Cummins LeaperX Project
Route Optimization

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Introduction

CityBus Lafayette has provided free transportation to Purdue students as a part of student tuition for years. In fall 2019, Purdue and Cummins introduced LeaperX, a free on-demand transportation service, mainly supporting the existing Black and Gold/Aviation Tech Loops. Ultimately, Cummins and Purdue want to determine how to better the existing transit system to fit student needs. With concerns such as student distribution on camp weather, and ensuring that students can move both safely and effectively, Purdue wants to take the next step in regards to transportation.

Research Questions

- Are there parts of campus with more need for transit than others?
- Are there parts of campus not seeing any transit need?

Methodology

- Given access to CityBus and Purdue Building Data
- Created "neighborhoods" for stops based on closest stop to each building per loop
- In much area does a stop cover, versus how many people does it serve?

Measures of Coverage

- Independent of usage, how can the usefulness of a stop be gauged based on other factors
- Based on distance rank, stop distance, population, and number of buildings, compared to stop usage

Figure 1: Live gif of current coverage rates for CityBus Stops adjusted for population, runs 7:30-5:30 M-F

Figure 2: A map depicting all of the stops on the nightly Black Loop, with its respective score representing the size of the dot. Stop scores are based on distance and if it is one of the 3 closest stops to a building

$$\sum_{n=1}^{3} \frac{1}{n}(.5 - distance)$$

Figure 3: Chart plotting the usage rates of Black Loop Stops vs their coverage rates at 11pm at night. Purdue Memorial Union and MacArthur and 1st (near Earhart Hall) see most usage, being centers of food and housing. Many stops fall into the low coverage, low usage stops, which could be deemed to be inefficient as a stop on a scheduled route.

CityBus Analysis
Assumptions and Measures of Student Population

- Students attend all classes at scheduled times in scheduled places
- All beds in residence halls are filled
- If not in class, students are independently dispersed throughout campus, regardless of major, year, learning communities, etc.
- No availability of library and dining hall information
- After 6pm, student population in parts of campus cannot be accurately calculated due to lack of class, club, and facility information
- If not in class, 70% of students are expected to not be in residence halls, based on estimates based on assumptions above

Night Analysis

- Compared coverage data to stop usages
- Used as a "substitution" for population, as population is unknown, per assumptions
- High coverage & high usage means stop is efficient
- High coverage and low usage means that it acts an 'umbrella stop'
  - Functions as a stops that serves a lot of area, but still does not see large counts
- Low coverage and high usage could break system
  - High concentration of people within small area; could lead to efficiency issue and mean that more stops are necessary nearby
- Low coverage and low usage means that stop is a potential outlier
  - People will use the stop, but does not serve a large population or area
  - Stops could be consolidated into "umbrella stop"
  - Do LeaperX users use service in these locations due to inefficiency with CityBus, and does that vary by time??
- MacArthur and First and Purdue Memorial Union Stops are most popular
  - Serves west extreme of campus where many residential halls as well as two dining courts are located
  - Union sees large student population due to location and services in the Union

LeaperX Analysis
Research Questions

- Where are LeaperX users using LeaperX to be picked up/dropped off at?
- Which LeaperX Stops are rendering CityBus stops inefficient/unnecessary
- What general areas of campus are students using LeaperX at different parts of the day?

Assumptions

- Same student population assumptions as CityBus analysis
- Same Measure of Coverage can be used
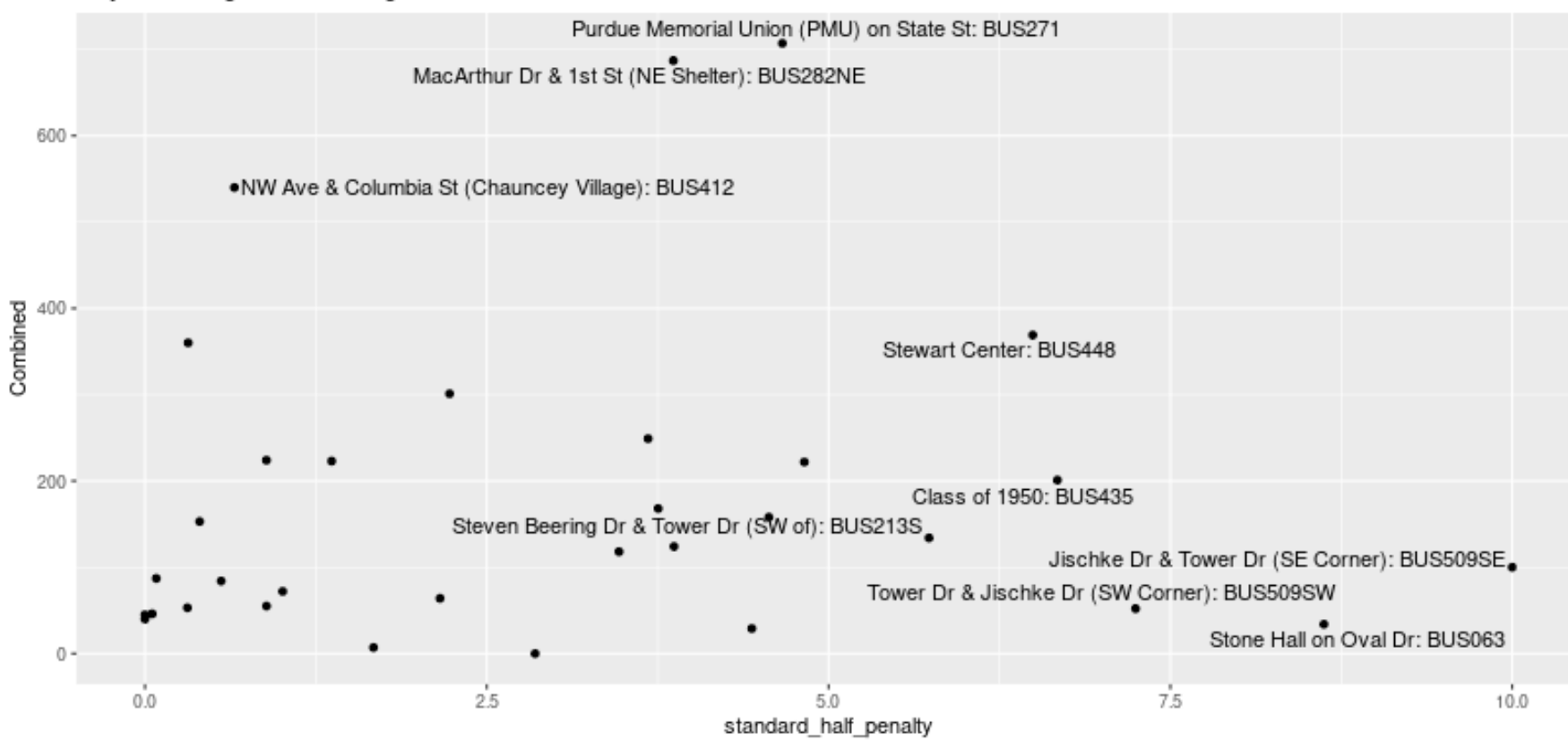- Stops are not necessarily inefficient at low usage, low coverage, as stops are on-demand, not scheduled

Figure 4: Live gif of current coverage rates for LeaperX Stops adjusted for population, runs 7:30-5:30 M-F
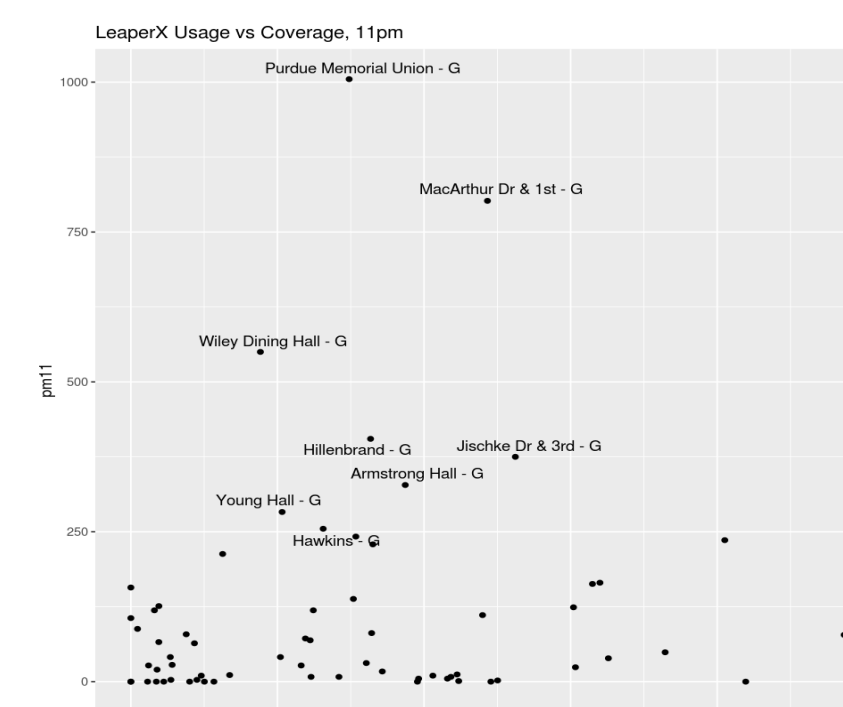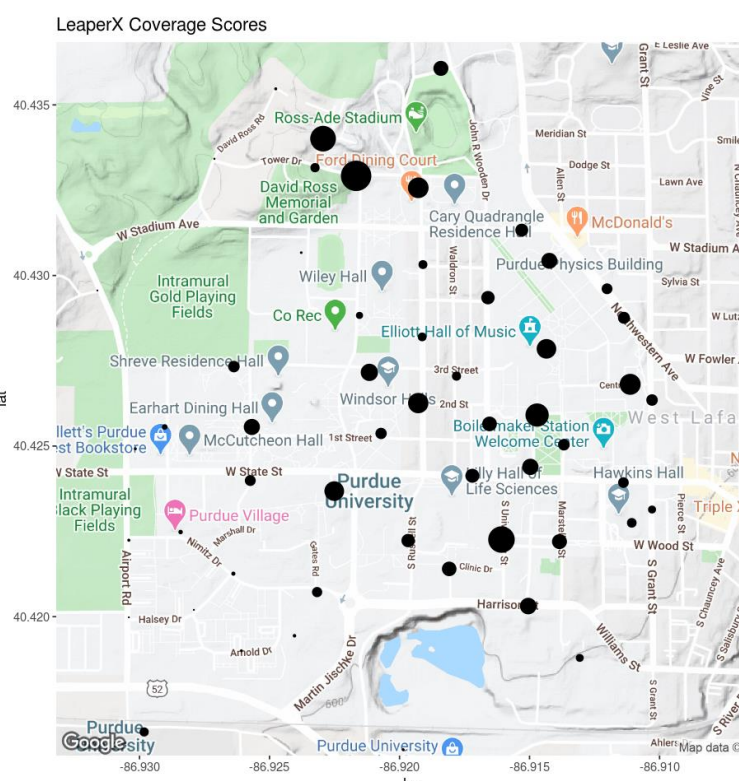

Figure 5: Graph with LeaperX coverage scores on the x-axis, and usage during Fall 2019 on y axis. Usage during 11pm hour only. Notable stops include PMU, Wiley, Hillenbrand, Armstrong, and Rawls Halls, all near residence halls or edges of campus, where off-campus students live

Figure 6: LeaperX version of night coverage map from figure 2. Coverage are less different in this map than in figure 2, meaning that stops are theoretically more efficient than on the Black Loop.

Findings

- Analyzed daytime coverage with the same metric but replaced locations with coordinates of LeaperX stops
- As seen in the moving pictures portraying the Purdue campus, LeaperX stops appear to have a higher coverage overall, but especially near the academic buildings.
- Coverage of most residence halls seem to be pretty similar.
- This leads to the result that LeaperX stops, with a more even spread across campus, will be of better benefit to students who live off-campus
- Sees most popular day stop near Aviation Tech building, at the southwest corner and was original goal of LeaperX
- Night hours see similar results in regard to popular stops, Hillenbrand, PMU, MacArthur are most popular stops
- Due to number of buildings in Hilltop Apartments, coverage outlier occurs at "Hilltop 1 - G", with a coverage rate double the next highest
- Aside from outlier, coverage rates are more uniform than CityBus coverage rates
- As night progresses, stops that are on the extremes of campus see more usage as opposed to earlier in the evening

Future Recommendations

- Based off findings, pilot program best served as complement to current transit system
  - Saw over 12,000 passenger pickup/drop-offs at Aviation Tech during daytime hours
- Filled in need for student movement to edges of campus during nighttime hours
  - Armstrong Hall, Rawls Hall, Hawkins Hall
- Best fits in as a way to reach outer, inaccessible locations by CityBus
- Allows better movement to academic buildings
- Increased transportation options for off-campus residents
  - Potential avenue to offer greater accessibility for students
- Future LeaperX Analysis
  - Cancellation Data determining how to improve LeaperX service
  - Natural Language Processing/Review Analysis to improve LeaperX service
  - Event/Weather Data to understand spikes in movement

Acknowledgements

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Cummins LeaperX Project

Student Volume – Maxim Barskiy, Jack Foster, Zane Greene, Krystian Misiewicz, Karthik Mutyala

Introduction

CityBus Lafayette has mainly provided free transportation to Purdue students for many years. During the Fall 2019 semester, Purdue and Cummins introduced LeaperX, a free service for Purdue students that provides transportation on the spot. LeaperX mainly supports the existing Black and Gold/Aviation Tech Loops. Ultimately, Cummins and Purdue want to determine how to better the existing transit system to fit students' needs. With an expanding student population and campus, Purdue would like to provide more options to their students to move around campus more efficiently and more safely.

The Cummins Corporate Partnership is focused on analyzing the intricacies of the existing CityBus transit system and the new LeaperX transit system. For the Student Volume team of the Cummins LeaperX Project, we investigated on how students move throughout campus and how this affect both transit systems. Specifically, we statistically analyzed the volume of students who go to class and who take either CityBus or LeaperX transportation.

Figure 1: Regression of Average Number of People on Bus versus Average Number of Students in Class (7:00 A.M. to 1:00 P.M.)
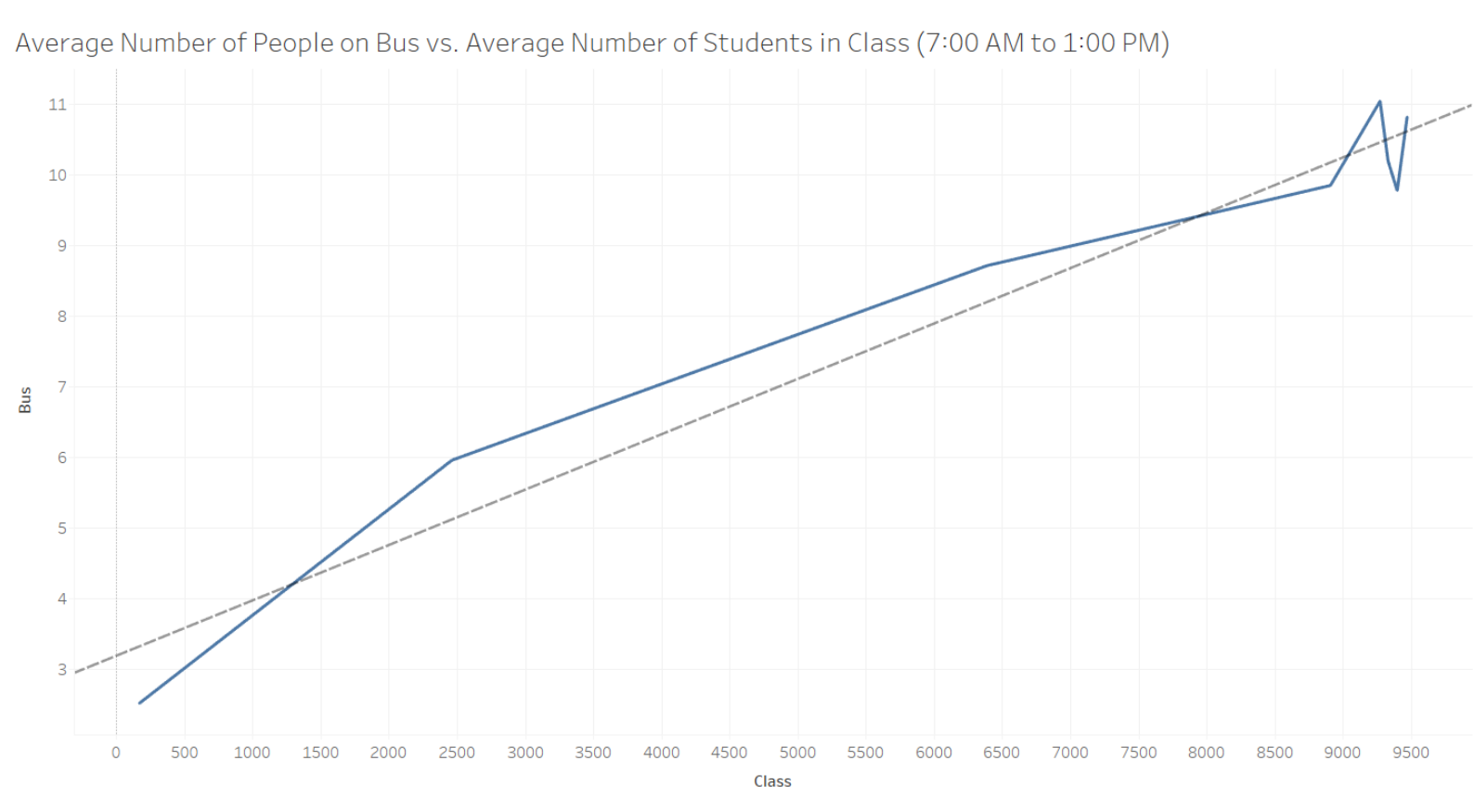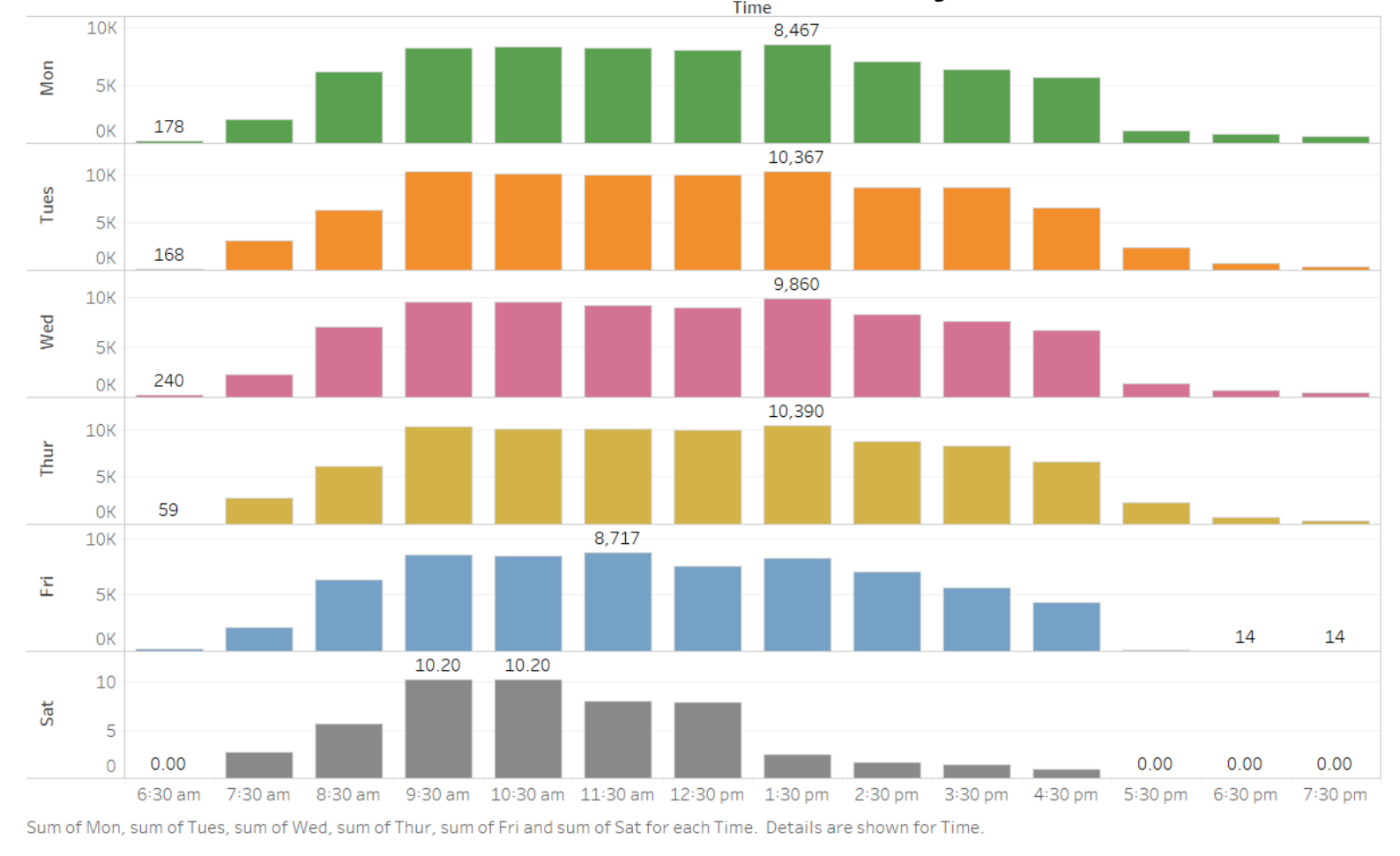

Average Number of People on Bus vs. Average Number of Students in Class (7:00 AM to 1:00 PM)

Figure 2: Distribution of Purdue Students in Class for Each Hour and Each Day

Class Distribution

Sum of Mon, sum of Tues, sum of Wed, sum of Thur, sum of Fri and sum of Sat for each Time. Details are shown for Time.

CityBus

Investigation:
• Is there a specific time of the day where the transit system is used the most?
• Is there a relationship between the average total count per loop and the number of students in class?
• Is there a relationship between the average board/load/alight counts and the hour of the day?

Methodology:
• Basic Statistical Analysis on R
• Linear Regression Analysis on Tableau

Insights:
• From 1:00 to 1:30 P.M., the CityBus transit system is used the most. We believe that since the number of students in class peaks at around 1:00 P.M., CityBus is used the most (see Figure 2).
• There appears to be a strong, positive relationship between the average total count per loop and the number of students in class from 7:00 A.M. to 1:00 P.M. (see Figure 1).
• There is a relationship between the average board/load/alight counts and the hour of the day (see Figure 5).
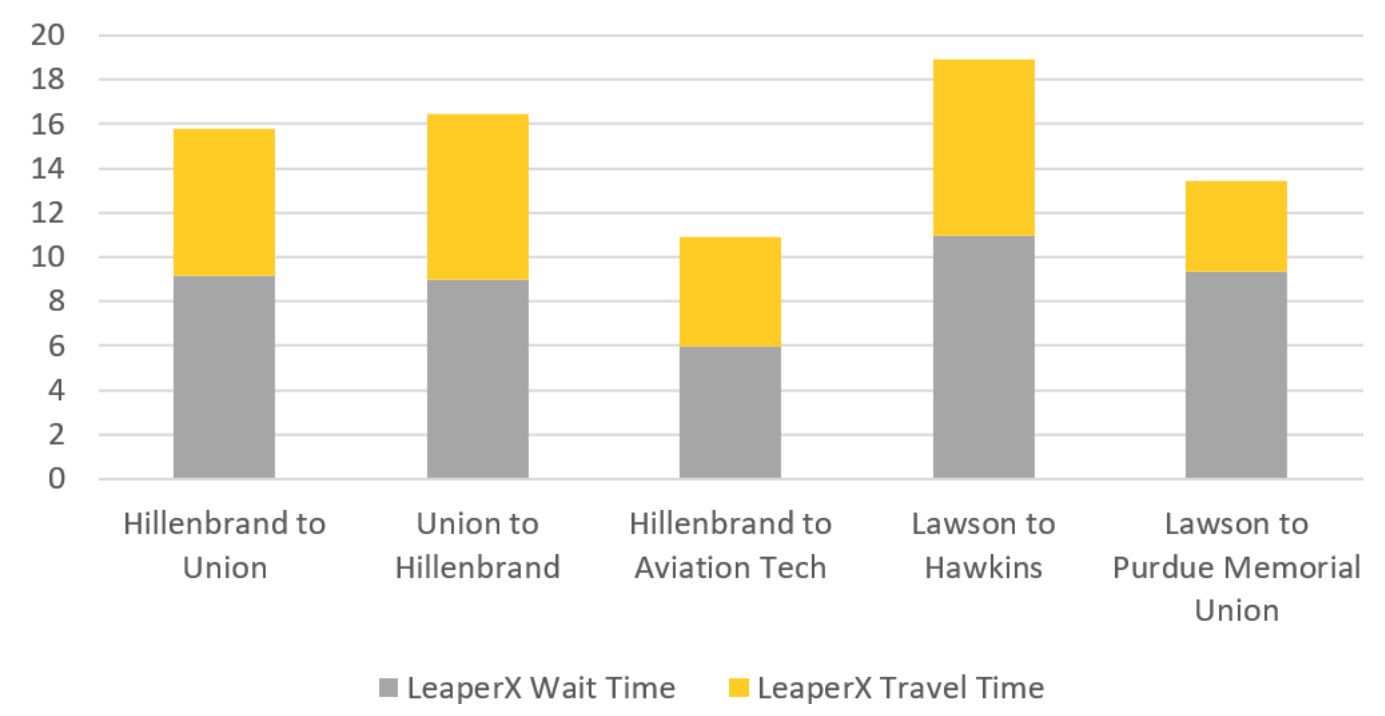
Figure 3: LeaperX Transit/Wait Times

■ LeaperX Wait Time ■ LeaperX Travel Time

Figure 4: Regression of Average Number of Passengers on LeaperX versus Hour of the Day
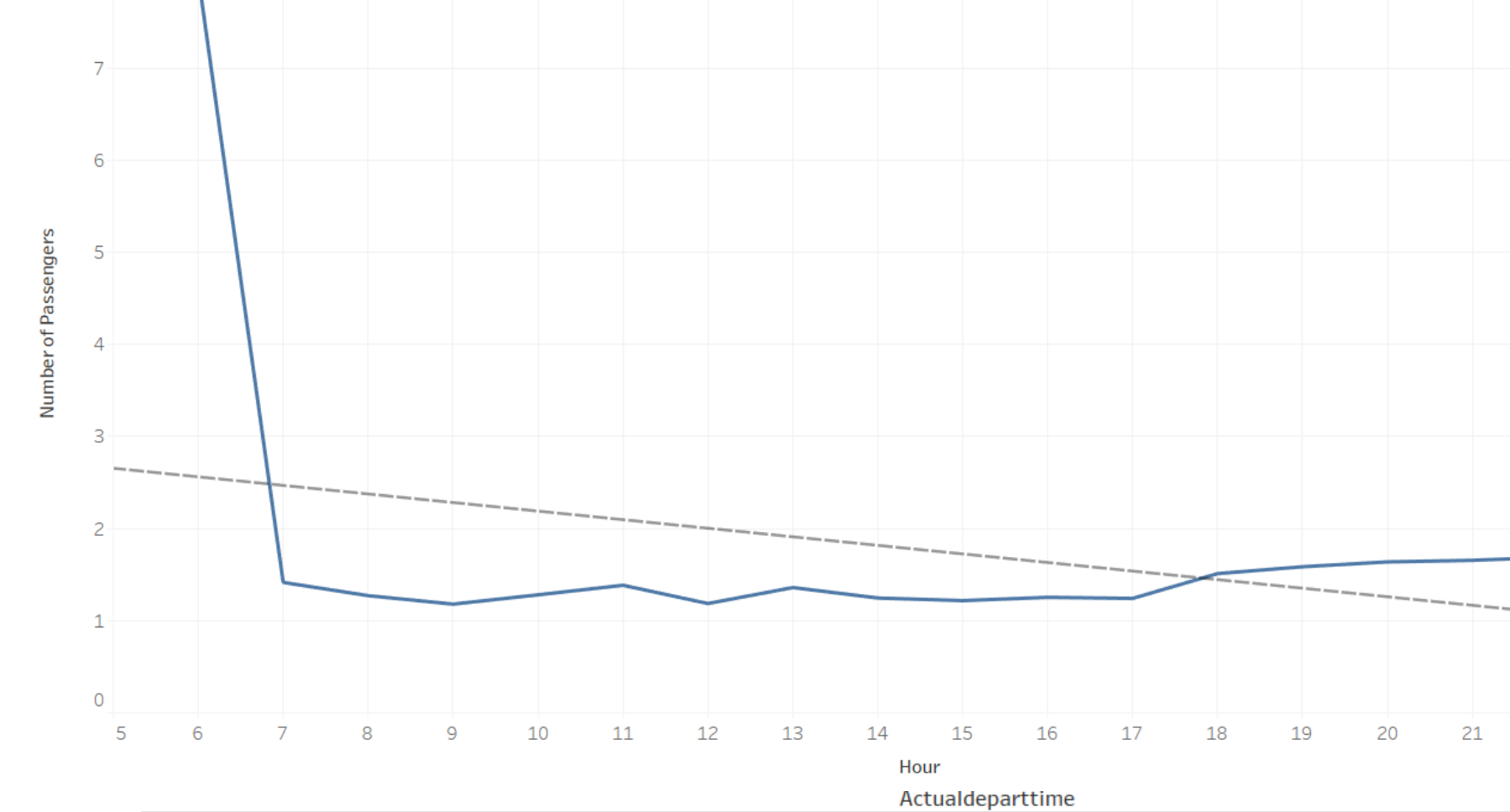

Number of Passengers vs. Hour of Day

Figure 5: Regression of Average Board/Load/Alight Counts versus Hour of the Day
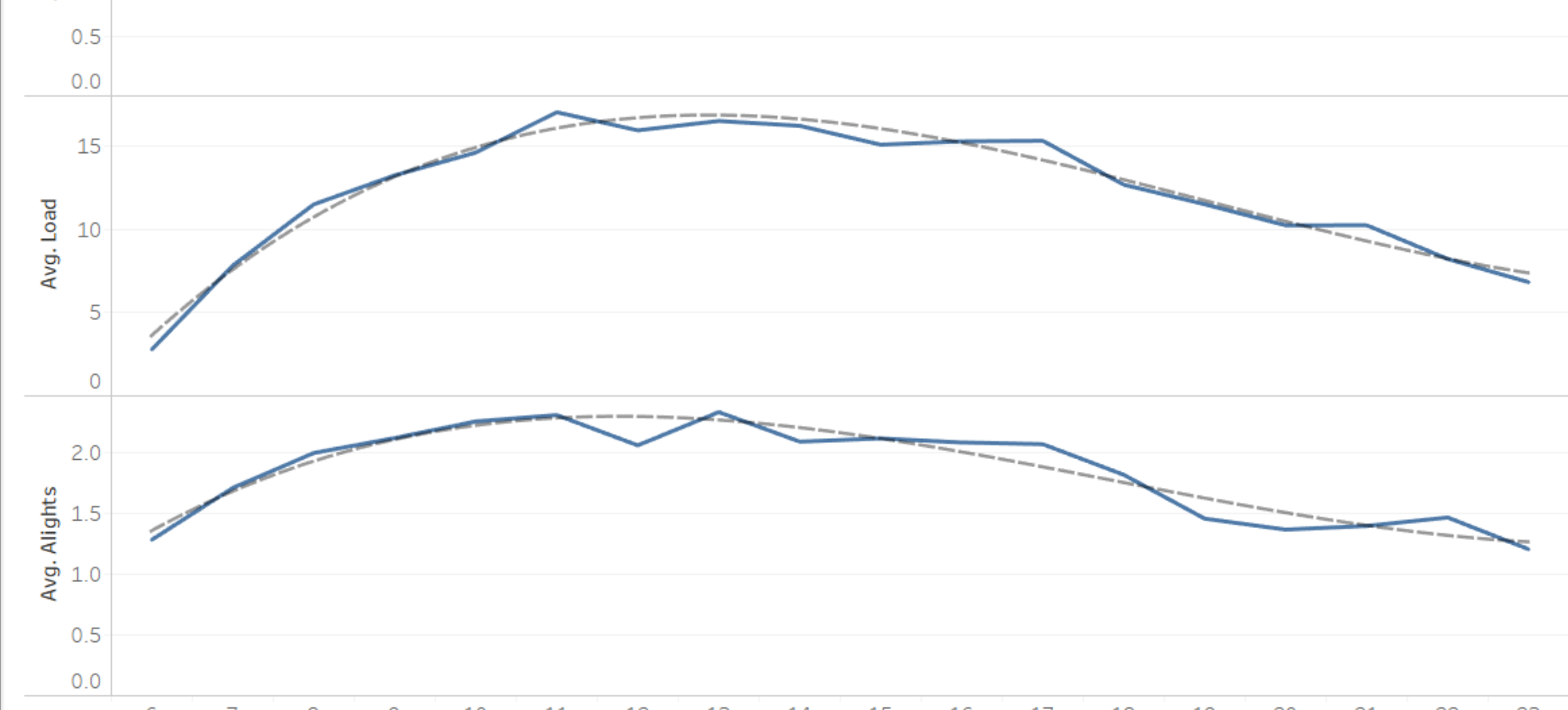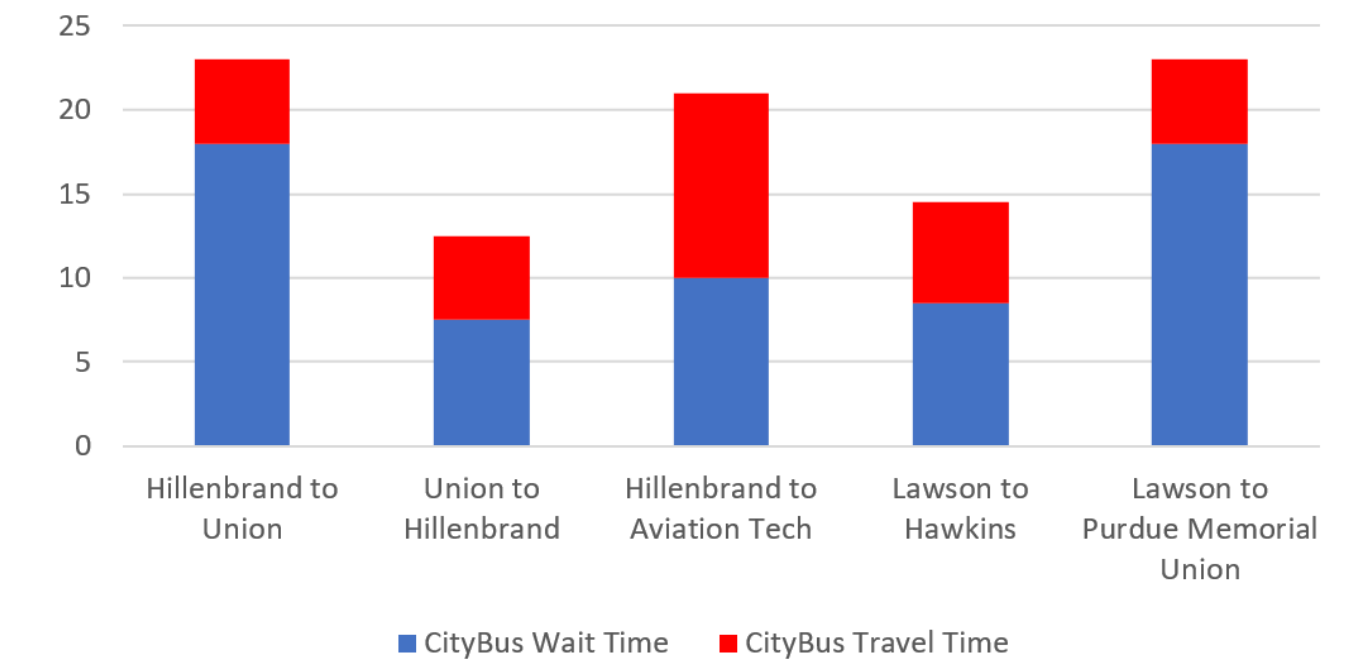

Figure 6: CityBus Transit/Wait Times

■ CityBus Wait Time ■ CityBus Travel Time

LeaperX

Investigation:
• How different are the transit/wait times for LeaperX and CityBus?
• Is there a relationship between the average number of passengers and the hour of the day?
• Is there a specific time of the day where the transit system is used the most?

Methodology:
• Basic Statistical Analysis on R/Python
• Linear Regression Analysis on Tableau

Insights:
• CityBus has longer transit/wait times on average than LeaperX (see Figures 3 and 6).
• There is no strong, linear relationship between the average number of passengers and the hour of the day (see Figure 4).
• From 6:00 to 7:00 A.M., the LeaperX transit system is used the most. We believe that Aviation majors take LeaperX early in the morning to the Aviation Tech building for flying and classes (see Figure 4).

Conclusion

• Based on our findings and the findings from the Route Optimization team, the LeaperX program is best served as a complement to the main CityBus transit system.
• From our findings, LeaperX best serves Aviation students who have to go to the Aviation Tech building early in the morning for classes and flying.

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We would like to thank Cummins for this opportunity to really give back to the Purdue and to be a part of this new innovation. Specifically, we would like to thank Eric Van Gorp, David Hall, Mrunal Chaudhary, Greesham Anand, Setu Namburu, and Ashish Menkudale for their amazing assistance and mentoring throughout the academic year. We would like to thank Cummins and CityBus for the data that made this project possible.

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