ANALYTICAL MEMORANDUM

OPTION 5: Public transit route evaluation

Urban Planning M255

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6 November 2021

Executive Summary

This analytical memorandum evaluates the Santa Monica Big Blue Bus (BBB) 17 line. Using ridership data from September 2021 provided by BBB and our experiences from riding the line during the peak and off-peak periods, we were able to determine attributes such as the line's service characteristics, the allocation of passengers by time of day, and the line's service effectiveness. Some of our key findings from this analysis include:

- Northbound ridership is higher during AM peak, and southbound ridership is higher during PM peak
- Ridership is low based on the passengers per vehicle service hour, passengers per vehicle mile, and load factor measures
- Students and commuters appear to be the primary users, and this is unlikely to change after the pandemic
- This line primarily serves trip types that include commuting to school or work, medical purposes, errands, and traveling to restaurants

Additionally, we propose implementing the following changes to improve the line:

- Rerouting the line at Sawtelle Boulevard between West Pico Boulevard and Exposition Boulevard from a clockwise circle to a more efficient U-shape
- Updating the timetable to account for delay times on Wilshire Boulevard to improve travel time reliability and potentially increase ridership
- Reducing headways for the final departures of weekday southbound trips to better accommodate students traveling home in the late evening hours

M E M O R A N D U M

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DATE: 6 November 2021

SUBJECT: Public Transit Route Evaluation: Santa Monica Big Blue Bus 17

For this project, we evaluated the Santa Monica Big Blue Bus (BBB) Line 17. We chose this line because we have ridden it to and from campus, so we are somewhat familiar with its path and types of passengers. Additionally, we had learned at the beginning of the quarter that the 17 was providing additional service for UCLA's BruinBus U1 Weyburn shuttle, so we believed that more students might be riding it now as well ("BruinBus"). Many bus lines have changed service since the beginning of the pandemic; in the case of the 17, the earliest two weekend buses in the northbound route and the earliest weekend bus in the southbound route are now only offered on Saturdays. Through this project, we hoped to identify ridership patterns and provide recommendations based on our own experience of riding the 17 line, with particular attention to how the pandemic might have affected and will continue to affect the line.

1. What were the methods of research?

We contacted BBB for ridership data, which they were able to provide for Septembers 2019, 2020 and 2021. To simplify analyses, we only used data for September 2021, which is linked as a Google Sheets file in Appendix A. We aggregated this data by service direction, service day type,

and start time using the Python data analysis library pandas, so we could determine the averages of various measures of service effectiveness based on start time. We rode the line on Friday, October 29, boarding at 2:51 PM and alighting at 5:07 PM after riding it round-trip. We decided on this time of day after looking at the BBB data and its PM peak for weekday service and comparing it with general congestion hours for Friday commutes in Los Angeles since the pandemic (Smith).

We used the September 2021 ridership data to estimate quantitative measures of effectiveness, and our experience for qualitative descriptions of passengers and demand. Using both sources in conjunction, we have determined recommendations for improving the line's service effectiveness.

2. What are the line's service characteristics?

Line 17 follows a northbound route that begins at Culver City Station and ends at MacGowan Hall at the UCLA campus, with the southbound route being the reverse. There are 34 stops in the route ("Route 17"). The northbound service runs from 5:50 AM to 7:15 PM on weekdays, 6:50 AM to 7 PM on Saturdays, and 7:50 AM to 7 PM on Sundays ("Little Blue Book"). The southbound service runs from 6:28 AM to 10:08 PM on weekdays, 7:35 AM to 7:43 PM on Saturdays, and 8:05 AM to 7:43 PM on Sundays ("Little Blue Book"). The headways are around 20 minutes on weekdays and around 30 minutes on the weekends ("Little Blue Book", Schweitzer). The exception on the weekdays is the southbound service, which has headways of 30 minutes and then finally of 1 hour in the last few departures of the day. The total round trip

time, from riding the line, was around 2 hours and 15 minutes. Based on the BBB data for September 2021, the average scheduled operating speed for the northbound route is 11.8 miles per hour and 12.0 miles per hour for the southbound route. Additionally, from the data, the total number of passengers for September 2021 was 11,410 for the northbound route and 10,495 for the southbound route, for a total of 21,905 (see Appendix A).

3. What is its allocation of passengers by time of day?

To evaluate the allocation of passengers by time of day, we used the ridership data obtained from BBB that includes total passenger counts for each scheduled bus in the month of September 2021 for both the northbound and southbound directions.

Based on BBB's definition of the time periods of the day, we have designated the following:

- AM peak: 6:40 AM to 9:45 AM
- Midday: 9:45 AM to 2:30 PM
- PM peak: 2:30 PM to 5:31 PM
- Evening: 5:31 PM to 10:08 PM

For each of the defined time periods in a day, we found its average passenger count for each service day type (full-service weekday, full-service Saturday, full-service Sunday) in September 2021. The results are given in Tables 1 and 2 below.

Table 1

Northbound 17 Line Average Passenger Count

	Weekday	Saturday	Sunday
AM peak	19.56	6.85	6.45
Midday	13.19	8.49	9.00
PM peak	13.77	9.24	8.67
Evening	7.52	8.00	4.78

Table 2

Southbound 17 Line Average Passenger Count

	Weekday	Saturday	Sunday
AM peak	7.40	4.12	3.17
Midday	10.94	8.61	8.26
PM peak	23.08	11.71	9.83
Evening	13.02	10.56	10.24

As we can see, the highest ridership occurs during the PM peak of weekdays in the southbound direction. It is possible that, during this time, many workers are commuting home to Culver City or connecting to the LA Metro E Line at the route's terminal. On the other hand, the lowest ridership occurs during the AM peak of Sundays in the southbound direction. In fact, we see that average passenger counts are relatively low for the southbound AM peak of all service day types. This could be because the 17 line is used to connect residential zones in its south end to Westwood, a major commercial district, in its north end; thus, it is unlikely that many workers or students would commute away from Westwood during weekend mornings.

4. What is the line's service effectiveness?

Using the same ridership data provided by BBB, we analyzed the service effectiveness of the 17

line using the following measures:

- Peak to off-peak bus ratio
- Passengers by service day type
- Passengers per vehicle service hour
- Passengers per vehicle service mile
- Load factor

Presented below are the results and analyses for each measure.

Peak to off-peak bus ratio

Table 3

Northbound 17 Line Peak to Off-Peak Bus Ratio

	Weekday	Saturday	Sunday
Total Peak Buses	595	80	70
Total Off-Peak Buses	121	9	9
Peak to Off-Peak Bus Ratio	4.92	8.89	7.78

Table 4

Southbound 17 Line Peak to Off-Peak Bus Ratio

	Weekday	Saturday	Sunday
Total Peak Buses	512	74	66
Total Off-Peak Buses	178	16	17
Peak to Off-Peak Bus Ratio	2.88	4.63	3.88

Assuming a constant number of passengers, a uniformly-distributed arrival of passengers, uniform headways, and constant operating cost, the optimal number of buses increases with the square root of the increase in the number of passengers (see Appendix B) (Black). This

means that, for example, to optimize for bus service, an increase in passengers by a factor of 4 would require a doubling of bus frequency (Black).

Comparing the peak to off-peak bus ratio to the peak to off-peak passenger ratio (see Appendix C), we see that for the northbound route, the peak to off-peak bus ratio surpasses the optimal bus ratio for all service day types (see Table 3). This means that the frequency of buses during peak hours exceeds the optimal amount, according to the formula in Appendix B. The same is true for the southbound route (see Table 4).

Table 5

Northbound 17 Line Optimal Bus Ratio

	Weekday	Saturday	Sunday
Peak to Off-Peak Bus Ratio	4.92	8.89	7.78
Optimal Bus Ratio	3.28	3.04	3.72

Table 6

Southbound 17 Line Optimal Bus Ratio

	Weekday	Saturday	Sunday
Peak to Off-Peak Bus Ratio	2.88	4.63	3.88
Optimal Bus Ratio	1.76	1.94	1.73

Although the peak to off-peak bus ratios suggest that BBB is servicing more buses during peak hours than it should (see Tabes 5 and 6), it is possible that headways have not changed during the pandemic to prevent crowding and allow passengers to social distance more easily (Goldberg). Additionally, studies have shown that the perceived burden of waiting for transit is 1.5 to 4.5 times greater than that of riding transit (Iseki et al.). Therefore, it is unreasonable to

“optimize” the line by decreasing frequency as this would be a major inconvenience to those who depend on the line and could lead to a further decrease in ridership.

Passengers by service day type

Table 7

Northbound 17 Line Passengers By Service Day Type

	Weekday	Saturday	Sunday
Average Passengers	14.02	8.28	8.06
Total Passengers	10036	737	637

Table 8

Southbound 17 Line Passengers By Service Day Type

	Weekday	Saturday	Sunday
Average Passengers	13.04	8.93	8.36
Total Passengers	8997	804	694

Analyzing the passengers by service day type in Tables 7 and 8, it is interesting to note that there were more passengers traveling northbound than southbound for all service day types. This may be due to the trend that people’s morning travel behavior on the weekdays is heavily influenced by their work start times, leading to large peaking patterns in the morning (Taylor). On the other hand, travel during the evening times of weekdays are typically more temporally flexible, spreading the PM peak travel times more evenly throughout the evening (Taylor). The ridership data that could support this conclusion can be seen in Appendix A.

Additionally, it is likely that the BBB 17 line experienced a particularly large drop in ridership due to the pandemic. The 17 line lies almost entirely in the West Hollywood and Westwood

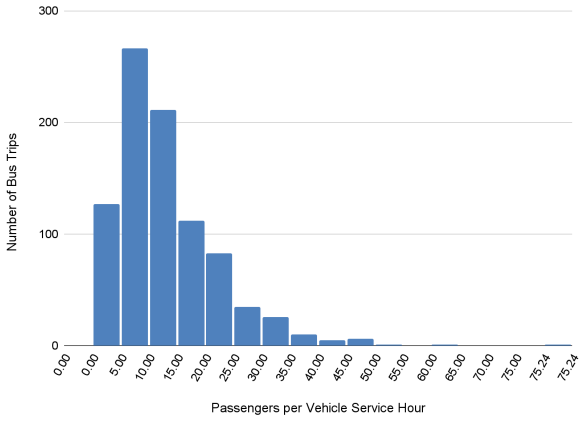
neighborhoods, which are approximately 75% and 86% white, respectively (*West Hollywood, CA*; *Westwood, CA*). By comparison, the racial makeup of Los Angeles County is only 26% white (*Los Angeles County, CA*). According to a New York Times article, neighborhoods that were whiter experienced the greatest loss in ridership in major cities in the US such as Atlanta, Miami, Minneapolis, and Portland, Oregon (Badger & Bui). If the pattern in these cities is any indication of a larger national trend, it is possible that the 17 line lost a greater percentage of riders during the pandemic than other lines in the county that serve more diverse populations.

Passengers per vehicle service hour

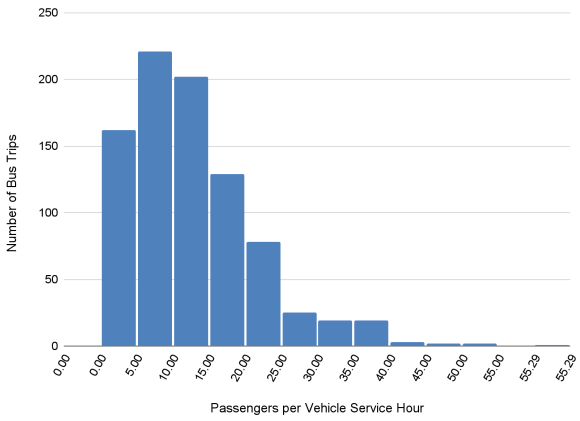
Figure 1

Histogram of passengers per vehicle service hour

Northbound



Southbound



The average passengers per vehicle service hour is 12.89 and 12.40 for the northbound and southbound route, respectively. However, as we can see from the histograms in Figure 1, the distribution of the passengers per vehicle service hour values is skewed right for both route directions, suggesting that there are a small number of high-value data points that are

impacting the overall average. For example, we can see in Figure 1 that there are data values that go up to 75.24, which is much greater than the average. Therefore, the median may instead be used to provide a more realistic sense of what passengers per vehicle service hour values may be expected for both directions. The median passengers per vehicle service hour is 10.91 for both the northbound and southbound routes.

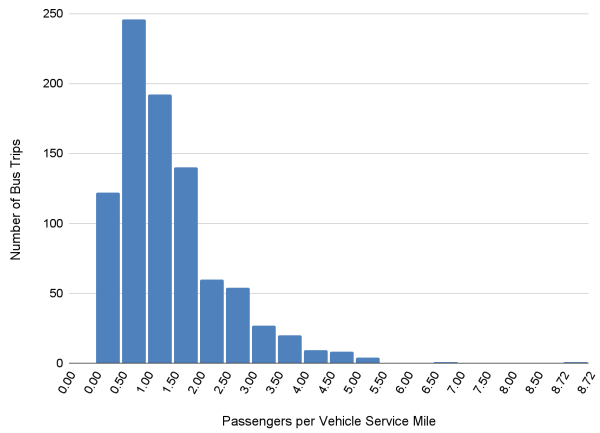
Given that there are approximately 38 vehicle seats on average, the median passengers per vehicle service hour seems relatively low for both directions as it amounts to only about 30% of the seat capacity available on the vehicle. This indicates that there are opportunities to increase headways to increase service effectiveness. However, as previously mentioned, headways may be kept low to encourage social distancing and decrease crowding as pandemic conditions remain.

Passengers per vehicle service mile

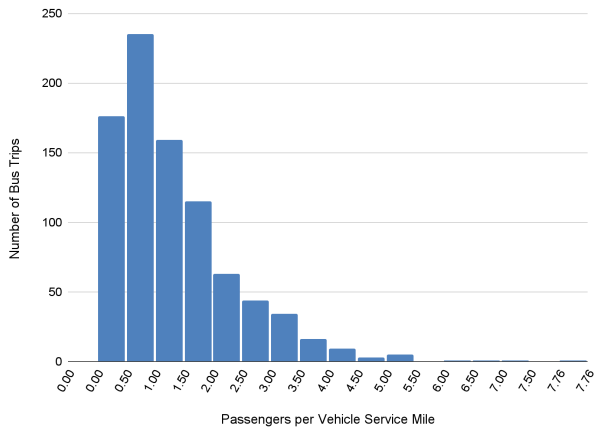
Figure 2

Histogram of passengers per vehicle service mile

Northbound



Southbound



The average passengers per vehicle service mile is 1.43 and 1.33 for the northbound and southbound route, respectively. Similar to the passengers per vehicle service hour measure, the distribution of passengers per vehicle service mile is skewed right, which suggests the median may be a better estimate of the expected passengers per vehicle service mile for a typical trip (see Figure 2). The median passengers per vehicle service mile is 1.10 for both the northbound and southbound routes. These median values are near the low end of the distribution of values, suggesting a low service effectiveness for the line.

Load factor

Table 9

Northbound 17 Line Average Max Load Factor

	Weekday	Saturday	Sunday
AM peak	0.33	0.13	0.10
Midday	0.22	0.16	0.16
PM peak	0.22	0.18	0.17
Evening	0.13	0.17	0.10

Table 10

Southbound 17 Line Average Max Load Factor

	Weekday	Saturday	Sunday
AM peak	0.12	0.08	0.06
Midday	0.18	0.15	0.15
PM peak	0.37	0.24	0.19
Evening	0.23	0.22	0.23

Note. To calculate the average max load factor values, the max load was divided by the number of seats for each trip in the data and then averaged. To see the average max load values, which does not divide by the number of seats for each trip, see Appendix D.

The load factor data shown in Tables 9 and 10 mirror the average passenger count data shown in Tables 1 and 2 in that the highest average max load factor occurs during the PM peak of weekdays in the northbound route and the lowest occurs during the AM peak of Sundays. Once again, this is likely due to commuting patterns to and from Westwood during the weekdays. The max load factor has likely changed during the pandemic due to work-from-home and hybrid work policies that have allowed for greater flexibility in workers' schedules and have led to a more even distribution of trips made throughout the day (Badger & Bui). Thus, it is likely that these new policies have led to a decrease in max load factor variability between peak and off-peak periods.

5. Who uses the line?

From riding the line, we noticed that passengers were predominantly students. We made this assumption because these passengers boarded or alighted at stops on UCLA campus, or often carried backpacks and seemed college-age. We noticed this was true for both directions, and for both peak and non-peak service types. Other than students, at the Veterans Affair Medical Center, several people boarded and alighted together at a later stop in Culver City. Additionally, as the route runs alongside the Sawtelle Shopping Center and the Trader Joe's on South Sepulveda Boulevard and Palms Boulevard, it is reasonable to assume that some riders use the line to run errands. UCLA students and others around the route may also ride the line to visit the abundance of restaurants in the Sawtelle neighborhood.

The 17 line also provides a unique route compared to other lines servicing UCLA. For one, the

line may be a critical connection for workers and students in Westwood and UCLA commuting from the southern areas of Los Angeles as the line is one of the only bus services that connects to LA Metro Rail stations from Westwood/UCLA. In addition, the 17 line is the only bus service that connects Westwood/UCLA to Palms, a diverse and dense residential neighborhood.

Although we tried to ride the line at peak hours for the southbound direction based on the ridership data provided by BBB, we realize that a Friday afternoon might not be typical of most weekdays, as many people — such as commuters — may follow slightly different schedules on Fridays.

We do not believe the user base will change significantly after the pandemic, as students who live further away from campus or who do not have other transportation options such as cars will still likely ride the line. Additionally, during the pandemic, many of the people still riding buses were essential workers who did not have the flexibility of working remotely, so we do not expect that the types of riders will change (“UCLA Arrowhead”). However, we would hope that ridership volumes would increase.

6. What trip types does the line serve?

Trip generators are locations that may motivate travel in the first place, such as schools, medical facilities, government services, recreational opportunities, and other high-density uses, while trip producers refer to the residential land uses where the trips may originate from.

From our experience riding the line, we determined the following major trip characteristics:

Trip generators:

- UCLA
- Veterans Affairs Medical Center
- Trader Joe's
- Sawtelle Shopping Center
- Sawtelle restaurants

Trip producers:

- Students living on UCLA campus
- Palms neighborhood residents

Trip types:

- Commuting to school
- Commuting to work
- Medical purposes
- Errands
- Traveling to restaurants

We do not think these have significantly changed due to, or will change after, the pandemic. We would imagine that these would have been different during the start of the pandemic — for instance, when UCLA courses were made remote, or many establishments were temporarily closed. But as things are gradually opening back up, and as the 17 seems to be heavily frequented by students and commuters, we believe these passengers who may not have

alternative transportation options would continue riding the bus for the same purposes.

7. What are the major patterns of travel demand?

The following are the patterns of travel demand that we determined from September 2021 data as well as our experience of riding during the pandemic.

Temporal

Figure 3

Northbound 17 Line Service Peak Times

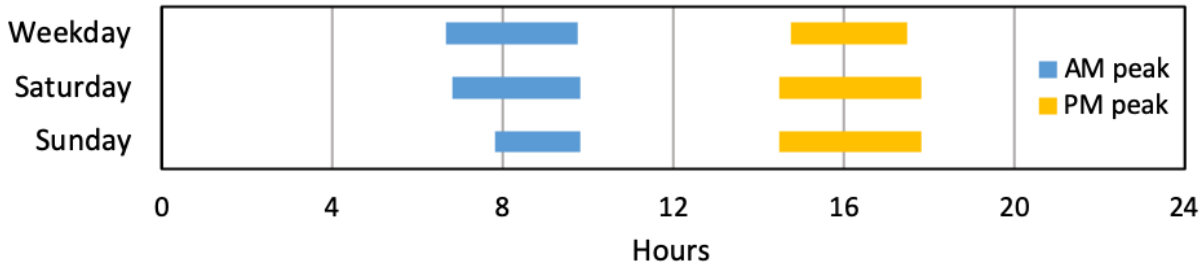
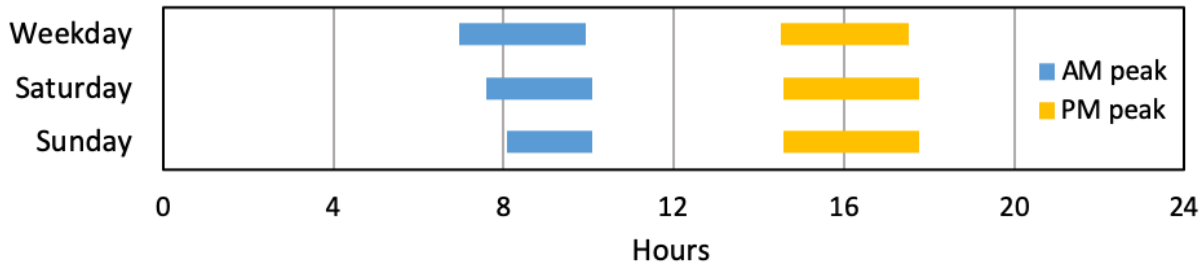


Figure 4

Southbound 17 Line Service Peak Times



Spatial

- Many passengers boarding and alighting at UCLA campus stops
- Several passengers boarding and alighting at stops by LA Metro Rail stations

Directional

- Northbound ridership higher during AM peak
- Southbound ridership higher during PM peak

We do not think these are likely to change after the pandemic, as it seems that many passengers are headed to and from the UCLA campus. Students and others working at UCLA would continue riding the bus if it was their preferred or only transportation mode option.

8. What are some strengths and weaknesses of the service?

We propose that the 17 line has the following strengths and weaknesses:

Strengths

- Many stops on UCLA campus for greater traveler flexibility
- Stops spaced out well along route
- Ability to reach three LA Metro Rail stations

Weaknesses

- Awkward routing on Sawtelle Boulevard between West Pico Boulevard and Exposition Boulevard
- Consistent delays when taking left turn from Wilshire Boulevard onto Veteran Avenue
- Low ridership during Fridays and weekends

9. How can the line be improved?

The following are some suggestions on how the 17 could be improved.

Awkward routing

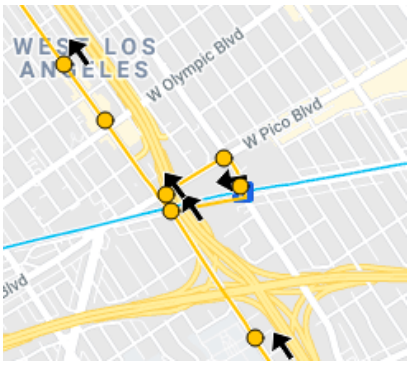
The routing on Sawtelle Boulevard between W Pico Boulevard and Exposition Boulevard involves a clockwise circle by going to:

1. Sawtelle / Exposition
2. Pico / Sawtelle
3. Pico / Sepulveda
4. Sepulveda / Exposition

Instead, the route could run with 2-4 in reverse, as:

1. Sawtelle / Exposition
2. Sepulveda / Exposition
3. Pico / Sepulveda
4. Pico / Sawtelle

Figure 5
Existing routing of northbound 17 line



However, to achieve this, four bus stop locations would need to be moved:

- Sawtelle / Exposition to the other side of Exposition Boulevard
- Sepulveda / Exposition to the other side of Sepulveda Boulevard
- Pico / Sepulveda to the other side of W Pico Boulevard
- Pico / Sawtelle to the other side of W Pico Boulevard

This would change the awkward clockwise circle route into a more efficient U-shape (Walker).

We recognize that moving bus stop locations can be very challenging, as the riders need to be

informed sufficiently early to avoid misunderstandings and potential conflict. Thus, while it will reduce total vehicle hours on the line and could reduce headways and thus increase frequency, it might be difficult to initially implement.

Consistent delay

Due to high levels of traffic on Wilshire Boulevard, in addition to the need to change two lanes to the left, the 17 does slow down along this street. The left turn on Veteran Avenue has two left turning lanes, but because of the traffic, many vehicles including the 17 have to often wait for more than one signal cycle to be able to take the turn. As a result, the 17 is consistently delayed at this point along its route. While this delay is not something that seems avoidable by changing the route of the 17 line, we believe that updating the timetable to account for this, such as modifying the stops following this turn to have a slightly later bus arrival and departure time, would be useful (Schweitzer). As mentioned earlier, the perceived burden of waiting for transit is, on average, 3 times greater than that of riding transit (Iseki et al.). Although routing applications like Google Maps and other apps do track the real-time locations of the buses and would update the time estimates, given the consistent nature of this occurrence, it makes sense to have it officially reflected in the timetable to make it easier for passengers to incorporate the later times into their own schedules.

Reduce headways for final departures of weekday southbound trips

UCLA's BruinBus U5 Evening/SafeRide shuttle loops around campus on weekday nights. Recently, however, the third to last departure, which leaves MacGowan Hall at 9:01 PM, is no

longer serviced (BruinBus). This means that for many students who might be out late on the east or south sides of campus, will only have two choices of getting home by bus, both of which have large headways (Schweitzer). The U5 shuttle stops southbound service at 10:20 PM and the 17 stops southbound service at 10:08 PM, but students who miss the 9:01 PM departure of the BruinBus and the 9:08 departure of the 17 will have to wait at least an hour to be able to take a bus back ("BruinBus", "Little Blue Book"). As a possible solution, the headways in the off-peak morning hours on weekdays could be increased slightly and another offering of the 17 going southbound could be departing MacGowan Hall at 9:38 PM. This will help students and other people who might be staying later on campus feel more comfortable about their transportation options, especially as the 17 southbound route runs past Westwood to Culver City and might reduce passengers' need to transfer at these later night times, which would also lower the perceived burden of waiting and transferring (Iseki et al.).

We hope that these recommendations will help increase ridership by attracting more riders due to increased frequency and reliability. However, we recognize that, as pandemic conditions continue, ridership may still be heavily dependent on those who rely on the line and that more may need to be done in the future outside of adjusting transit routing and service such as policy reform to encourage a modal shift from vehicle travel to transit (Taylor).

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Appendix

Appendix A

Link to September 2021 ridership data for the BBB 17 line:

https://docs.google.com/spreadsheets/d/19P5v-3AlNrHswa83oQJ0JpDtm30gONOo/edit?usp=sharing&ouid=102413519726003852206&rtpof=true&sd=true

Link to calculations spreadsheets:

https://drive.google.com/drive/folders/1bKVIm4s1uaYItPRCqzACd3Qd7MDONakE?usp=sharing

Appendix B

$$f_{optimal} = \sqrt{pt/2q}$$

where:

- f = frequency of service, buses per hour
- p = passengers per hour
- q = operating cost per bus-hour, $
- t = value of time, $/hour

Note. Reprinted from *Urban Mass Transportation Planning* (p.196), by A. Black, 1995, McGraw-Hill.

Appendix C

Peak to off-peak passenger ratio

Table 11

Northbound 17 Line Peak to Off-Peak Passenger Ratio

	Weekday	Saturday	Sunday
Peak Passengers	9182	665	594
Off-peak Passengers	854	72	43
Peak to Off-peak Passenger Ratio	10.75	9.24	13.81

Table 12

Southbound 17 Line Peak to Off-Peak Passenger Ratio

	Weekday	Saturday	Sunday
Peak Passengers	6802	635	520
Off-peak Passengers	2195	169	174
Peak to Off-peak Passenger Ratio	3.10	3.76	2.99

Appendix D

Table 13

Northbound 17 Line Average Max Load

	Weekday	Saturday	Sunday
AM peak	12.62	4.60	3.55
Midday	8.62	5.43	5.43
PM peak	8.60	6.08	5.50
Evening	4.97	5.89	3.56

Table 14

Southbound 17 Line Average Max Load

	Weekday	Saturday	Sunday
AM peak	4.79	2.76	2.08
Midday	6.94	5.48	4.87
PM peak	14.14	7.92	6.57
Evening	8.88	7.56	7.24