This report is a compendium of research papers written by students participating in the 2016 Undergraduate Transportation Scholars Program. The 10-week summer program, now in its 26th year, provides undergraduate students in civil engineering the opportunity to learn about transportation engineering through participating in sponsored transportation research projects. The program design allows students to interact directly with a Texas A&M University faculty member or Texas A&M Transportation Institute researcher in developing a research proposal, conducting valid research, and documenting the research results through oral presentations and research papers.

The papers in this compendium report on the following topics: 1) Generalized Trends in Wrong-Way Driving; and 2) Travel Rates of an Aging Population: A Texas Analysis.
COMPRENDIUM OF STUDENT PAPERS:
2016 UNDERGRADUATE
TRANSPORTATION SCHOLARS PROGRAM

Dr. Lisa Green (Mentor), Christopher Garcia (Student), Mitchell P. Fisher, II (Student),
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Program Sponsored by

Transportation Scholars Program Southwest Region
University Transportation Center
Texas A&M Transportation Institute
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College Station, TX 77843-3135

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August 2016
PREFACE

The Southwest Region University Transportation Center (SWUTC), through the Transportation Scholars Program, the Texas A&M Transportation Institute (TTI), and the Zachry Department of Civil Engineering at Texas A&M University, established the Undergraduate Transportation Engineering Fellows Program in 1990. The program design allows students to interact directly with a Texas A&M University faculty member or TTI researcher in developing a research proposal, conducting valid research, and documenting the research results through oral presentations and research papers. The intent of the program is to introduce transportation engineering to students who have demonstrated outstanding academic performance, thus developing capable and qualified future transportation leaders.

In summer 2016, the following students and their faculty/staff mentors were:

<table>
<thead>
<tr>
<th>STUDENTS</th>
<th>MENTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitchell P. Fisher, II</td>
<td>Ms. Melisa D. Finley</td>
</tr>
<tr>
<td>Auburn University</td>
<td></td>
</tr>
<tr>
<td>Christopher Garcia</td>
<td>Dr. Lisa Green</td>
</tr>
<tr>
<td>Brigham Young University</td>
<td></td>
</tr>
</tbody>
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Sincere appreciation is extended to the following individuals:

- Mrs. Colleen Dau, who assisted with program administrative matters, and Mrs. Barbara Lorenz in the preparation of the final compendium.

The authors recognize that support was provided by a grant from the U.S. Department of Transportation, University Transportation Centers Program to the Southwest Region University Transportation Center.
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DISCLAIMER

The contents of this report reflect the view of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.
Generalized Trends in Wrong-Way Driving

Prepared for
Undergraduate Transportation Scholars Program

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Southwest Region University Transportation Center

August 5, 2016
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Since his junior year, Mitch has been involved with the national service organization, Silver Wings, serving as chapter president his senior year. He has done previous research on vulnerable user policy for Alabama and helped with tutorial development for an ArcGIS course offered by Auburn’s civil engineering department. After he graduates, he plans on pursuing a graduate degree in transportation planning from Auburn University.

ACKNOWLEDGMENT

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The author would like to express his appreciation to Mrs. Melisa Finley, Dr. Jeff LaMondia, and Dr. Rod Turochy for their support and guidance on this opportunity.

SUMMARY

Wrong-way crashes are a rare but deadly event occurring on major roadways throughout the world. Previous research into the subject has focused mostly on limited access freeways and has been restricted mainly to individual states. This study will focus on wrong-way crashes on limited access freeways, as well as those that occur on divided highways. Findings from three states (California, Florida, and Texas) were compared to determine if any dominate trends exist. From the research, it was found that Texas and Florida shared very similar trends on crash times and driver characteristics. California data presented a unique weekday-daytime trend for wrong-way crashes compared to the standard weekend-nighttime patterns found in Texas and Florida. Driver data for Texas and Florida showed overarching trends of primarily male wrong-way drivers with alcohol influence being the leading factor. Florida drivers above the age of 65 were found to make up 25 percent of all wrong-way drivers for the state’s divided highway wrong-way crash population with an increased chance of occurrence during daytime hours. Furthermore, it was found that Texas drivers ages 21 to 34 were the most likely group to result in a fatality at 10 percent of all involved drivers.
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INTRODUCTION

Wrong-way driving (WWD), the act of operating a vehicle in the opposing lanes of traffic, is a rare but well covered event in the media due to their unusual and usually fatal nature. These types of incidents have been a problem for transportation officials since the introduction of the interstate system. Research has spiked in the past decade over the cause and prevention of these incidents due to response to the Federal Highway Administration’s (FHWA’s) Toward Zero Death Vision. To properly comprehend the nature of WWD events and put forth appropriate countermeasures, an understanding of the characteristics of WWD is needed. Currently, there is little research into general WWD trends for the United States as a whole. Most research to date has been conducted within individual states and on limited access freeways. To affectively bring the FHWA’s vision into fruition, this must be changed. This project focused on comparing wrong-way crash (WWC) trends on limited access freeways and divided highways for three states: California, Florida, and Texas.

BACKGROUND INFORMATION

The research completed was part of a larger project sponsored by the National Cooperative Highway Research Program, Traffic Control Devices and Measures for Deterring Wrong-Way Movements (Project No. 03-117). The research focused on identifying overall trends and characteristics of WWCs on limited access freeways and divided highways, and the drivers involved using a three state crash dataset.

Traffic Control Devices and Measures for Deterring Wrong-Way Movements

Texas A&M Transportation Institute (TTI) researchers are currently investigating the impact of traffic control device placement and median width in areas of WWCs on divided highways. Additional goals involve identifying inconsistencies found within the Manual on Uniform Traffic Control Devices (MUTCD) on signage and markings for wrong-way movements. The goal of this research is to propose appropriate definitions, text, and figure changes where applicable in the MUTCD. Researchers have determined the most appropriate approach would be to choose three target states representing the United States, geographically (Figure 1). These states, California, Texas, and Florida, not only represent western, central, and eastern population trends, but also have been shown to have the greatest occurrence of WWC fatalities in the United States (1).

Previous Research

Research on national trends in WWCs was few and far between, but research on state levels was prevalent enough to obtain a decent picture on past local trends and characteristics. In California (2), roughly 80 percent of all drivers involved in WWCs on limited access freeways were male and that nearly a third of all drivers were intoxicated at the time of the incident. Furthermore, crashes peaked at 2300 and 0200 hours relating back to times alcohol serving establishments in California closed. This correlation enforces the amount of crashes involving alcohol. Additionally, it was determined that roughly half of the recorded crashes onto limited access freeways originated at exit ramps. Californian drivers, based on population proportions, ages 70
Generalized Trends in Wrong-Way Driving

to 79 years old were found to be overrepresented in recorded crashes by nearly double the expected number, while young drivers (ages 16 to 19 years old) were underrepresented (3).

![Figure 1. Target States](image)

Florida research (4) yielded similar results for limited access freeways, with drivers 75 years and older being overrepresented in crashes by more than three times the expected number while 42 percent of crashes involved drivers less than 30 years old. Intoxication by drugs and/or alcohol accounted for 45 percent of crashes, and once again, late night/early morning hours were peaks in wrong-way activity.

Texas data, based on previous TTI research (5), also resulted in intoxication being the leading contributing factor in limited access freeway WWCs. Additionally, 44 percent of drivers were between the ages of 16 and 34 years old and 59 percent of drivers were male. Late night and early morning hours were also found to show peaks in crash prevalence with more than half of the recorded crashes occurring between midnight and 0600 hours (6). Texas establishments that serve alcohol close around these early morning hours showing possible correlation. Researchers also determined that limited access freeway WWCs represented less than 1 percent of all traffic crashes, but tended to be more severe in nature and have higher rates of fatality.

Regarding divided highways, Virginia (7) found 40 percent of WWD entries occurred at crossover intersections and exit ramps connecting to interstate routes. Additionally, 25 percent happened when the driver was exiting from businesses and 20 percent occurred at the beginning of divided highway sections, crossovers, and construction sites.
Overall, previous research suggested the typical WWC involved a male, below the age of 35, driving under the influence between the hours of 2200 and 0600 resulting in a probable fatality. In addition, drivers over the age of 70 were found to be overrepresented in crashes. This was used as a baseline for the impending analysis to determine if these trends held between each of the target states, as well as between limited access freeways and divided highways.

**DATA REDUCTION AND ANALYSIS**

For this analysis to be successful, access to crash metadata, including occupant data, was required to determine the statistical probability of the following major factors:

- Limited access freeway versus divided highway road classification.
- Urban versus rural road type.
- Age of driver.
- Driver gender.
- Alcohol involvement.
- Crash time.
- Occupant and driver attained injuries.
- Environmental lighting.

These factors were found from each state then compared to each other to determine any overarching trends. Crash metadata, provided by the parent project, had already been sorted by road classification, crash type (WWD only), and road type. The crash years associated with each state varied with availability, but the overall range of years stretched from 2008 to 2014. Due to the lack of previous file compilation, the occupant data files for Florida and California had to be reduced to reflect only occupants affected by a WWC. This was accomplished by cross-referencing the unique crash identification with the corresponding points using ArcGIS for Florida and Visual Basic coding for California. Unfortunately, there was no way to determine the at-fault driver from the California occupant data so all related driver and alcohol statistics had to be abandoned for that state. Additionally, several crashes produced null data for various factors, leading to an inconsistent crash total across state data.

Once all individual state statistics were compiled using Excel and ArcGIS, cross state analysis was conducted using chi-square distribution methods due to the multivariable nature of the data. Alpha levels for all such tests were set to 0.05. Chi-distribution was not performed on all possible cases due to sample size limitations of the method. Results were compiled and then compared to previous research conclusions.

**SETTING THE PICTURE**

The choice of Texas, Florida, and California not only represented the U.S. geographically, but also comprised the greatest percentage of U.S. vehicle miles traveled (VMT) annually (Figure 2) ([8–13]). With higher VMTs, higher instances of WWCs were to be expected, producing a large sample population. Overall, Texas, Florida, and California produced total sample sizes of 752, 429, and 1283 WWCs over their respective years of data. The average number of total crashes for each state was found and then compared to the average number of WWCs showing that they
made up less than a quarter of a percent of all crashes. When compared with average total crash fatalities, the average overall fatality percent was found to be staggeringly low (0.8 to 2.2 percent) compared to the average percent of fatalities for WWCs (4.0 to 23.1 percent).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>8.1% Total VMT</td>
<td>446,112 Total Crashes</td>
<td>0.8% Total Fatalities</td>
<td>251 WWCs (0.06%)</td>
</tr>
<tr>
<td>Florida</td>
<td>6.5% Total VMT</td>
<td>169,717 Total Crashes</td>
<td>1.4% Total Fatalities</td>
<td>143 WWCs (0.08%)</td>
</tr>
<tr>
<td>California</td>
<td>10.9% Total VMT</td>
<td>135,834 Total Crashes</td>
<td>2.2% Total Fatalities</td>
<td>321 WWCs (0.24%)</td>
</tr>
</tbody>
</table>

**Figure 2. Crash Overview**

**RESULTS AND DISCUSSION**

Due to the vast amount of data being conveyed, this section will be divided into subsections reflecting the major factors set forth in the analysis section. Alcohol involvement will be mentioned where appropriate in the following subsections as it becomes relevant.

**Location**

Once the crashes were divided by road classification, they were further divided into urban and rural roadways. As shown in Table 1, urban roadways overwhelmingly tended to suffer from WWCs compared to rural roadways, with the exception of Texas rural, divided highways, which had a greater occurrence than its urban counterpart (shaded cells in Table 1). With Texas having a larger rural landmass and their fondness for divided highways, this was to be expected and came to no surprise. Regarding the urban trend, since these locations traditionally have higher concentrations of access points (i.e., ramps, crossovers, intersections) and users, the probability of a wrong-way event would be anticipated to be greater than rural areas.
Table 1. Urban versus Rural Crash Percentiles

<table>
<thead>
<tr>
<th>State</th>
<th>Limited Access Freeway</th>
<th>Divided Highway</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
<td>Rural</td>
</tr>
<tr>
<td>Texas</td>
<td>82%</td>
<td>18%</td>
</tr>
<tr>
<td>Florida</td>
<td>72%</td>
<td>28%</td>
</tr>
<tr>
<td>California</td>
<td>82%</td>
<td>18%</td>
</tr>
</tbody>
</table>

**Time**

Data were analyzed for day of week and time of day occurrence comparing between states, road types, and location. The results are divided into the following sections.

*Day of the Week*

Overall comparisons in Figure 3 showed a strong trend for weekend (Saturday through Sunday) peaks for both Texas and Florida limited access freeway data. In contrast, California exhibited a more straight-line trend throughout the week. When limited to only alcohol involved WWCs (Figure 4), Florida’s alcohol involved crashes mirrored its overall limited access freeway crashes very closely. Texas showed similar patterns earlier in the week, but alcohol involved crashes decreased slightly on Saturday as opposed to the increase Figure 3 showed.

![Figure 3. Limited Access Freeway Day of the Week Occurrence](image-url)
Divided highway data (Figure 5) showed a similar trend for Texas and California (with the exception of a major Friday peak in California). In contrast, Florida tended to peak on Monday and Wednesday rather than the weekend. In Figure 6, alcohol involved crashes resulted in trends very similar to limited access freeway results with increases on the weekend and an overall limited weekday presence. Monday and Friday’s high alcohol levels, although not officially considered the weekend, could be contributed to late night or early morning crashes where drinking occurred within weekend time.

Chi-square testing showed statistical similarities among roadway classifications in Texas ($\chi^2 = 4.81$ at critical value $(0.05, 6) = 12.59$) presenting a Texas general trend of weekend peaks. California WWC data also displayed statistical similarities among roadway classifications ($\chi^2 = 8.49$ at critical value $(0.05, 6) = 12.59$), but showed an overall even distribution of WWCs. Florida did not show statistical similarity among roadway classifications ($\chi^2 = 23.30$ at critical value $(0.05, 6) = 12.59$) due to the weekend peaks on limited access freeways. Additionally, only Texas and Florida divided highway crashes showed any statistical similarity between states ($\chi^2 = 9.43$ at critical value $(0.05, 6) = 12.59$). Alcohol involvement in Texas and Florida also passed testing among roadway classifications ($\chi^2 = 21.47$ at critical value $(0.05, 18) = 28.87$) showing the similar trend of weekend drinking, as expected.
Results showed similar trends to limited access freeway day of the week results, in that Texas and Florida mirrored each other while California displayed almost opposite trends. In this case, Texas and Florida limited access freeway data showed an increase at night and early morning hours (2000 to 0600) with a significant peak from the 0201 to 0300 range. This peak
coincides with previous research’s claim (6) that drinking establishment closures at that time may contribute to WWCs. In contrast, California WWCs tended to occur during daytime hours (0600 to 2000) with peaks at rush hour times, conflicting with previous research showing similar late night/early morning peaks (2). Comparing these results to the alcohol related crashes in Figure 8, Texas and Florida exhibited very similar trends leading to some possible correlation between WWC times and alcohol serving establishment closures.

![Figure 7. Limited Access Freeway Time of Day](image)

![Figure 8. Limited Access Freeway Time of Day Alcohol Involvement](image)
Divided highways (Figure 9) tended to display less of an extreme peak than their limited access freeway counterparts but still reflected the nighttime trend of crash occurrence in Texas and Florida and the rush hour peaks in California. Both the Texas and Florida data showed peaks before midnight instead of the early morning hours with limited access freeways. Reviewing the alcohol data showed similar peaks before midnight and the general trend of daytime inactivity (Figure 10).

![Figure 9. Divided Highway Time of Day](image)

![Figure 10. Divided Highway Time of Day Alcohol Involvement](image)
Texas and Florida showed statistical similarities with their limited access freeway WWC time of day data ($\chi^2 = 23.31$ at critical value $(0.05, 23) = 35.17$) and with their divided highway WWC time of day data ($\chi^2 = 13.31$ at critical value $(0.05, 23) = 35.17$). California WWC time data, while vastly different from the other states, was found to exhibit similarities between its roadway classifications ($\chi^2 = 28.24$ at critical value $(0.05, 23) = 35.17$). With this similarity, a trend of nearly 75 percent of WWCs in California occurred between 0600 and 2000 hours could be stated.

**Environmental Lighting**

Since time of day is not always a reliable gauge of lighting conditions, it was decided to verify claims by comparing the recorded environmental lighting. Conditions were normalized into five categories: “Daylight”; “Dawn-Dusk”; “Dark, Not Lighted” (no artificial lighting); “Dark, Lighted” (artificial lighting present); and “Other” as shown in Tables 2 and 3. California results reflected the daytime trend with an average of 62 percent of WWCs occurring during “Daylight” conditions for both roadway classifications.

Most of the Texas WWCs on limited access freeways occurred in dark conditions with artificial lighting (46 percent). In contrast, 50 percent of the Texas WWCs on divided highways happened in dark, unlit areas. Recalling earlier results stating a predominance of rural divided highway WWCs in Texas, the lack of artificial lighting was to be expected and complies with general roadway design practices for these conditions. A driver, even one that is sober, could easily become confused as to which side of the road they’re entering on a divided highway, when visual cues are missing or obscured by road darkness. This could easily lead to a possible wrong-way event unbeknownst to the driver.

<table>
<thead>
<tr>
<th>State</th>
<th>Daylight</th>
<th>Dawn-Dusk</th>
<th>Dark, Not Lighted</th>
<th>Dark, Lighted</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>26%</td>
<td>1%</td>
<td>26%</td>
<td>46%</td>
<td>1%</td>
</tr>
<tr>
<td>Florida</td>
<td>17%</td>
<td>4%</td>
<td>34%</td>
<td>45%</td>
<td>0%</td>
</tr>
<tr>
<td>California</td>
<td>63%</td>
<td>4%</td>
<td>14%</td>
<td>18%</td>
<td>1%</td>
</tr>
<tr>
<td>OVERALL</td>
<td>49%</td>
<td>3%</td>
<td>19%</td>
<td>29%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State</th>
<th>Daylight</th>
<th>Dawn-Dusk</th>
<th>Dark, Not Lighted</th>
<th>Dark, Lighted</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>32%</td>
<td>3%</td>
<td>50%</td>
<td>15%</td>
<td>1%</td>
</tr>
<tr>
<td>Florida</td>
<td>37%</td>
<td>3%</td>
<td>32%</td>
<td>27%</td>
<td>1%</td>
</tr>
<tr>
<td>California</td>
<td>61%</td>
<td>6%</td>
<td>19%</td>
<td>14%</td>
<td>0%</td>
</tr>
<tr>
<td>OVERALL</td>
<td>42%</td>
<td>4%</td>
<td>34%</td>
<td>20%</td>
<td>0%</td>
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Florida produced a similar pattern to Texas with “Dark, Lighted” conditions contributing to 45 percent of WWCs on limited access freeways, but had less dark, unlit WWCs on divided highways (32 percent). Overall, Florida had 59 percent of its divided highway WWCs occur at night coinciding with the 55/45 nighttime/daytime hour split from earlier results.

Wrong-Way Driver Gender and Age

Previous research had shown that the majority of wrong-way drivers were male (2, 5), and the results from Florida and Texas confirmed this claim for both road classifications. Shown in Figure 11, an average of 63 percent of the wrong-way drivers was found to be male compared to the 33 percent identified as female. This proved to be so consistent that chi-square testing produced the lowest score of all generated tests ($\chi^2 = 1.99$ at critical value $0.05, 3 = 7.815$). The cause for this trend could not be identified in this research, but speculation leads to the common conception of males being more prone to driving under the influence than females as a possible culprit.

Driver age showed a different story between limited access freeway and divided highway data for Florida and Texas. Previous research had stated that roughly 44 percent of wrong-way drivers in Texas would fall between 16 and 34 years old, and drivers over the age of 75 would be overrepresented (approximately 4 percent of wrong-way drivers compared to 1.4 percent of all freeway crashes) in Florida (4, 5) for limited access freeways—this too was predicted for divided highway crashes. The limited access freeway results in Figure 12 show that in Texas, 47 percent of wrong-way drivers were under the age of 34, confirming previous results. Florida limited
access freeway wrong-way drivers under the age of 34 made up 55 percent, exceeding previous research at 42 percent (4). Wrong-way drivers over the age of 75 comprised 4 percent of Florida limited access freeway total showing that they are still overrepresented.

![Figure 12. Limited Access Freeway Driver Age](image)

Results in Figure 13 showed a different story for divided highways. In both states, most wrong-way drivers (roughly 40 percent) on divided highways tended to be a little older (35 to 65 years old). Furthermore, the spike for Florida drivers over the age of 65 contributed to over 25 percent of all wrong-way drivers on divided highways with 13 percent of wrong-way drivers over 75 years old.

When cross-examined with time of day data (Table 4), overall numbers suggest drivers over the age of 65 and under the age of 21 are more likely to be in a WWC during daytime hours than the rest of the population. Texas in particular showed this as the majority of their drivers under 21 and over 65 crashed during the day. This could be a result of driver inexperience for younger drivers and cases of confusion for older ones. Considering the prevalence of alcohol involved WWCs, the bias of nighttime crashes for the primary drinking population (21 to 34 years old) was not surprising.
Generalized Trends in Wrong-Way Driving

Figure 13. Divided Highway Driver Age

Table 4. Wrong-Way Driver Age vs. Time of Day

<table>
<thead>
<tr>
<th>Age</th>
<th>Limited Access Freeway</th>
<th></th>
<th>Divided Highway</th>
<th></th>
<th>OVERALL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Florida Day</td>
<td>Florida Night</td>
<td>Texas Day</td>
<td>Texas Night</td>
<td></td>
<td>Florida Day</td>
</tr>
<tr>
<td>&lt;21</td>
<td>12%</td>
<td>88%</td>
<td>57%</td>
<td>43%</td>
<td>38%</td>
<td>62%</td>
</tr>
<tr>
<td>21–34</td>
<td>23%</td>
<td>77%</td>
<td>17%</td>
<td>83%</td>
<td>28%</td>
<td>72%</td>
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<tr>
<td>35–65</td>
<td>24%</td>
<td>76%</td>
<td>39%</td>
<td>61%</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>&gt;65</td>
<td>29%</td>
<td>71%</td>
<td>55%</td>
<td>45%</td>
<td>66%</td>
<td>34%</td>
</tr>
</tbody>
</table>

Note: Shading indicates the condition (day or night) with the majority of occurrences.

Injuries

Of the 2464 WWCs examined, a total of 5082 individuals were involved with 70 percent of them related to limited access freeway crashes (Table 5) and 30 percent to divided highway crashes (Table 6). Both roadway classifications showed similar overall fatality percentages (5 percent and 6 percent) and injury percentages (40 percent and 46 percent). Florida limited access freeway crashes had a higher chance of injury compared to the other states (52 percent versus 37 and 39 percent). California showed low fatality percentages (2 percent) for both roadway classifications.
Generalized Trends in Wrong-Way Driving

Table 5. Limited Access Freeway Total Occupant Injuries

<table>
<thead>
<tr>
<th>State</th>
<th>Killed</th>
<th>Injured</th>
<th>Not Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>9%</td>
<td>37%</td>
<td>54%</td>
</tr>
<tr>
<td>Florida</td>
<td>9%</td>
<td>52%</td>
<td>38%</td>
</tr>
<tr>
<td>California</td>
<td>2%</td>
<td>39%</td>
<td>59%</td>
</tr>
<tr>
<td>OVERALL</td>
<td>5%</td>
<td>40%</td>
<td>55%</td>
</tr>
</tbody>
</table>

Table 6. Divided Highway Total Occupant Injuries

<table>
<thead>
<tr>
<th>State</th>
<th>Killed</th>
<th>Injured</th>
<th>Not Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>11%</td>
<td>43%</td>
<td>46%</td>
</tr>
<tr>
<td>Florida</td>
<td>5%</td>
<td>49%</td>
<td>46%</td>
</tr>
<tr>
<td>California</td>
<td>2%</td>
<td>44%</td>
<td>54%</td>
</tr>
<tr>
<td>OVERALL</td>
<td>6%</td>
<td>46%</td>
<td>48%</td>
</tr>
</tbody>
</table>

Shown in Table 7, Florida wrong-way drivers were more likely to be killed or injured on limited access freeways and divided highways, compared to Texan wrong-way drivers. Wrong-way drivers in general, were more likely to be killed (13 percent) or injured (54 percent) than others involved in a crash. Of all age groups across both states, 21 to 34 year olds in Texas had the highest amount of fatalities at 10 percent of the total wrong-way driver population. Furthermore, cross-comparisons with time data showed the majority of wrong-way driver fatalities occurred during nighttime hours on limited access freeway (85 percent) and divided highways (53 percent).

Table 7. Wrong-Way Driver Injuries

<table>
<thead>
<tr>
<th>Injury</th>
<th>Limited Access Freeway</th>
<th>Divided Highway</th>
<th>OVERALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Florida</td>
<td>Texas</td>
<td>Florida</td>
</tr>
<tr>
<td>Killed</td>
<td>17%</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Injured</td>
<td>70%</td>
<td>37%</td>
<td>80%</td>
</tr>
<tr>
<td>Not Injured</td>
<td>13%</td>
<td>50%</td>
<td>7%</td>
</tr>
</tbody>
</table>

CONCLUSION

In this analysis, three states (California, Florida, and Texas) were observed for general WWC trends. Urban road settings were found to have more WWCs than rural locations with the exception of Texas divided highways, which had more rural crashes. Florida and Texas exhibited a more conventional weekend-nighttime pattern for WWCs while California presented a unique weekday-daytime trend. Limited access freeway WWCs were overall found to occur evenly during the day and at night. Most divided highway crashes were found to occur at night. Wrong-way drivers in Florida and Texas were found to be predominately male, and most crashes had alcohol as the leading factor. Wrong-way drivers over the age of 75 in Florida were found to be
overrepresented for both roadway classification WWCs. Finally, wrong-way drivers were more likely to be injured or killed than other involved individuals and Texas wrong-way drivers ages 21 to 34 were the most likely group to be killed at 10 percent of all wrong-way drivers.

REFERENCES

Travel Rates of an Aging Population: A Texas Analysis

Prepared for
Undergraduate Transportation Scholars Program

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August 5, 2016
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Chris enjoys being an active participant in school activities, serving for one year as a BYU-ASCE officer, and regularly attending theater and musical productions with his wife. Upon graduation, he plans on entering into a graduate program with the intent to pursue a Ph.D. His interests lie in transportation planning, computer programming, and teaching.

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SUMMARY

Seniors are a growing proportion of Texas. Senior driving tendencies are different than other travelers and possess unique travel needs that will become increasingly prevalent as the Texas population continues to age. This project was performed in an effort to quantify the travel demand impact due to demography shifts in the coming years. The percentage change in the number of trips and miles traveled by various age groups and genders was analyzed, which included comparisons from 2015 to 2025 and 2015 to 2045. Household travel survey travel data were used in this project, collected as part of the Texas Travel Survey Program. Seven study areas—each comprised of one or more counties—were chosen for inclusion in this research.

For gender differences, females take more trips in the earlier years of their life than males (until about 54 years of age), but males nonetheless account for a higher proportion of vehicle miles traveled (VMT). Additionally, males are more likely to continue driving after reaching 65 years of age than females, although both genders are likely to drive fewer miles per day than other
cohorts. Small, medium and large metropolitan planning organizations (MPOs), as defined in this report, experienced decreases in both person trips and person miles traveled (PMT), although large MPOs experience the least variance in PMT between 2015 and 2025. Moreover, the VMT per capita decreases between 2015 and 2045 for small, medium, and large MPOs; however, more driver trips are made. Thus, there is an overall trend of more trips but shorter trips. It will be important for transportation planners to consider how travel changes spurred by an aging population may best be addressed to ensure senior needs are met in the future and that societal issues linked to aging, such as safety and congestion, are addressed.
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INTRODUCTION

Boyd K. Packer, American religious leader and former educator, remarked, “We face an ominous challenge. Populations worldwide are declining. The birthrate in most countries is falling and life expectancy increasing. … In some countries, in just a few years there will be more grandparents than there are children” (1). Over the last 100 years, the Texas median age has steadily increased, as has the number of senior drivers (2). High levels of mobility have been associated with freedom and opportunity, yet, with increasing age, people are more likely to incur driving disabilities or other impairments that can restrict their driving capabilities (3).

An aging Texas populace will impact the travel needs of the future, and different needs will be seen from a short-term and long-term planning horizon. Understanding senior travel trends and behaviors will become increasingly imperative for Texas transportation planners to prepare for the older, emerging populace, and ultimately develop policies that contribute toward a high quality of life for all Texans.

PROJECT OBJECTIVE AND PAPER STRUCTURE

The purpose of this paper is to assess how aging will affect travel demand in Texas by ultimately addressing the following questions:

- How does Texas senior travel differ from that of other drivers?
- What differences are there between male and female drivers?
- If today’s population had the demographics of 2025/2045, how would trip making and miles traveled change?
- What implications might this have for Texas transportation planners?

This paper is organized as follows. First, a discussion of the Texas Department of Transportation (TxDOT) Travel Survey data used in this analysis is provided. This is followed by a literature review containing topics related to aging and transportation needs. Then, the methodology employed during this project is discussed. This is followed by the results and discussion section. Lastly, future research areas to build off the findings of this report are discussed.

TEXAS TRAVEL SURVEY PROGRAM

Texas travel surveys have their roots back before the 1980s, but it was not until 2000 that TxDOT instituted a 10-year, recurring survey cycle, known today as the Texas Travel Survey Program (TSP). The TSP is conducted over a 10-year cycle for 14 different regions encompassing the 25 metropolitan planning organizations (MPOs) of Texas. The TSP gathers extensive statewide travel data in the form of the following surveys:

- Household.
- Work Place.
- Commercial Vehicle.
- Border Crossing.
- External.
After information has been collected by the TSP, the data are analyzed and the resulting analysis outputs are provided to MPOs for use in their travel demand models. The Texas A&M Transportation Institute (TTI) stores the full travel data for all 25 Texas MPOs. This allows TTI to use the information to represent today’s travel trends and provides easy access for performing research in a variety of areas. Household travel survey data obtained from the TSP were used in this project.

The seven study areas used in this project, organized by study area population size, are listed below. Only study areas composed of whole counties were selected for inclusion in the analysis, with study areas being composed of one or more counties. Names within parenthesis are the counties contained in the study area.

- **Small/medium study areas: 50,000—499,999 people:**
  - Amarillo (Potter, Randall).
  - Corpus Christi (Nueces, San Patricio).
  - Lubbock (Lubbock).
  - Victoria (Victoria).
- **Large study areas: 500,000 or more people:**
  - Austin (Bastrop, Caldwell, Hays, Travis, Williamson).
  - Houston (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller).
  - San Antonio (Bexar, Comal, Guadalupe, Kendall, Wilson).

**LITERATURE REVIEW**

Kanaroglou et al. notes that seniors have different driving tendencies than other age cohorts (4), while Alsnih and Hensher suggest that people are likely to maintain the type of driving behavior they are used to as long as possible (5). In Texas, seniors are expected to see the largest percent growth among all ages in the ensuing years. In a recent publication on the Austin-Round Rock metro area’s changing demographics, it was noted this area had the fastest growing pre-senior population (age 55–64) in the nation and the second fastest growing senior population (age 65+) between 2000 and 2010 (6).

Zmud et al. note that, as America ages, there will be a decrease in VMT per capita and a decrease in the number of work trips (7). However, Collia et al. suggest that even within seniors’ gender, travel differences exist (8). So, although Zmud et al. submit there will be a general decrease in VMT per capita, Alsnih and Hensher report that “older women will be negatively [affected] by a lack of transportation alternatives” the most (p. 908, [5]).

Alsnih and Hensher also advocate that high levels of mobility are equated with the highest levels of choice, opportunity, freedom, access, and independence (5). Chen et al. relate that seniors’ depression levels are connected to their ability to remain mobile and connected with society (9). Thus, the loss of vehicle privileges resulting in reduced living standards may be one more reason why autonomous vehicles (AVs) are anticipated to have large impacts on senior travelers in the forthcoming years (10). AVs are projected to integrate into U.S. society over the next three decades. In fact, in one study, eight different scenarios map out AV adoption rates through 2045,
promoting an AV adoption rate as high as 87 percent \((11)\). Although not explored in this report, AVs are likely to change the travel rates and tendencies of future seniors because of their purchasing power \((10)\).

**METHODOLOGY**

**Comparative Analysis of Areas**

The research methodology included the analysis and comparison of seven study areas. Because the TSP is conducted for MPOs, the survey is only performed for urbanized areas with populations greater than 50,000, and rural areas are not considered in this study. As mentioned previously, the TSP is performed over a 10-year cycle. To eliminate discrepancies due to demography and survey-year changes within the 10-year cycle, each area’s travel behaviors were scaled to match 2015 populations. In other words, 2015 served as the base line year for all study areas in this project. The year 2025 was selected as a forecast year because it represents a relatively short-term planning horizon, and provides an intermediate picture of how trends change by the more long-term planning horizon year. The year 2045 was also selected as a forecast year. It aligns nicely with several automated vehicle dissemination predictions and may facilitate future research efforts to do scenario planning involving AVs. Small and medium MPOs were grouped together and compared to large MPOs.

**Travel Demand Forecasting**

Three primary assumptions were employed in this research to simplify the procedure for quantifying future travel and to minimize the total number of assumptions:

1. The household distributions\(^1\) and total number of households were held constant through 2015, 2025, and 2045, and were taken from the respective study area’s survey year values.
2. Driving patterns were held constant through 2015, 2025, and 2045. In other words, the average rates for the number of trips taken and miles traveled by gender and age remained the same over the years.
3. The 2015 total population stayed the same for 2025 and 2045, but age and gender demographics within the 2015 population were changed to match 2025 and 2045 estimates assumed under a 0.5 migration scenario.

Although more assumptions could have been used to model future travel demand, these assumptions allowed for maximum productivity and minimum speculation about changes of the future. Nonetheless, in order to validate the aforementioned assumptions, the Austin and Lubbock data were tested using multiple assumption approaches. The previously described methodology was compared to the results obtained when changing each study area’s demographics to match its respective projected total number of households and population in 2045. The results of the two approaches were remarkably comparable, with deviation in trips and

---

\(^1\) Household distributions represent the percent distribution of household type based on: 1) household size, 2) household income, and 3) number of employees per household.
VMT percent changes slightly more than 1 percent for Lubbock, and slightly more than 0.1 percent for Austin.

**Household Weights and Age-Gender Adjustment Factors**

Household weights and age-gender adjustment factors (AGAFs) were applied to the sample TSP data to obtain estimates reflective of the population for each study area. Household weights are derived by dividing the total number of households in a given household size, household income, household employment cell by the corresponding sample number of households. There are five classes of household size (1, 2, 3, 4, and 5+), five classes of income levels (1, 2, 3, 4, and 5), and three classes of number of employees (0, 1, or 2+). These three classifications (household size, household income level, and number of employees) combine to give a total of 75 different categories; however, five do not exist, as there cannot be a household with one member and two employees. As stated previously, the total number of households and household distributions were assumed to remain at 2015 levels for all years considered in the analysis, and, consequently, household weights remained the same.

While households are scaled to the known population, when applied to persons within each household, the known age and gender totals may no longer be correct. As shown in Table 1, AGAFs restore the population totals based on age and gender back to forecasted values. For example, in Austin in 2015, there were 271,080 males between the ages of 0 and 19. When household weights were applied, the calculated population for males for this age cohort was 214,167.5. To account for this difference resulting from applying the household weights, the known age cohort value (or projected population, as is the case for 2025 and 2045) is divided by the value obtained when the household weights are applied, and AGAFs are obtained.

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Sex</th>
<th>Population</th>
<th>Population Proportion*</th>
<th>Calculated Population from HH Weight</th>
<th>Age-Gender Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–19</td>
<td>Male</td>
<td>271,080</td>
<td>28.7%</td>
<td>214,167.5</td>
<td>1.266</td>
</tr>
<tr>
<td>20–24</td>
<td>Male</td>
<td>72,934</td>
<td>7.7%</td>
<td>26,923.6</td>
<td>4.310</td>
</tr>
<tr>
<td>25–29</td>
<td>Male</td>
<td>72,431</td>
<td>7.7%</td>
<td>26,835.6</td>
<td>2.699</td>
</tr>
<tr>
<td>30–34</td>
<td>Male</td>
<td>78,200</td>
<td>8.3%</td>
<td>39,855.5</td>
<td>1.962</td>
</tr>
<tr>
<td>35–39</td>
<td>Male</td>
<td>77,267</td>
<td>8.2%</td>
<td>55,353.4</td>
<td>1.396</td>
</tr>
<tr>
<td>40–44</td>
<td>Male</td>
<td>72,742</td>
<td>7.7%</td>
<td>55,369.9</td>
<td>1.314</td>
</tr>
<tr>
<td>45–49</td>
<td>Male</td>
<td>63,185</td>
<td>6.7%</td>
<td>63,011.0</td>
<td>1.003</td>
</tr>
<tr>
<td>50–54</td>
<td>Male</td>
<td>59,586</td>
<td>6.3%</td>
<td>65,221.5</td>
<td>0.914</td>
</tr>
<tr>
<td>55–59</td>
<td>Male</td>
<td>52,934</td>
<td>5.6%</td>
<td>44,151.0</td>
<td>1.199</td>
</tr>
<tr>
<td>60–64</td>
<td>Male</td>
<td>43,137</td>
<td>4.6%</td>
<td>39,084.3</td>
<td>1.104</td>
</tr>
<tr>
<td>65–69</td>
<td>Male</td>
<td>33,585</td>
<td>3.6%</td>
<td>24,792.6</td>
<td>1.355</td>
</tr>
<tr>
<td>70–74</td>
<td>Male</td>
<td>21,241</td>
<td>2.2%</td>
<td>24,717.0</td>
<td>0.859</td>
</tr>
<tr>
<td>75–79</td>
<td>Male</td>
<td>12,828</td>
<td>1.4%</td>
<td>12,209.8</td>
<td>1.051</td>
</tr>
<tr>
<td>80+</td>
<td>Male</td>
<td>14,758</td>
<td>1.6%</td>
<td>14,552.4</td>
<td>1.014</td>
</tr>
</tbody>
</table>

* Population proportions based on total male population
New AGAFs had to be computed for each respective year to account for changing age and gender demographics. As shown in Table 2, the proportions of Austin cohorts have been modified for 2025 and 2045, and new AGAFs were calculated. It can be observed that seniors’ AGAFs, particularly “old” seniors’, change more than any other cohorts, resulting from the changes in population proportions. The number of trips and miles traveled were then calculated using the new age-gender adjustment factors.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0–19</td>
<td>Male</td>
<td>28.7%</td>
<td>1.266</td>
<td>27.1%</td>
<td>1.199</td>
<td>25.1%</td>
<td>1.109</td>
</tr>
<tr>
<td>20–24</td>
<td>Male</td>
<td>7.7%</td>
<td>4.310</td>
<td>7.9%</td>
<td>4.437</td>
<td>7.0%</td>
<td>3.938</td>
</tr>
<tr>
<td>25–29</td>
<td>Male</td>
<td>7.7%</td>
<td>2.699</td>
<td>6.9%</td>
<td>2.438</td>
<td>6.8%</td>
<td>2.407</td>
</tr>
<tr>
<td>30–34</td>
<td>Male</td>
<td>8.3%</td>
<td>1.962</td>
<td>6.4%</td>
<td>1.522</td>
<td>6.8%</td>
<td>1.618</td>
</tr>
<tr>
<td>35–39</td>
<td>Male</td>
<td>8.2%</td>
<td>1.396</td>
<td>7.1%</td>
<td>1.208</td>
<td>6.8%</td>
<td>1.169</td>
</tr>
<tr>
<td>40–44</td>
<td>Male</td>
<td>7.7%</td>
<td>1.314</td>
<td>7.6%</td>
<td>1.307</td>
<td>6.7%</td>
<td>1.148</td>
</tr>
<tr>
<td>45–49</td>
<td>Male</td>
<td>6.7%</td>
<td>1.003</td>
<td>7.2%</td>
<td>1.079</td>
<td>6.0%</td>
<td>0.896</td>
</tr>
<tr>
<td>50–54</td>
<td>Male</td>
<td>6.3%</td>
<td>0.914</td>
<td>6.5%</td>
<td>0.947</td>
<td>5.4%</td>
<td>0.783</td>
</tr>
<tr>
<td>55–59</td>
<td>Male</td>
<td>5.6%</td>
<td>1.199</td>
<td>5.6%</td>
<td>1.190</td>
<td>5.5%</td>
<td>1.181</td>
</tr>
<tr>
<td>60–64</td>
<td>Male</td>
<td>4.6%</td>
<td>1.104</td>
<td>5.1%</td>
<td>1.238</td>
<td>5.6%</td>
<td>1.367</td>
</tr>
<tr>
<td>65–69</td>
<td>Male</td>
<td>3.6%</td>
<td>1.355</td>
<td>4.4%</td>
<td>1.674</td>
<td>5.1%</td>
<td>1.958</td>
</tr>
<tr>
<td>70–74</td>
<td>Male</td>
<td>2.2%</td>
<td>0.859</td>
<td>3.4%</td>
<td>1.313</td>
<td>4.5%</td>
<td>1.712</td>
</tr>
<tr>
<td>75–79</td>
<td>Male</td>
<td>1.4%</td>
<td>1.051</td>
<td>2.5%</td>
<td>1.902</td>
<td>3.5%</td>
<td>2.682</td>
</tr>
<tr>
<td>80+</td>
<td>Male</td>
<td>1.6%</td>
<td>1.014</td>
<td>2.2%</td>
<td>1.435</td>
<td>5.1%</td>
<td>3.288</td>
</tr>
</tbody>
</table>

* - Population proportions based on total male population

**Programming and Data Checking**

Microsoft Excel 2013 and PostgreSQL 9.6 were used in automating the data analysis process. Byron Chigoy, TTI researcher and data scientist, was largely responsible for the processing of TSP data in PostgreSQL for easier use and manipulation. After processing the household travel data, the information was copied into Excel. From here, various Excel functions were used to quickly auto-populate the information needed for this project’s analyses.

Throughout the process of transferring and manipulating data from PostgreSQL to Excel, the data had to be revised and cleaned. Because this project approach used novel techniques in quantifying future travel demand, and because TTI alone stores the full TSP dataset, ensuring that the data were in good condition prior to their use in the analysis described was an important preliminary step. When needed, data clarifications were quickly applied, and, by the end of this project, the data were more accurate and complete than before.
RESULTS

The first task was to establish if Texas seniors exhibited different travel tendencies than other age cohorts (4) and to assess if different genders also exhibit different travel tendencies (8). Figure 1 shows both the average daily vehicle (driver) miles traveled (VMT) and the average daily driver trips for various age groups. Because young cohorts’ (age 0–19) driving behaviors are skewed because of their inability to drive until about 15 or 16 years of age, the 0–19 year-old age cohort was excluded from Figure 1.

As Figure 1 depicts, females engage in more driver trips than males until about 50–54 years of age. However, more trips do not indicate more VMT. Rather, in almost every age group males drive farther than females, suggesting that females are making more but shorter trips than males until about 50–54 years of age. Another important trend is the consistent drop in female driver trips from about age 35 on. After 35–39 years of age, females take fewer and fewer driver trips until, at 80 years and older, they are taking just slightly more than one driver trip per day, on average. From about 55–79 years of age, females take longer but fewer driver trips when compared to females between the ages of 30–54. This can in part be due to changes in trip purpose distributions, as exhibited in Figure 2. From age 30–54, women take proportionally fewer home-based work (HBW) trips. Female VMT steadily decreases after 65–69 years of age, and an almost linear trend occurs in senior female VMT such that females drive approximately 0.6-miles shorter for every year they age after 65.

For males, from 20–64 years of age, there is a strong positive correlation between the two: as one goes up the other goes up; as one goes down the other goes down. After reaching their senior years, males begin to drive considerably shorter distances though the number of driver trips resembles those of younger cohorts (males between 24 and 64 years of age). This result can be explained in part by looking at trip purposes. As shown in Figure 3, between 20 and 64 years of age, 21–27 percent of male driving trips are HBW trips. Then, after reaching senior years, males engage in HBW trips 6–12 percent of the time.

After illustrating the differences in travel behavior associated with gender and age, the next task was to demonstrate age-demographic changes in the study years of interest. In Table 3, it can readily be observed that, of the selected age groups, only seniors are projected to increase proportionally from 2015–2025 and from 2015–2045—by an astonishing 30.6 percent and 60.3 percent, respectively. The greatest negative proportional changes from 2015–2025 occur in young cohorts (0–19 years of age) and middle-aged to pre-senior adults (50–64 years of age). The greatest negative proportional changes from 2015–2045 occur again in young cohorts and, this time, in young adults (20–34 years of age). This reinforces the notion that the birthrate is falling and life expectancy is increasing (12, 13).

Moreover, aging is even taking place within the senior population. As shown in Table 4, young seniors (defined to be those 65–74) comprise the majority of the senior population in small/medium and large MPOs in 2015 and 2025. However, in 2045, old seniors (defined to be those 75+) comprise a larger proportion of the senior population for small/medium and large MPOs. Small/medium MPOs’ old senior proportions increase by 80 percent from 2015–2045 to comprise 10.1 percent of the population. Large MPOs old senior population comprises about
9.8 percent of its population in 2045, slightly less than that of small/medium MPOs. However, the growth rate for old seniors in large MPOs is an astonishing 148 percent, whereas small and medium MPOs see a 79.5 percent change.

**Figure 1**: Average daily vehicle miles traveled and driver trips versus age groups, for all areas: 2015.
Figure 2: All areas by trip purpose for various female age groups: 2015.

Figure 3: All areas by trip purpose for various male age groups: 2015.
Once travel differences between ages and genders were displayed, and after modeling the aging impact in Texas’ population, the question to answer was, “If today’s population had tomorrow’s demographics, what would change?” By employing the above-mentioned methodology with the demographic changes exemplified in Table 3 and Table 4, the following results were obtained.

In Figure 5, the percent changes in total person trips and PMT between 2015 and 2025, and 2015 and 2045 are expressed. In small and medium MPOs, from 2015–2025, person trips and PMT decrease by 0.4 percent and 0.6 percent, respectively. This trend continues in the percent changes from 2015–2045.

For large MPOs from 2015–2025, there is a 0.6 percent decrease in the number of person trips yet a minimal negative change in PMT. This means fewer trips are being taken, but those trips are longer than in 2015. From 2015–2045, person trips and PMT both decrease considerably by 1.6 percent and 1.5 percent, respectively, suggesting that people are traveling less and shorter distances as the Texas population ages.

### Table 3: Texas Demographic Proportions and Comparison: 2015, 2025, and 2045.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0-19</td>
<td>29.3</td>
<td>27.4</td>
<td>-6.3%</td>
<td>25.6</td>
<td>-12.4%</td>
</tr>
<tr>
<td>20-34</td>
<td>21.3</td>
<td>20.8</td>
<td>-2.4%</td>
<td>19.3</td>
<td>-9.4%</td>
</tr>
<tr>
<td>35-49</td>
<td>19.8</td>
<td>19.2</td>
<td>-2.7%</td>
<td>19.4</td>
<td>-2.0%</td>
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<tr>
<td>50-64</td>
<td>17.8</td>
<td>17.1</td>
<td>-4.2%</td>
<td>16.7</td>
<td>-6.1%</td>
</tr>
<tr>
<td>65+</td>
<td>11.8</td>
<td>15.4</td>
<td>30.6%</td>
<td>18.9</td>
<td>60.3%</td>
</tr>
</tbody>
</table>

*Population projections found using 0.5-migration factor

### Table 4: Percentage of Population in Young Senior Category vs. Old Senior Category.

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage of Population (%)</th>
<th>Young Seniors (65–74)</th>
<th>Old Seniors (75+)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Small/Medium^a</td>
<td>Large^b</td>
</tr>
<tr>
<td>2015</td>
<td>7.6</td>
<td>6.6</td>
<td>6.7</td>
</tr>
<tr>
<td>2025</td>
<td>9.8</td>
<td>8.9</td>
<td>9.0</td>
</tr>
<tr>
<td>2045</td>
<td>8.2</td>
<td>9.5</td>
<td>9.4</td>
</tr>
<tr>
<td>2015-2025 Percent Increase</td>
<td>28.9</td>
<td>35.0</td>
<td>34.3</td>
</tr>
<tr>
<td>2015-2045 Percent Increase</td>
<td>7.5</td>
<td>44.1</td>
<td>40.3</td>
</tr>
</tbody>
</table>

^Small/Medium defined to be those study areas with a population less than 500,000 people

^Large defined to be those study areas with a population of 500,000 people or greater
In Figure 5, percent changes in driver trips and VMT are analyzed from 2015–2025 and from 2015–2045. Small/medium MPOs maintain the same number of driver trips in 2025 as 2015, yet there is a 0.5 percent decrease in VMT. This trend of trips becoming shorter is even more pronounced from 2015–2045. Small/medium MPOs experience a 0.6 percent increase in driver trips and a 0.3 percent decrease in VMT. Large MPOs likewise exhibit this behavior in comparing 2015 and 2045, with a 1.2 percent increase in the number of driver trips, and only a 0.1 percent increase in VMT. This can be explained in part by, as the population ages, the population will have a proportionally higher number of licensed drivers. However, the decrease in VMT is affected by the VMT trends exhibited by seniors, as demonstrated in Figure 1. From 2015–2025, large MPOs experience increases in both driver trips and VMT by almost 1 percent.
CONCLUSIONS AND DISCUSSION

Figure 1 supports findings by Collia et al., particularly among the old male and female seniors, that seniors “tend to take fewer trips [and] travel shorter distances” than other cohorts (p. 469, (8)). Figure 1, Figure 3, and Figure 2 illustrate the existence of travel differences between genders and ages, concurring with previous findings by Kanaroglou et al. and Collia et al. But perhaps the most significant finding in this report is the decrease in Texas seniors’ VMT per capita, which coincides with projections provided by Zmud et al. (7).

Texas is likely to experience more congestion within MPO districts, whether small/medium or large, due to the effects of aging. More than 65 percent of seniors reported being bothered by road congestion, resulting in seniors taking the majority of their trips between the hours of 9 a.m. and 4 p.m. (8). However, trips taken by seniors are generally short trips. Perhaps as the population ages, even mid-day and mid-afternoon traffic will become an issue.

Regarding women travel behavior, the combination of driving proportionally less to and from work while taking the highest number of driver trips among both genders and age groups alludes to the child rearing years (14), although this research did not investigate the matter more fully.
Figure 4 indicates fewer trips are being taken, and trips are becoming shorter. These two results point toward the effects of aging once again, as Texans tend to travel fewer times and shorter distances per day as they age. This short trip-type behavior leads to an increasing number of cold starts—the time during which a vehicle engine’s temperature is below its normal operating temperature. Catalytic converters do not usually start until about 3 km after a cold start. Thus, seniors comprise a higher proportion of their travel time in this condition (5). With the combined effects of more but shorter trips, it is possible that pollution levels will increase more within MPO districts. Figure 5 shows the effects of senior males maintaining their driver-trip behavior but driving shorter distances. This, nonetheless, coincides with Alsnih’s and Hensher’s findings: that “people stay as long as possible with the type of [driving behavior] they are used to” (p. 904, [5]).

IDEAS FOR FUTURE RESEARCH

As stated previously, the travel model years (in particular, 2045) were selected for this analysis with the intent of facilitating future research in various areas, such as the integration of autonomous vehicles into society. Changes such as people without a driver’s license or with a disability traveling alone are two possible areas for research. Additionally, population forecasts could be modeled using a 0.0- or 1.0-migration factor.

The Austin-Round Rock metro area had the second fastest growing senior population in America between 2000 and 2010. However, poverty among older adults increased by 42 percent during the same time period (6). So, a more in-depth analysis of possible demographic changes could be employed in future research. One area of future research, perhaps the most straightforward of all, is to include external trips in the analysis. Because large MPOs encompassed a significantly larger geographic area than small or medium MPOs, this could potentially normalize some of the impact of trip rates and VMT calculations caused by only considering internal trips.

In recent years, Katie’s Law was passed, imposing regulations on driving seniors to renew their driver’s license in person starting at age 79, and requires in-person renewals every two-years starting at age 85 (15). This law may decrease travel rates for seniors, and provides another aspect of future research related to Texas senior travelers. Lastly, developing a method for obtaining rural area demography and trips could be used in expanding the scope of the research. Rural areas compose approximately 15 percent of the Texas population, according to the U.S. Census Bureau (16). However, rural areas were ignored in this analysis, because the TSP survey data includes only urbanized areas with 50,000+ people.
REFERENCES

APPENDIX: FIGURES

Figure 6: Percent of driver trips for all study areas taken by age group.

Figure 7: Percent of VMT for all study areas taken by age group.
Figure 8: Percent change in person trips and PMT for each study area: 2015 to 2045.
Figure 9: Percent change in driver trips and VMT for each study area: 2015 to 2045.
Figure 10: Percent of home-based work trips for "young" and "old" seniors: 2015.
Figure 11: Percent of non-home-based work trips for young and old seniors for each study area: 2015.
Figure 12: Average daily VMT by seniors for each study area: 2015.