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CSUMB Sustainability Systems Fall 2015 - Final Report

CSUMB Bicycle Study

Issue

In 1917 Ford Ord became an United States Army Base situated between Seaside and Marina, California. Then from 1950 to 1970 Ford Ord was a location for basic training for events such as the Vietnam War. During this time 1.5 million men and women received basic training and a special forces unit known as Lightfighters later became the name of a main road connected CSUMB to Highway 1. Inter-Garrison Road is a busy main road that runs through the CSUMB campus which was named because it connected the East and West Garrisons of the base. In 1994 Ford Ord closed as a military based and was approved as the site for the new established California State University, Monterey Bay. CSUMB opened and held its first class in 1995. Today there are over 7,000 students attending CSUMB, and the school is expecting to grow towards tens of thousands of students in the future. The growing amount of students has lead to traffic congestion and does not uphold CSUMB's vision for a sustainable campus. Therefore, funds have been allocated to promote bicycle use and reduce vehicle traffic on campus.

We are interested in seeing where the highest amount of bicycle traffic occurs on campus by using the cheaper bike counter strips at three locations: (1) Inter-Garrison Rd. & 6th Ave., (2) the pathway between the library and World Theater parking lot, and (3) Divarty St. & 4th Ave. near the Meetinghouse Church. The first location could give us an idea of how many bicyclists come from East Campus; the second location could show us how much bike traffic occurs near the center of campus; and the third location could tell us about the bike traffic that comes from the Seaside area through General Jim Moore Blvd. By comparing the results of these three locations to see which has the most traffic, we can identify an area on campus where a more expensive, incentivized bike counter could be more effective.
Possible bike counter locations

Relevant Factors

Our hypothesis for the CSUMB project is with more transportation opportunities, less people will be driving onto campus, using more bikes, and using the bus options. With viewing the amount of bus and bike activity on Inter-Garrison Rd. & 6th Ave, the pathway between the library and World Theater parking lot, and Divarty St. & 4th Ave. near the Meetinghouse Church, we can estimate how many people are coming are coming onto campus in different directions and by which transportation. We can use this data to place a permanent-incentivized bike counter for the campus and to estimate how many students, faculty, and community members use these roads. Our main stakeholders involved are students/faculty, local residents, and other people that commute between Marina and Seaside. These will influence the amount of traffic and parking for the students. With more people driving, there will be less places to park, which will hopefully decrease the traffic. We believe if there are more transportation options, including a bike friendly campus, more students will be less likely to drive and either travel by bike or bus. As the leading CSU for "green" practices, along with our compost bins and solar panels, it is only fit that our transportation be up to date on our green practices as well. Also, it is our goal to not make drivers feel irresponsible for driving. We would, however like to encourage sustainable driving practices such as carpools and perhaps self-assigned driving black out days.

Stakeholder Perspectives

California State University, Monterey Bay, or CSUMB, is currently undergoing some campus-wide changes. There are many posed questions about CSUMB's future developments. One of which is what direction CSUMB will take regarding its parking deficiency. CSUMB has grown quickly within just a few years, and the construction of the Business and Information Technology building has reduced campus parking by removing a major parking lot.

Most of main campus will be considered since this is the area where most classes are held. There are two primary entrances into CSUMB: a northeast entrance through Inter-Garrison Rd, and a southern entrance through General Jim Moore Blvd. We would like to compare the amount bike traffic that occurs at the two main entrances and the center of campus near the Tanimura and Antle Library. As such, we have defined our project boundaries to be within General Jim Moore Blvd, Inter-Garrison Rd, 6th St, and the World Theater.

It is worth noting that the previously mentioned roads are used not only by students, but by local residents and other city people that need to commute between Marina and Seaside. Although we consider this group of people to be a minor stakeholder, they may indeed support our proposed bike program because it could help reduce traffic at peak hours. This bike project would mainly impact CSUMB students, which are the major stakeholders in this issue. But CSUMB students represent too large a group, so we subcategorized them as commuters and campus residents. We assume that commuters live far enough away from campus that they have limited options in their mode of transportation, and that they get the most benefits out of driving. In that sense, implementing incentivized bike counters would have the least impact on them. On the other hand, we assume that students who live in campus housing are close enough to the main campus that riding a bicycle or taking the bus is much more feasible. Campus residents could then make the highest impact by not driving, and could benefit the most from an incentivized bike counter. However, driving might be necessary for some students who live on campus because of work, or other tightly scheduled activities that require faster transportation. Staff and faculty also factor in, but may be considered a minor stakeholder, assuming they represent a smaller portion of the CSUMB population.

If we want to predict how this bike program could affect the amount of single passenger vehicles on campus, our STELLA model would need certain variables. First, we would need to know the total amount of students currently attending CSUMB; and more specifically, how many students live on campus and off campus. Second, we would need data from the bike counters at our three chosen locations. With the assumption that most students riding bikes live on campus, we can roughly estimate the percentage of on campus students that are currently using bicycles. Third, we would need to know how many cars generally park on campus, which we could possibly estimate by the number of parking permits sold in a semester. Current data will set the parameters of our model, which can be manipulated to simulate the effects of a growing student population.

Graphs and Data Collection

Bike Counter. This graph in Figure 1 represents the Easy Zelt Quality of battery life. The zelt has a two year battery life and has a one-to-six month recording time. The Easy Zelt is a temporary counting system usually less than six months. It has high accuracy and a quick installation with no engineering work. It uses an automatic data transmission and this is ideal for temporary (one to six months) off-street bike counting. It uses a single use adhesive loops rather than permanent loops that are cut into the path, which makes it easy to install and simple to move from one location to the next. It analyzes the electromagnetic signature of each bicycle wheel using 13 different criteria. It also uses the unique SIRIUS algorithm that allows the system to detect all types of bicycles with extreme precision. This zelt is not permanent meaning moving it to another location can cause a decrease in battery life without it being used to count bicycles. There is no engineering work and is waterproof so other weather can affect this zelt. At the end of the two years, the batteries will need to be changed or adjusted.

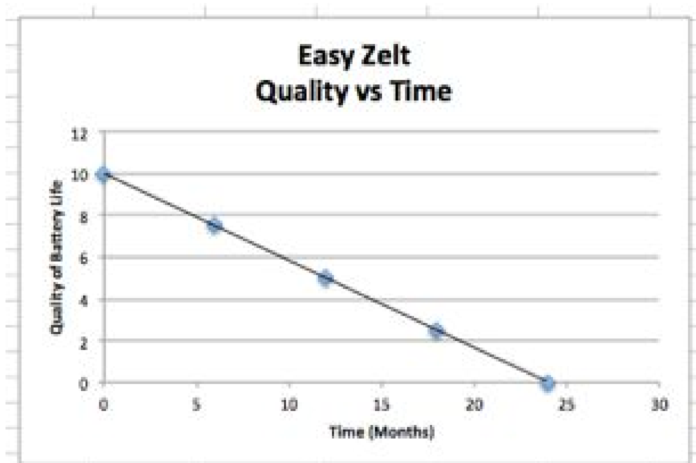


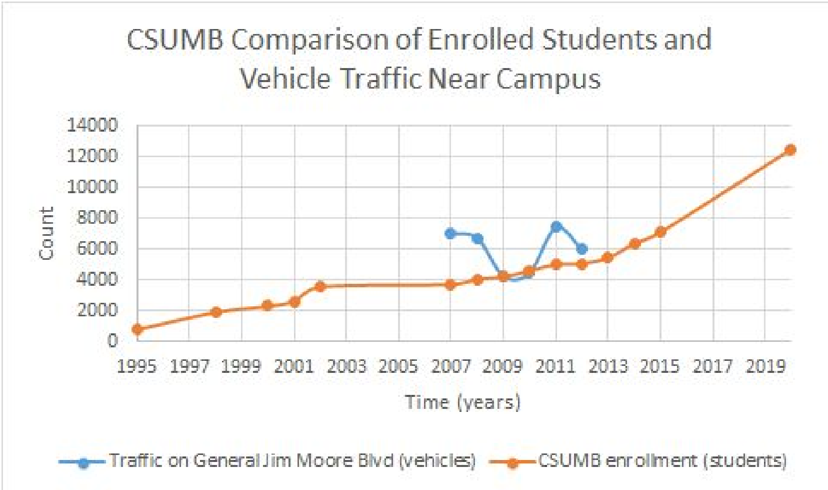
Figure 1.Easy Zelt Battery Life over Time

This was chosen because it can be portable but also last up to two years. This is the perfect amount of time to gather new bike data and after two years the easy zelt could move to a new location. This will count the number of bikes with no tag necessary and will detect all types of bicycles that pass by not including the cars or buses. According to the graph, the battery will last about 24 months or two years. The x-axis represents the time in months while the y-axis represents the quality of battery life (10 being fully charged). This Easy Zelt would be placed on Divarty and 4th Ave.

Traffic on CSUMB. Figure 2 shows traffic counts vs student population. Enrollment data is missing for some years due to CSUMB website updates and broken webpage links. Enrollment numbers are estimated, or stated as the spring semester enrollment for that academic year. CSUMB has shown a small amount of steady growth from its first year of establishment in 1995 up until about 2012. Afterwards, enrollment begins to grow at a larger rate which resembles the initial shape of an exponential growth. The yellow highlighted cells in the table above is CSUMB's prediction of accommodating 12,500 students by the year 2020.

Traffic count data was retrieved from the Transportation Agency for Monterey County (TAMC) website. The data set did not identify the corresponding year for the 5981 traffic count, but traffic counts are taken twice a year every year, so it is assumed to be the year following the most recent traffic count data. The traffic count data used above is from the total count during the peak time of year in August. Peak data was used to account for conditions when the traffic system near CSUMB experiences the most pressure and traffic. Traffic counts for General Jim Moore between Lightfighter and 1st Street was used because it was the closest location to CSUMB's main campus. Although more data is needed, traffic count appears to show an oscillating pattern and does not seem to relate to the growth in CSUMB enrollment. Possible explanations for the trends in traffic count could include gas prices and the economic recession, or a local event such as nearby roadwork or construction.

General Jim Moore Blvd. - Between Lightfighter and 1st St.		CSUMB Enrollment	
Year	Total Traffic Count - Peak	Academic Year	Students
2007	7053	1995	786
2008	6715	1998	1900
2009	4247	2000	2301
2010	4475	2001	2624
2011	7413	2002	3551
2012	5981	2007	3719



2008	4054
2009	4198
2010	4603
2011	5002
2012	5069
2013	5447
2014	6368
2015	7102
2020	12500

Figure 2. CSUMB student enrollment vs Traffic counts near campus

Bicycle Count - Data Collection. On December 9 from 1-2pm we counted bikes passing through three different locations as shown in Figure 3. The first on Inter-Garrison Rd. & 6th Ave., second the pathway between the library and World Theater parking lot, and third Divarty St. & 4th Ave. near the Meetinghouse Church. This bike count was important to decide where to place our bike counter for CSUMB. The greatest number of bikes that were counted in one hour was 14 bikes on Divarty St. & 4th Ave. near the meetinghouse. This is where we would place our bike counter to monitor the progress of bikes coming onto campus. On the x-axis represents Inter-Garrison Rd. & 6th Ave., the pathway between the library and World Theater parking lot, and Divarty St. & 4th Ave. near the Meetinghouse Church. The y-axis represents the amount of bicycles counted during the one hour time period.

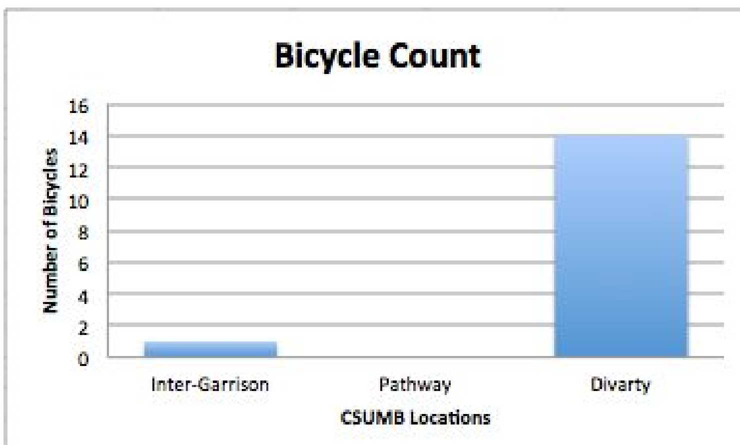


Figure 3. CSUMB Bicycle Counts Data Collection

Causal Loop Diagram

As the CSUMB student body continues to grow, automobile traffic has increased while parking availability has gone down. There were several ways to address how campus transportation will accommodate the expected increase of students. The loop diagram in Figure 4 considers how three transportation methods--car, bike, and bus--affect the amount of traffic on campus.

It is possible for CSUMB to create new parking lots to accommodate the amount of students that travel by car. The first loop between Parking Lots and Driving illustrates our hypothesis that creating more lots will encourage students to keep driving because parking space would be readily available. But once the student body grows and continues the driving behavior, more parking lots will eventually need to be constructed. This first loop is a reinforcing loop and its delays account for the time it takes for the student body to grow and fill the lots to capacity, which would then require the construction of a new parking lot. Then as long as student driving increases, campus traffic will also increase which is an unwanted outcome. The link between traffic and driving assumes that as traffic increases, driving becomes more inconvenient and will decrease. Overall, creating new parking lots is not recommended because it eventually leads to more cars and increased traffic, which does not support CSUMB's sustainability goals of reducing vehicular carbon emissions.

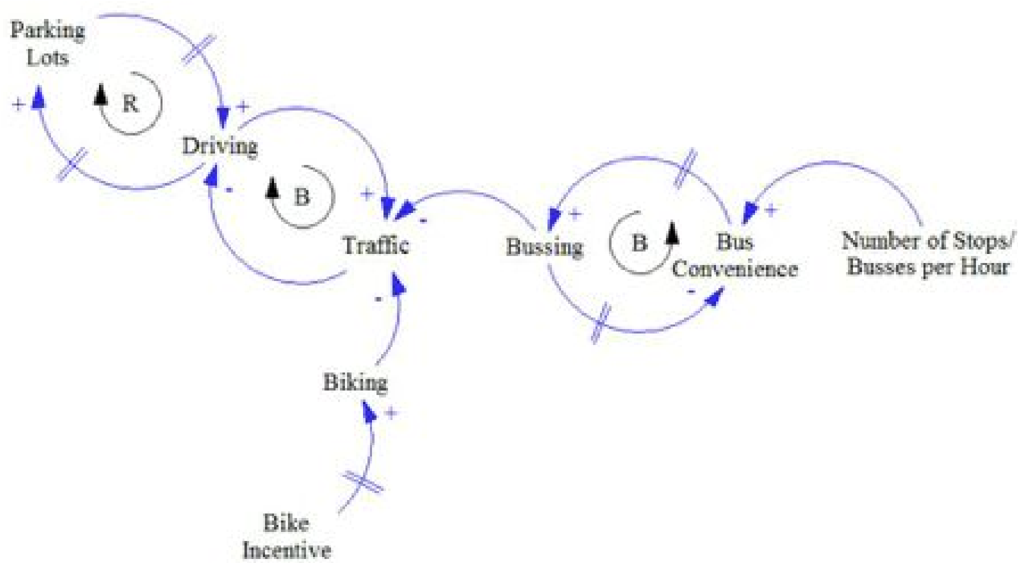


Figure 4. CSUMB Bike Project Causal Loop Diagram

Promoting the MST bus system is another approach for transporting students. By increasing the number of stops and the number of busses en route per hour, bussing becomes more convenient, which would increase the likelihood of students bussing to campus. The more students decide to take the bus, the less cars there will be on the road, and therefore less traffic on campus. Although increasing bus convenience increases the use of busses, it becomes inconvenient when the system is overcrowded with students, which creates a balancing loop. There are delays in the loop because it would take time to inform students about new bus schedules before they utilize the busses, and it would take time for the busses to fill up to the point of overcrowding. A good example of increasing bus convenience would be to add a bus stop at Inter-Garrison and 6th near the Chapman Science Academic Center for bus 25 towards Salinas. It is currently difficult for students at the east end of campus get out of class ten minutes before the hour and rush to the student center stop in six minutes. It's doable, but it is a close call and having to rush would be off-putting for students that could switch to using the bus.

Since funds have been allocated for bike counters, including the more sophisticated data collection models that could be used for incentivization, our class is focusing on promoting bicycle use on campus. We expect that as more biking incentives are offered, more students will choose to bike to campus, which reduces traffic. We would also expect a delay between introducing the incentive and the time it takes for students to respond by choosing to bike; in other words, it will take time to increase campus awareness about the incentives and benefits. This option best supports CSUMB's sustainability goals because it produces zero vehicular carbon emissions.

Road Diet - West Alisal, Salinas

Issue

In 1850 Salinas evolved from the purchase of Rancho Nacional and Rancho Sausal, and the business dealings of two early settlers known as James Bryant Hill and Jacob Leese. James Bryant Hill purchased 6,700 acres of land in hopes of setting up a massive farming project on Rancho Nacional. Jacob Leese would go on to purchase 10,000 acres of land of the opposite side of the Salinas river to Hill Rancho Sausal. During 1862 the entire population of the Monterey county was only 4,700 people. In 1867 the first streets of Salinas were laid out. In July of 1868, Salinas contained only 12 to 14 buildings both complete and in construction, but by the end of the year the city grew to 125 buildings. In November 1872, The Southern Pacific Railroad came to Salinas, and in November of the same year, the Monterey County Board of Supervisors granted Salinas City limited status of incorporation. In 1877, Monterey County began accessing irrigation . By the mid 1880s, accessing a steady water supply and the ready availability of rapid transport to markets had greatly increased the production of dairy products. By this point Salinas was enjoying the benefits of speed and efficiency. In 1901 the California Rodeo was beginning to be recognized as a Salinas tradition. Its formal inception was in 1911. With travelers visiting the rodeo pressure was on for a more efficient way to travel. In 1915 with the construction of Highway 101 being completed, Salinas would soon follow with its fully paved streets. Hartnell College is one of the oldest educational institutions in California. Founded in 1920 as Salinas Junior College, the school was renamed Hartnell College in 1948. As of 2015, Hartnell serves nearly 10,000 students.

For the Salinas Sustainable City Year project, we are interested in modeling how a road diet would affect pedestrian safety and traffic along crosswalks on the Hartnell side of West Alisal Street. We have a rough idea that the main stakeholders involved would be students and staff from Hartnell College and W. Alisal St. residents. We would need to gather data on how often pedestrians typically cross W. Alisal; notably, students who park across the street during peak hours and need to cross the street. We would also need to gather data on how long it

currently takes a pedestrian to cross the street, and how that time would change if the crosswalks were shortened with the road diet. In that case, it might also be helpful to know how the speed of automobile traffic would change with the road diet, assuming slower cars would be safer for pedestrians, but that by itself could be a whole project aspect for another group.
Crosswalks to study along W. Alisal and Hartnell College

Relevant Factors

For the Salinas Sustainable City Year Project, our hypothesis is similar to the CSUMB hypothesis. We believe that with modeling the road into two lanes including bike lanes would positively affect the pedestrian safety and the traffic along the Hartnell side of West Alisal Street. This would also influence more people to use different transportation using either the bus or a bike. The main stakeholders would be students and staff from the Hartnell College and W. Alisal St. residents. We would gather data on how often pedestrians cross W. Alisal and how often students or community members park on the street during peak hours. We will take note of the speed of automobile traffic now and how it would change by switching to two lanes. We believe that with fewer lanes, the traffic will lighten up and more people will be prone to use their bikes or buses. With less traffic this will also increase the safety for the students and staff at Hartnell and the surrounding community. This project is intended to increase the livability in the W. Alisal and encourage other forms of transportation such as walking, biking, or using the bus.

Stakeholder Perspectives

The whole neighborhood surrounding this area is involved. All the streets connected to W. Alisal and the college is an important aspect for the surrounding this area. The start of this road begins at Blanco Rd and turns into East Alisal a couple blocks before the 101 freeway entrance. The entire road should be considered for a road diet because the whole community uses it to either leave Salinas by going onto Blanco road, or driving towards the Highway 101 farther into Salinas. The road diet could best benefit pedestrians on the section along Hartnell College because many students use street parking on West Alisal and need to cross the street to get to campus.

There are three major stakeholders to be considered before implementing a road diet: residents who live on West Alisal, students who attend Hartnell College, and commuters within the city who use the road to get to work or school on a daily basis. Residents may be concerned about the frustrations that accompany adaptations to a change in their immediate environment, such as increased traffic on their street. On the other hand, residents might welcome a middle turn lane because it can bring them out of traffic while they wait to make a safe turn into their driveway. As previously mentioned, students can benefit from the road diet because it slow down traffic and shorten their time spent on crosswalks. However, street parking on often involves parallel parking, which could be problematic during peak hours--traffic may have to stop and wait for someone to park because they only have one lane to travel through. Commuters may not want a road diet because they only use the road for driving--they would not experience the pedestrian benefits, there may be a period of increased traffic as drivers adapt to the change, and they may not want the intentional slowing of traffic that comes with a road diet.

Ultimately the goal of the road diet is to increase livability in the West Alisal area and encourage walking as a preferable mode of transportation. As a result, we hope this will benefit the environment by reducing the amount of cars on the road. To reach this goal we want to making walking a more inviting mode of transportation by increasing pedestrian safety. There are several critical factors we must consider that will become important variables as we create a simulated model of the road diet in STELLA. We would need to collect data on how fast cars typically drive past Hartnell with the two-way four lane road; as well as the typical amount of traffic during peak hours and normal hours. It would also be interested to figure out an average amount of a time a driver needs to parallel park. Lastly, we would need to define an average amount of time it takes a person to cross West Alisal. We may be adding more variables as we conceptualize and work on our model.

Graphs and Data Collection

Traffic Counts vs. Population. The relationship between the population of Salinas and traffic counts on W. Alisal are shown in Figure 5. Data for the population of Salinas was retrieved from the United States Census Bureau via Google. The population of Salinas has steadily grown by about 50,000 people since 1990, but we do not know the cause for the large increase between 1999 and 2000. Both Salinas and the CSUMB student body population have shown growth, but the rate is expectedly lower for Salinas because of its much larger sample size.

Traffic counts for Alisal Street between Front Street and Prader Street was chosen because it is the closest location to the West Alisal road diet near Hartnell College. Total counts during the peak time of year in August was also used to represent the traffic system at a fuller capacity. Our assumption was that traffic counts would increase with population in that an increase in people would translate to an increase in cars driven in the city. However, traffic counts along Alisal Street have generally decreased over five years as Salinas grew in population. This may be explained by the fact that the South Salinas neighborhood around Alisal Street is relatively old compared to the newer developed suburbs around North Salinas, where we assume the new growing population moves into. In any case, the decrease in traffic count at this location could indicate that a two-way four lane road is unnecessary and that a road diet could be effective on Alisal Street. However, more data are needed given the upward trend with the most recent traffic counts. It is interesting to note that both General Jim Moore and Alisal experienced their lowest traffic counts in 2009 and 2010, meaning a larger cause--such as the national recession in 2008--could have an overarching effect on driving habits.

Alisal St. - Between Front St. and Prader St.		Salinas Population			
Year	Total Traffic Count - Peak	Year	People	Year	People
2007	23557	1990	108820	2002	146455
2008	18156	1991	110329	2003	146575
2009	17155	1992	111770	2004	146200
2010	15795	1993	110994	2005	143971
2011	16273	1994	110323	2006	141875
2012	18187	1995	112899	2007	141496
		1996	116425	2008	142705
		1997	118903	2009	144278
		1998	121458	2010	150781
		1999	123607	2011	152649
		2000	143497	2012	154201
		2001	145377	2013	155662

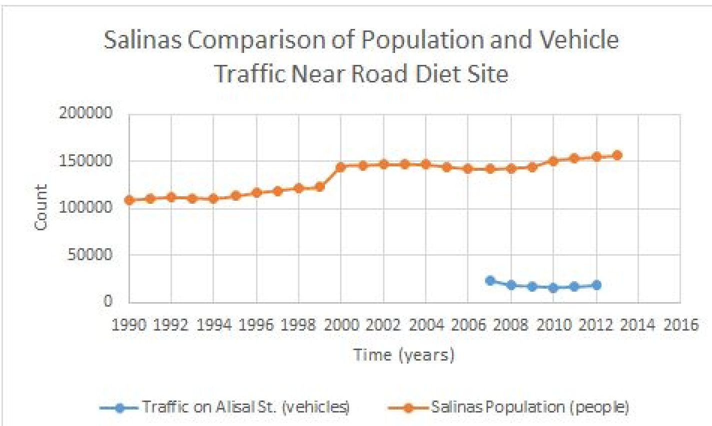


Figure 5. Salinas Population vs Car Counts near W. Alisal

W. Alisal Traffic Observation - Data Collection. On December 09, 2015 we observed and counted the number of cars backed up at the stoplight on the intersection of W. Alisal and Homestead from 10 am to 11 am. These observations could give us an idea of the traffic density that occurs on W. Alisal and whether or not it seems necessary to have two through lanes for each direction. We observed an average of 3.12 cars backed up at the stoplights traveling in either direction. Although the average was around 3 cars, the amount of cars ranged from 1 to 10, with the mode being 1 car waiting at the stoplight, as shown in Figure 6. Since these data were collected between 10 am and 11 am, it is not representative of the traffic density during the peak hours around 8 am and 5 pm.

Street Crossing Observation - Data Collection. During our data collection on December 09, 2015, we also observed people crossing W. Alisal at the Homestead intersection as shown in Figure 7. On average it took people about 13.8 seconds to cross the street. We thought of the time it takes to cross the street as a function of safety, and we assumed that pedestrians would be safer if it took them a shorter amount of time. This is important because many Hartnell students use off-street residential parking to avoid the costs of school parking permits, so many students have to cross W. Alisal to get to campus. Unfortunately many students must jaywalk because the crosswalks are spread so far apart, so students' safety are at risk when they have to cross the street without the assurance of a stoplight or warning light.

Other Variables of Data Collection. Our data also included counts of pedestrians, bicyclists, and people taking the bus. We counted 138 pedestrians, 7 bicyclists, and 6 people at the bus stops, for a total of 151 people walking, biking, and busing. This data tells us about the current walking, biking, and busing, which could provide a good comparison once the road diet is completed and changes are observed.

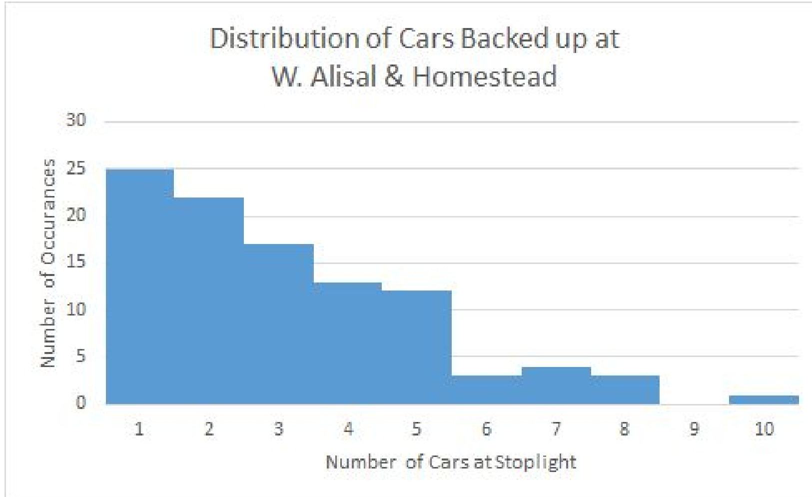


Figure 6. Number of cars backed up at stoplight on W. Alisal and Homestead

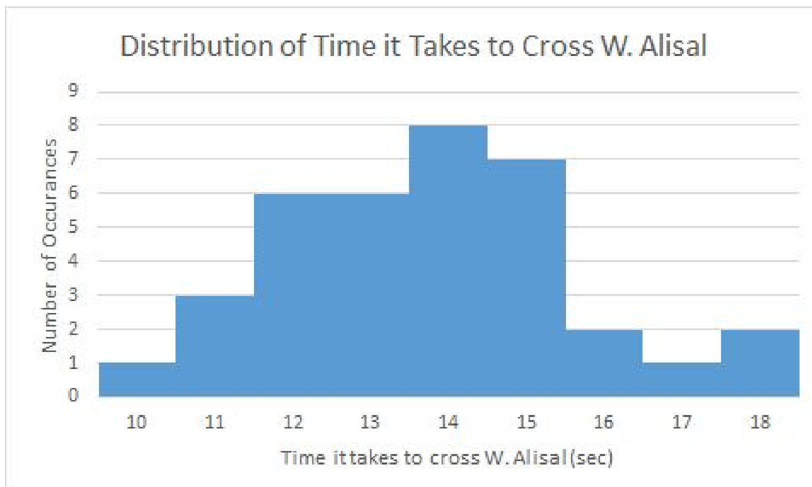


Figure 7. Amount of time it takes to cross W. Alisal

Causal Loop Diagram

The elements on the far left of the diagram in Figure 8 represent some variables that would result from the road diet on W. Alisal St. in Salinas, which are the amount of time it takes to cross the street, the addition of bike lanes, and the addition of bulb outs. The elements on the upper right of the diagram (Quality of Life and Carbon Emissions) represent the goals and benefits that could result from the road diet.

The major change in the road diet would be changing the width of the road by reducing the number of lanes from 4 to 3. This would have an immediate effect on traffic in that the narrower roads are the slower traffic flows. However, by reducing the speed of traffic, safety increases all around for drivers, bicyclists, and pedestrians. This is because the reduction of speed allows for a greater amount of reaction time in dangerous situations so that drivers have a

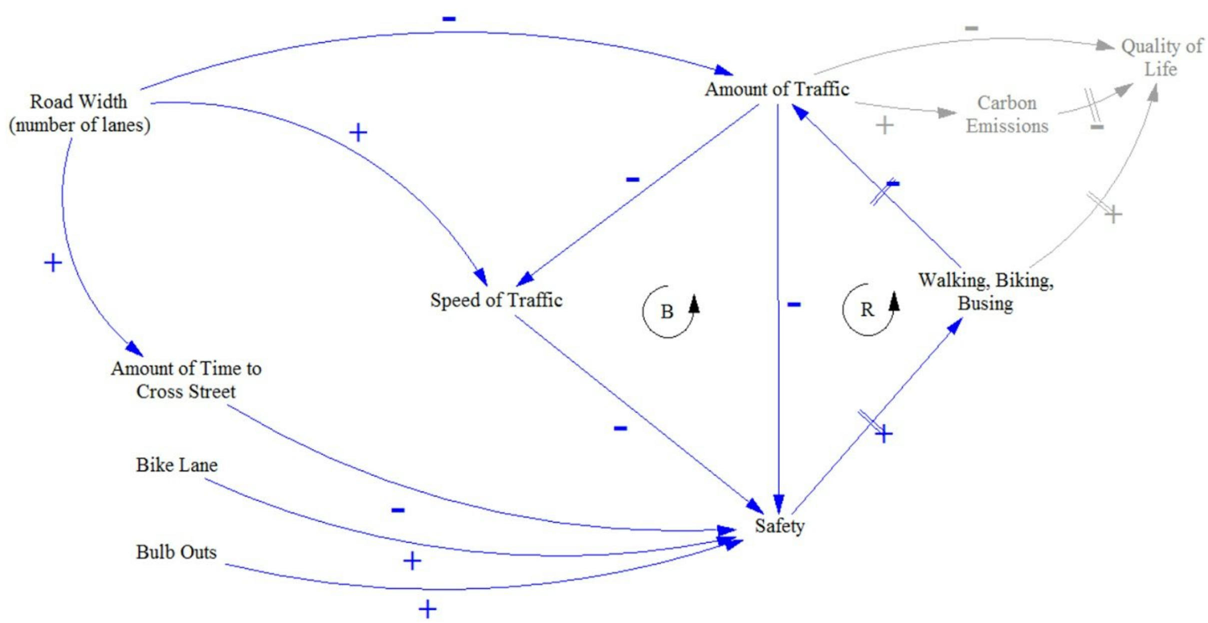


Figure 8. W. Alisal Road Diet Causal Loop Diagram

better chance of avoiding accidents. We assume that as safety increases, the aspect of walking, biking, or busing, instead of driving becomes more inviting, and more people will choose those alternative modes of transportation. However, there would be a delay between the increase in safety and people choosing different transportation because it would take time for residents to adjust to the change in their neighborhood, and it would take time for people to try a new mode of transportation and get used to using it regularly.

The increase in safety would create a reinforcing loop by promoting more environmentally friendly methods of transportation, and reducing traffic, which would increase safety again. The increase in walking, biking, or bussing would have several beneficial impacts. First, it reduces the amount of traffic because people would use their cars less; second, carbon emissions would be reduced because less cars would be on the road; and third, it would improve the quality of life for local residents by providing exercise, a better sense of public transportation and community, and reducing vehicle traffic.

A point of contention is that as traffic decreases, people would drive faster, safety would decrease and discourage alternative transportation, causing more people to drive their cars again, which finally increases traffic--an overall balancing loop. However, the road diet would mitigate this effect because the narrow width of the road would impose a slower speed limit.

By narrowing the width of the road in the road diet, space would be available for the creation of bike lanes. This increases safety by giving bicyclists a designated space on the road, and it also helps keep bicycles off of the sidewalk so that pedestrians feel safer. Narrowing the road width would also allow pedestrians to spend less time in the crosswalk which would increase safety. Bulb outs are an optional element that can be implemented with the road diet. Bulb outs would extend the sidewalk into the crosswalk so that pedestrians could safely look for traffic around the cars that are parked along the curb.

STELLA Stock and Flow Model

There are five stocks in our model (Figure 9) that relate to elements from our causal loop diagram: Road width; Speed of traffic; Perceived safety; the Average number of people walking, biking, and busing on W. Alisal; and the Average number of cars backed up at a given stoplight on W. Alisal. There are four converters in our model that affect the Perceived safety stock: Pedestrian walking speed, Time spent in crosswalk, Bike lanes, and Bulb outs.

Road Width. We estimated the road width of W. Alisal to be 62ft using Google Maps Pedometer. Although road width is not a dynamic value that changes easily, it is included as a stock because the outflow that decreases it is a necessary element that will trigger changes in two other stocks. The Road diet outflow has a graphical input that starts with zero feet, goes to 10 feet for one timestep, and then returns to zero; This will affect the outflow of the Speed of traffic stock and the inflow of the Average number of cars backed up at stoplight stock.

Time Spent in Crosswalk. The Road width stock itself is an input for the Time spent in crosswalk converter, which is calculated as Road width/Pedestrian walking speed. Our value for Pedestrian walking speed was 4.2 feet/second, which was the average walking speed from our data collection at W. Alisal and Homestead.

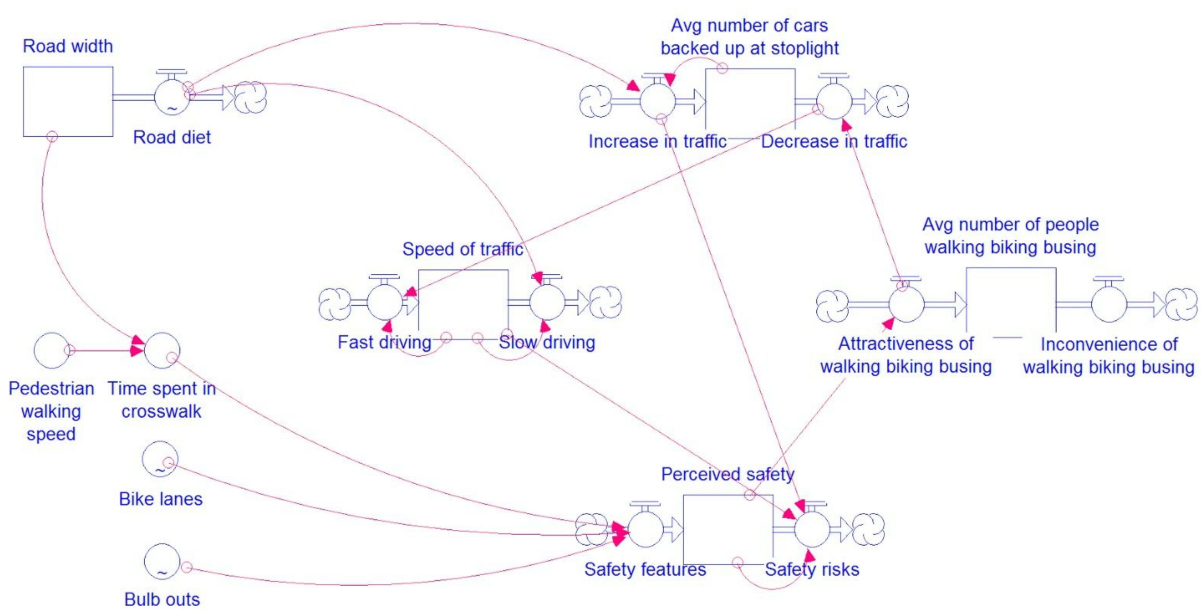


Figure 9. Road Diet Stock and Flow Model

Bike Lanes, Bulbouts. The other two converters are Bike lanes and Bulb outs. The value for Bike lanes used a graphical input that starts with 0 miles, goes to 1.53 miles for one timestep that corresponds to the road diet, then returns to zero. We estimated 1.53 miles of bike lanes along W. Alisal from Lincoln Ave. to Blanco Rd. using Google Maps Pedometer. The Bike lane converter is linked to the inflow of the Perceived safety stock. The Bulb out converter has a graphical input that starts with zero, goes to 5 for one timestep corresponding to the road diet, and returns to zero. The value of 5 points is an arbitrary number that corresponds to the walkability rating unit of Perceived safety and is linked to the inflow of the Perceived safety stock.

Speed of traffic. The initial value of the Speed of traffic stock was calculated using the speed limit of 25 mph on W. Alisal and research statistics on driving speed behaviors. An analysis of drivers' perception of speed limit and safety cited that two-thirds of drivers travel over the speed limit, half of which drive 10 mph faster than other vehicles on the road (Mannering, 2009). To calculate the initial value of the average speed of traffic we took the average of one-third of drivers driving at 25 mph, one-third driving 5 mph over at 30 mph, and one-third driving 10 mph over the speed limit at 35 mph. We calculated that the initial value of the average speed of traffic was 29.7 mph. The Fast driving inflow that increases the Speed of traffic stock was linked to the outflow of Average number of cars backed up at stop light and the Speed of traffic, which used the following function:

IF Decrease_in_traffic>0 THEN .66*.01*speed_of_traffic ELSE 0

This function means that if the Average number of cars backed up decreases, then two-thirds of drivers will drive 1% faster than the average Speed of traffic. One percent was just an arbitrary percentage used to indicate that people were driving faster than average. The Slow driving outflow that decreases the Speed of traffic stock was linked to the Road diet outflow of Road width and the Speed of traffic, which used the following function:

SUM((IF Road_diet>0 THEN 2 ELSE 0)+(.34*.022*Speed_of_traffic))

This function means that the average Speed of traffic will reduce by 2 mph only when the Road diet happens; and otherwise, about one-third of drivers will drive 2.2% slower than everyone else. The 2.2% was also an arbitrary percentage used to indicate that people were driving slower than average

*Perceived safety***.** The initial value of Perceived safety was 53 points, based on a walkability rating for Salinas, California, out of 100 points (*Cities in California*, 2015). The Safety features inflow that increase Perceived safety were linked to the three converters; Time spent in crosswalk, Bike lanes, and Bulb outs; which used the following function:

```
SUM((5*Bike_lanes/.5)+(IF Bike_lanes>0 AND Time_spent_in_crosswalk<13
THEN 5 ELSE 0)+Bulb_outs)
```

This function had arbitrary values which meant the Perceived safety would increase by 5 points for every half mile of Bike lanes added, 5 points when Time spent in crosswalk fell below 13 seconds in correspondence to the road diet, and 5 points when Bulb outs are added. The Safety risks outflow was linked to the Speed of traffic stock, the Increase in traffic outflow of the Average number of cars backed up stock, and the Perceived safety stock:

```
SUM((IF Speed_of_traffic>27.5 THEN .005*Perceived_safety ELSE 0)+
(IF Increase_in_traffic>0 THEN 5 ELSE 0))
```

This function means that as long as the Speed of traffic was faster than 27.5 mph, then Perceived safety would decrease by 0.5%, and if traffic was increasing Perceived safety would decrease by 5 points. These numbers were arbitrary and many other variables relating to pedestrian, bike, and bus safety were not included.

Average number of people walking, biking, busing. The initial value for this stock came from our data collection where 151 people were observed walking, biking, or busing at the W. Alisal and Homestead intersection. The Attractiveness of walking biking busing inflow was linked to the Perceived safety stock and used the following function:

```
Perceived_safety/(.1*9439)
```

This function means that for every point of Perceived safety, 10% of the Hartnell student body would add to the Average number of people walking, biking, and busing, with 10% being an arbitrary number. For the limits of our model, we decided to focus on how transportation behaviors of Hartnell College students would be affected. Hartnell College had 9,439 students enrolled during the 2013-2014 school year (*Hartnell College Overview*, 2014). The Inconvenience of walking biking busing outflow was not linked to any other elements, and was set at a decreasing rate of 1%. However, there are errors with this coding that will be explained in our limitations section.

Average number of cars backed up at stoplight. We measured the amount of traffic by the average number of cars backed up at the W. Alisal and Homestead stoplight. The initial value for this stock was from our data collection, which was an average of 3.12 cars over one hour. The Increase in traffic inflow was linked to the Road diet outflow of Road width and the Average number of cars backed up at stoplight stock, with the following function:

```
IF Road_diet>0 THEN Avg_number_of_cars_backed_up_at_stoplight ELSE 0
```

This function means that when the Road diet happens, the Average number of cars backed up at stoplight will double. Since W. Alisal currently has two lanes in each direction and the road diet would create only one lane in each direction, we assumed that traffic would increase. However, there are errors in this logic that will be explained in our limitations section. The Decrease in traffic outflow is linked to the Attractiveness of walking biking busing inflow of the Average number of people walking biking busing. Our reasoning is that any increases of people walking biking or busing would mean a decrease in the amount of people driving in traffic. The outflow function is as follows:

.2*Attractiveness_of_walking_biking_busing

Assuming one car equals one person, we said that the Average number of cars backed up at stoplight would decrease by 20% for each new person who starts walking, biking, or busing,

Simulation Results & Limitations

Our model ran for 60 months for a five year simulation. Figures 10 and 11 show that Road width decreased; Average speed of traffic decreased; Perceived safety increased; the Average number of people walking, biking, busing increased; and the Average number of cars backed up at stoplight increased. The overall limitations of our model are that road dimensions were estimated; data was only collected on one day for one hour, during off-peak traffic hours; and that many variables were assigned arbitrarily due to the lack of knowledge on the various relationships in this system.

	Initial	Final
Road Width	62 ft	52 ft
Avg. Speed of Traffic	29.7 mph	26.3 mph
Perceived Safety	53.0 pts	70.4 pts
Avg. Number of People Walking, Biking, Busing	151 people	154 people
Avg. Number of Cars Backed Up at Stoplight	3.1 cars	5.3 cars

Figure 10. Simulation Results

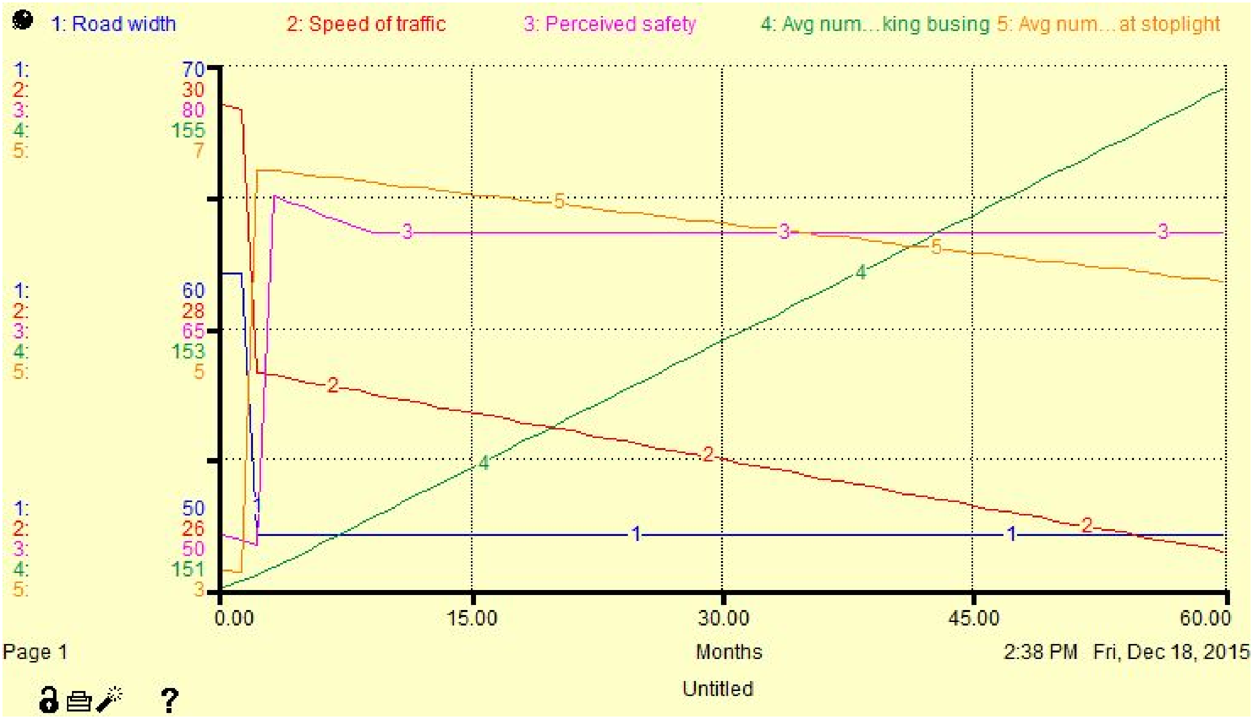


Figure 11. Simulation Results Graph

In our simulation Road width decreased from 62 ft to 52 ft because we assumed that one 10ft wide lane would be removed. These values are limited in that we did not actually measure the current road and lane widths on W. Alisal, but actual measurements could easily inputted into our model. This result meets our expectation and we find it reasonable because how lane widths vary from 9 ft to 12 ft which includes our estimated width of the removed lane (Parsons Transportation Group, 2003).

The average Speed of traffic decreased from 29.7 mph to 26.3 mph in our simulation over five years. These results are limited in that current research literature has been inconclusive on the relationship between road width and driving speed. Parsons Transportation Group has found that driving speeds reduce from 3 to 0 mph for every foot of lane reduction (2003). However, we expect a drop in speed as people adjust to the road changes, and afterward we expect the average Speed of traffic to reduce as people are confined to one lane and must drive at the speed of the lead driver, which means slower drivers could have a larger effect on the average speed of traffic. Overall, we find this result reasonable because it is within a realistic range of driving speeds, but currently our model would not be able to show a leveling-out around the 25 mph speed limit.

In our model Perceived safety increased from 53 points to 70.4 points, but the accuracy of this result is highly limited. The biggest limitation is that perceived safety is a subjective opinion, a walkability rating is not necessarily representative of safety, and our model omits many other variables that relate to safety like adequate lighting, sidewalk quality, crime rates, and rates of traffic accidents. We find this result neither reasonable nor unreasonable, but plausible.

The average number of people walking, biking, and busing increased from 151 people to 154 people in our five year simulation. We expected an increase, however we found an increase of three people over five years to be small. First, these results are limited in that we only included Hartnell students as the main population sample to respond to the road diet, but another limitation is that bus people likely double counted as pedestrians during our data collection. Although the increase is small, we find it reasonable considering we estimated a conservative percentage of students would respond to the road diet. However, we found in error in the outflow of this stock in that it was set only at a rate of 0.01 per timestep, instead of 1% of the Average number of people walking, biking, or busing per timestep.

The average number of cars backed up at stoplight increased from 3.1 to 5.3 cars in our five year simulation. However, there was an error in our logic, assuming that the number of cars backed up would double if a lane was removed. The error is that the units for the Average number of cars backed up is cars per hour, not cars per lane. It is possible that the change from two lanes to one lane per direction would still be able to accommodate the average number of cars backed up at the stoplight.

Overall we believe our model could be improved with more data--especially for qualitative variables like perceived safety--because many of our links and values were arbitrarily assigned. We recommend using community surveys to gather more objective numbers and variables that relate to perceived safety. We do recommend the road diet on W. Alisal, despite the fact that our systems model was designed with the assumed benefits of having a road diet.

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