, though if its on-demand portions are eliminated by the advent of route 6, route miles on route 1 could drop by as much as 8 percent. This should substantially improve travel time reliability on route 1, the busiest of all City Routes.

The modifications to route 2 will decrease its route miles by around 5 percent, providing more direct service in the eastern portions of the City. This should free up some room in route 2's schedule, which can bolster travel time reliability along the route when making on-demand runs. In some cases, the route may be at risk of running slightly ahead of schedule, so extended stops at transfer locations (Valley Mall, RMH) may be needed from time to time.

Estimated Costs

Capital expenses: Capital expenses associated with implementing the new route are expected to include a new bus to operate the new route 6. HDPT is in the process of procuring new buses to replace its existing fleet and augment its reserve fleet capacity. As such, this capital expense item is assumed to have already been accounted for at this stage. Additional capital expenses may include the provision of stop infrastructure and amenities at new stops created by the new and modified routes, although some of these may fall under 'operations' or 'maintenance' categories as well. For the purposes of this analysis, costs of creating new stops or moving existing stops is assumed to be negligible as a capital expense item.

Operating expenses: Estimates of operating expenses associated with the new routing scheme that includes the new route 6 and modified routes 1 and 2 were developed by referencing average operating costs on a per revenue mile and per revenue hour basis for existing services. The unit cost assumptions

were developed from figures reported by HDPT to the National Transit Database (NTD) and from HDPT's most recent Transit Development Plan (TDP). These sources suggest average operating costs of around $55 per hour or $5.40 per mile. These unit costs were multiplied by the relevant estimates of annual revenue miles or hours of travel to obtain a prospective range of future annual operating costs for the proposed changes and additions to the City Routes network. Table 3 summarizes the expected operating costs for the existing system and the new system as well as the increment associated with the new route 6.[6]

Table 3 – Existing and Future Operating Costs

Operating cost estimate based on...	Revenue Vehicle Hours (in $1,000's)	Revenue Vehicle Miles (in $1,000's)
Existing System	$959	$1,377
Future System	$1,150	$1,571
Proposed Route 6	$192	$213

Operating costs are expected increase by 15 to 20 percent with the addition of Route 6. The hours-based cost estimate anticipates an increase commensurate with the increase in route service provided (a new route adds a "route's worth" of costs, represented as 12 hours of weekday service, 9 hours of weekend service), but this ignores the streamlining of routes 1 and 2. The miles-based estimate shows that the costs of the new system as a whole are less than the sum of the old system plus the new route 6. This means that the streamlining of routes 1 and 2 should result in some marginal cost savings and reinforces that the changes to the system will result in some operational efficiencies.

The notes above on incremental costs provide some cues for interpreting the cost estimate ranges. Each of the unit cost variables relates more appropriately to certain costs associated with transit operations than others. For example, wages paid to drivers generally represent the largest single cost item for transit service providers. These wages are more closely connected to the revenue hours of service provided than to the revenue miles of service provided, since drivers are typically paid on a per-hour basis. Other operational expenses, such as fuel and general maintenance costs are more sensitive to the miles driven by a transit vehicle. As such these costs are more closely associated with revenue miles of service. Since the labor costs are expected to dominate the cost equation, it is reasonable to expect that actual operating costs will be closer to the lower values of the ranges presented here - the value based on revenue hours of service - than to the upper values.

Finally, dollar values were assumed to be in "today's dollars," even though they were derived from reports that may be one to three years old. Given the expected quick implementation of the new route, inflation effects should be muted, but it may be worth noting that costs may be a little higher than stated here depending on the rate of inflation and timing of implementation.

[6] To allow a consistent comparison, costs for the existing City Routes network have been estimated using the same methods used to estimate costs for the future City Routes network.

Accessibility Benefits

Accessibility is measured by analyzing the travel time associated with making a trip by transit (using the City Routes only) from a point of origin to all destination points reachable by transit. The accessibility provided by the existing City Routes network is described and mapped in the "Performance" section above. A similar analysis was conducted for future conditions using synthesized GTFS data.[7] Table 4 shows the results of this analysis of future conditions. Since the time this analysis was conducted, the future City Routes network has been modified slightly based on coordination with HDPT. However, the summary figures in the table are expected to be similar to those that would result from running the same analysis on the network proposed in this document.

Table 4 – Change in Accessibility Resulting from City Route Modifications and Addition of Route 6

	Population having access to a transit stop	Jobs having access to a transit stop	Average number of connections	Average accessibility score
Existing City Routes Network	39,658	26,996	651	1,977
Proposed City Routes Network	39,735	27,467	865	2,268
Change	77	471	214	291
Percent Change	0.19%	1.74%	32.87%	14.72%

The table reveals that the proposed changes and additions to the City Routes network will provide only a negligible increase in the coverage of the transit system. This is to be expected, since the new route 6 covers much of the same area served by the existing route 2 and since the existing network covers the vast majority of the City of Harrisonburg already. However, when analyzing the accessibility provided by the system, the effects are more pronounced.

By making service more direct in south Harrisonburg and introducing new transfer opportunities, the proposed City Routes network increases the average number of connections available from a given location by nearly 33 percent. This means that from a given census block in Harrisonburg (for those that are located within walking distance of a transit stop), a traveler will be able to reach 865 other census blocks within an hour's ride using the proposed network compared to 651 blocks using the existing network.

The accessibility metric elaborates on the connectivity indicator by weighting the connections to census blocks by the number of jobs located there and applying a decay factor that weights closer destinations more heavily than further destinations. When the jobs and time-decay weights are applied, the analysis suggests that accessibility by transit should increase by nearly 15 percent over existing conditions. On

[7] A new dataset mirroring the GTFS data structure was developed using coarse estimates of future stop locations and schedule changes associated with the new routing scheme. Since the actual stop times and locations are likely to vary from those used in this analysis, the results may likewise vary - though the variation is expected to be marginal.

average, a traveler will be able to reach 2,268 gravity-weighted jobs from a given starting point on the proposed network compared to 1,977 gravity-weighted jobs on the existing network.

In summary, the proposed enhancements to the City Routes network will result in **substantially improved opportunities for making transit trips** and make it **easier to access the places that people want to go**. These benefits will extend to the transit dependent populations, helping HDPT serve its core ridership base.

Scheduled Speeds

Each route (existing and new) was broken up into several (usually seven to ten) "legs" defined by major time points located along the route. The travel times along these legs were obtained by referencing the GTFS schedule data (or synthesized GTFS data for new/modified routes) at the starting and ending points of each leg and calculating the hours of travel. These travel times were then compared to the route miles (miles the transit vehicle travels along its route) associated with each leg to estimate the travel speed associated with that leg. The term "scheduled speed" is used because the travel times reflect how fast the GTFS schedules suggest the transit vehicle must travel in order to travel between the time points at the scheduled times. Figures 7 and 8 below show transit vehicle average speed per leg under existing and proposed future route configurations. Below are some key observations relating to schedule speeds.

- Average scheduled speed decreases system wide from 19.5 mph to 18.2 mph, suggesting that the new and modified routes will provide more 'wiggle room' in the schedule to enhance on-time performance throughout the system.
- On route 1, the busiest and most strained route in the City Routes network, average scheduled speeds drop from 15.5 mph to 13.9 mph, a decrease of around 10 percent.
- On route 2, average scheduled speeds decrease from 14.9 mph to 14.1 mph, a 5 percent drop. This should help route 2 stay on schedule during construction on Reservoir Street which is expected to create some abnormal delays and when serving the on-demand run to Linda Lane.
- The average scheduled speed on the new route 6 is 12.8 mph, the lowest average value in the system. Since this route does not have on-demand legs to serve, it should be fairly reliable, though, like route 2 it may encounter some delays in the near term resulting from construction on Reservoir.
- Comparing the anticipated scheduled speeds of the new and modified routes to the existing system, they are generally slightly slower, which should make it easier for them to stay on schedule, though there may be some risk of "running hot" or getting ahead of schedule during off-peak travel periods.

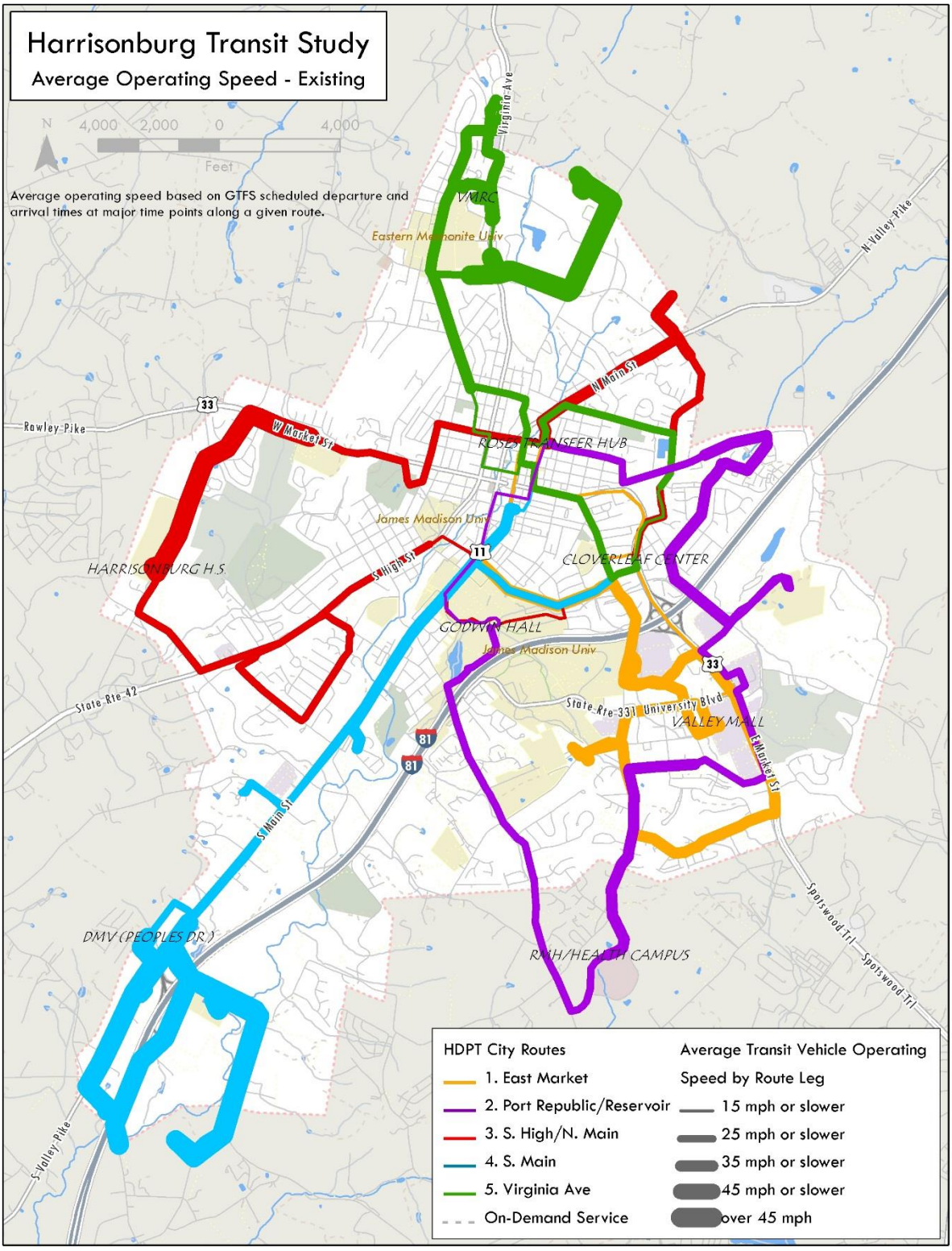


Figure 7 – Map of Average Transit Vehicle Operating Speed by Route Leg for Existing System

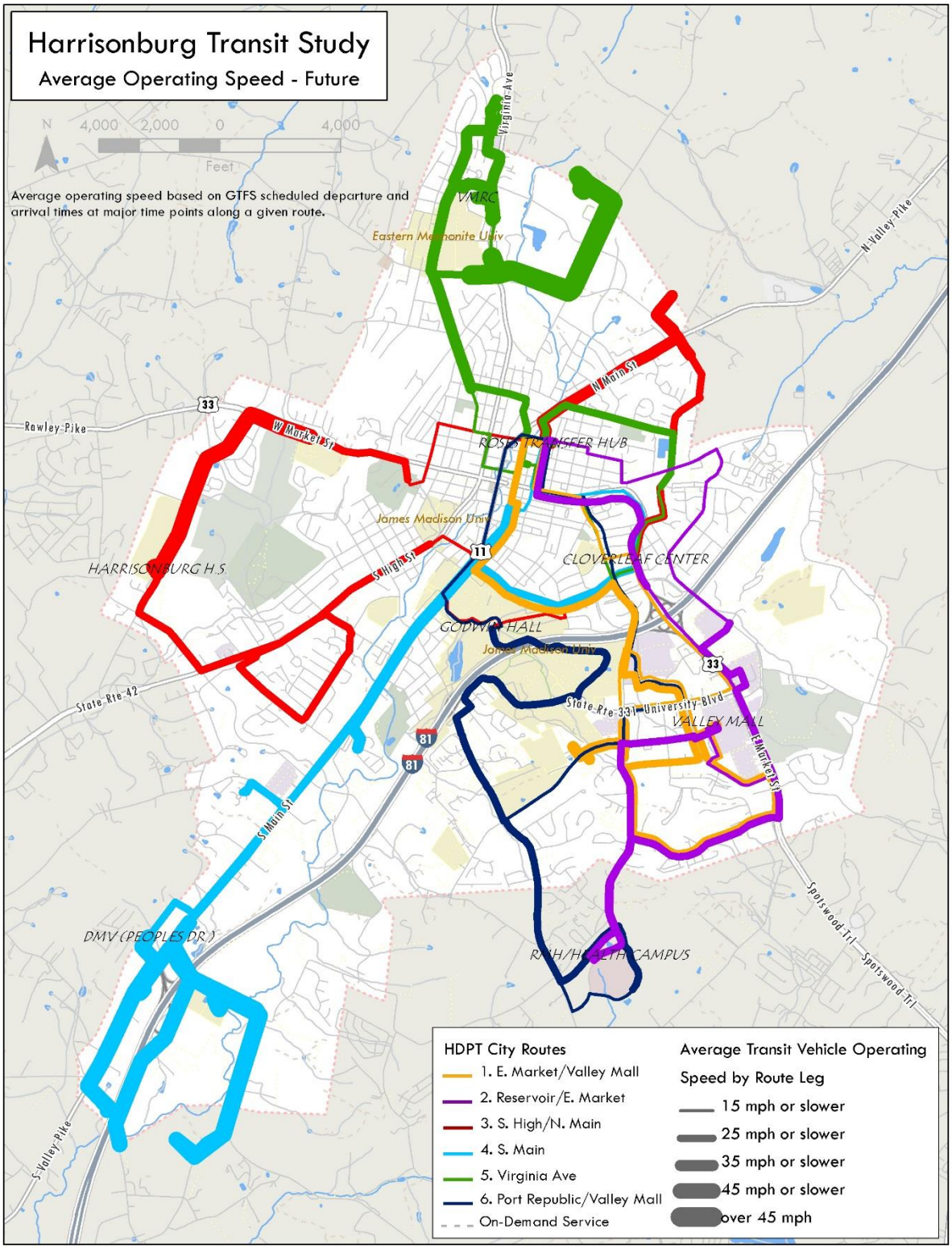


Figure 8 – Map of Average Transit Vehicle Operating Speed by Route Leg for Proposed Future System

Ridership

Estimates of ridership activity associated with the new routing scheme that includes the new route 6 and modified routes 1 and 2 were developed by referencing average passengers per revenue mile and per revenue hour. Similar to the estimation of operating costs, ridership rates were obtained from NTD and the TDP and reflect system wide average performance. An additional source - automated passenger counts (APCs) from HDPT - was also referenced to compare ridership rates on the City Routes network to those observed for the entire system. Reviewing all of these sources, average ridership rates of 12.77 passengers per hour and 0.96 passengers per mile were used in this analysis. Table 5 shows the projected ridership for the existing and proposed City Routes network and for the new route 6.[8]

Table 5 – Ridership Estimates for Existing and Future Systems

Ridership estimate based on...	Revenue Vehicle Hours	Revenue Vehicle Miles
Existing System	222,387	244,751
Future System	267,179	279,297
Proposed Route 6	44,465	37,933

The table reveals that ridership is expected by about 15 to 20 percent, commensurate with the increase in service provided and operating costs.

Summary of Findings

The HTS has proposed the addition of the new route and modification of two existing routes. The proposed changes address some of the issues and limitations confronting the existing system and enhance HDPT's service to its core ridership markets, including students, seniors and low income populations.

- System wide accessibility increases by around 15 percent, making transit service more relevant and convenient to all residents, workers, and visitors in Harrisonburg.
- Connectivity increases by around 30 percent, allowing more varied and expedient travel itineraries between some key generators.
- The accessibility and connectivity benefits are partly attributable to new transfer opportunities that will be available in southeast Harrisonburg. These transfer opportunities should reduce the frequency with which buses are held to accommodate transferring passengers.
- Some redundant routing options have been provided to and from southeast Harrisonburg. Redundancy gives patrons a fall-back option if they miss their regular bus, benefitting low income riders especially, who often have limited options for accessing employment opportunities.
- Routes 1 and 2 have been modified to make their routing more direct, which will enable those routes to stay on schedule more often. This should have a knock-on effect, improving on-time performance and travel time reliability throughout the system.

[8] As was done for cost comparisons, ridership estimates for the existing City Routes network have been estimated using the same methods used to estimate costs for the future City Routes network, providing a consistent framework for comparing future ridership with existing ridership.

- Travel speeds on the new and modified routes are expected to be more consistent and manageable, improving on-time performance and making travel more predictable for patrons.
- Ridership is expected to increase commensurately with the amount of service provided, but operational costs are likely to increase at a slightly slower rate, suggesting that the proposed enhancements to the City Routes network are an efficient use of available resources.

Additional Considerations for Future Expansions and/or Modifications of the City Routes Network

As Harrisonburg continues to grow, transit service will become an increasingly important travel option for more and more people in the City. The ridership profile may shift slightly to include more choice riders - individuals who have access to a car but choose to use transit for various reasons.

- Create more bi-directional service: Most of the current service is one-way. This can make it difficult for patrons to take advantage of the service HDPT.
- Increase opportunities to transfer between routes: Currently there are three main transfer points: the Roses hub, the Cloverleaf Center, and Godwin Hall. The proposed City Routes network will create additional transfer opportunities at Valley Mall and the Walmart location in southeast Harrisonburg. Creating additional transfer locations as part of further system expansions or modification would add redundancy to the system, enhance system connectivity and accessibility, and alleviate system wide scheduling strains resulting from holding other buses to accommodate riders' transfer needs.
- Consider cross-town routes: All existing routes converge at the Roses hub near downtown Harrisonburg. Adding cross-town routing options could create more direct service between popular destinations outside the downtown area, augment new transfer opportunities, and make service more attractive to a larger share of the traveling public.
- Normalize on-demand service: A substantial contributor to delays on the existing City Routes network is on-demand service provided to locations with infrequent ridership. In some cases, it may be worth considering eliminating the on-demand nature of these legs and incorporating them into regular or alternative fixed route service. For example, the on-demand legs at the southern end of route 4 are lengthy, and serving calls to the area creates substantial delays for the route, and by extension the system. It may be possible to create alternating service in which route 4 serves the northern on-demand leg as part of regular fixed route service one hour and serves the southern on-demand legs as part of regular service the next hour. This would enhance the predictability of the route, making it more convenient for all users.
- Improve span and frequency of service: As resources become available to improve transit operations in Harrisonburg, it may be more efficient to use those funds to increase the frequency of transit service on the busiest routes and/or expand the hours of operation rather than add a new route.