

these points to establish the percentage of vehicles by type entering and leaving the study area. Regarding the international crossings, it was decided that information on total traffic by mode could be obtained from border authorities of both countries.

External stations

External stations were located at each international crossing, as well as every highway with access to the city. The following 7 external stations were evaluated:

<u>External Station</u>	<u>Direction</u>	<u>Modes</u>
1. Paso del Norte bridge	Outbound movement	Passenger vehicles, Pedestrians
2. Stanton bridge	Inbound movement	Passenger vehicles, Pedestrians
3. Bridge of the Americas	Both	All ¹
4. Zaragoza Bridge	Both	All
5. Casas Grandes highway	Both	Vehicular traffic only
6. Chihuahua highway	Both	Vehicular traffic only
7. Porvenir highway	Both	Vehicular traffic only

Figure 1 shows the geographic location of the 7 external stations.

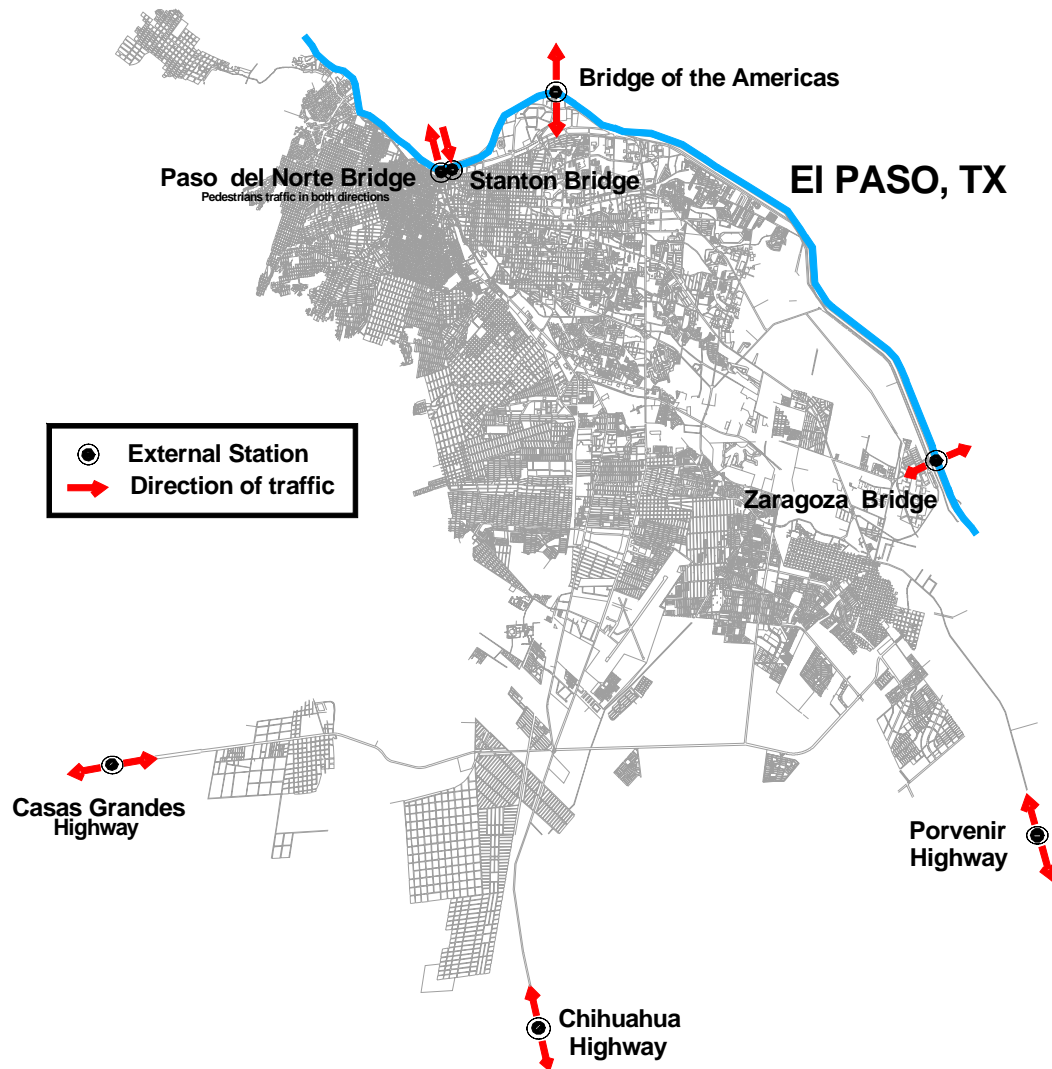


Figure 1. Location of external stations

¹ Due to structural repairs, in 1996 commercial vehicles were allowed to use the Bridge of the Americas only if their total weight was less than 20 tons.

In an initial validation process, many of the surveys were found to be unusable due to missing or inconsistent information. But at the end 5,629 surveys at all external stations were approved for data entry, which included 1,635 pedestrians, 2,625 passenger vehicles, and 1,369 commercial trucks.

Database design

The external station database has the simplest design of those developed for the 1996 Juarez travel survey. Its base layout is formed just by a sole table named {Encuesta V_E}, which includes 20 fields. As in the case of the other databases, the {Interseccion} table was added to provide details on geocode information. A general layout of the database and its fields is shown in Figure 2. A description of each of the fields is given in Appendix A.

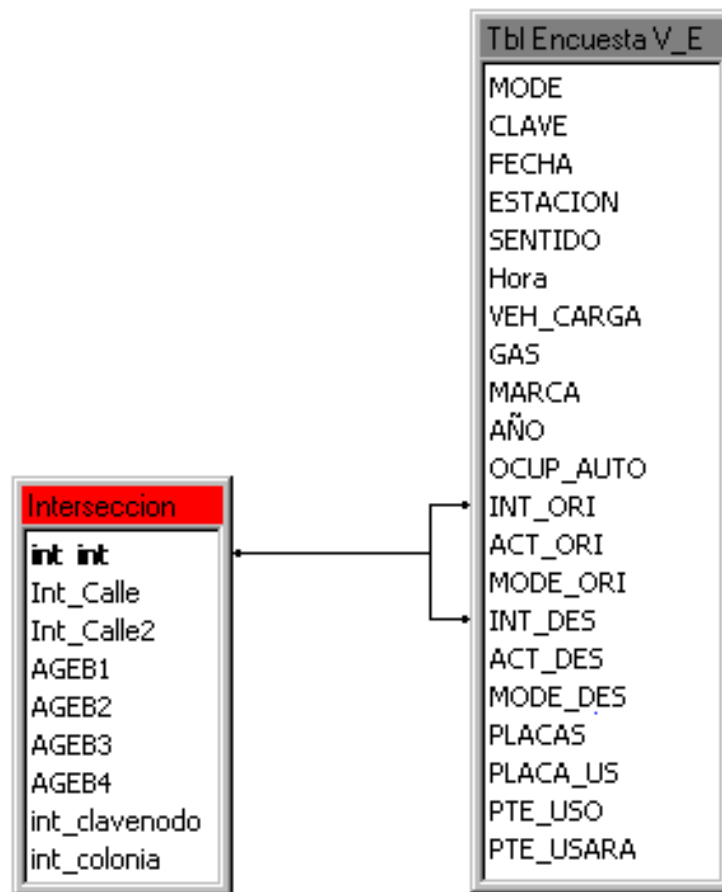


Figure 2. External station survey database layout

The georeference information table is related to the survey table through the field int_int.

Edit checks

To identify logical or numerical errors or inconsistencies in the external station survey database, twenty-three different checks were developed using the powerful query capabilities of MS-Access. Table 1 provides a description of these checks. The checks were designed to run in 3 separate groups or stages to avoid excessive repetition of error detection. Queries for one group at a time were programmed, and until the detected records were edited, the next group queries were generated.

Table 1. MS-Access queries developed for error checking

Group	Serial	Description	Records detected	Records modified	Surveys erased
1	ES-01	Surveys entered with invalid or unusual unique code.	3	3	1
	ES-02	Surveys entered with invalid or unusual date.	0	0	0
	ES-03	Surveys entered with invalid or unusual station code.	2	2	0
	ES-04	Surveys entered with invalid or unusual direction code.	0	0	0
2	ES-05	Surveys where origin intersection geocode appears in {Encuesta V_E} table, but in {Interseccion} table.	49	49	0
	ES-06	Surveys entered with invalid code for origin activity.	11	11	0
	ES-07	Surveys where destin intersection geocode appears in {Encuesta V_E} table, but not in {Interseccion} table.	14	14	0
	ES-08	Surveys entered with invalid or unusual trip purpose to destination.	18	18	0
	ES-09	Surveys entered with invalid or unusual vehicle model year.	13	7	0
	ES-10	Surveys entered with blank record for vehicle make.	6	0	0
	ES-11	Surveys with invalid or unusual code for fuel type.	20	0	0
	ES-12	Surveys with invalid or unusual code for vehicle classification.	2	2	0
	ES-13	Surveys with blank record for U.S. state license plates.	56	1	0
	ES-14	Surveys with invalid or unusual record for number of occupants in vehicle.	55	2	0
	ES-15	Surveys with invalid or unusual code for mode of transportation to border crossing (only pedestrians).	9	5	0
	ES-16	Surveys with invalid or unusual code for mode of transportation from border crossing (only pedestrians).	12	12	0
	ES-17	Surveys with invalid or unusual code for international bridge used to cross into Mexico.	2	2	0
	ES-18	Surveys with invalid or unusual code for the international bridge to be used to cross into the U.S.	6	6	0
3	ES-19	Surveys of commercial vehicles with illogical code for trip purpose.	24	24	0
	ES-20	Surveys of non-commercial vehicles or pedestrians with illogical code for trip purpose.	118	118	0
	ES-21	Surveys that were made outside the designated time (7:00 am – 7:00 pm).	214	81	0
	ES-22	Surveys with null time.	0	0	0
	ES-23	Surveys with invalid code for mode.	0	0	0

Using these queries, the errors and inconsistencies detected were corrected. Quite similar to the workplace survey, many of the errors were originated at the time of electronic data entry (input typos) where the system did not have a validation rule from its design, and very few of the errors detected were inconsistencies registered in the field. Again this was probably the result of having a team of trained personnel conducting the travel interviews, instead of school children.

Preliminary summary of travel behavior

Table 2 presents the resulting surveys and total daily traffic obtained under each external station and for each mode. As previously mentioned, traffic data at the bridges was originally scheduled to be obtained from border authorities of both countries. After several failed attempts to acquire this information from them, the IMIP team had to rely on annual traffic data provided by the MPO in El Paso, and shown in detail in Appendix B. This information was then converted to average daily traffic. The traffic data at access highways was obtained through actual 24-hour counts.

Table 2. General survey distribution at external stations

Station No.	Facility	Mode	Direction	24-Hr vol data source	24-Hr Volume	Usable Surveys	Percent Surveyed
1	Paso del Norte International Bridge	Pedestrians	Outbound	MPO	9,501	293	3.1%
			Inbound	IMIP estimation	5,900	0	0.0%
		Passenger Vehicles	Outbound	MPO	11,931	80	0.7%
			Inbound		Not allowed		
		Commercial Vehicles	Outbound		Not allowed		
			Inbound		Not allowed		
2	Stanton International Bridge	Pedestrians	Outbound		Not allowed		
			Inbound	MPO	3,602	288	8.0%
		Passenger Vehicles	Outbound		Not allowed		
			Inbound	MPO	6,138	330	5.4%
		Commercial Vehicles	Outbound		Not allowed		
			Inbound		Not allowed		
3	Bridge of the Americas	Pedestrians	Outbound	MPO	1,936	300	15.5%
			Inbound	IMIP estimation	2,658	209	7.9%
		Passenger Vehicles	Outbound	MPO	21,550	471	2.2%
			Inbound	IMIP estimation	28,200	342	1.2%
		Commercial Vehicles	Outbound	MPO	668	291	43.6%
			Inbound	IMIP estimation	842	164	19.5%
4	Zaragoza International Bridge	Pedestrians	Outbound	MPO	921	276	30.0%
			Inbound	MPO	199	269	135.2%
		Passenger Vehicles	Outbound	MPO	7,891	174	2.2%
			Inbound	MPO	7,034	358	5.1%
		Commercial Vehicles	Outbound	MPO	952	279	29.3%
			Inbound	MPO	778	265	34.1%
5	Casas Grandes Highway	Passenger Vehicles	Outbound	site count	824	110	13.3%
			Inbound	site count	569	127	22.3%
		Commercial Vehicles	Outbound	site count	217	87	40.1%
			Inbound	site count	119	34	28.6%
6	Chihuahua Highway	Passenger Vehicles	Outbound	site count	2,873	110	3.8%
			Inbound	site count	2,071	177	8.5%
		Commercial Vehicles	Outbound	site count	800	72	9.0%
			Inbound	site count	683	109	16.0%
7	Porvenir Highway	Passenger Vehicles	Outbound	site count	4,110	159	3.9%
			Inbound	site count	3,936	187	4.8%
		Commercial Vehicles	Outbound	site count	392	19	4.8%
			Inbound	site count	264	49	18.6%

To establish if the trips at the external stations were local or through, trip ends outside of the study area were geocoded as follows:

<u>External trip end (within El Paso area)</u>	<u>Trip end geocode</u>
El Paso/Northwest area	15726
El Paso/North area	15727
El Paso/Central area	15728
El Paso/East area	15729
El Paso/Southeast area	15730

<u>External trip end (outside Juarez-El Paso)</u>	<u>Trip end geocode</u>
Las Cruces, NM (general direction)	15731
Alamogordo, NM (general direction)	15732
Carslbad, NM (general direction)	15733
Van Horn, TX (general direction)	15734
Fabens, TX (general direction)	15735
Porvenir, CHIH (general direction)	15736
Chihuahua, CHIH (general direction)	15737
Casas Grandes, CHIH (general direction)	15738

Thus, Table 3 shows the resulting percentage of External-Local and External-External trips identified from the survey at each station. In addition, the table disaggregates by mode, and by direction of traffic flow.

Table 3. Estimated percentage of External-Local and External-External Trips by Stations

Station No.	Facility	Mode	Direction	% E-L	% E-E
1	Paso del Norte International Bridge	Pedestrians	Outbound	79.9%	20.1%
			Inbound	no surveys	no surveys
		Passenger Vehicles	Outbound	97.5%	2.5%
			Inbound	N/A	N/A
Commercial Vehicles	Outbound	N/A	N/A		
	Inbound	N/A	N/A		
2	Stanton International Bridge	Pedestrians	Outbound	N/A	N/A
			Inbound	98.6%	1.4%
		Passenger Vehicles	Outbound	N/A	N/A
			Inbound	95.8%	4.2%
Commercial Vehicles	Outbound	N/A	N/A		
	Inbound	N/A	N/A		
3	Bridge of the Americas	Pedestrians	Outbound	91.7%	8.3%
			Inbound	97.6%	2.4%
		Passenger Vehicles	Outbound	90.9%	9.1%
			Inbound	86.0%	14.0%
Commercial Vehicles	Outbound	97.6%	2.4%		
	Inbound	91.5%	8.5%		
4	Zaragoza International Bridge	Pedestrians	Outbound	87.3%	12.7%
			Inbound	97.0%	3.0%
		Passenger Vehicles	Outbound	94.8%	5.2%
			Inbound	91.3%	8.7%
Commercial Vehicles	Outbound	82.4%	17.6%		
	Inbound	78.9%	21.1%		
5	Casas Grandes Highway	Passenger Vehicles	Outbound	87.3%	12.7%
			Inbound	83.5%	16.5%
		Commercial Vehicles	Outbound	72.4%	27.6%
			Inbound	88.2%	11.8%
6	Chihuahua Highway	Passenger Vehicles	Outbound	76.4%	23.6%
			Inbound	73.4%	26.6%
		Commercial Vehicles	Outbound	77.8%	22.2%
			Inbound	78.9%	21.1%
7	Porvenir Highway	Passenger Vehicles	Outbound	93.1%	6.9%
			Inbound	92.0%	8.0%
		Commercial Vehicles	Outbound	94.7%	5.3%
			Inbound	93.9%	6.1%

By expanding the survey data to the total daily traffic volume, Table 4 summarizes the estimated total daily trips passing through each external station, characterized as External-Local and External-External. Vehicle occupancy was established also from the survey information in order to convert vehicle trips to person trips. Unfortunately due to a form design error, the surveys for commercial vehicles failed to ask for number of occupants on the vehicle, thus an additional sample of trucks at two of the external stations was recently taken just to establish their overall vehicle occupancy. As a result, all commercial vehicles at all external stations show the same value of 1.100 (in red) for vehicle occupancy.

Table 4. Estimated External-Local and External-External Daily Trips by Stations

Station No.	Facility	Mode	Direction	VEHICLE TRIPS		VEHICLE OCCUPANCY		PERSON TRIPS	
				E-L	E-E	E-L	E-E	E-L	E-E
1	Paso del Norte International Bridge	Pedestrians	Outbound					7,588	1,913
			Inbound					4,712	1,188
		Passenger Vehicles	Outbound	11,633	298	2.128	4.500	24,754	1,342
			Inbound	N/A	N/A	N/A	N/A	N/A	N/A
		Commercial Vehicles	Outbound	N/A	N/A	N/A	N/A	N/A	N/A
Inbound	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
2	Stanton International Bridge	Pedestrians	Outbound	N/A	N/A	N/A	N/A	N/A	N/A
			Inbound					3,552	50
		Passenger Vehicles	Outbound	N/A	N/A	N/A	N/A	N/A	N/A
			Inbound	5,878	260	2.203	3.286	12,948	856
		Commercial Vehicles	Outbound	N/A	N/A	N/A	N/A	N/A	N/A
Inbound	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
3	Bridge of the Americas	Pedestrians	Outbound					1,775	161
			Inbound					2,594	64
		Passenger Vehicles	Outbound	19,583	1,967	1.734	2.605	33,956	5,125
			Inbound	24,242	3,958	1.833	3.333	44,436	13,192
		Commercial Vehicles	Outbound	652	16	1.100	1.100	717	18
Inbound	770		72	1.100	1.100	847	79		
4	Zaragoza International Bridge	Pedestrians	Outbound					804	117
			Inbound					193	6
		Passenger Vehicles	Outbound	7,483	408	1.800	2.111	13,469	862
			Inbound	6,425	609	1.960	3.032	12,593	1,847
		Commercial Vehicles	Outbound	785	167	1.100	1.100	863	184
Inbound	614		164	1.100	1.100	675	181		
5	Casas Grandes Highway	Passenger Vehicles	Outbound	719	105	1.979	2.429	1,423	255
			Inbound	475	94	2.462	2.571	1,169	242
		Commercial Vehicles	Outbound	157	60	1.100	1.100	173	66
			Inbound	105	14	1.100	1.100	116	15
6	Chihuahua Highway	Passenger Vehicles	Outbound	2,194	679	2.774	3.462	6,086	2,351
			Inbound	1,521	550	2.392	2.522	3,638	1,387
		Commercial Vehicles	Outbound	622	178	1.100	1.100	684	196
			Inbound	539	144	1.100	1.100	593	159
7	Porvenir Highway	Passenger Vehicles	Outbound	3,826	284	2.020	2.272	7,728	646
			Inbound	3,620	316	2.186	2.267	7,914	716
		Commercial Vehicles	Outbound	371	21	1.100	1.100	409	23
			Inbound	248	16	1.100	1.100	273	18
Daily trips at international crossings				78,063	7,921	1.861	2.990	166,477	27,183
Daily trips at highways				14,397	2,461	2.098	2.468	30,205	6,072
Total daily trips at external stations				92,461	10,381	1.898	2.866	196,683	33,256

Concluding remarks

A couple of quick observations can be made from these tables. The first one is that people movement tends to be more intense at the international crossings than at the highways. More so at those crossings near

the central cores of both Juarez and El Paso (Paso del Norte, Stanton, and Americas bridges). Combined, person travel at the international crossings is more than five times the person travel at the highways. This is not totally new based on previous counts. Besides, the proximity of the border cities intuitively would appear to have travel patterns between them of more of an urban nature. The interesting result though is the proportion of external-local trips to through trips of about six times, which was previously unknown or at least undocumented.

Finally, according to the preliminary results obtained from the household survey, external trips represent between 10 and 15% of the total daily person travel taking place in study area. Again, most of it occurring at the international crossings. Since most of the external trips at the international crossings are in fact trips to or from the El Paso urban area, further research should consider both El Paso and Juarez together as a broader study area for regional transportation analyses, and to characterize the travel interaction between the two border cities.

Appendix A

External Station Survey database.
Component tables and description of fields.

INSTITUTO MUNICIPAL DE INVESTIGACION Y PLANEACION
Estudio Integral de Transporte para Ciudad Juarez
Component tables for External Station Survey database

TABLE NO.	TABLE NAME	FIELD NAME	DESCRIPTION	RELATION
1	Encuesta V_E	MODE	Mode: Pedestrians=1, Passenger veh=2, Commercial veh=3	
		CLAVE	Sample unique number	
	(External trip survey)	FECHA	Date of survey	
		ESTACION	External station number: Paso del Norte br=1, Stanton br=2, Americas br=3, Zaragoza br=4, Casas Grandes hwy=5, Chihuahua hwy=7, Porvenir hwy=8	
		SENTIDO	Direction of flow: outbound=1, inbound=2	
		Hora	Time of day	
		VEH_CARGA	SCT Vehicle classification (only commercial veh): C2=1, C3=2, T2S1=3, T2S2=4, T3S2=5, T2S1R2=6, Other=7, No answer=8	
		GAS	Fuel type: Gasoline=1, Diesel=2, Other=3, No answer=4	
		MARCA	Make of vehicle (only motorized vehicles)	
		ANO	Model year of the vehicle (only motorized vehicles)	
		OCUP_AUTO	Number of vehicle occupants (only passenger vehicles)	
		INT_ORI	Origin geocode	Int_Int (Tbl Interseccion)
		ACT_ORI	Origin activity: Pedestrian or Passenger veh (Home=1, Work=2, School=3, Recreation=4, Shop=5, Serv pax=6), Commercial veh (Pick load=7, Drop load=8, Pick/Drp load=9, Pick veh without load=10), Other=11, No answer=12	
		MODE_ORI	Mode of transportation to external station (only pedestrians)	
		INT_DES	Destination geocode	Int_Int (Tbl Interseccion)
		ACT_DES	Destin activity: Pedestrian or Passenger veh (Home=1, Work=2, School=3, Recreation=4, Shop=5, Serv pax=6), Commercial veh (Pick load=7, Drop load=8, Pick/Drp load=9, Pick veh without load=10), Other=11, No answer=12	
		MODE_DES	Mode of transportation to destination (only pedestrians)	
		PLACAS	License plate type (only motorized vehicles): In Land=1, Border=2, Foreign=3	
		PLACA_US	U.S. State license plate (only if foreign)	
		PTE_USO	International bridge used to cross into Mexico (only for highway external station/outbound, if origin was in the U.S.)	
		PTE_USARA	International bridge to be used to cross into the U.S. (only for highway external station/inbound, if destination is in the U.S.)	
2	Interseccion	Int_Int	Primary key for relaing tables (intersection index)	Int_Ori, Int_Des (Tbl Encuesta V_E)
		Int_Calle	Name of street 1	
	(intersection)	Int_Calle2	Name of street 2 (intersecting street 1)	
		AGEB	AGEB (census zone) where the intersection is located	
		int_clavenodo	Transcad node code (for the intersection)	
		int_coloniia	Subdivision where the intersection is located	

Appendix B

Traffic at the International Border Crossings (1996).

1996 northbound crossings (source: MPO)			
International bridge	Pedestrians	Pax vehicles	Trucks
Paso del Norte	3,467,912	4,354,826	-
Stanton	-	-	-
Bridge of the Americas	706,702	7,865,798	243,744
Zaragoza	336,086	2,880,218	347,562
ALL BRIDGES	4,510,700	15,100,842	591,306

1996 southbound crossings (source: MPO)			
International bridge	Pedestrians	Pax vehicles	Trucks
Paso del Norte	not available	-	-
Stanton	1,314,558	2,240,567	-
Bridge of the Americas	not available	not available	not available
Zaragoza	72,751	2,567,362	284,019

ALL BRIDGES: Not available, but assumed equal to northbound traffic

Estimated 1996 southbound crossings *			
International bridge	Pedestrians	Pax vehicles	Trucks
Paso del Norte**	2,153,354	-	-
Stanton	1,314,558	2,240,567	-
Bridge of the Americas	970,037	10,292,913	307,287
Zaragoza	72,751	2,567,362	284,019
ALL BRIDGES	4,510,700	15,100,842	591,306

(equal to northbound)

* Estimated traffic volumes in red.

** Difference of Paso del Norte Northbound - Stanton Southbound.