



ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE
FAKULTA DOPRAVNÍ

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ANALÝZA PŘESHraniČNÍ MOBILITY OSOB V
SOUMĚSTÍ EL PASO A CIUDAD JUÁREZ

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Při zpracování bakalářské práce se řiďte následujícími pokyny:

- Souměstí El Paso - Ciudad Juárez, historie, charakteristika, místní specifika, přeshraniční mobilita osob
- Strategický plán rozvoje souměstí a jeho důležité aspekty
- Návrh dotazníkového průzkumu mapujícího přeshraniční mobilitu osob
- Vyhodnocení dotazníkového průzkumu
- Analýza vhodných řešení pro zlepšení přeshraniční mobility osob
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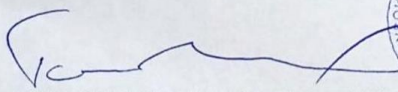
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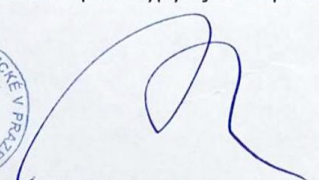
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Předkládám tímto k posouzení a obhajobě bakalářskou práci, zpracovanou na závěr studia na ČVUT v Praze Fakultě dopravní.

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ABSTRAKT

Předmětem bakalářské práce „Analýza přeshraniční mobility osob v souměstí El Paso a Ciudad Juárez“ je návrh dotazníku a dotazníkový průzkum s cílem zjistit postoj ke Smart řešením, které by mohly pomoci zlepšit situaci v cílové oblasti.

ABSTRACT

The subject of the bachelor thesis “El Paso - Ciudad Juárez cross-border mobility problem analysis” is the survey design and survey mapping with the goal to obtain information about the position of Smart solutions, which could help improve the situation in the target region.

KLÍČOVÁ SLOVA

Přechod hranic, mobilita, hranice, lidé, bezpečnost, bi-národní, region El Paso-Ciudad Juárez, dotazník, Smart řešení

KEY WORDS

Cross-border, mobility, border, people, security, binational, region El Paso-Ciudad Juárez, survey, Smart solutions

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1 Introduction

This bachelor thesis is a reaction to an existing problem. It is dedicated to the analysis of the cross-border mobility issue between El Paso, TX, USA and Ciudad Juárez, Mexico, the largest bi-national metropolitan area.

It is important to see the current mobility situation in the given area from several perspectives. This is an area with multiple border crossings, specifically between El Paso and Ciudad Juárez there are four of them. This metropolitan area is divided both geographically and politically. The geographical boundary is formed by the river Rio Grande and politically this area is divided by two states – the United States and Mexico. When crossing the border, passport control and residence permit control are conducted. This creates a bottleneck for cross-border mobility; there are traffic jams and during peak hours the condition is even worse. The situation gets all the more difficult because many people work on the other side of the urban area located in a different country. The same happens to students or people who have relatives and homes on the other side of the border. The general approach of my analysis can be used around the world in similar cases, where a bottleneck is created near border cities.

Unfortunately, the current political situation is not prone to changes. Not both governments are interested in an easier border crossing. They have to acknowledge the economic benefits of supporting mobility, and start acting on it and applying solutions. This is also a reason why this topic is very relevant for the local people since it is a part of their daily lives.

My motivation for writing this thesis is to define the mobility problem, draw attention to this issue and outline different solutions.

I have chosen this topic, because I am studying logistics, I also have a personal attachment to the culture of both countries and I would like to help the people in this area to find solutions. However, what spiked my interest the most is reading the article called Smart border as a Part of Smart and Resilient El Paso.[25] There I found many interesting points which I will examine in more detail in this work.

The main goal of this thesis is to outline options for improvement of the current process of cross-border mobility and to confirm or disprove the possible acceptance among people of some of the suggested smart solutions through a survey.

In the first part of this thesis I described the subject in whole by giving the background information so as to create a base for the analysis.

In the second part of this thesis I had designed a survey that was conducted among The University of Texas at El Paso students. In this survey I presented the students with suggestions and allowed them to express their own opinions of the current cross-border mobility situation. I found out how people are fond of some solutions and based on that I recommended those which could best improve the current cross-border process.

This topic is worth exploring since it can help the local system. This process has the potential to function much faster, make the crossing seamless and to improve the quality of life on both sides of the border.

By reading this work I hope to educate the reader and to get more people involved in the discussion.

2 Bi-national metropolitan area El Paso – Ciudad Juárez

2.1 History

El Paso – Ciudad Juárez bi-national metropolitan area is the largest cross-border metropolitan area in the United States and Mexico. Its combined population is over 2,4 million people with around another half of million people living in the surrounding area of the cities which makes it the largest bilingual and binational work force in the Western Hemisphere.[1] The cross-border mobility currently relies on international road bridges that serve as points of entry to the Unites States.[2]

Historically it is known that the earliest settlers in the region were corn farmers. Before the arrival of the Spanish this area was populated by the Manso, Suma and Jumano tribes which have formed the basis of the Mestizo culture in the present.

The first European explorer to arrive at the Rio Grande near the current El Paso – Ciudad Juárez in 1598 was Don Juan de Oñate.[3] However, the first settlement in this area was founded much later by the Spanish conquistadors in 1659. This settlement lay on the south bank of the Río Bravo del Norte (Rio Grande) and was called El Paso del Norte which is today known as Ciudad Juárez. The soil was then perfect for agriculture so this area thrived on the regional production. The local authorities of El Paso del Norte and The Spanish Crown then brought the agricultural production to the northern bank of the river which is today known as El Paso.

American traders started visiting the area in 1804 which added to the city growth.[4] The city kept prospering up until the Mexican War of Independence in 1810. El Paso del Norte luckily did not have any combat in the region but some trades were negatively affected. The city was also lucky during the Texas Revolution in 1836 because this part of the region was still not under Texas yet.

El Paso became the largest city in present day New Mexico until in 1850 when its north side was transferred to the United States. Back then the Texas Republic was interested in the Santa Fe trade so the Treaty of Guadalupe Hidalgo made settlements on the north bank of the river, separate from El Paso del Norte on the Mexican side.[4] The present Texas – New Mexico boundary was drawn in the Compromise of 1850.

The city was divided into two communities, one on each side of the river. After the separation the communities became more independent of each other. The United

States Senate set a boundary between Texas and New Mexico using the thirty-second parallel. In 1854 was established the first military post. The north part was worked on through plans and general development of the area and changed its name to as we currently know it – El Paso.[5]

On the other side of the river, during the French intervention in Mexico in 1862-1867, El Paso del Norte served as a temporary stop for republican forces of the rebel leader Benito Juárez. In 1888 El Paso del Norte was renamed in honor of him to Ciudad Juárez.

Later in the 19th century the population in the region began to grow rapidly. Many new railroads were built in this area and the trade with the rest of the United States increased considerably. Many new people started arriving to the northern side – El Paso. These people had various backgrounds for example they were businessmen, priests, gunfighters and prostitutes. El Paso had soon a big criminality rate and prostitution and gambling were prospering.

During World War I, Ciudad Juárez experienced a tourist boom and its criminality rates caught up with El Paso. Later with the Depression era and World War II the population started declining. After the war the area had to be redeveloped. Military expansion and oil discoveries were a part of that process too.

The differences in wages and cost of living of the US and Mexico started to be very tempting for many manufacturing businesses and this trend was even more supported by the signing of the 'NAFTA' - North American Free Trade Agreement.

Ciudad Juárez has changed greatly during what is called the Drug War which started in 2008. It lasted for four years during that period of time Ciudad Juárez became infamous as the world's most dangerous city. The drug cartels were battling to control the city because of its location – very close to the border of the US. It was a very profitable entry to the US drug market. Ciudad Juárez became full of violence.[6] There is an estimation that about 10 innocent people a day were violently killed. In these four years, 10 000 people were murdered in Juárez as a result of the war between the drug cartels and them trying to gain power over the city. In the present the situation has greatly improved since those hard times. The homicide rate has dropped and the violence between the cartels has dropped as well. The law enforcement has improved and the local people are starting to feel much safer nowadays. There are still situations

which are best to avoid for example being in the streets after dark but the city is much safer than it was and it is accepting even tourists.

On the other side of the river, the city of El Paso has been constantly voted for as being one of the safest cities of the US.[7]

2.2 Characteristics of the area

El Paso – Ciudad Juárez face a relatively limited risk from climate related threatening events due to minimal probability. This metropolitan area in comparison to other cities has a relatively stable climate and it is not in the zone of hurricanes, tornadoes or earthquakes. Risks put on by nature are frequently predictable and manageable. In El Paso – Ciudad Juárez the extreme climatic conditions are defined by very fast changes due to environmental conditions. The most common of conditions are extreme heat, flash flooding, drought and sudden freezing weather. All these are based on the location of this metropolitan area which is a desert environment.

Vastly probable to happen are extremely high temperatures which can follow up with severe effects to mainly children, elderly and the impoverished in the population. Extreme heat is very typical for the southwest desert. The temperatures in this region in the mid-summer months are often reaching between 40°C and 44°C. The average number of over 38°C days is increasing yearly. The usage of air conditioning may help greatly to some people but at the same time this increases the stress on the local electrical grid and it doesn't meet the needs of people who do not have the resources to afford it. The emergency reaction to this situation is very adequate as well as neighborhood community support is. The only issue is that there are not many training programs and they often have limited capacity. The period of time when the temperatures are so high is also putting a lot of strain on local infrastructure. Furthermore, there is a need to address energy usage and apply safety measures during this period.[8]

A commonly occurring condition in this region of the desert is drought. The drought is a great risk factor to the agricultural community and access to irrigation water is crucial to business and family income. El Paso – Ciudad Juárez and the surrounding region are dependent on both surface and ground sources for water supply. The surface water is supplied by the Rio Grande river which is reliant on the upstream sources in New Mexico and Colorado. The river is usually about 50% of the total water supply. Apart

from surface water, the cities are also supplied via the groundwater Hueco and Mesilla Bolsons. Unfortunately, in the last few years the water level in the river has been receding so there have been occasions where the groundwater was forming 90% of the water supply. These events have pressured the advance of technology of the El Paso Water Utilities. The solution was operating a plant of inland desalination. This plant is the largest in the world with the production up to 27 million gallons of water daily.[8]

Another occurring reality of this desert environment is the flash flooding. The floods are mainly caused by frequent and severe storms. El Paso – Ciudad Juárez receives only approximately 20 centimeters of total rainfall a year but flooding can usually happen even in light rainfall conditions, around 5 – 10 centimeters at a time. However, even with such a quantity when focused in a small geographic area with steep slopes can have severe impacts on the inhabitants and property. In 2006 the storms damaged a large part of the area so after this event the City Council of El Paso has established a storm water management plan. This plan relied on investments in infrastructure of the channeling or retaining the storm water overflow. In the future this water might be integrated and used as another water supply of the cities.[8]

2.3 Local specifics

El Paso itself has a population of approximately 700 000 habitants and is connected with Ciudad Juárez by three international road bridges. The proportion of Hispanics in the population is over 80%.[9] The cities are connected also by the railroad but it is not used to carry passengers and is only for the transportation of goods.

Ciudad Juárez has a population of approximately 1,5 million habitants.[10] About 500 000 Juárez residents live in poverty or extreme poverty which characterizes about 34% of the population that are unable to meet their basic needs and unfortunately the number keeps increasing. For a long time, Ciudad Juárez was not believed to be a poverty zone because the employment levels were very high but after some inspecting it has been discovered that most of the jobs in the city pay very low wages. The majority of the workers are the ones from factory production lines and they receive only about 120 000 Mexican pesos yearly which is around 124 000 Czech crowns.[11] This means the workers get around 10 000 Mexican pesos monthly which to our standards is very insufficient and, in some cases, even considered underpaid.

El Paso is one of the largest cities in the Western Hemisphere. Annually the city has \$80 billion in imports and exports.[12] El Paso is strong in manufacturing and logistics with great opportunities for innovating and expanding the city. The city is facing challenges for being a border community. For instance, the existence of a large population that speaks at least two languages on average being also bi-national can be an immense asset. Yet many bilingual inhabitants do not have the formal fluency in either language and this is at times representing itself as a development deceleration.[13]

On the other hand of El Paso having such incredible opportunities, over a quarter of residents are facing very similar struggles like in Ciudad Juárez and that is poverty or extreme poverty. Although the city has a lower cost of living compared to the whole United States, it is not focused on increasing the quality of life or prosperity.

2.4 Cross-border mobility

The two cities are connected by three international bridges as was mentioned before. These bridges are owned and operated by the City of El Paso.[15] There is also one other international road bridge owned by the International Boundary and Water Commission and it is operated by the US Customs. The bridges serve as a point of entry to the United States and they are currently used for vehicle and pedestrian transportation. In 2018 the Paso del Norte, the Stanton bridge and the Zaragoza bridge have registered over 3.7 million passenger vehicle crossings and over 4.3 million pedestrian crossings into the United States.[2] The bridges are currently lacking advanced smart equipment but the Strategic Plan “25 by 25” along with the Resilient El Paso plan expects the development of the existing cross-border infrastructure with the goal to create a “seamless binational community”.

Below in Figure 1 is the map of the area with depicted crossing points.



Figure 1 - El Paso and Ciudad Juárez map. Source: Google.com/maps

The first bridge is The Paso del Norte Bridge. In the map it is depicted under the red color and can be in found also in Figure 2 in more detail. It was originally built in the 1800s and has since been rebuilt. Now it has six lanes for non-commercial traffic only. It's one of the busiest border crossings of the US.[2] Through this bridge more than 10 million people enter the US from Mexico each year.



Figure 2 - The Paso del Norte Bridge. Source: [14]

The second bridge is The Bridge of the Americas. In the map it is under the green color. This bridge has four separate structures. It has 2 two-lane bridges for truck traffic and 2 four-lane bridges for other vehicular traffic. The original bridge was from 1967 and the construction of the four replacement bridges started in 1996 and was completed in 1998. The bridges provide a total of eight lanes for passenger vehicles, four lanes for trucks and two sidewalks for pedestrians. It also has a FAST lane included. We can find the aerial view of this bridge in Figure 3.



Figure 3 - The Bridge of the Americas. Source: [14]

The third bridge is The Stanton Street Bridge and it lies closely to The Paso del Norte Bridge. It is known as the “Good Neighbor Bridge”. [14] During the time period from 1967-1999 this bridge was dedicated only to southbound traffic. After this period, it was set to northbound traffic again. This bridge is currently used by pedestrians, buses and cars for crossing the borders. It has a SENTRI or Dedicated Commuter lane (also known as DCL) which I will speak later about. [14] We can find the view of this bridge in Figure 4.



Figure 4 - The Stanton Street Bridge (right); The Paso del Norte Bridge (left). Source:[18]

The fourth bridge is The Ysleta Bridge, also commonly known as the "Zaragoza Bridge". This bridge lays under the blue color in the map above. The bridge was constructed in 1938 but has been rebuilt and renovated many times. The latest renovation was in 1990, when it was split into two bridges. One bridge is now serving the purpose of transporting the commercial vehicle traffic with 4 lanes and the other is dedicated to the non-commercial vehicle traffic and pedestrians with 5 lanes. Two are southbound, two northbound and one SENTRI lane. The non-commercial bridge also has two pedestrian walkways. The commercial bridge has four lanes. Two are southbound, one northbound and one FAST lane.[18] There are plans to increase the number of lanes only by redesigning and not increasing the bridge width. After this redesign the commercial bridge would have an extra northbound lane added to its current state.[14] We can see the picture of the bridge in Figure 5.



Figure 5 - The Ysleta Bridge. Source: [15]

Now I would like to further explain the differences between the SENTRI and the FAST lanes. SENTRI was established to speed up the movement of low-risk, prescreened and preapproved travelers. The short cut stands for Secure Electronic Network for Travelers Rapid Inspection. The applicants must undergo a thorough criminal, customs, immigration and terrorist background check.[16] They have to also submit their fingerprints for a law enforcement check and then they have to pass a personal interview with a CBP officer (Customs and Border Protection officer). Furthermore, the cost of this program is \$122.25 per person which is almost 3 000 Czech crowns and it is valid for five years.

The FAST lanes program is a commercial clearance program. The short cut stands for Free and Secure Trade. This program secures the entering of low-risk shipments to the US from Mexico and also from Canada. In general, FAST vehicle lanes process commercial cargo at land border ports of entry to the US.[17]

To cross the border from Mexico to the US the given person must have a passport and visa to be granted access. To leave from Mexico there is a fee of 4 pesos that has to be paid which is about 4 Czech crowns.[18] At the border the officers can also issue an inspection at any time to prevent illegal import of goods for sale and there's also a security check along with x-ray machines. All these processes create huge queues.

On the other hand, crossing from the US to Mexico doesn't require showing any papers or passport, no questions will be asked and the amount of people in queues is minimal.

Both cities have an independent public bus transit. The only way to cross the borders by a bus is to use the Transborde bus company. Apart from only crossing the border with this company, the route of the buses also connects the airports of El Paso and Ciudad Juárez. At the bridge the passengers have to leave the bus to go through the customs line before boarding the bus again. Their price to take the passengers from airport to airport is \$20 which is about 500 Czech crowns but this can be expensive for some.[19]

There is also the possibility to cross the bridge with a taxi but that can turn out to be even more expensive. It is suggested to use the services of Uber which can be up to a half cheaper than a classical taxi and the application is very handy since it works the same in the US as in Mexico.

The cheapest and probably the fastest way to cross the border would be by foot. The waiting lines are considerably smaller than those of vehicle traffic and it takes only about 10 minutes to walk across the bridge. The most typical use of this procedure would be to use a car or a taxi to one side of the bridge, cross by foot and then use another car or a taxi to continue in one's way to their destination.[20]

There is also a possibility to travel between these two cities by plane. Due to the current situation of COVID-19 the prices of the plane tickets are higher than usual or completely suspended. During the writing of this thesis the situation escalated even more and I wasn't able to find any flights between El Paso and Ciudad Juárez. I assume they have been suspended.

2.5 Existing transit systems

The existing transit system in El Paso relies on buses. In addition to that, the city has also a single light rail which is similar to a tram or a streetcar line. This rail is connecting Downtown Transfer Center and Glory Road Transfer Center but it is more suitable for visitors due to low speed, little integration and long headways. I will be speaking more about this line further in the work.

2.5.1 Bus transit

The city of El Paso has two types of buses; the first type is the circulator buses under the company named Sun Metro. These buses are intended for the coverage of the large low-density residential areas. To complete this task, the single lines of the buses meet in many transfer knots located around the city. This basic bus network has most of the characteristics typical for such a level of transit service. For example, since the circulator bus lines are covering large areas of the city their routes have very long headways with sometimes up to 40 minutes. Furthermore, their routes tend to be winding which in consequence leads to the decrease of attractivity with increasing distance traveled. Another characteristic they have is their low speed.

The second type of buses is forming the pillar of the local public transit system. Local people call these buses Brio because they belong to the Bus Rapid Transit (BRT) system. It is also known as the metrobus. El Paso has been working on this system over several years. The plan is to have 4 lines named after the major streets on which the Brio buses operate or will operate. The names would be Mesa, Dyer, Montana and Alameda. Currently only Mesa line is in function. The BRT system in El Paso is designed to greatly improve the transportation to the existing circulator buses. Its characteristics are straight routing, fewer numbers of stops and higher speed than the circulator buses. The length of each line is from 12 to 25 km. After these lines are fully in use, the majority of the city will be covered. The only limitation that these lines have to face is the fact that they share the road infrastructure with cars. This means that the average speed of the BRT buses will be affected and will be only around 30 km/h. Below we can find the attached map of the Sun Metro's Bus System Map in Figure 6 and the map of the whole network in Figure 7.

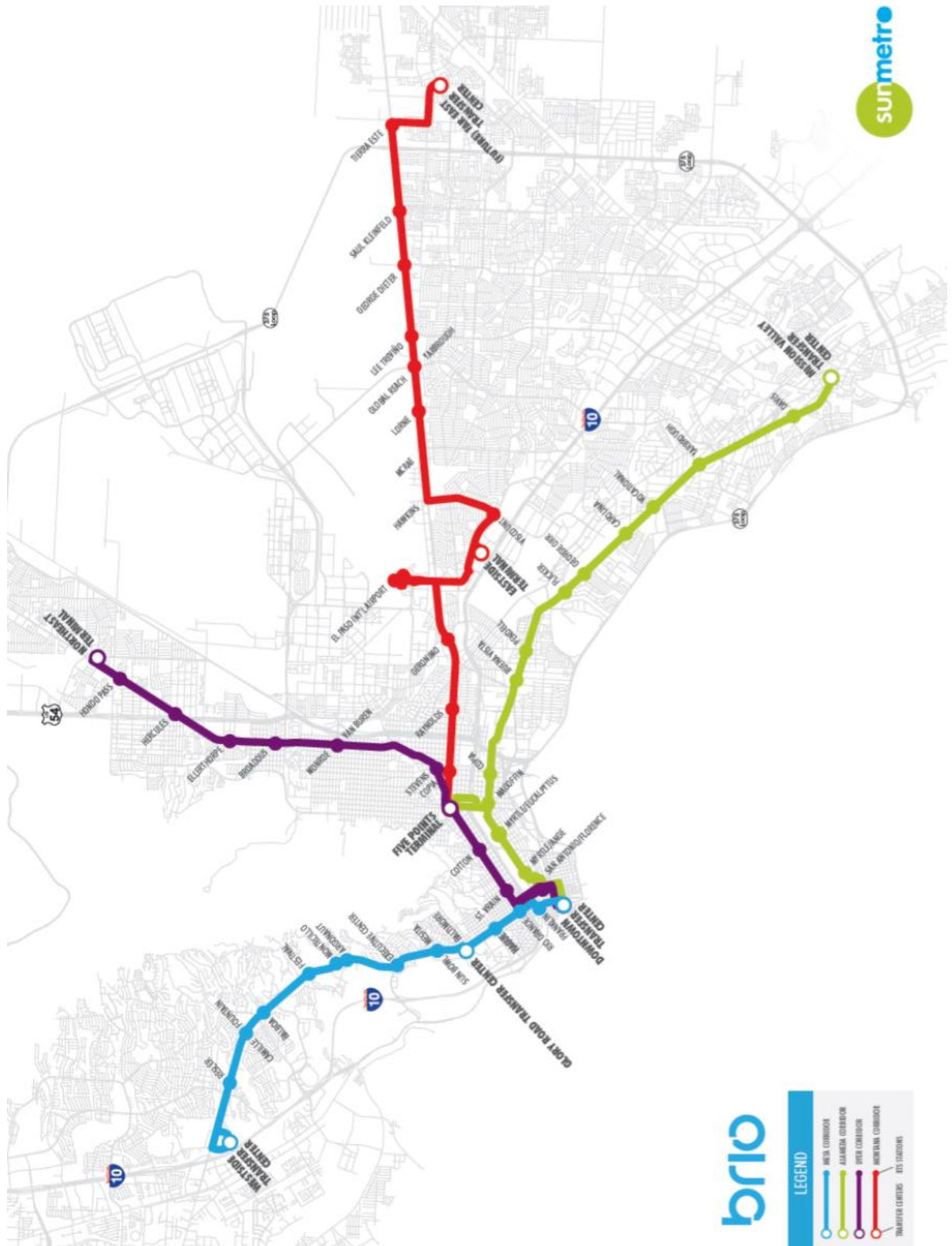


Figure 6 - Sun Metro's Bus System Map. Source: [22]

The major issues that limit the development of the public transit system in El Paso are the absence of a central transit bus terminal and integration.

Speaking about the central transit bus terminal, in the current state of concept of Brio and circulator buses, the city might be intending on making the Downtown Transfer Center a central bus terminal since three of the four Brio lines cross over there. The terminal itself is however still not in function.

The issue with integrity is the fact that the above-mentioned supposed terminal joins only local city bus lines. The regional a long-distance bus lines have their own bus terminals. This results in isolated transportation subsystems without any means of combining one another; the public transit systems cannot be connected into one functional system as it is common in most large European cities.[21]

2.5.2 Tram transit

The city of El Paso has another small part in the transport system called the Streetcar. This is very similar to our trams. The Streetcar has a line of only 7,7 km which is divided into two loops that connect to each other as we can see in Figure 8.

This system is again separated from other transit systems. Even though the stops are close from the border the line doesn't have a clear destination and has little integration. It is very attractive for tourists but for locals it is not so handy. Furthermore, the line was suspended for the precautions for COVID-19. This line could be used as an addition to the already set system, but for now it cannot be used as such because of the earlier mentioned poor integrity and long waiting times.[22] In Figure 9 we can see how the vehicle looks like.



Figure 8 - Route map of Streetcar. Source: [22]



Figure 9 - Streetcar. Source: [22]

It is also important to mention that this system in El Paso is not functionally connected with the one of Ciudad Juárez. This could be possibly the influence of the United States-Mexico border and existing immigration checkpoints in this border.

The transit systems existing in Ciudad Juárez are based on buses but the mapping of them is very poorly documented. I wasn't able to find any structured comprehensive description of it.

2.5.3 Rail transit

Further, I would like to elaborate on the rail network. The existing rail transit system in this region is depicted in Figure 10.

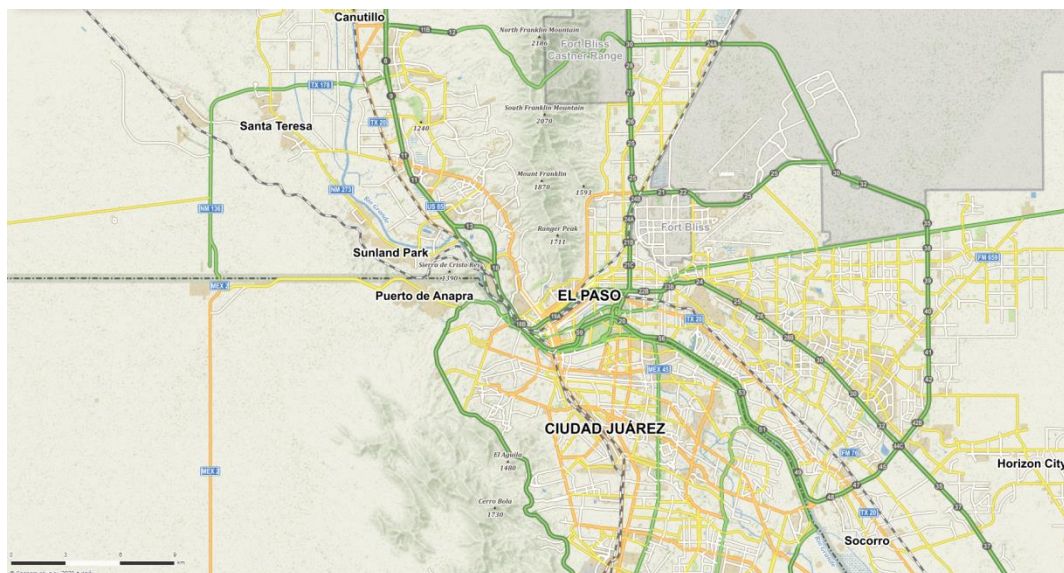


Figure 10 - Rail network in El Paso and Ciudad Juárez. Source: Mapy.cz

There is an existing rail network proposal. The plan is to have a network of radial rail lines connected into diametral rail lines. The center of these rail lines would be the multimodal transportation hub. This network is proposed to be a star type radial

network with 5 lines in total. This system would be integrated with the already existing Brio bus transportation.

The first line would connect Ciudad Juárez with El Paso and at least two stations will be needed due to the size of the covered area. The second proposed line would connect from the west and will hopefully be the base of improving the hub of the cross-border rail links. The third line will be connecting the Northwest and it is not expected to be a heavily used line because of the distance. This line would be ideally operated only by each second train. The fourth line would connect the Northeast and finally the fifth line would connect the Southeast. This line also based on the distance is proposed to be operated only by each second train. The planned network is depicted in Figure 11.

The lines would be as follows:

- Ciudad Juárez-El Paso (downtown)–Shearman
- Ciudad Juárez-El Paso (downtown)–Anthony
- Sunland Park-El Paso (downtown)–Shearman
- Sunland Park-El Paso (downtown)–Socorro, TX
- Las Cruces-El Paso (downtown)–Fabens

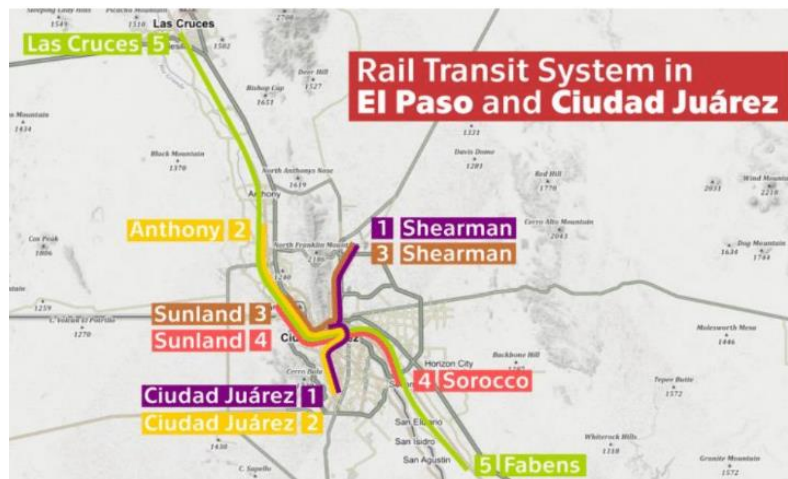


Figure 11 - Proposed Public Rail Transit System for El Paso and Ciudad Juárez. Source: [21]

To make the best integration possible it will be needed to find additional conversion points with the already existing bus networks. In addition, if more parking lots are created near the rail stations, it would support the demand. The current rail network has a very advantageous layout throughout the city and it makes a window of opportunity to create a functional and integrated public transit system.[21]

3 The strategic plan of development of the Bi-national metropolitan area and its important aspects

The bi-national metropolitan area of El Paso and Ciudad Juárez has put together a strategic plan of development in 2019. This plan has 8 main goals and it is expected to be completed by the year 2025. The strategic plan sets priorities in organization and focusing energy and resources to improve the quality of life and place of the community. The vision is to develop a stable regional economy, make the neighborhoods safe and welcoming for the inhabitants as well as providing cultural and educational opportunities to the people.

Goal number 1 is focused on the cultivation of the environment. This includes the stabilization and expansion of the tax base which would then activate the development of medical centers, airports, parking spaces, renovations of hotels followed also by investing in historic structures. Expanding the airports is a very important step in the attraction of tourists because it also brings the visitor revenue to the cities. Another part of the regional economy are the local businesses which will be supported by a better system of obtaining permissions, improvement of the inspection processes and donations or reinvestments in those businesses.

Goal number 2 sets the standards for safety and security. This means investing in the public safety operations, for example adding more police officers, replacing the malfunctioning Police and Fire vehicles annually and launching new public safety facilities with educational programs for the community. Improving the safety also includes refining the infrastructure with traffic management solutions along with proactive approaches to prevention of fire and medical incidents and enhancing overall health.

Goal number 3 is mainly promoting the visual image of the city. The plan will set a standard for infrastructure across the area. It includes upgrading the city gateways, corridors, intersections and parklands.

Goal number 4 is dedicated to enhancing the recreational, cultural and educational environments for a better life quality. The projects in this goal are focused on children's museums, cultural centers, sports complexes, zoos, aquatic centers with indoor competition pools and on building of community centers with an option of a Performing

Arts Center. The goal also includes expanding free Wi-Fi services to 27 Quality of Life facilities.

Goal number 5 promotes transparency and consistency of communication among all members of the community. The plan supports productive dialogs between community groups and public agencies. This includes expanding the use of current and new technologies to reduce any inefficiencies in the communication. The internal communication and employee engagement will also be supported by the City Council. Media will be invited to have a proactive community outreach and will strengthen messaging opportunities to the general public.

In goal number 6 we will find the setting of standards for governance and fiscal management. The city is going to recruit and retain a skilled workforce from various backgrounds. Employees will be given benefits and services for their financial security. Companies will be invited to provide training for employees as well as activating partnerships for the growth of the community. Financial stability will be ensured by optimizing resources, aligning service delivery mechanisms, budgeting, reporting one's results and identifying potential new revenue streams. The government and Municipal Court efficiency will be transparent and inclusive. Part of the 6th goal is also the Cybersecurity Plan. The plan will implement a Smart Community Roadmap into city operations. It will document and maximize existing smart technology along with implementing an open data initiative. It is planned to establish a laboratory environment to explore the smart technology applications and to develop partnerships to help with smart neighborhood development. All above mentioned will enhance the resilience within the organization of the city.

Following is the goal number 7. In this part the strategic plan discusses the enhancement and sustainability of the infrastructure network. Starting with the reliable water supply and distribution systems it is planned to implement support vehicles which would advance the region in energy and water distribution. Another part is the implementation of Bike Plan and street reconstruction projects. These reconstructions will include reconstructing the streets, entryways and city aesthetics meaning for example planting more vegetation around the city. New transportation systems will also be implemented which would align with the standards for infrastructure across the city.

Goal 8 focuses on nurturing and promoting a healthy and sustainable community. The target is to minimize health risks. The city is planning on supporting affordable, high quality housing options with the focus on vulnerable populations. Along with this the animal services will also be enhanced. These services will continue to care about the animals in shelters but with more support from the city. Generally, the city will be also focused on reducing the operational energy consumption, improving the air quality and on providing sustainable regional waste solutions. And last but not least the city will be also supporting the community resilience through environmental education and cultivation of local, regional and global relationships that support trade and tourism.

To sum it all up, there are plans for big projects that should greatly improve the current state of things. With improvements mentioned above the city should be more prospering and also more tourist attractive. The impact will resolve into a bigger cash flow which will lead to an even bigger success and the rise of the living quality.[23]

4 Survey mapping the cross-border mobility

In order to find out about the real situation, I have designed a survey mainly for the students of the University of Texas at El Paso (UTEP).

UTEP is a nationally recognized public university established in 1914. With its 12 institutions it has received national acclaim for innovative programs in business, fine arts, education, the humanities, health sciences and nursing.[24]

I have specifically targeted these students because of the collaboration of our universities.

The first introduction of the survey to the students was on the 27th of August in their class, by the supervisor of my bachelor thesis.

The survey had 24 questions and was divided into three parts. Part A focused on the interviewee. There were 5 closed questions about basic sociodemographic data – age, gender, nationality, place of residence and pursued degree at UTEP.

Part B was dedicated to the current border crossing experience with 11 questions divided into 9 closed questions and 2 open questions – reasons to cross the border, border crossing frequency, means of transportation used in El Paso and Ciudad Juarez, fast lanes utilization, wait times, comments on positive and negative aspects of the existing border crossing system.

The last part was part C which focused on the improved border crossing system using smart border concepts with 8 questions divided into 5 closed questions and 3 open questions – dynamic lane allocation, reservation system, pre-check on Juarez side, cross-border public transit and the respondent's own proposals to improve the system.

The survey questions are to be found in appendix number 1.

The most interesting answers were to questions from part C. Here are few listed for an example.

- Q18: What type of public transportation would you prefer? (to cross the border)
- Q21: What do you think about having more officers at the border check?
- Q23: Would you welcome dynamic lane selection at the border crossing?
(Number of lanes will vary on amount due to the current traffic)

- Q24: What would you propose to improve the border crossing?

The site I used to prepare the survey is an online tool – SurveyMonkey – which offers a feature that allows adding logic sequences to the questions. This logic is depicted in the scheme in Figure 12.

Questions 6, 10 and 18 are decision nodes. Question 6 is asking whether the respondent has crossed the border at least once in the past year, Question 10 creates two branches with a subset of questions based on the answer whether the respondent had used a car to cross the border and finally, Question 18 leads to the complementary Question 19 asking about an acceptance of a pre-check on the Juarez side of the border in case the respondent indicated the willingness to use the public transit to cross the border.

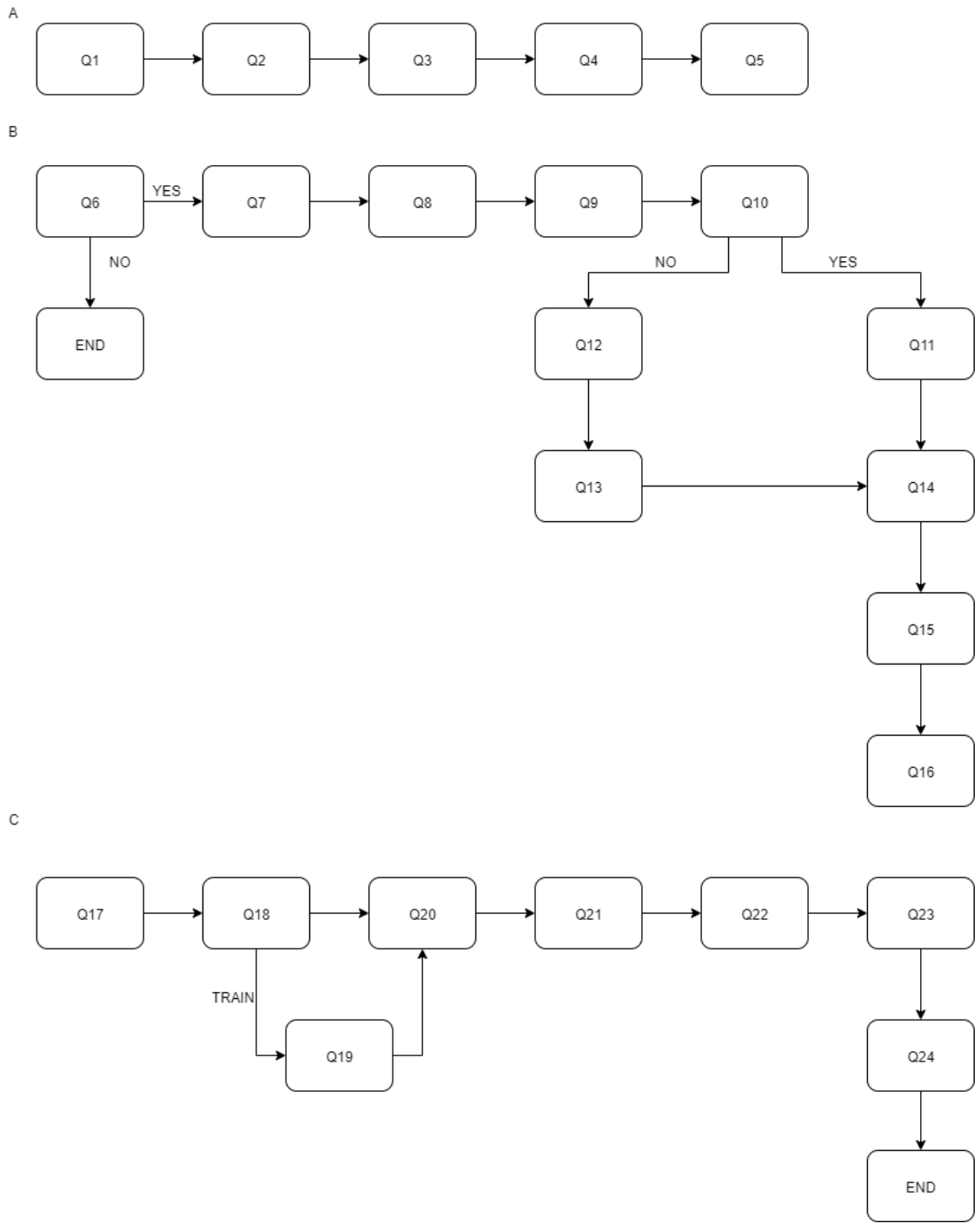


Figure 12 - Logic of questions. Source: own work

5 Survey summary

5.1 Survey distribution

The survey was first introduced to UTEP engineering students in class on August 27, 2019 resulting in limited number of responses during that day and on the following days. The low response rate leads to the second presentation by one of the teachers during a class on August 30, 2019. Students were given time complete the survey in class. The responses volume is depicted in Figure 13 from August 2019 to November 2019. Most of the responses were collected on the 30th of August with 55 of them. The survey was kept open until November 30, 2019 with the last response collected on November 29, 2019. In total, 92 valid responses were collected with the survey completion rate of 97 %. On average, the survey took 3 minutes and 45 second to complete.

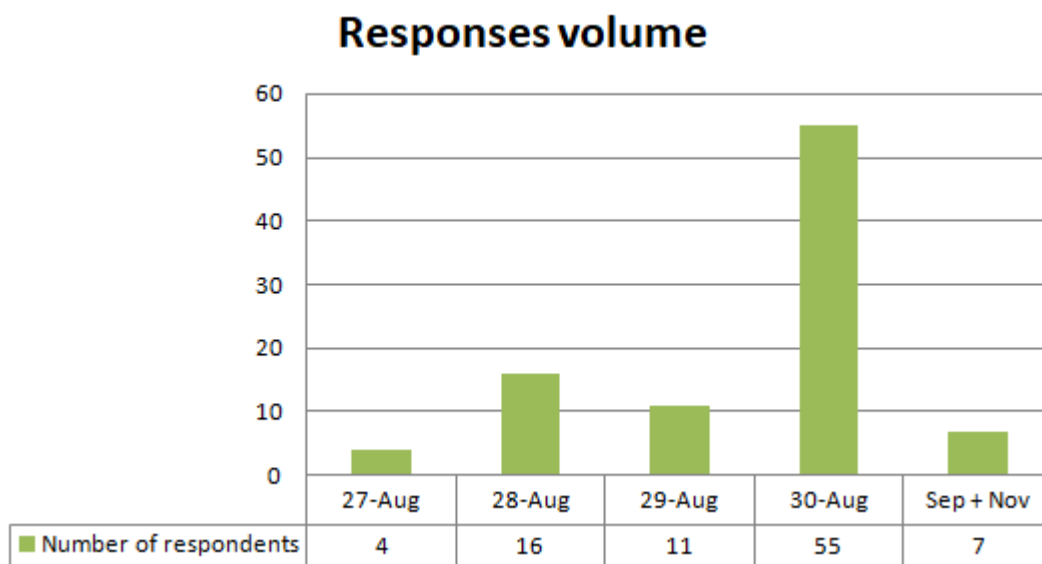


Figure 13 - Responses Volume Source: own work

5.2 Survey evaluation

The evaluation of the survey took place along with writing an article which was publicized at the Smart Cities Symposium in Prague 2020.[27]

5.2.1 Part A

The survey starts with part A. Part A consisted of 5 closed questions and was focused on basic sociodemographic data. In Figure 14 we have the graph of answers to question number 1. I asked what age the respondents were. Since the survey was conducted among university students, no significant variation in age distribution of

respondents was expected. This anticipation was confirmed with the average reported age being 25 years and median being 23 years. The youngest respondent was 20 and the oldest 55. In total, 7 respondents were over 40 hinting on UTEP’s role in providing continuing education in the region.

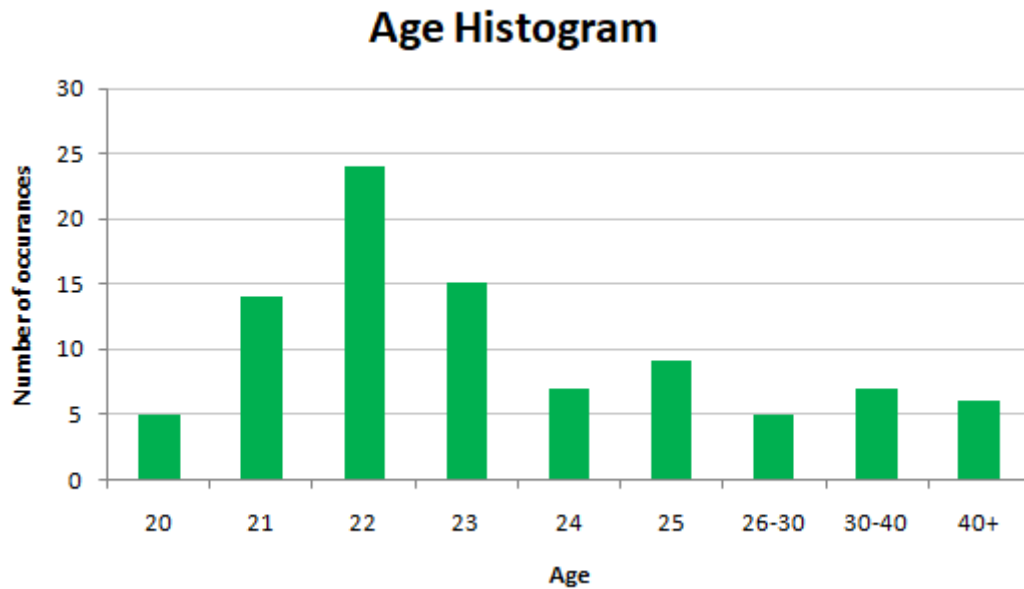


Figure 14 - Q1 Age Source: Generated by Survey Monkey

In the second question I asked about their gender. In Figure 15 we can see that respondents who answered the questionnaire were 67% men and 33% women. I have added an option “Other” but no respondents identified as such. This outcome of gender composition was expected since the survey was conducted during a class at the College of Engineering.

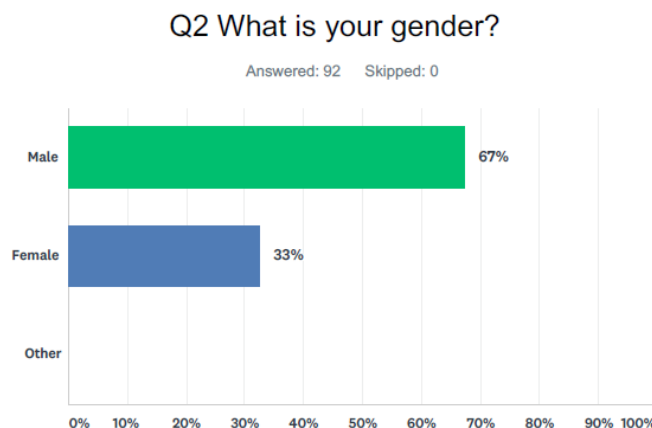


Figure 15 - Q2 What is your gender? Source: Generated by Survey Monkey

In Figure 16 we have the graph of answers to question number 3 where the respondents were asked about their nationality. Most of the students with 76% were citizens of the United States, 13 % were with a Mexican nationality and the remaining 11 % consisted mostly of exchange students from Bhutan and Kuwait. However, three students out of this group reported that they have both American and Mexican citizenship.

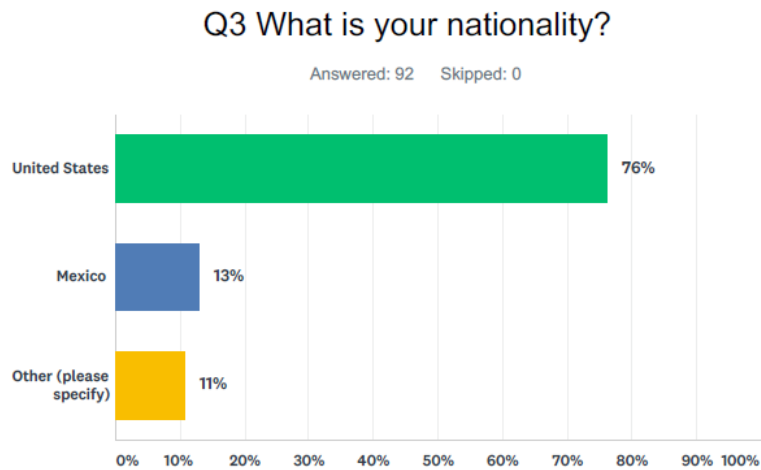


Figure 16 - Q3 What is your nationality Source: Generated by Survey Monkey

In Figure 17 we have the graph of answers to question number 4 where the respondents were asked where are they currently living. We can see that most of the respondents live in El Paso off campus with 87%, 12% live in Ciudad Juarez making them regular cross-border commuters and only 1% live on the university campus which came as a surprise.

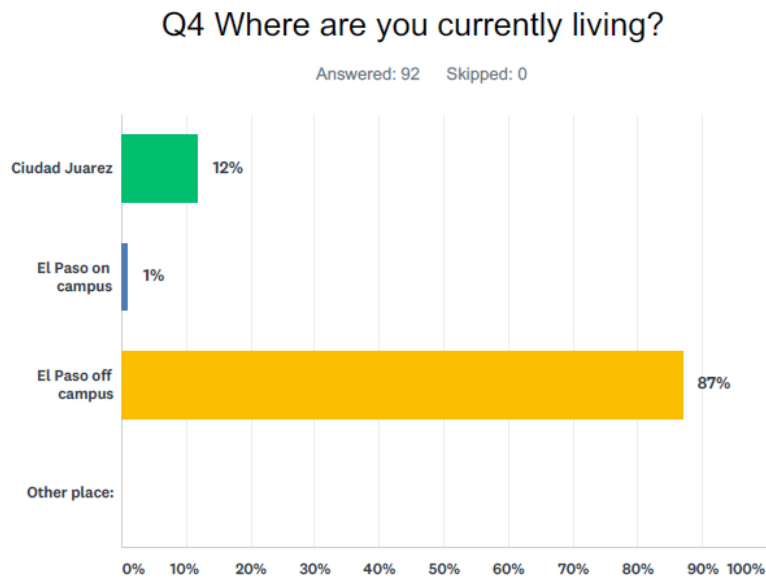


Figure 17 - Q4 Where are you currently living Source: Generated by Survey Monkey

In Figure 18 we have the graph of answers to question number 5 where the respondents were asked, what degree they are studying for. The vast majority of the respondents were undergraduate students (85 %) followed by graduate students (12 %) and Ph.D. students (3 %). This was the last question from part A.

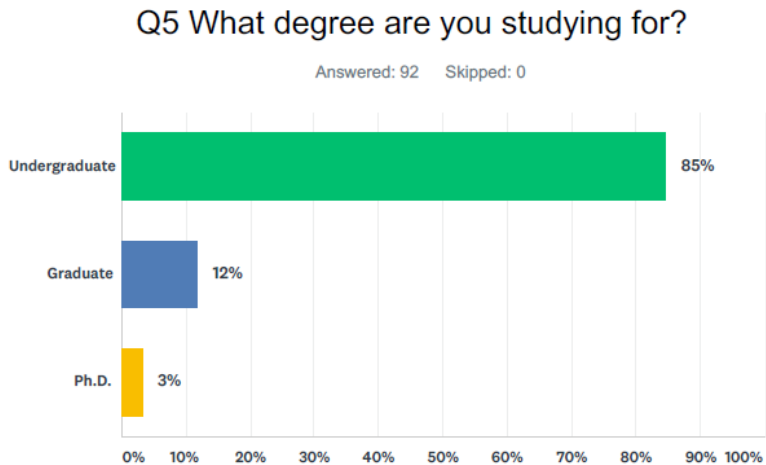


Figure 18 - Q5 What degree are you studying for Source: Generated by Survey Monkey

5.2.2 Part B

Part B started with question 6 which was the first decision node. In Figure 19 we have the graph of answers to this question. The respondents were asked whether they have crossed the border at least once in the past year. Based on their answer, the survey was split into two branches. In case the respondents indicated they have not crossed the border at all in the past year, the survey ended for them in order to avoid bias by including not up to date experience with current border crossing. That was the case of one third (34 %) of respondents, whereas the remaining 66 % crossed the border at least once in the past year.

Q6 Have you crossed the border at least once in the past year?

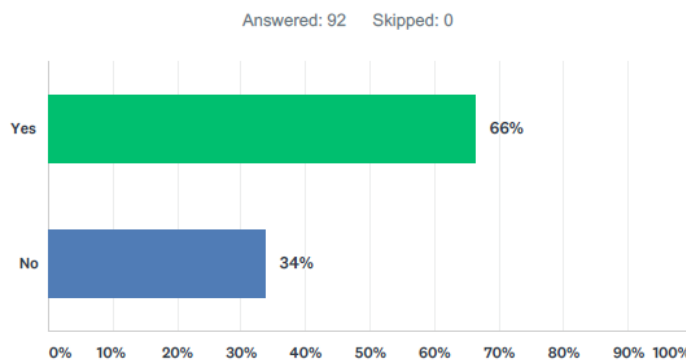


Figure 19 - Q6 Have you crossed the border at least once in the past year Source: Generated by Survey Monkey

In Figure 20 we have the graph of answers to question number 7. In this graph we can find the details concerning frequency of border crossing. We can see that 20% of students cross the border every week at least once, 30% of students cross the border monthly and 33% cross less often. 18% of the students travel daily across the border. These regular commuters are especially affected by inefficiencies and delays at the border. The percentage of daily commuters roughly corresponds to the percentage of students with Mexican citizenship.

Q7 How often are you crossing the border?

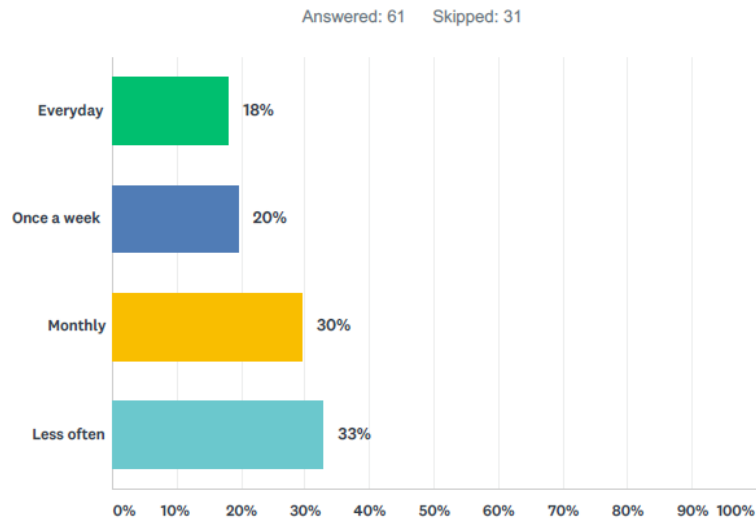


Figure 20 - Q7 How often are you crossing the border? Source: Generated by Survey Monkey

In Figure 21 we have the graph of answers to question number 8. I asked if the respondents have family members on the other side of the border. 82% of the respondents do have relatives across the border, 18% answered they don't have.

Q8 Do you have family members (including relatives) on the other side of the border?

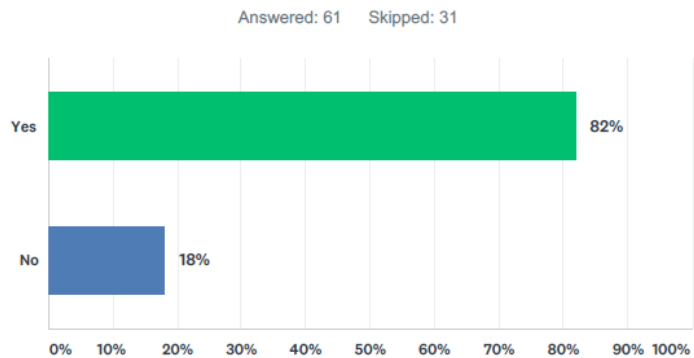


Figure 21 - Q8 Do you have family members on the other side of the border? Source: Generated by Survey Monkey

In Figure 22 we have the graph of answers to question number 9. This question had a multiple-choice configuration – respondents could select more than one answer. In this graph we can see the reasons of the crossing of the border. The most prominent reasons included family visits and entertainment followed by shopping. The family visits being one of the main reasons to cross was not surprising because we already

knew from the earlier graph that 82% have family members across the border. Commuting to UTEP was not the major driver; however, this was expected since most of the students said they live in El Paso. Out of the “Other” reasons, the most frequent was the doctor’s appointment.

Q9 What are your reasons of crossing the border?

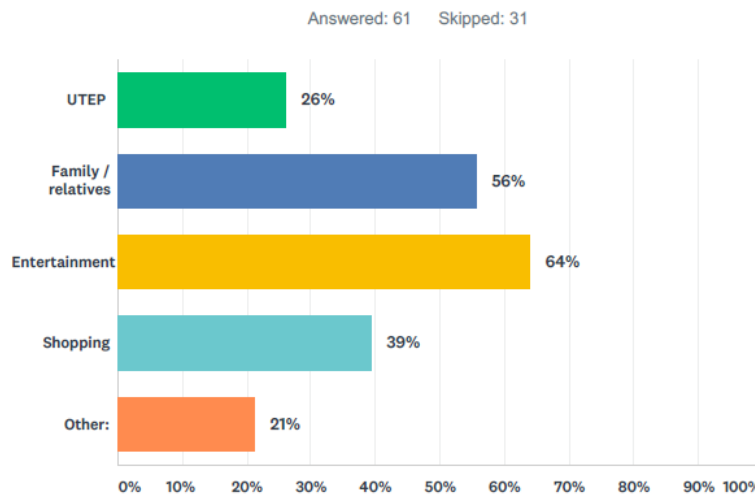


Figure 22 - Q9 What are your reasons of crossing the border? Source: Generated by Survey Monkey

The next questions focused on the means of transportation used to cross the border and when moving around El Paso and Ciudad Juarez.

In Figure 23 we have the graph of answers to question number 10. The respondents were asked if a car was being used while they were crossing the border. This question was the second decision node. Those who answered yes were directed to question number 11. Those who answered that didn’t cross using a car (14 respondents) were directed to question number 12. The majority of students (77 %) said they cross the border by car either as drivers or passengers.

Q10 Do you use a car (driving or as a passenger) to cross the border?

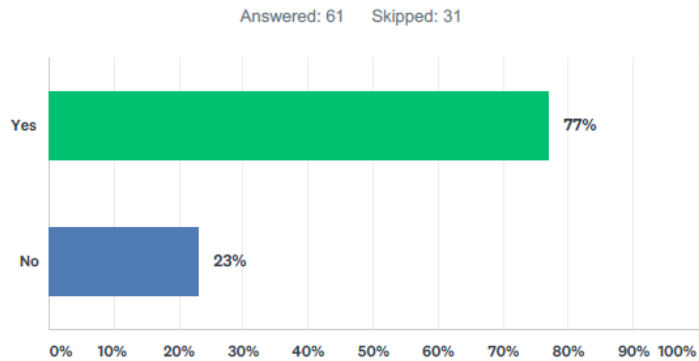


Figure 23 - Q10 Do you use a car to cross the border? Source: Generated by Survey Monkey

In Figure 24 we have the graph of answers to question number 11. The respondents were asked if they used the Express Lane (Fast Track) for crossing the border to minimize the time needed to make the crossing. The answers from 47 respondents were collected – only 30% answered yes and 70% answered no. These respondents were then directed to question number 14.

Q11 Do you use Express Lane (Fast Track)?

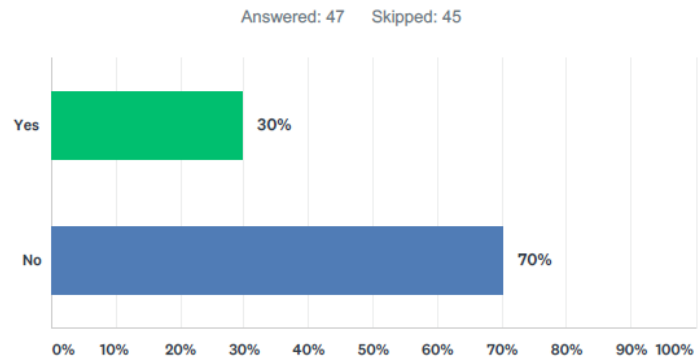


Figure 24 - Q11 Do you use Express Lane? Source: Generated by Survey Monkey

In Figure 25 we have the graph of answers to question number 12. Those were the responses from those who in question 10 answered they didn't use a car to cross the border. They were asked what means of transport do they use in Ciudad Juarez. The most frequent answer with 50% was that they used a taxi or an uber, 29% said they either walk or cycle and 21% said they use a car of a friend or family. This implies that they mostly rely on for-hire options such as Uber/taxi to reach the border or on their

family or friends to drive them to or from the border. These respondents were then directed to question number 13.

Q12 What means of transport do you use in Ciudad Juárez?

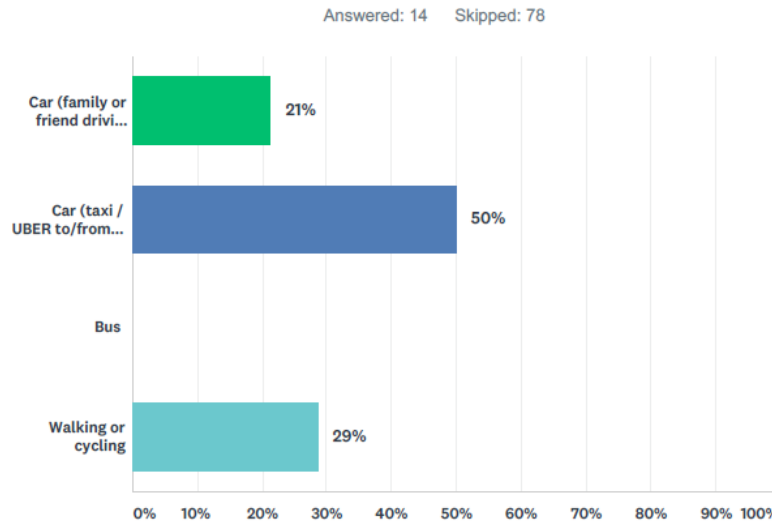


Figure 25 - Q12 What means of transport do you use in Ciudad Juárez? Source: Generated by Survey Monkey

In Figure 26 we have the graph of answers to question number 13. Here we can see the answers to what means of transport do the respondents use in El Paso. The most dominant answer with 93% was that they use a car of a family member or of a friend and enter the United States. The rest 7% use a public transit Sun Metro bus to move away from the border area. The reason for that can be the lack of spatial public transit integration with the border crossings, even in dense downtown area, where the nearest Sun Metro bus terminal is located over half a kilometer away. The tram stop is located closer to the crossing, however, due to lack of integration with the rest of the bus-reliant public transit system and long headways it is not a viable option for travelers, especially commuters.

Q13 What means of transport do you use in El Paso?

Answered: 14 Skipped: 78

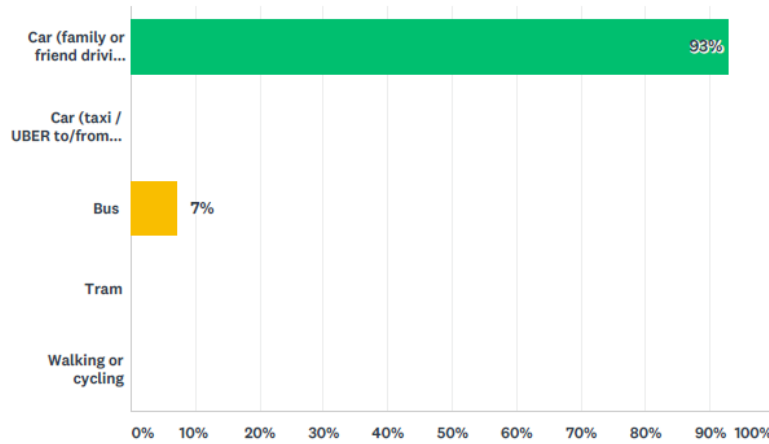


Figure 26 - Q13 What means of transport do you use in El Paso? Source: Generated by Survey Monkey

In Figure 27 we have the graph of answers to question number 14 which was also the last closed question in Part B. All respondents were directed to this question after previous questions. We can see that one respondent decided to exit the survey and didn't continue to answer. In this question I asked how long it takes to cross the border from Ciudad Juarez to El Paso. Almost 50% of the student's experience wait-times exceeding 1 hour. Only 13% of students reported wait times lower than 15 minutes, 18% said it takes them between 15-30 minutes, 22% said it takes them up to an hour, 27% said it takes between 1 and 2 hours and 20% said it takes longer than 2 hours. As I've mentioned earlier, the crossing in the opposite direction usually has negligible wait time due to absence of regular border inspection in Mexico. Only travelers beyond the Ciudad Juarez city limits are required to have their passports checked.

Q14 How long does it take you to cross the border from Juárez to El Paso?

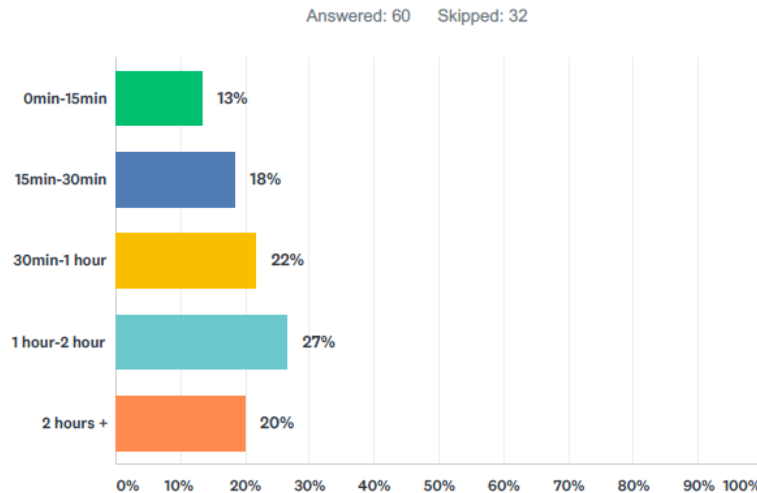


Figure 27 - Q14 How long does it take you to cross the border from Juárez to El Paso? Source: Generated by Survey Monkey

In question number 15 I asked if the respondents see any positive aspects regarding the existing cross-border system with focus on existing infrastructure and existing inspection process. This was an open answer question. The following responses were analyzed and were divided into five clusters based on similarity in meaning. They are also left in the original form directly from the respondents which means there are typing and grammatical errors included.

Cluster 1 = Seen as negative

- No (*this answer appeared 10 times in total*)
- Not really
- Nope
- Not really.
- I believe that everything that they are doing is worthless
- Worse now due to political problems
- It's become a nightmare and a very humiliating at times with the birder patrol even when you are an American citizen

Even though the question was formulated to identify *positive* aspects, 12 out of 40 responses were outward negative, often stating plainly “no”, meaning there are no positive aspects regarding the current system. Two respondents indicated that the situation has gotten worse (Fall 2019), while one respondent blamed what he or she called as “worsening political situation”.

Cluster 2 = Security / Positive

- Inspection Help to improve Homeland Security
- Inspection
- Inspection
- Inspection is efficient however it is time consuming
- Yes, our security
- They take the time to ensure that the person crossing will not be a threat to our country
- Security, processing, technology, personnel, size
- Custom officers provide safety
- Not many, only that it adds more security to the border
- Helps prevent illegal trafficking
- Its hard to find positive aspects but the goal is to keep us all safe.
- Cbp makes it long but it's necessary
- Yes
- Its worth
- Yes, I'm when inspecting vehicles and verifying identities.

There were 14 respondents who said that the positive aspect of the current system is security. Two respondents said that the inspection is necessary though it is often time consuming. One respondent mentioned prevention of illegal trafficking.

Cluster 3 = Express lane

- Inspection is efficient on the express lane
- The express line
- express lane
- The express line is very organized but the normal line needs a lot of improvement.
- The simple opportunity to cross the border is a positive aspect, in my case having the express is the best thing and in terms of the system it fits perfect for the needs of a person who crosses the border everyday

Five respondents saw fast lane as a positive aspect of the current system. One of these five respondents said that the fast lane is well organized and that it is the regular lane that needs improvement.

Cluster 4 = Infrastructure

- Multiple points of access
- The number of bridges available
- The bridges are in decent condition as far as infrastructure
- Yes, the infrastructure in the border is good
- When all lanes are open it can make it go by at a quicker pace
- The infrastructure itself is ok. It is shaded for the most part and there are enough lanes to make it a fast crossing.
- Good structure
- It tries to make crossing as smooth as possible
- The entrance and directions are well displayed and understandable

In total, 9 respondents praised the existing infrastructure (international bridges) including driving directions or that there are multiple access points (that there are more international bridges). However, two respondents mentioned the need for all lanes to be open in order for the crossing to be smoother.

Cluster 5 = Other reasons

- Encourages everyone to get a passport.
- At non-peak hours the line waiting time can shorten to less than 45 minutes if Juarez to El Paso crossing users have correct documentation (i.e. passport card or book).
- I usually cross walking and not by car and I think that it is well organized but sometimes when computers stop working there is not backup system so they make the people wait until system is back online and that may take about 30 extra mins.
- The pedestrian walk is usually quickest way.
- Fairly easy

Finally, the fifth cluster collected 5 answers that did not belong to any of the other clusters. Two respondents said that crossing on foot is usually the quickest, although there was a comment that in case of a computer malfunction the wait time can easily increase by half an hour. One respondent said the border “Encourages everyone to get a passport.”, one said that the crossing is “fairly easy.” and one commented that: “At non-peak hours the line waiting time can shorten to less than 45 minutes if Juarez to El Paso crossing users have correct documentation” (which was seen as positive).

In question number 16 I asked if the respondents see any negative aspects regarding the existing cross-border system (infrastructure, inspection). This was an open answer question as well. The following responses were also divided into five clusters and left in their original form from the respondents.

Cluster 1 = Long waiting time in general

- A lot of time
- yes to slow
- time
- long waiting time
- Yes, the waiting has increased during the time

- Some weekdays take excessive amount of time to cross
- Long time
- Crossing back some times take long time
- Increases the time it takes to cross the border
- Too slow and curenly in-efficient
- Long time wait in the regular line
- When they close one or more lanes it greatly affects the time spent in line
- Yes, waiting times for crossing greater

The long wait times were seen as negative by 18 respondents. One of them mentioned the excessive time needed to cross especially on weekdays and that even a single lane closure causes significant increase in wait times. One respondent said the computer system needs backing up so it does not collapse so often, while one complained about vendors slowing down pedestrian traffic on the Mexican side. There was a complaint that even fast lanes may take a long time (30 minutes to 1 hour and sometimes even more) and that they are expensive.

Cluster 2 = Inspection time

- They ask a lot of unesessary questions and it makes lines longer
- In-efficient, Slow, poor Inspection.
- Inspection takes too long
- Yes, sometimes inspection is very slow
- It takes too long and isn't efficient enough
- The lines are to slow and inefective
- There is definitely improvements than can be made to increase efficiency and mobilization
- Due to the thorough questioning, it does take a long while for others to cross
- cbp makes it long but it's necessary

- The inspectors have no sense of urgency. The lines are really long most of the time, so I strategically plan my visits to Juarez based on wait times.
- There is a serious immigration crisis that is causing stress on the border. They are understaffed and they have gotten stricter as result, causing lines to get longer.

For 11 respondents the inspection time itself was seen as negative. The respondents complained about its inefficiency and slowness of the whole process. Two respondents said the officers are asking unnecessary questions, one said that the officers “have no sense of urgency” and that he plans his or her cross-border trips solely based on the actual wait times. One respondent said that: “There is a serious immigration crisis that is causing stress on the border. They are understaffed and they have gotten stricter as result, causing lines to get longer.”

Cluster 3 = Infrastructure and traffic

- The cross in downtown El Paso has traffic lights very close to it which can be very annoying when there is a long line. It creates a lot of traffic even for the people that may not be crossing. On the Juarez side there are also issues like that.
- The number of lanes on each bridge, long waiting time
- Not many lanes, just 2 , one for ready lane and the other one for people with documents
- Amount of lanes open to allow cars to get inspected is too low.
- Not all lanes open
- Current conditions with the four lanes combining to one or tow lanes have elongated the waiting times to up to 4-5 hours at peak hours or at night which not only affects the daily Juarez to El Paso commuters, but also the air quality.
- Not enough lanes
- Mexican infrastructure, long inspections
- Yes, infrastructure is a mess, wait times are excessive

- Infrastructure is not being used to its potential. Minimal amount of inspection booths are open for usage
- not enough personnel to use the infrastructure at its max capabilities
- Lot of traffic
- Infrastructure could be better for the people walking the bridge
- The inspection border entry lines get large, because the entrance to the different lines is crushed close.
- the facilities are too small
- "Some entrances aren't as aesthetically pleasing. I hear stories of it being backed up often."

For 16 respondents, the issue was with the existing border infrastructure, the common denominator here was that not all inspection lanes are open at all times making the lines very long. Two respondents mentioned the issue being with multiple lanes converging into one (as was the case in Fall 2019) probably for security reasons at the top of the bridge and then again splitting into multiple lanes. Some of the respondents claimed that the existing infrastructure is not used up to its potential mainly due to low staffing, while there were also calls for its expansion.

Cluster 4 = No negative aspects

- Nope
- No

Only two respondents did not see any negative aspects regarding the current border crossing system.

Cluster 5 = Other reasons

- Negative would be the wait time, system could be improved by having a backup computer system whenever it goes down.
- Horrible waiting times and entering the border isn't very well protected. A lot of vendors also make the time to cross longer and they block the pedestrian bridge

- The time to cross is too long. Even when a driver is on the Express Lane, it can take many hours. Also sometimes it's closed and it takes away the advantage of having a passport.
- To have the express line is expensive and besides that it makes me be late for school in the morning. Its unfair that I'm paying like 500 dollars each year for the express lane and still I'm making 30 min-1hr waiting in line.
- time, pollution of cars running for an extensive period, heat, number of border patrol agents
- The recent pre-inspection at mi bridge is really extensive and just adds more time
- Bad organization, people not respecting the line can cause accidents.
- Harder to cross due to pilótalo problems
- Everything
- Yes
- Yes

Finally, there were 7 responses that did not clearly fall into any of the four previous clusters. One respondent complained about environmental impact of slowly moving or idling vehicles waiting to cross, while several said that the whole system does not work, it is not well organized, drivers are not always respecting the lanes and may easily cause accidents by often changing lanes in order to find the “fastest” lane.

5.2.3 Part C

The Part C was aimed at proposing smarter ways how to approach the existing border-system. One of the new concepts was introduction of the cross-border public transportation system. This was question number 17 and in Figure 28 we have the graph of answers to it. We can see the answers if the respondents would use public transportation to cross the border. 58% said that they would be willing to use such system and 42% answered negatively.

Q17 Would you use public transportation to cross the border?

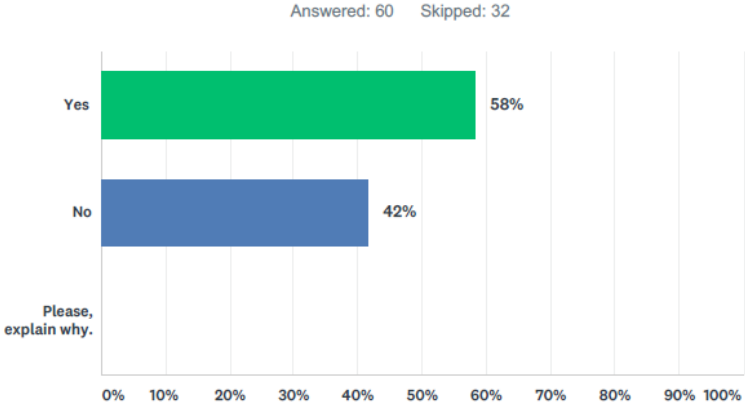


Figure 28 - Q17 Would you use public transportation to cross the border? Source: Generated by Survey Monkey

In Figure 29 we have the graph of answers to question number 18. This graph shows what type of public transportation the respondents would prefer to use. 35% said they would prefer a bus, 27% that would prefer a train, 27% would prefer a tram and 12% that answered Other specified they would prefer a subway (1 respondent), a taxi (3 respondents) and 3 other respondents answered they wouldn't prefer any form of public transportation.

Q18 What type of public transportation would you prefer?

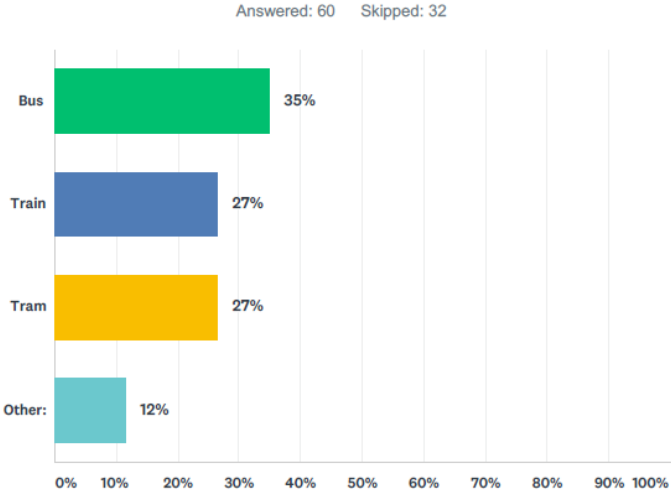


Figure 29 - Q18 What type of public transportation would you prefer? Source: Generated by Survey Monkey

In Figure 30 we have the graph of answers to question number 19. This question used the logic functions of the survey; respondents who answered they would prefer a train were directed to this question. Here I asked if they would accept US immigration pre-check on the Mexican side of the border. The pre-check would have a similar concept as the Express Lane but it would be for public transportation passengers. Most of the respondents answered that they would prefer so with 94% of them. The rest 6% said they wouldn't prefer such of a process.

Q19 Would you accept a US immigration pre-check (similar concept as Express Lane but for public transportation passengers) on the Mexican side of the border?

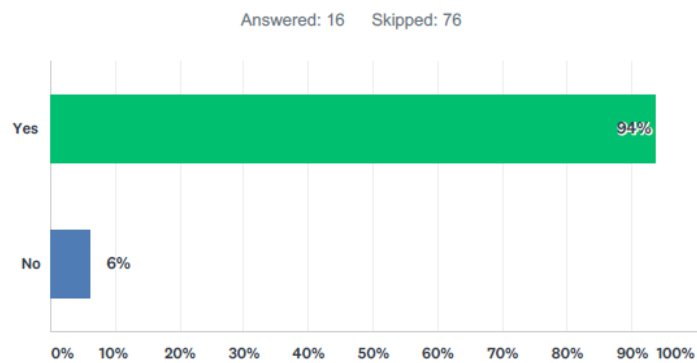


Figure 30 - Q19 Would you accept a US immigration pre-check on the Mexican side of the border?
Source: Generated by Survey Monkey

In Figure 31 we have the graph of answers to question number 20. All the respondents were directed back to this question. In this question the respondents were asked if they think that the use of public transportation would be an improvement to the current border crossing. The majority of 80% answered that they believe so, 20% answered that they don't believe so.

Q20 Do you think the use of public transportation will be an improvement to the current border crossing?

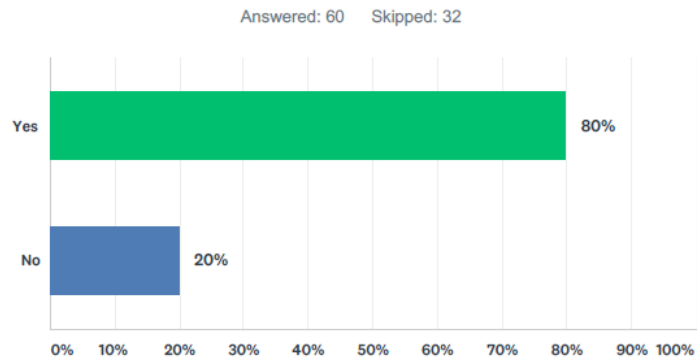


Figure 31 - Q20 Do you think the use of public transportation will be an improvement to the current border crossing? Source: Generated by Survey Monkey

In Figure 32 we have the graph of answers to question number 21. Here I asked what the respondents think about having more officers at the border check. 78% said that it would help the situation to have better staffing of the inspection booths, 17% said it wouldn't be of any difference and 5% said it would make the situation worse.

Q21 What do you think about having more officers at the border check?

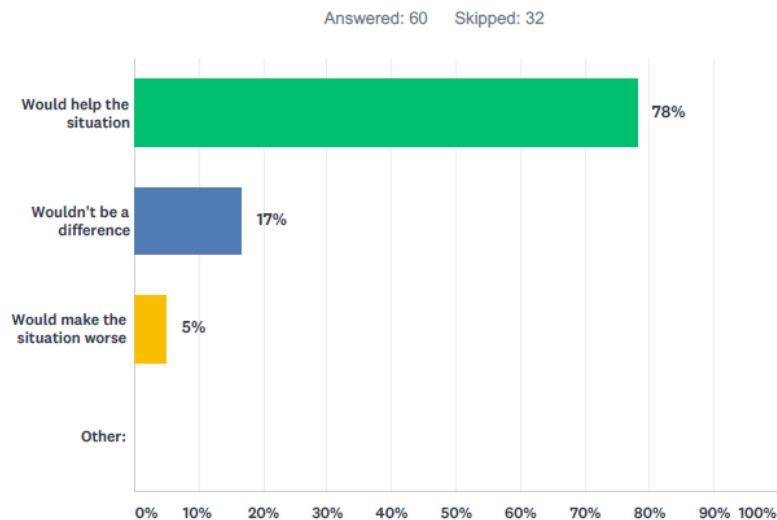


Figure 32 - Q21 What do you think about having more officers at the border check? Source: Generated by Survey Monkey

In Figure 33 we have the graph of answers to question number 22. The question inquired if the respondents would welcome a reservation system at the border check. This reservation system means that people would be able to make a reservation of the

time of the border check for faster proceeding. 77% answered they would welcome such a system and 23% answered that they wouldn't.

**Q22 Would you welcome a reservation system at the border check?
(Reservation of the time of the border check for faster proceeding)**

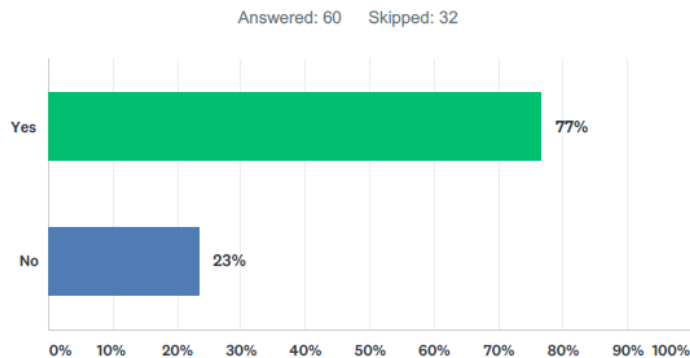


Figure 33 - Q22 Would you welcome a reservation system at the border check? Source: Generated by Survey Monkey

In Figure 34 we have the graph of answers to question number 23. In this question the respondents were asked if they would welcome a dynamic lane selection at the border crossing. This means that the number of lanes will vary on their amount due to the current traffic. The overwhelming majority of respondents (97%) would welcome dynamic lane selection based on the actual traffic situation and only 3% were in disfavor.

**Q23 Would you welcome dynamic lane selection at the border crossing?
(Number of lanes will vary on amount due to the current traffic)**

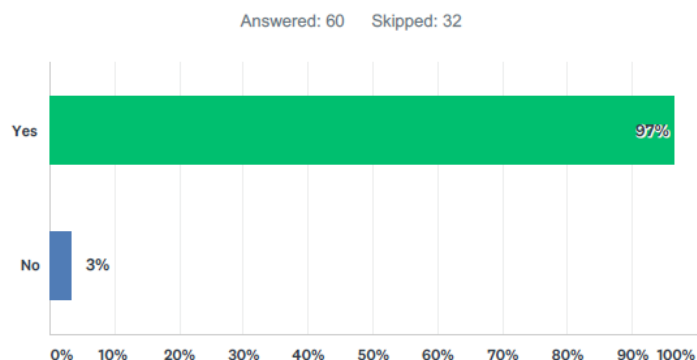


Figure 34 - Q23 Would you welcome dynamic lane selection at the border crossing? Source: Generated by Survey Monkey

The last question – number 24 – of the survey was an open question asking about ideas how to improve the existing border crossing system. This was an open answer question and again, answers to this question were analyzed and grouped into five clusters; left in their original form from the respondents.

Cluster 1 = None

- 4x None
- I do not cross often enough to know what could be improved
- Don't know

For six respondents, no improvements are needed or they do not have any specific recommendations.

Cluster 2 = More lanes or more agents

- Line expansion
- More lanes/access points is a good idea
- Not closing all the lanes
- Open more lanes
- More Lanes and better control of traffic and inspection
- More Officers in the lanes for inspection that can be performed previously instead of doing them at the check point
- Border lines preparation
- Increasing the number of lanes open - at some times only two or three are open, but almost never all open.
- More lanes and more officers
- Having more staff and keeping all lanes open
- More lanes open
- More lane openings

- All lanes need to be opened all the time. Sometimes border patrol is understaffed and only has 2 or 3 of the 7 lanes opened and it creates the worst traffic jams
- Have the Fast Lanes open 24 hours.
- More lanes and better infrastructure
- Open all inspection booths! Not just 1
- Like a tourist lane and a normal commute lane
- I think the proposed solutions are great. Perhaps the heavy waiting times can be analyzed and during those times are when more officers are on Staff and more lanes are open.
- More personnel
- build another bridge to cross
- More bridges and faster traffic flow
- opening another international port of entry

Twenty-two respondents said that keeping all lanes open and fully staffed would, according to their opinion, solve the problem. There were even calls for opening a new port of entry.

Cluster 3 = Dedicated lane

- To have a crossing lane for students only
- A car line just for students, or for people who cross everyday

Two respondents proposed having a dedicated lane for students or daily commuters.

Cluster 4 = Efficiency / Technology

- push immigration officers to work with a sense of urgency. sort crossing lanes into traffic modal categories
- Limit the BP officer from wasting
- Making the costumes (sic) take less time in check points.

- pre-check
- Pre screen
- More technology at the inspection
- Maybe improving the system in terms of technology, so the individual and the vehicle are checked already by the time it gets to the officer, having the officer doing less revision by hand

Seven respondents called for of new technologies including introduction of dedicated lanes and pre-checks.

Cluster 5 = Other

- The political climate to change that would help.
- Place barriers to prevent cars from switching lanes causing turmoil.
- People with express lane crossing should not have to go through car checks. When accepted to the express lane those things were checked before hand, there is no need. This has happened to me multiple times this year. Having police officers checking that people are not trying to advance the line. There are multiple people who go into a lane that they are not supposed to be in that actually do it to advance on the line next to it by cutting in.
- There is in place a bus that waits on one side of the border and crosses several people who dont want to wait in line. There is a specific line for them once they cross the bridge. It is a much faster process and you only pay about two dollars. This is a great system but I think that having a specific lane for this bus would be way better.
- overhead shade so cars dont over heat, porter potties, something that can help bring the amount of polltion down or technology that can capture the CO2 and take advantage of it.

Five responses fell into the “others” category by proposing minor improvements such as physical separation of fast lanes, so they cannot be used to cut into regular lanes or general physical separation of regular lanes making lane change impossible.

6 Analysis of the suitable solutions for improvement of the cross-border mobility

This survey presented answers for entry-level cross-border (Ciudad Juarez – El Paso) mobility questions conducted among The University of Texas at El Paso students in Fall 2019. The aim of the survey was to start discussion on streamlining of the cross-border mobility using the smart border concept.

The survey was divided into three parts with the first part focused on sociodemographic data collection, the second part focused on perceptions regarding the existing border crossing experience and finally, the third part focused on improvement of the existing situation by application of the smart border concept.

From the first part we can see that the age median of the respondents is 23, more than half are male, the majority have a US nationality and live in El Paso off campus and most of them are undergraduates.

The survey confirmed that the border crossing as it is currently organized is a major bottleneck both for daily commuters to El Paso from Ciudad Juarez including students as well as for those, who travel to Ciudad Juarez to visit their relatives or for shopping and entertainment every week or even less frequently. The current border wait times far exceed what can be regarded as smooth border crossing with almost half of the respondent stating they often have to wait for over one hour in case they use car to cross the border. Also, it seems that the use of fast lanes is not always reliable as far as wait times are concerned.

In order to improve the situation, the respondents often called for increased staffing of immigration checkpoints, increasing the number of lanes or even building a new international bridge creating a new port of entry. However, these proposals are not sustainable and it is not corresponding with our premise. The goal of this program is seamless border-crossing, sufficient speed and comfort of the passengers and workers and this is not a realistic solution for it to be achieved.

We need to find solutions in a different direction and for this we created part C. The survey asked about the perception on introduction of some of the applications included in the smart border concept such as dynamic lane allocation, booking system or cross-border public transportation utilizing smart technologies and immigration pre-check in

Ciudad Juarez. The vast majority of respondents indicated they would be willing to use these applications if they materialized. People were very receiving and positively reacting to this proposal of technical solutions

The deployment of smart applications that are in line with El Paso strategic and resilience plans as well as with the smart border concept could alleviate the appalling situation in the largest cross-border metropolitan area of the United States – Mexico.

The message that we can take from this survey is that the people have the will for change. Smart solutions proposed in the survey came out very positively.

7 Recommendation of suitable and appropriate solutions to the cross-border mobility

The topic of crossing the border between El Paso and Ciudad Juárez has been analyzed. From the analysis of the survey comes a conclusion that the smart solutions are positively accepted by the people. When I started writing this thesis, I was interested to know how the cross-border mobility between El Paso and Ciudad Juárez looks like in real life. I wanted to see whether some of the examples of the smart solutions would be accepted by people.

There is an already existing concept: Smart Border as a Part of Smart and Resilient El Paso that is based on system approach.

System approach to the smart border is based on modeling the boundary area with the usage of systems theory.[26] The border components include functions for improving the border crossing like setting a timeslot for the crossing over the border, incorporating common logistics and enhancing the management and response to natural catastrophes.

To sum it all up, the border is to be understood as a system containing many different subsystems and the cooperation of these systems will lead to an effective border. The border's subsystems such as energies (water, gas and electricity), urban development, public services, healthcare and many others are typically considered to be independent on each other but they share a common goal of making the border area efficient and sustainable.[25]

The process of managing the movement of people and goods across the border between El Paso and Ciudad Juárez has to be strong. In this concept we can find suggested Smart ways how to address the border crossing problem.

One of the suggestions is increasing the number of lanes on the bridge. Since the traffic jams are only in the direction from Mexico to the United States there could be more lanes in this direction. One of the possible implementations could be that only one bridge is dedicated to the crossing from the United States to Mexico and the rest of the bridges are one-way crossings from Mexico to the United States.

Another proposal is to implement systems of containers for only goods transportation. These containers can be next to the bridges or as a part of the bridge infrastructure. Creating a separation like such would ease the existing traffic jams on the bridge.

Following to another suggestion, there is an idea to create an advanced reservation system for crossing the border also considering the different categories of users (students, seniors, citizens of other countries and such). The reservation would take in account adequate timeslots, different check-in procedures as well as check-ins at the airport.

Next suggestion is the idea of having a check-in procedure. This procedure can be done on the Mexican side as a form of pre-check to speed the actual check on the side of the United States.

The second to last suggestion is using the existing rail system for mass-passenger transportation across the border. This would be done separately from the bridge traffic. It is believed that the existing railway infrastructure holds unused potential.

The last suggestion is using a car-sharing system on both sides of the border.

The items mentioned are according to the author only examples of how the existing cross-border problem could be solved. The key is using smart technologies in combination with the smart border.[25]

All the above mentioned was the input to my contemplation and the suggestions in the survey were based on this article.

In the survey I asked about three systems and the outcome was positive. I asked directly about a few suggested solutions and their results are summarized below.

One of the recommendations is the proposal of advancing the use of the existing rail system. This was embodied in my questions number 17 and 18. The respondents reacted very positively to this idea. From the viewpoint of implementing and building this system it would be fairly easily to complete since the tracks already exist. The respondents also viewed positively the implementing of new bus lines and trams, which all together would complete an integrated public transportation system.

The second suggested solution of using a US immigration pre-check on the Mexican side of the border was in great majority answered positively by the respondents as we

can see in Figure 30. Based on their reaction this is a realistic solution to the problem. This answer in combination with the input from the given article is corresponding to one another.

Following with another suggestion regarding the reservation systems, this idea was also greatly accepted by the respondents as we can see in Figure 33. Implementing this arrangement would require very little changes to the already existing system.

The last suggestion regards the dynamic lane selection. The responses are to be found in Figure 34 where we can see that the respondents also with overwhelming majority agree with this idea. This makes it another acceptable solution.

I recommend the direction of the smart border concept which was also confirmed by the local people (students in my case). The solution is not more agents nor bigger bridges but it is important to implement smart systems; Smart system approaches are the way of the future.

I have come to the outcome of three recommendations. The first one is the Smart border pre-check; the second recommendation is the rail transit system and the third is the dynamic lane selection at the border crossing.

It was successfully confirmed by the survey that from the side of the students there is will to change things and that they are not indifferent to this situation. It is important that this fact is not over looked and it is necessary that this energy from the locals is used.

From the view of the user the solutions proposed are suitable.

8 Conclusion

My bachelor thesis was focused on the introductory analysis of the El Paso-Ciudad Juárez cross-border mobility of people. The aim of my thesis was to design and conduct a survey mapping the current state of the cross-border mobility and to find out attitude toward the deployment of smart solutions to tackle the issues related to the border crossing. The thesis had two parts.

In the first part I introduced the El Paso-Ciudad Juárez bi-national metropolitan area. I presented the area's history and development continuing with the portrayal of the area from a geographical point of view, and then followed by the quality of life viewpoint. Furthermore, I described the existing cross-border mobility, infrastructure and related systems of transportation. These facts are necessary to know to understand the complexity of the situation and to be able to put all in context; also, to gain a better visualization and understanding of the region. At the end of this part, I also analyzed the main goals and plans for the future improvements for the city in the Strategic plan.

The second part was intended to start a discussion on the current cross-border mobility and to come up with options for improvement of the current process. The survey mapping was used to accomplish this goal. The survey asked about and identified the basic issues in the existing processes. It mainly consisted of questions asking about the description of the current state and questions asking about the improvements which can be made. Based on the responses I was able to make an analysis and confirm many of the proposed solutions which led me to the adequate recommendation of improvements of the current state. Some solutions on the other hand had to be discarded for their unsustainability.

We can see that the local people (students) are unhappy with the current processes and I have found out that they are willing to accept changes and are welcoming new smart solutions. The respondents reacted positively to the proposals.

The preferred solutions are advancing the use of the existing rail system, US immigration pre-check and dynamic lane selection.

Based on the survey we are able to integrate many more systems. For example, another solution which would be possible and which would widen the range is

implementing the reservation systems. This could be another way to improve the border crossing process.

It was vital to have all the suggestions based on a smart border concept which meant implementing smart systems for the highest effectivity.

During the writing of this work I have confirmed for myself, that there is not only one correct solution. There are always several ways that can help improve the current situation. I believe that this study may open a discussion on the issue and help to identify the road to the effective solutions.

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List of appendices

Appendix 1 – Survey questions

Appendix 1 – Survey questions

The survey questions are as followed:

Part A)

Q1: How old are you?

Q2: What is your gender?

Male

Female

Other

Q3: What is your nationality?

United States

Mexico

Other (please specify)

Q4: Where are you currently living?

Ciudad Juárez

El Paso on campus

El Paso off campus

other:

Q5: What degree are you studying for?

Undergraduate

Graduate

Ph.D.

Part B)

Q6: Have you crossed the border at least once in the past year?

Yes

No

Q7: How often are you crossing the border?

Everyday
Once a week
Monthly
Less often

Q8: Do you have family members (including relatives) on the other side of the border?

Yes
No

Q9: What are your reasons of crossing the border?

UTEP
Family/relatives
Entertainment
Shopping
Other:

Q10: Do you use a car (driving or as a passenger) to cross the border?

Yes
No

Q11: Do you use Express Lane (Fast track)?

Yes
No

Q12: What means of transport do you use in Ciudad Juarez?

Car (family or friend driving you to/from the border)
Car (taxi/ UBER to/from the border)
Bus
Walking or cycling

Q13: What means of transport do you use in El Paso?

Car (family or friend driving you to/from the border)
Car (taxi/ UBER to/from the border)
Bus
Tram
Walking or cycling

Q14: How long does it take you to cross the border from Juárez to El Paso?

0min-15min

15min-30min

30min-1 hour

1 hour-2 hours

2 hours+

Q15: Do you see any positive aspects regarding the existing cross-border system (infrastructure, inspection)?

Q16: Do you see any negative aspects regarding the existing cross-border system (infrastructure, inspection)?

Part C)

Q17: Would you use public transportation to cross the border?

Yes

No

Q18: What type of public transportation would you prefer?

Bus

Train

Tram

Other:

Q19: Would you accept US immigration pre-check (similar concept as Express Lane but for public transportation passengers) on the Mexican side of the border?

Yes

No

Q20: Do you think the use of public transportation will be an improvement to the current border crossing?

Yes

No

Q21: What do you think about having more officers at the border check?

Would help the situation

Wouldn't be a difference

Would make the situation worse

Other:

Q22: Would you welcome a reservation system at the border check? (Reservation of the time of the border check for faster proceeding)

Yes

No

Q23: Would you welcome dynamic lane selection at the border crossing? (Number of lanes will vary on amount due to the current traffic)

Yes

No

Q24: What would you propose to improve the border crossing?