SPRING 2015 ARIZONA TOWN HALL BACKGROUND REPORT

TRANSPORTATION & ARIZONA

EDITED BY MICHAEL KUBY AND AARON GOLUB
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ARIZONA TOWN HALL
Creating Solutions

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It was a pleasure working with the team at the Arizona Town Hall, especially President Tara Jackson, whose enthusiasm and insight guided us from start to finish. The report was shaped and improved during two meetings with the Town Hall Research Committee, whose members shared patiently their extensive knowledge of transportation, Arizona history and politics, and their Town Hall experience.

Finally, we would like to thank two different groups of contributors of content to the report. First, our thanks go out to the chapter authors from our 2009 Town Hall report, who graciously allowed us to build on that foundation and helped us to update their original insights. Second, we wish to thank all of the new contributors of spotlight projects and other content for their expertise and the great work they have done. We have learned a great deal from all of you.

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SPRING 2015

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Michael Kuby and **Aaron Golub**

School of Geographical Sciences and Urban Planning
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FROM THE AUTHORS

We have had the distinct privilege of preparing two background reports on transportation for Town Hall participants—one in 2009 in the wake of an unprecedented economic crisis, and now again in 2015. Working on a second report has given us a unique perspective on transportation in Arizona. Six years ago we called attention to some potential changes that have since come to pass—a drop in average miles driven per year, denser urban development around the brand new light rail stations, and electric and alternative-fuel vehicles finally reaching Arizona's consumers. Other changes have surprised us, such as gasoline briefly under $2 per gallon, a steady decline in deaths due to distracted driving, and serious exploration of a Phoenix-Tucson passenger rail line.

Unfortunately, there is also that third category—problems that were getting worse and yet still haven't been addressed. Arizona remains one of the least safe states for driving and walking, it is ill-prepared for the mobility needs of our growing aging population, our rural and tribal areas remain poorly served by public transportation, and we are only just beginning to plan for the impact of climate change on the transportation system. Most importantly, the writing has been on the wall for quite some time that our transportation financing model at the federal, state, and local levels is unsustainable. In the 24 years since Arizona last raised its gas tax (and 21 since Congress raised the federal gas tax), our ability to provide a good level of service and mobility options to all populations across the state has been steadily eroded.

Ignoring these problems does not make them go away—and they have serious economic, social, health, and environmental consequences. When transportation systems don't work—when congestion, repairs, or flooding stalls movement, when transportation costs are too high for some to afford, when streets are unsafe to walk, and when critical goods don't reach their destination in time—there can be significant repercussions for the people and businesses in our community, such as:

- Employment: when mobility is challenged by bad public transportation or unfordable transportation by car, people are constrained in where they can live and work, which forces them to settle for lower pay than they would if they were more mobile.
- Health: People who live in areas where it is safe and convenient to walk to nearby destinations are shown to be healthier than those who live in areas where the only reasonable option is to drive.
- Economy: Congestion costs the average driver in the Phoenix metro area 35 hours per year, and 38 hours in the Tucson area.
- Environment: Emissions from vehicles causes significant pollution, which nationally causes billions of dollars in health costs, lost work productivity and early death.
- Energy: Our reliance on gasoline and diesel cars makes us dependent on petroleum, leaving us vulnerable to swings in international oil prices; The National Bureau of Economic Research credits oil price shocks for causing six recessions in the United States economy since World War II.[1]

These are just a sampling of the important issues tied to our transportation systems. Improving our transportation systems can bring large benefits to our neighborhoods, our children, our environment and our economy, and so we hope the details in these pages can help you understand the important issues to confront in moving our policies and practices forward.

Sincerely,

Michael Kuby
Professor, School of Geographical Sciences and Urban Planning
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ARIZONA TOWN HALL
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FROM THE CHAIRMAN

We thank you for making the commitment to participate in the 106th Arizona Town Hall to be held at the Casino Del Sol Resort on April 19-22, 2015. You will be discussing and developing consensus with fellow Arizonans on the topic of Transportation In Arizona. An essential element to the success of these consensus-driven discussions is this background report that is provided to all participants before the Town Hall convenes. Arizona State University coordinated this detailed and informative background material and it provided a unique resource for a full understanding of the topic.

Special thanks to ASU Professors Michael Kuby and Aaron Golub for spearheading this effort and marshaling many talented professionals to write individual sections. For sharing their wealth of knowledge and professional talents, our thanks go to the authors who contributed to the report. Our deepest gratitude also goes to Arizona State University President, Michael Crow; and Dean of the College of Public Programs, Jonathan Koppell, who made great efforts to ensure that the university could provide this type of resource to Arizona.

The 106th Town Hall could not occur without the financial assistance of our generous Professional Partners, which (at the time of this printing) include Premier Partner APS; Collaborator Partner Union Pacific; and Civic Leaders Snell & Wilmer L.L.P. Law Offices and Cox Communications.

When the 106th Town Hall ends, the background report will be combined with the recommendations from the Town Hall into a final report. This final report will be available to the public on the Town Hall's website and will be widely distributed and promoted throughout Arizona. The Town Hall's report of recommendations and background report will be used as a resource, a discussion guide and an action plan to support a thriving economy for all of Arizona's diverse communities.

Sincerely,

J. Scott Rhodes
Board Chair,
Arizona Town Hall

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BACK TO THE LECTURE HALL BOXES

BY THE NUMBERS BOXES

LIST OF ACRONYMS USED IN THIS REPORT

AADT	Annual average daily traffic
ADA	Americans with Disabilities Act
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
AFV	Alternative fuel vehicle
AGFD	Arizona Game and Fish Department
AICP	American Institute for Certified Planners
ASCE	American Society of Civil Engineers
AV	Automated Vehicle
B20	20% biodiesel, 80% diesel blend
BLS	Bureau of Labor Statistics
BNSF	Burlington Northern Santa Fe Railroad
BQAZ	Building A Quality Arizona
BRT	Bus rapid transit
BTS	Bureau of Transportation Statistics
CAFE	Corporate Average Fuel Economy
CBG	(Arizona) Cleaner Burning Gasoline
CMAQ	Congestion Management and Air Quality
CNG	Compressed natural gas
CNT	Center for Neighborhood Technology
CO	Carbon monoxide
CO	Carbon dioxide
COG	Council of Government
CYMPO	Central Yavapai Metropolitan Planning Organization
DOT	Department of Transportation
DPS	Department of Public Safety
E85	85% ethanol, 15% gasoline blend
EAS	Essential Air Services
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EV	Electric vehicle
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FY	Fiscal year
GARVEE	Grant Anticipation Revenue Vehicles
GHG	Greenhouse gases
GPS	Global positioning system
HELP	Highway Expansion and Extension Loan Program
HOV	High-occupancy vehicle
HUD	Department of Housing and Urban Development
HURF	Highway Users Revenue Fund
IPCC	Intergovernmental Panel on Climate Change
ISTEA	Intermodal Surface Transportation Efficiency Act
ITCA	Inter-Tribal Council of Arizona
ITEP	Institute on Taxation and Economic Policy
ITS	Intelligent Transportation Systems

LDV	Light duty vehicle
LID	Low-impact development
LNG	Liquefied Natural Gas
LRTP	Long Range Transportation Plan
LTAF	Local Transportation Assistance Fund
MAG	Maricopa Association of Governments
MAP-21	Moving Ahead for Progress in the 21st Century Act
MPO	Metropolitan Planning Organization
NAFTA	North American Free Trade Agreement
NAIPTA	Northern Arizona Intergovernmental Public Transportation Authority
NCA	National Climate Assessment
NEPA	National Environmental Policy Act
NMT	Non-Motorized Transportation
NO	Nitrogen oxides
NPS	National Park Service
O&M	Operations and maintenance
OHV	Off-highway vehicle
OPEC	Organization of Petroleum Exporting Countries
PAG	Pima Association of Governments
PARA	Planning Assistance for Rural Areas
PE	Professional Engineer
PHEV	Plug-in hybrid electric vehicle
PM	Particulate matter
PPP	Public private partnership
PRT	Personal rapid transit
PTP	Professional Transportation Planner
RARF	Regional Area Road Fund
ROD	Record of Decision
RSA	Road Safety Audit
RTA	Regional Transportation Authority (Tucson)
RTP	Regional Transportation Plan
SDP	Service Development Plan
SMF	South Mountain Freeway
SR	State Road
SRTS	Safe Routes to School
STAN	Statewide Transportation Acceleration Needs
STIP	State Transportation Improvement Program
TCM	Transportation Control Measures
TIGER	Transportation Investment Generating Economic Recovery
TIP	Transportation Improvement Program
TSP	Tribal Transportation Safety Plan
TTP	Tribal Transportation Program
UP	Union Pacific Railroad
USDOT	US Department of Transportation
VMT	Vehicle miles traveled
YMPO	Yuma MPO

EXECUTIVE SUMMARY

THERE IS NO DOUBT THAT THE CURRENT FUNDING SYSTEM IS INADEQUATE

This report provides background information for participants at the 106th Town Hall on April 19-22, 2015, in Tucson. The focus of this meeting is transportation of people and goods to, from, and within Arizona. This system consists of the hard infrastructure and vehicles employed for that movement, as well as the soft policies, programs, investments, and myriad behaviors of private travelers and public agencies that affect how the system operates and is developed and shaped over time. We document a number of significant trends across these systems—some positive, some negative—which we summarize below.

The Great Recession was both a crisis and an opportunity for transportation. Government budgets at all levels were devastated as tax revenues slumped, but the federal stimulus package injected $746 million into the Arizona Economy (out of $50 billion nationally) on transportation projects across the state, including the Tucson Streetcar, charging infrastructure for electric cars, as well as routine infrastructure maintenance.

In 2009, no one knew if the plateau in America's century-long growth in vehicle-miles traveled (VMT) was a temporary result of the mid-2000's high gasoline prices or were Americans and Arizonans taking their foot off the gas pedal for good? It's now clear that per capita VMT continued falling even as the economy recovered. This change is bolstered by fewer young Arizonans getting drivers' licenses. In concert with changes in driving is an emerging back-to-the-city lifestyle movement, and cities such as Phoenix, Tucson, and Tempe are seeing strong growth and densification in central areas.

Before it opened, the Phoenix-Tempe-Mesa Light Rail inspired much debate about how many people would ride it given our hot climate and dispersed land-use patterns. Ridership has exceeded expectations and has already surpassed 2020 projections. In 2014, the Tucson Streetcar opened and performed similarly above expectations. Many Arizonans are embracing urban rail not just for the journey to work but for school and entertainment trips, and doing so in large enough numbers that the real-estate market is responding by investing in projects near many stations. One important open question is, will Arizonans and Arizona developers respond similarly to Bus Rapid Transit—a train-like bus experience that is far cheaper to build? Several Arizona communities are now developing BRT, and at the next Town Hall on transportation we should have better answers to that question.

Coming off the shock of 2008's $4 per gallon gasoline, few experts predicted that by early 2015 we would see gasoline prices under $2 and the US would return to being the largest oil producer in the world. While predicting oil prices is a fool's game, we caution readers against over-reacting to current oil prices, given growing costs of production and continued growth in countries like China and India; prices are likely to rise again soon.

In the meantime, real alternatives to oil have matured enough to allow households and businesses to adopt them today. Commercial and government fleets are leading the way with vehicles that run on propane, natural gas, electricity, and biofuels blends. Fleet managers are seeing substantial maintenance savings on top of fuel savings. Consumers can choose from these same alternative fuels, plus hydrogen fuel-cell vehicles that are finally hitting the market in 2014-2016. Alt-fuel vehicles cost more up-front but may

pay off down the road, and may be essential for mitigating greenhouse gas emissions someday. While the lack of refueling and recharging infrastructure inhibits their adoption, flex-fuel vehicles and plug-in hybrids are attractive today for their ability to run on alternative forms of energy or gasoline or diesel in a pinch.

In air transport, enthusiasm about the expansion of commercial service at Gateway Airport in Mesa was tempered by the loss of the US Airways headquarters in Tempe. The one-two punch of high fuel prices and the subsequent recession led US Airways to merge with bankrupt Dallas-based American Airlines. If American Airlines were to downgrade its hub operations at Sky Harbor, it would have negative economic impacts not only on airline-related jobs, but also on travelers who enjoyed direct service on many routes. Rural Arizonans remain dependent on the federal Essential Air Services program to subsidize commercial carriers to continue serving our smaller airports.

Economically, transportation costs place a large burden on Arizona households, especially lower-income workers who cannot easily reach dispersed jobs using public transportation. Equally important, congestion places a huge burden on our time budgets. While traffic congestion and delays have been improving in Phoenix and worsening in Tucson, congestion is not only a rush-hour phenomenon on urban highways, but can affect smaller towns and rural areas and costs our economy dearly.

Trade and tourism are integral to Arizona's economy, and both depend heavily on good transportation infrastructure. Unless freight is coming from or going to Arizona, it mostly passes through without stopping. Efforts are underway to capture some of that business by developing inland ports that would handle freight here rather than in congested Southern California ports. Improvements to our international ports of entry between Sonora and Arizona are also being proposed.

One of the major initiatives under study is the potential trade corridor from Nogales to Las Vegas, broadly known as the I-11 corridor, although it also involves I-19, I-10, and I-40. The I-11 portion of it would complete a missing link in the interstate system between Phoenix and Las Vegas, and help connect the Southwest to Canada and Mexico. I-11 is often linked in studies to the emergence of a megapolitan Arizona Sun Corridor stretching from Tucson to Prescott. While growth has been spreading between these once-separate metropolitan areas, it is not a foregone conclusion that we will get continuous urbanization from Prescott to Green Valley. Nevertheless, the I-11 corridor has sparked conversations about thinking differently about transportation infrastructure. There is a budding movement for "next generation" infrastructure that is multi-modal, innovative, and sustainable, which can only be achieved through broader public participation and cross-agency collaboration. Passenger rail between Tucson and Phoenix is gaining attention and could be a pivotal part of the greater "super-corridor" vision.

Mobility is a challenge for many members of our society. Arizona is not prepared for the coming age wave of senior citizens, most of who grew up driving. Door-to-door paratransit for aging or disabled Arizonans is extremely expensive to provide, and can serve just a fraction of the potential demand. At the other end of the age spectrum, Arizona children are walking and biking to school less and getting more obese. On average, rural households earn lower incomes, driver farther distances, and have fewer transportation choices. Tribal areas face concerns about safety, rights of way through and alongside their reservations, and the impacts of those rights of way on pollution and archaeological and cultural resources.

Arizona's roadways remain some of the most dangerous in the country; our fatality rate is double that of the safest states. One bright spot has been declining fatalities and injuries from distracted driving, though it still causes as many serious injuries as impaired driving.

Several Arizona counties remain in non-attainment for federal air quality regulations: Maricopa County for particulates and ozone, and Yuma for particulates. Maricopa and Pima counties now meet carbon monoxide standards but are still monitored by the EPA to ensure they stay in compliance. The state must continue investing in measures to reduce emissions or risk losing federal highway funding.

Arizona is just starting to come to grips with the reality of climate change; some stakeholders push for aggressive action while others deny its existence. Transportation is both causing climate change through carbon emissions and being affected by it in real and measurable ways. Across the country, governments are assessing the risks of climate change to prepare for its likely impacts on transportation as well as future restrictions on vehicular emissions of carbon. ADOT commissioned a study of climate-related "Extreme Weather Vulnerability" of the I-10/I-17 corridor. Without any ocean coastline, Arizona is somewhat protected from the worst impacts of climate change,

but significantly higher temperatures are likely to damage pavement, bridges, and railways, impact infrastructure construction schedules, and suppress non-motorized modes of transportation, including use of public transit.

This report summarizes the process by which transportation is planned, including forecasting, project evaluation, public involvement, and adherence to civil rights and environmental laws. It highlights key concepts for planning for local, metropolitan, state, federal, rural, tribal, park, public transit, and non-motorized systems. Smart growth has become a fairly mainstream approach to leverage the underlying synergy between transportation and land use

Transportation planning activities thrive across the state, from small towns revitalizing downtowns to the multi-billion dollar transportation plans of mega-regions, and from tribal communities' road safety audits to the statewide "What Moves You Arizona" long-range plan. This report highlights a few of the many exciting transportation initiatives happening around the state. There is no shortage of great ideas in Arizona, but as is often the case, the question is how to pay for them.

Sadly, in this critical area, we've seen backwards progress since our last report. Transportation is a capital-intensive industry, and most of the infrastructure is publicly owned and operated. Transportation is financed through a maze of taxes, fees, federal grants, and loans. There is no doubt that the current funding system is inadequate; our primary source of state funds, the tax on gasoline and diesel fuel, has not been adjusted for inflation in 24 years, and the rise in infrastructure costs along with more efficient vehicles has seriously eroded the buying power of the state's transportation funds. As ADOT's Long-Range Transportation Plan makes clear, the estimated business-as-usual revenues of $26.2 billion for 2010-2035 would be insufficient to cover the "essential" needs of $88.9 billion, let alone the Building a Quality Arizona vision plan that would require $250 billion to fund.

In addition, the weak link between the real costs of driving and how we pay for roads does not promote efficient use of the system. Our largest counties and several other cities have passed sales tax increases to supplement state and federal sources, and while all residents benefit from transportation in many ways, both gas and sales taxes fall more heavily on lower-income households. The current financing system is not well designed to meet multi-modal transportation needs, demanding a reexamination of the entire transportation funding system. Possible solutions include a variable-rate gas tax, a VMT tax, more public-private partnerships, tolls, and value-capture mechanisms through which the adjacent land uses that benefit from public investments would help finance them. As other states experiment with these ideas, Arizona will have to play catch up or suffer from eroding infrastructure and service cuts.

INTRODUCTION

THE ULTIMATE TASK OF PRIORITIZING THESE ISSUES AND RECOMMENDING SOLUTIONS LIES WITH YOU

This report provides background information for participants at the 106th Town Hall, *Transportation and Arizona*, on April 19-22, 2015, in Tucson.

Our goal is to inform readers about transportation and why it matters, not only in broad strokes, but also in the context of the physical and social geography of Arizona. In doing that, we strive to present a diverse and balanced view of Arizona's transportation issues by drawing on the knowledge and experience of a select group of contributors from the academia, business leaders, elected and appointed government officials, and civic leaders across Arizona and beyond.

This report is organized into three (3) main parts. In **Part I**, we provide an in-depth discussion of transportation fundamentals. Chapter 1 discusses transportation trends and Chapter 2 discusses the modes of transportation. Chapter 3 is devoted to the important interaction between land use and transportation. In **Part II** we highlight why transportation matters to people and businesses across the state. We explore transportation's role in the economy (Chapter 4), its societal significance (Chapter 5), energy use (Chapter 6) and its two-way relationship with the environment (Chapter 7). **Part III** focuses on issues related to transportation planning (Chapter 8), and financing (Chapter 10), and spotlights innovative transportation projects and plans around the state (Chapter 9).

Along the way, we introduce some key analytical concepts used by transportation practitioners to aid in our readers' thoughtful analysis of transportation and related issues. These "**Back to the Lecture Hall**" boxes are distributed throughout the report, as are a series of "**By the Numbers**" boxes, which highlight some surprising statistics, both good and bad.

The report purposely omits a concluding section that distills the main issues and questions that emerge from this broad review of transportation in Arizona. The ultimate task of prioritizing these issues and recommending solutions lies with you, the Town Hall participants.

PART I

TRANSPORTATION FUNDAMENTALS

CHAPTER 1

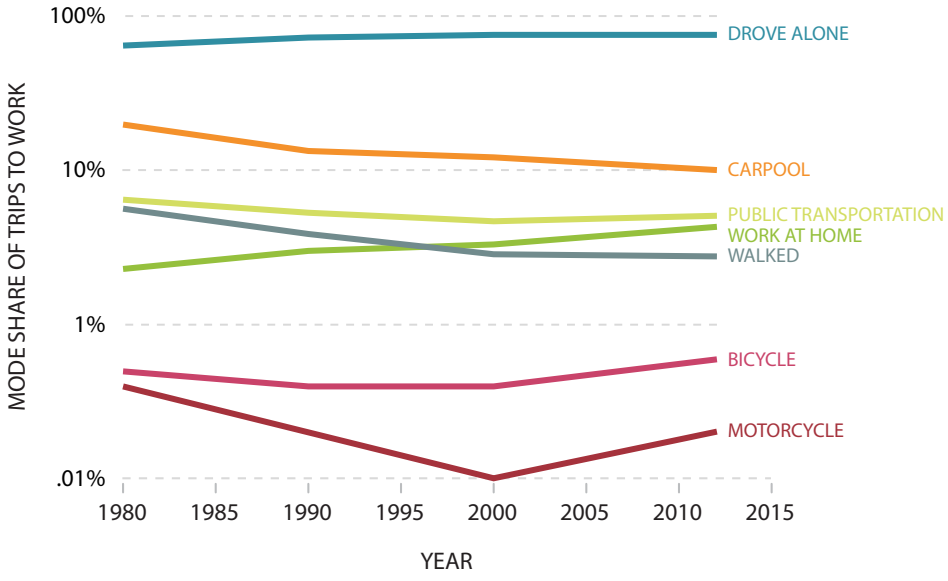
TRANSPORTATION TRENDS

We begin this overview of recent transportation trends in the US and Arizona with a brief synopsis of the historical long view. The Industrial Revolution had a profound impact on transportation, as it did on all aspects of American society. Prior to the Industrial Revolution, we traveled by foot, horse, wagon, or sailing ship. Correspondingly, our cities were small and compact and our interactions with other places limited. With mechanization, we began traveling faster and farther. Regions traded over longer distances and specialized more. In the 1800s, mechanized transport was limited to railroads, steamboats, and streetcars, and our cities and industries concentrated along those networks. Then came the automobile, which changed everything. By the early 20th century, families could purchase their own personal form of mechanized transport, and as America got richer more families could afford one or more cars.

Growth of the automobile had major impacts on traditional forms of transportation. Streetcar ridership peaked in the 1920s, while bus ridership dropped precipitously after World War II. Through most of the 20th century, rail transport was battered on all sides. Passenger rail was squeezed by car travel for shorter trips and air travel for longer ones, while trucking stole much of its freight business. Meanwhile, mechanization of agriculture led to massive rural-urban migration, and our cities mushroomed in population and even more so in geographic extent, thanks in large part to the automobile as well.

Now we will look more closely at recent decades and the current picture. For most Americans, the journey to work is the most important trip of the day. The long-run trend towards increasing dependence on driving alone to work and the decline of the other modes finally shows signs of abating or reversing (Figure 1.1). Between 2000 and 2012, the number of workers grew by 9% with driving alone growing by 10%. In contrast, public transit use grew by 17%, motorcycling by 123%, bicycling by 61% and working at home by 43%.

Figure 1.1 Recent National Trends in Mode Share to Work



Source: Oak Ridge National Laboratory (2014). "Transportation Energy Data Book: Edition 33." cta.ornl.gov/data/spreadsheets.shtml.

KEY POINTS

- The need to travel has grown over the past century as our urban areas have spread out and places have become more specialized.
- The automobile has dominated passenger transportation over the past century, with around 80% of workers commuting by car every day to work and only 9% of households owning no vehicles at all.
- Similar to the growth in automobile use, freight is now moved predominantly by truck (75% of all weight and 91% of the value).
- Long-term trends of increasing vehicle travel in both the US and Arizona appear to be slowing or even reversing: per-capita travel has declined, and fewer young people are getting licensed.
- Major investments in road capacity in the major metros (Phoenix and Tucson) have not balanced out the substantial population growth, and road capacity per capita continues to fall.

Arizonans are about as dependent on driving to work as the nation as a whole, but carpool at a higher rate (Table 1.1). Adding together the drive-alone and carpool shares, 88% of Arizonans drove to work, compared with 86% nationally. Arizonans use transit and walk significantly less, but bicycle and work from home more than most Americans. These patterns vary somewhat among regions in Arizona.

Table 1.1 Arizona Journey-to-Work Mode Shares, 2007-2011

Geography	Drive Alone	Carpool	Public Transit	Walk	Bike and Motorcycle*	Work at Home
United States	76%	10%	5.0%	2.8%	1.7%	4.2%
Arizona	76%	12%	2.0%	2.1%	2.5%	5.4%
Maricopa County	76%	12%	2.4%	1.7%	2.4%	5.5%
Pima County	76%	11%	2.3%	2.5%	3.3%	4.8%
Flagstaff Metro Area	67%	13%	1.2%	8.2%	4.1%	6.2%
Prescott Metro Area	74%	13%	**	2.7%	2.0%	7.6%
Yuma Metro Area	76%	14%	1.6%	2.8%	2.3%	3.5%

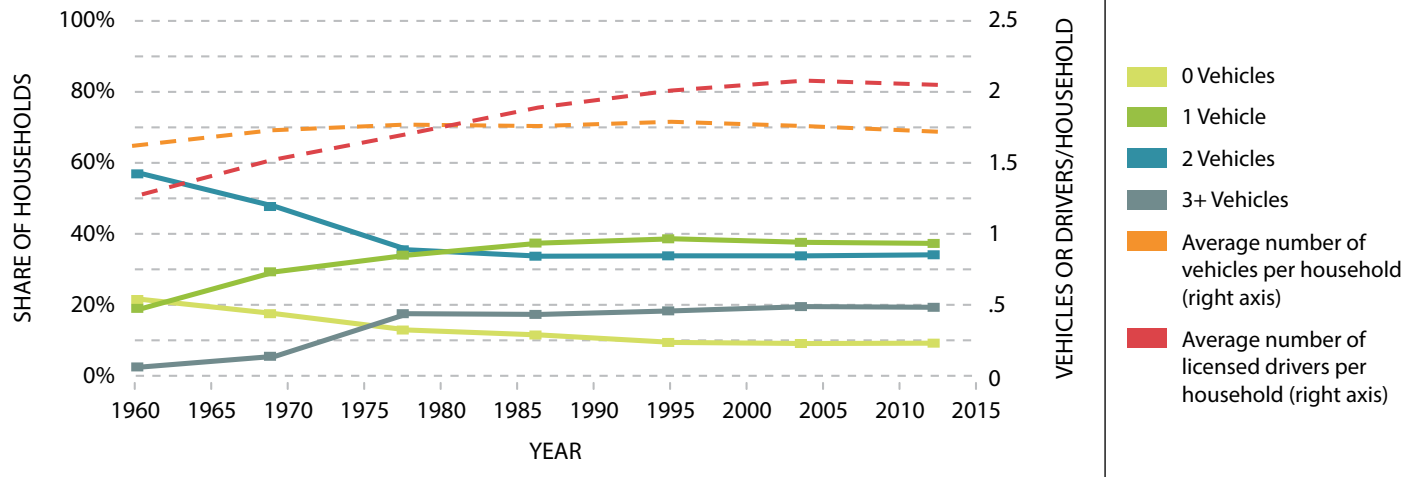
** Not significantly different from zero.

* Most of this category is bicyclists.

Source: American Community Survey, 2007-2011.

Another important trend relates to trip purpose. Work trips in 2009 made up only 15.6% of all trips and 19% of miles traveled.[2] Work trips per person increased only slightly from 1977 to 2009, while family and personal errands nearly doubled. These trends have important implications for congestion, which is spreading to other times of day, and for use of mass transit, as work trips tend to be easier to make by public transit than others.

Figure 1.2 National Trends in Vehicle Ownership; Licensed Drivers per Household



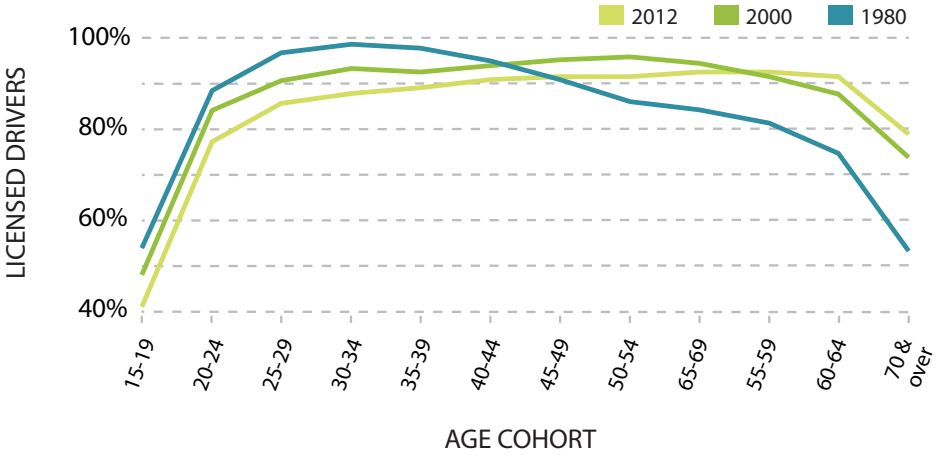
Source: Oak Ridge National Laboratory (2014). "Transportation Energy Data Book: Edition 33." cta.ornl.gov/data/spreadsheets.shtml.

Figure 1.2 shows the share of households with access to various numbers of vehicles. Between 1960 and 2010, the number of households with no car at all decreased dramatically, from 23% of total households to 9%, while the share of households with two or more vehicles exploded (see solid lines, left axis). Long-term trends notwithstanding, the overall car ownership rate has ticked down since 2010 while the number of licensed drivers per household began declining in the mid-2000s (see dashed lines, right axis).

Car ownership is significant, because the public transit mode share to work in households without a car is over 30%, but drops to less than 2% for households with two or more cars. In other words, when people have access to a car and pay the substantial fixed costs of ownership, they use it. Licensing is also important and while overall licensure rates have declined slightly, profound decreases can be seen when looking more carefully at individual age cohorts. Figure 1.3 compares the licensure rates for age cohorts over three time points – 1980, 2000 and 2012. The decline in licensure rates for the younger cohorts is significant; typical 20 to 24 year-olds today are 15% less likely to have driver's licenses than the same age group 30 years ago. The same pattern holds for nearly all of the younger age groups. This trend begs the question – how will this affect travel patterns as these groups mature and move into their peak traveling years while older, more licensed age groups, retire from the workforce? Following the pattern forward another ten or twenty years suggests a significantly lower licensure rate for the overall population.

WHEN PEOPLE HAVE ACCESS TO A CAR & PAY THE SUBSTANTIAL FIXED COSTS OF OWNERSHIP, THEY USE IT

Figure 1.3 National Trends in Licensure Rates by Age Cohort and Population



Source: US Department of Transportation, Federal Highway Administration. "Highway Statistics," Table d220.

We may already be seeing the initial effects of the decline in licensing and vehicle ownership. Since the mid-2000s, there has been a significant reversal in long-term travel trends as measured by "vehicle miles traveled" (VMT), a measure of total vehicle travel, mostly consisting of automobile travel but also including trucks.[3] Total VMT in Arizona had been growing continuously for decades, in accordance with growing travel per capita, and a growing overall population. Figure 1.5 shows the VMT growth for the whole state and its urban areas. Note that growth began stagnating in the mid-2000s—notably before the high gasoline prices of 2007 to 2008 and the ensuing recession.

On a per capita basis, both the nation's and Arizona's VMT peaked around 2005 and has dropped nearly 10% since that time (Figure 1.6). Thus, there appears to be a decoupling of travel indicators from economic factors, with demographic, technological, social, and environmental factors starting to play a larger role in VMT.[4] This parallels the

BACK TO THE LECTURE HALL 1.1

DERIVED DEMAND

Derived demand is a key concept in transportation studies and is important when considering why people travel so much and how to accommodate that travel. According to this concept, most of our demand for transport is derived from our demand for some other activity—we need to take classes, shop, work, socialize, or play, but because the activities are located somewhere else, we need to make a trip to do them. This is significant because it means that people are not traveling for fun, but to accomplish something else other than movement; they move merely because they have to. Occasionally, people drive, bike, or walk just for the sake of the activity of driving, biking, or walking, but few of our trips are made simply because we wish to make a trip. This means that if we can offer other ways to perform activities (telecommuting, online shopping, social media), or make it possible to perform them at different times (flex-time, 4-day work weeks) or locations (mixed-use development), we can satisfy people's underlying needs with less motorized travel.

Figure 1.4 Vehicle Miles Traveled in Arizona, Total and Urban

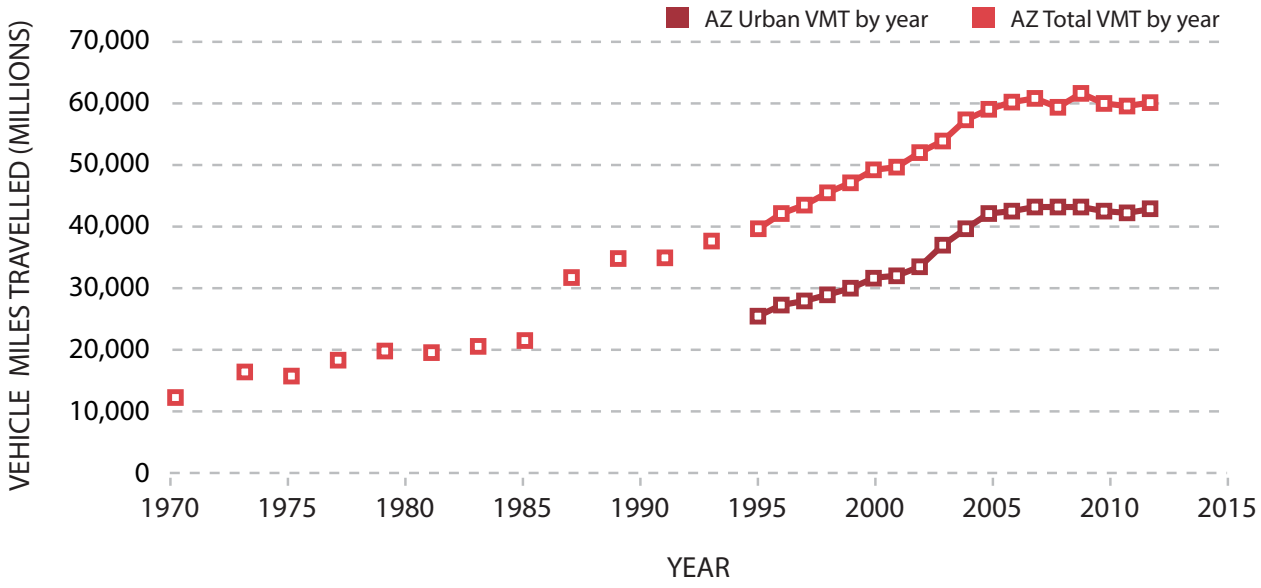
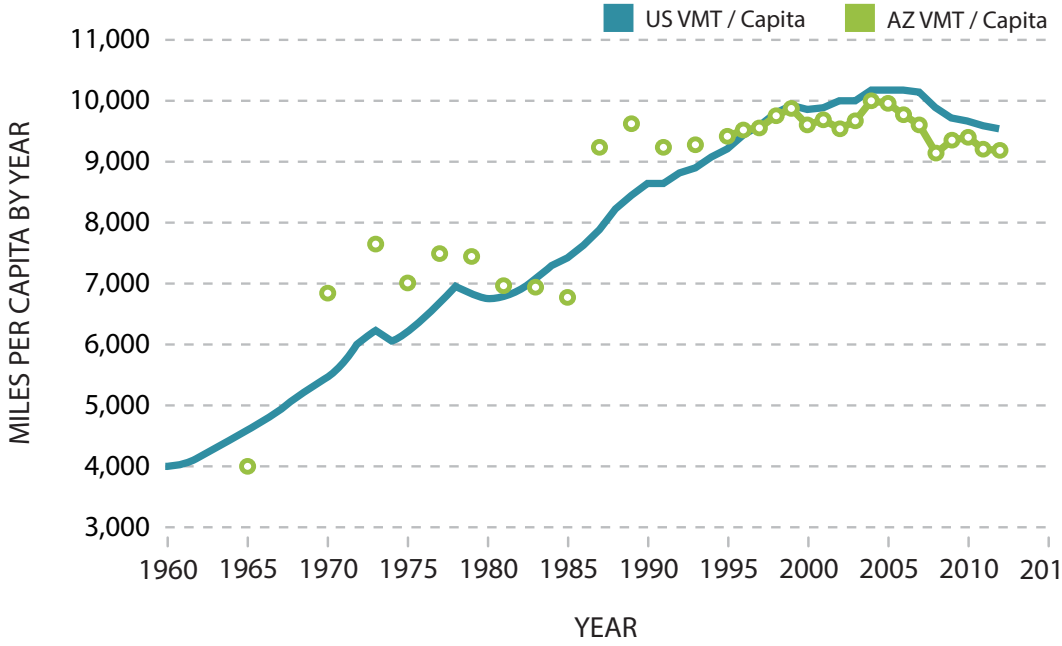


Figure 1.5 Vehicle Miles Traveled Per Capita, US vs. Arizona



Source: US Department of Transportation, Federal Highway Administration. "Traffic Volume Trends." fhwa.dot.gov/policyinformation/travelmonitoring.cfm and US Census Bureau, "Population Estimates." census.gov/popest.

Table 1.2 Arizona Freight Carried by Mode of Transportation, 2007

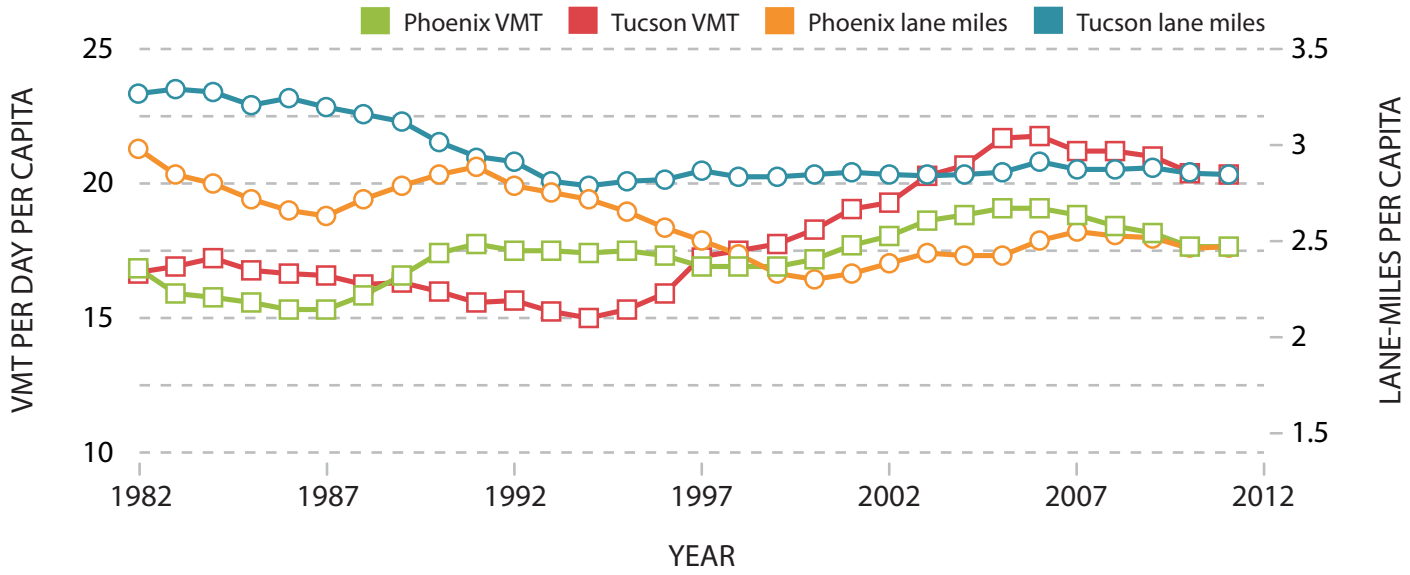
Mode Type	Tons	Tons (%)	Value	Value (%)	Average Shipping Distance (miles)	Ton-Miles	Ton-Miles (%)
Truck only	169,571	90.7	$123,371	74.9	326	19,702	81.4
Rail only	97,767	5.8	$1,811	1.1	465	1,867	7.7
Air* (including truck and air)	112	0.1	$8,545	5.2	1,401	116	0.5
Multimodal							
Parcel*	317	0.2	$26,913	16.3	1,351	365	1.5
Truck and Rail	n.a.	n.a.	$489	0.3	1,202	1,614	6.7
Other or unknown	3,267	n.a.	$3,454	2.1	287	n.a.	n.a.
Total	175,439	100	$137,545	100	780	24,207	100

n.a. = not available.

*Air shipments are over 100 lbs. Parcel shipments (including post office, courier, UPS, Fedex, etc.) are less than 100 lbs. and use some combination or air and truck.

Source: US Department of Transportation, Bureau of Transportation Statistics (2007). "2007 Commodity Flow Survey," Table-1a, Shipment Characteristics by Mode of Transportation for State of Origin.

Figure 1.6 Vehicle Miles Traveled and Lane-Miles per Capita for Phoenix and Tucson, 1982 to 2012



Source: Data from Schrank, D., B. Eisele, and T. Lomax (2013). "TTI's 2012 Urban Mobility Report." Texas A&M Transportation Institute.

rising popularity of disruptive technologies like car sharing (Zipcar) and ride sharing (Uber, Lyft) as viable (convenient and affordable) alternatives to car ownership especially for young drivers in urban areas.[5]

VMT is the best measure of demand for road capacity, so it is important to understand the factors behind it. A recent study indicates that nearly half (46%) of the growth of VMT during the late 20th century was due to an increase in the number of daily trips per person. Population growth accounted for 28%, people switching from other modes to driving for 16%, and people making longer trips for 10%.[6]

As is typical in the United States, trucks carry most of Arizona's freight on our streets and highways. Table 1.2 shows that trucks handle roughly 74.9% of all weight and 90.7% of the value of merchandise moving from businesses in Arizona (including in-state, out-of-state, and the domestic segment of exports from Arizona). Combined, air freight and parcel shipping account for only 0.3% by weight and 21.5% by value. Trucking averages

the shortest shipping distances, while air freight and parcels ship almost five times farther. Intermodal truck/rail shipments move almost as far as air freight. Multiplying tonnage by average distance yields ton-miles of freight, which is somewhat similar to VMT in that both represent total demand on the transportation system. In Arizona, trucking also dominates in terms of ton-miles with 81.4%, with rail-only and rail-truck combined accounting for 14.4%.

In Phoenix and Tucson, VMT has increased faster than lane miles (Figure 1.6), resulting in a steady increase in congestion and travel delay, with significant economic impacts (see Chapter 4).

CHAPTER 2
MODES

Transport "modes" are the means by which we move people and freight. They are primarily defined by the surface on which they move and the type of vehicle or movement technology—road modes (bus, car, bike, walk), rail, pipeline, water (barge, ship), and air. Many passenger and freight trips involve multiple modes in a single trip, such as when freight is transferred from a ship to a truck at a port, or when someone walks to the bus stop to catch a bus.

Transportation is one of the more capital-intensive sectors of the economy. To achieve fast speeds and carry large volumes, transportation uses three main types of capital— vehicles, networks, and terminals. Vehicles load and unload people and goods at terminals and carry them over networks. Networks are the lines on which vehicles move—roads, rails, rivers, pipelines, bike paths, sidewalks, and air traffic corridors. Terminals range from driveways and parking lots to bus stops, rail stations, seaports, and airports, as well as warehouses, transfer stations, and maintenance facilities of all kinds. Because of the capital intensity of transportation, economies of scale and utilization figure prominently in the costs of transportation (Back to the Lecture Hall, Box 1-1). In addition to these three kinds of capital, one must consider the people, policies, institutions, and information systems that make the system work.

By the numbers I: Approximate Cost to Build Transportation Infrastructure

Cost per Mile

- South Mountain Freeway: $90-$110 million[#]
- Central Mesa Light Rail Extension: $65 million[†]
- Tucson SunLink Streetcar: $50 million, incl. vehicles[††]
- Phoenix-Tucson Intercity Rail (est., incl. right of way): $15 million[##]
- Dedicated Lane Bus Rapid Transit: $4-40 million[§§]
- US-93 (Kingman to Hoover Dam) widening from 2 to 4 lanes: $4.8 million[#]
- Separated bike path: $500K-$4 million[§]
- Sidewalk: $150-200K[§]
- Bike lane on street: $133K[§]
- Signed bike route: $25K[§]

Cost of Each

- Interstate Highway Bridge rehab (I-15 Virgin River Bridge): $27 million[#]
- Steel Overpass/Underpass: $125K[§]
- Bus shelter: $11-12K[§]
- Streetlight: $5K[§]
- Speed hump: $2,640[§]
- Curb wheelchair ramp: $810[§]
- Striped crosswalk: $300-$3,000[§]
- Bike rack: $600[§]
- Street trees: $400-500[§]

Sources: # azdot.gov/projects
azdot.gov/docs/planning/rail-framework-study-final-report.pdf?sfvrsn=0
† www.valleymetro.org/projects_and_planning/project_detail/central_mesa
†† www.apta.com/resources/hottopics/circulators/Documents/Tucson-Streetcar-Fact-Sheet.pdf
§ katana.hsrc.unc.edu/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf
§§ www.reconnectingamerica.org/assets/Uploads/bestpractice175.pdf

KEY POINTS

- Cars and trucks continue to dominate Arizona's transportation system for passengers and freight, but other modes play important roles for certain types of freight and passenger movements.
- Bus remains the backbone of Arizona's public transit systems, but passenger rail has been successfully reintroduced with Valley Metro's light rail and Tucson's SunLink modern streetcar, and ADOT is now seriously studying long-distance passenger rail between the two cities.
- While still a small share of overall travel, bicycle and pedestrian transport is up dramatically since 2000, and is important for health, sustainability, affordability, and quality of life.
- Tucson International Airport has lost traffic, and Phoenix-Mesa Gateway Airport has expanded to where it now boards half as many passengers annually as Tucson.
- Transportation of both passengers and freight is increasingly viewed as an intermodal system.

PRIVATE ROAD TRANSPORT: CARS AND TRUCKS

WITH SOYOUNG AHN, ZUDUO ZHENG & SRAVANI VADLAMANI

For the purpose of this report, road transport will refer to motorized private transportation on roads. We discuss cars and trucks together here, because they share the same roads.

The inherent advantage of road transport stems from the speed and affordability of vehicles and the density of the road network. Arizona has 129,780 total lane-miles of roads[7]—far more than all other modes of transport combined. Most households and companies can afford to own a motorcycle, car, van, or truck and they use it whenever they want to go anywhere at relatively high speeds. In addition to their flexibility, road vehicles are quick and inexpensive to load and unload, which gives them an inherent advantage over shorter distances. Road vehicles, however, are less efficient at moving large volumes of passengers and freight compared with the economies of scale of trains, ships, and pipelines. Other disadvantages of road transport include affordability and safety (see Chapter 5), less-efficient energy use (Chapter 6), more pollution (Chapter 7), and the effect of auto dependency on land-use patterns (Chapter 3).

BACK TO THE LECTURE HALL 2.1

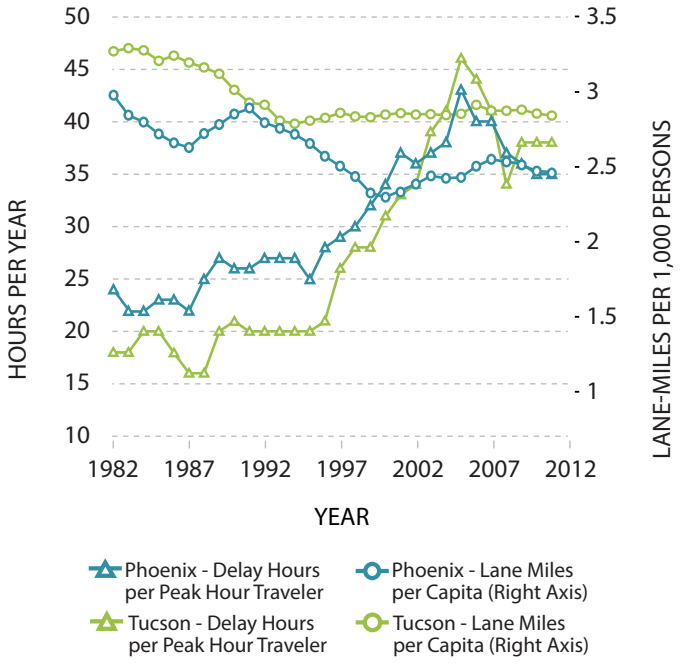
ECONOMIES OF SCALE VS. ECONOMIES OF UTILIZATION

In these two terms, the word "economies" means cost savings. Economies of scale imply savings from a larger scale of operations—larger vehicles, volume purchasing, mechanization, and specialization of employees and equipment. Historically, economies of scale have been a major factor in lowering transportation costs. Economies of utilization, on the other hand, refer to savings from fully utilizing one's capital equipment and thus spreading its fixed costs (purchase, insurance, licensing, etc.) over more trips, passengers, or tons. Airlines, trucking companies, and transit agencies hate to see their expensive vehicles sitting idle or running with just a fraction of a full load, so they try to maximize their utilization. Economies of utilization (or "load management") lowers average costs in the short term with existing capital stock, while economies of scale do so over the long term while increasing capital stock.

Arizona was late in developing its urban freeway infrastructure.[8] Until 1948, Phoenix relied heavily on streetcars and was connected with neighboring cities by arterial streets. I-10 was built in the late 1950s, followed by I-40 and I-17 in the 1960s, and I-15 and I-19 in the 1970s. For a long time, the region depended on ever-expanding arterial roads and suffered from worse-than-average congestion. In the early 1980s, Phoenix ranked 2nd worst for congestion delay per traveler among the 85 largest cities in the nation. Today, according to the 2012 Urban Mobility Report, it has greatly improved (now 40th worst).[9] From the 1980s until the mid-1990s, the lane-miles of major roads in Phoenix and Tucson failed to keep up with population growth, and the delay hours per traveler—not surprisingly—went up (Figure 2-1).

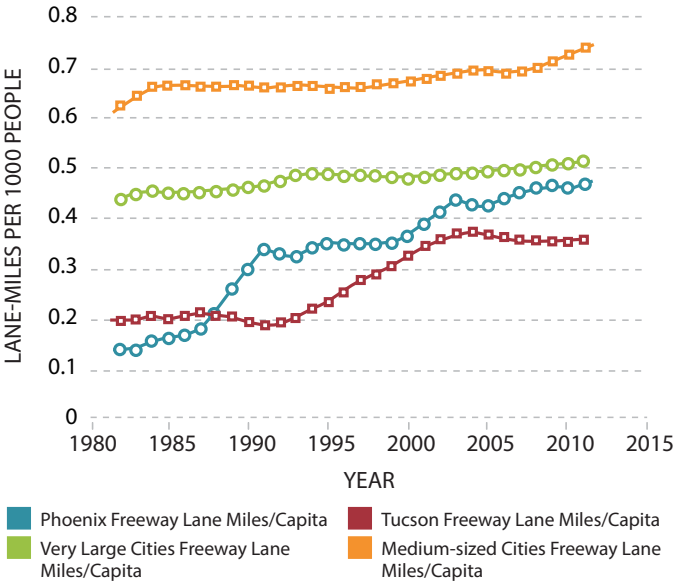
Phoenix's urban freeway construction program hit full stride in the 1990s and, as shown in Figure 2-2, almost caught up with its peer "Very Large Cities" in the US by 2003. Tucson still relies more heavily on arterial streets than freeways compared with peer "Medium-Sized" peer cities and now has a higher congestion delay per traveler than Phoenix.[10] Since 1982, it has gone from 52nd to 6th worst among mid-sized cities.

Figure 2.1 Total (freeways and arterials) lane miles per capita and delay hours per traveler



Source: Data from Schrank, D., B. Eisele, and T. Lomax (2013). "TTI's 2012 Urban Mobility Report." Texas A&M Transportation Institute.

Figure 2.2 Freeway Lane-Miles per Capita for Phoenix and Tucson compared to their peer cities



Source: Data from Schrank, D., B. Eisele, and T. Lomax (2013). "TTI's 2012 Urban Mobility Report." Texas A&M Transportation Institute.

Even though only 12% of Arizona's population is rural,[11] roads in rural areas account for 30% of statewide VMT. Many rural trips tend to be longer than urban trips and many rural roads are heavily used by both urban residents and through traffic. Annual average daily traffic (AADT) on rural roads in 2013 ranged from a few hundred vehicles per day on the most lightly traveled routes to more than 40,000 on I-10 between Phoenix and Tucson (compared with 275,000 on I-10 through downtown Phoenix).[12]

In rural areas, heavy trucks make up 40-50% of the vehicles on interstate highways, or as many as 10,000 trucks per day, and 21-35% of traffic on State Route 85, US 93, and other non-interstate highways.[13] Truck traffic consists of both local deliveries and longer shipments. The commodities that move by truck are generally less bulky and more valuable than on rail. Most of the road freight traveling in Arizona moves on I-10 or I-40, adding to urban congestion in Phoenix, Tucson and Flagstaff.

Road congestion is caused by both recurring and nonrecurring conditions. Recurring congestion occurs mostly where demand regularly exceeds the capacity of roads and ramps. Congestion is worst on urban freeways during rush hour but is also a problem at off-peak times and on streets and rural roads. Non-recurring congestion is caused by traffic incidents, construction, and special events. Technological enhancements can improve transportation operations and manage demand and congestion. ADOT has implemented freeway management systems (FMS) for nearly 100 miles of regional freeways, and is planning to expand the system in the region (see box on page 25).The Freeway Service Patrol (FSP)[14] is an incident-management program coordinated by ADOT, Maricopa Association of Governments (MAG), the Arizona Department of Public Safety (DPS), and Federal Highway Administration (FHWA) to assist motorists dealing with disabled vehicles and promptly clear minor incidents. Service vehicles patrol highways and freeways in the Phoenix area to locate and help motorists with these minor incidents.

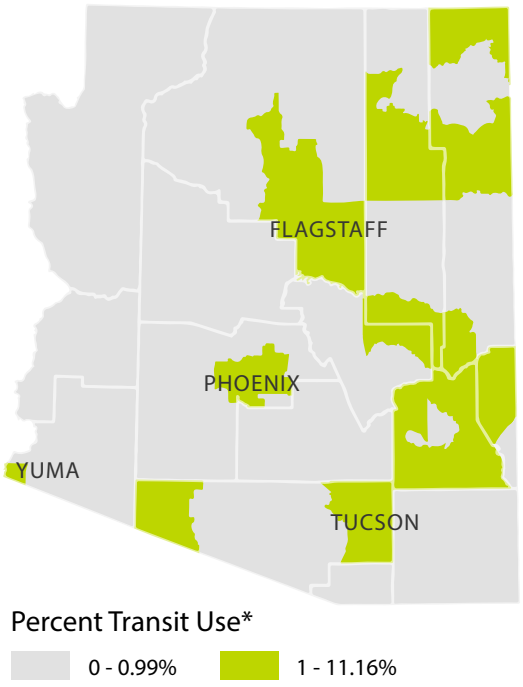
PUBLIC TRANSPORTATION

WITH MARK HICKMAN

WHAT IS PUBLIC TRANSIT?
PUBLIC TRANSPORTATION IS A MOBILITY SERVICE PROVIDED TO THE PUBLIC THAT IS OWNED AND OPERATED BY THE PUBLIC SECTOR, OR UNDER CONTRACT TO THE PUBLIC SECTOR.

There are two types of public transportation: (1) scheduled, fixed-route service by bus, van, light rail, and streetcar (mass transit) and (2) paratransit provided in response to specific requests for service. Arizona's public transit operates in suburban and rural areas as well as urban areas (see Figure 2.3). It is mostly local or metropolitan, with minimal long-distance service. Across Arizona, regional authorities operate transit, coordinating public transit service among several municipalities or within single cities or towns. More than 60 transit systems operate in Arizona (www.apta.com/resources/links/united-states/Pages/ArizonaTransitLinks.aspx), including 18 federally funded rural systems.[15]

Figure 2.3 Areas with Significant Transit Use, Arizona, 2013



*transit use shown by county subdivision

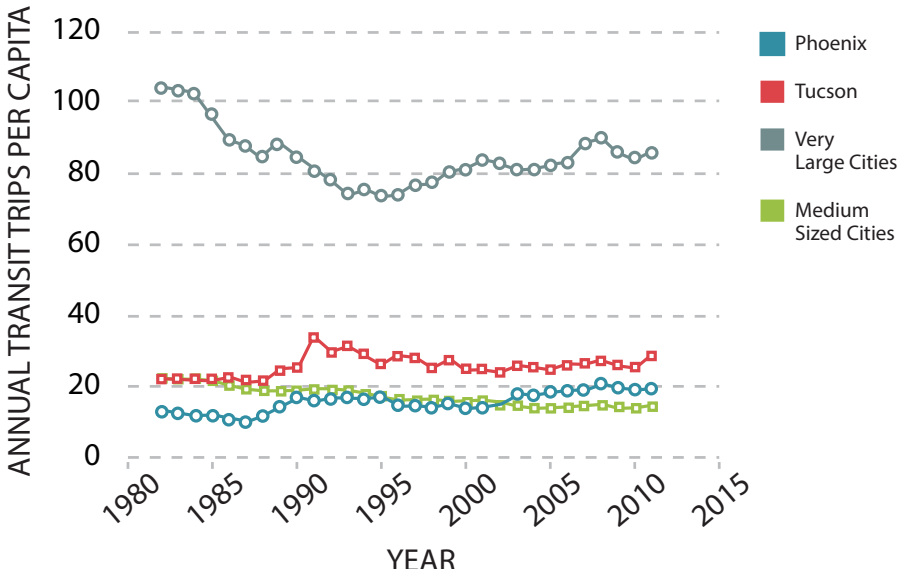
Source: Map by Meggan Dugan, Arizona State University. Underlying data from US Census Bureau, 2009-2013 5-Year American Community Survey, and "Means of Transportation to Work by Age."

Public transportation can be highly efficient in moving large volumes of passengers but can be expensive where it is not heavily utilized. With its higher passenger capacity, rail transit needs denser corridors with heavier flow volumes than bus transit. Using 2005 data, half of the nation's commuters by transit were found to live in 10 very large, dense cities: Baltimore, Boston, New York, Philadelphia, Washington, Chicago, Houston, Los Angeles, San Francisco, and Seattle.[16]

Public transit is viewed as an important and desirable service worthy of public financial support in nearly every country in the world, including the United States. It plays a vital role in meeting the mobility and access needs of a wide variety of people. In addition, it can help meet urban and rural goals for economic development, land use, air quality, energy efficiency, and reducing greenhouse gas emissions.[17] The need for funding is also justified by the need to balance many government policies that currently subsidize and provide economic incentives for automobile use.[18,19] Energy constraints, rising prices, and climate change will make public transit even more important in the future.

Public transit ridership in Arizona has grown significantly over the past decade because of population growth and demographics, rising gasoline prices, expansion of transit services, and perhaps a change in cultural attitudes. Nevertheless, in Phoenix, only 2.4% of the total commuting trips rely on mass transit, about four times lower than its peer (very large) cities (Figure 2.4). In Tucson, the percentage is about the same, which is higher than its peer (medium-sized) cities. In rural areas (less than 50,000 people), local and regional transit systems reported 1.48 million bus boardings and 1.7 million paratransit boardings in 2013.

Figure 2.4 Transit Ridership Per Capita for Tucson and Phoenix, Compared to Peer Cities



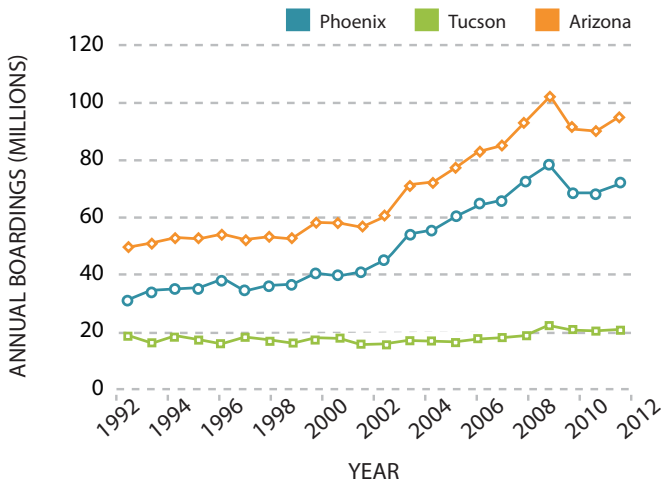
Source: Data from Schrank, D., B. Eisele, and T. Lomax (2013). "TTI's 2012 Urban Mobility Report." Texas A&M Transportation Institute.

The largest group of public transit users have a lower income and often cannot travel by automobile. The majority of public transit users in Tucson (65%) and Phoenix (61%) are low income (earning $30,000 or less per year),[20,21] while 47% of passengers in Phoenix and 46% of passengers in Tucson have no working vehicle in their household. [22,23]

INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

- Intelligent transportation systems include a variety of technologies to manage congestion. Two major categories of ITS in use in Arizona are ADOT's Freeway Management System (www.azmag.gov/archive /itsystems/fms.asp) and Advanced Traveler Information Systems (www.az511.gov). Some of the key services provided by ITS are as follows:
- Lane traffic sensors to provide real-time vehicle-count, speed, and occupancy data
- Ramp metering to regulate inflows from on-ramps to increase efficiency of the mainline freeway traffic and reduce overall delays
- Closed-circuit television to continuously monitor freeways and verify traffic incidents
- Dynamic message signs to inform motorists about road construction, closures, traffic incidents, and travel times
- GPS (the global positioning system via satellites) and RFID (radio-frequency identification) for real-time data collection and traffic control
- Communications systems to integrate all of the above technologies
- Traffic Operations Center (TOC) to oversee the FMS, dispatch crews to manage and clear incident sites, and serve as the central control system 24 hours a day, 365 days a year
- Information systems such as az511 to provide information via message signs, Internet, and cell phones about estimated travel time, traffic conditions (speed), incidents, and construction.

Figure 2.5 Annual Ridership for Valley Metro (Phoenix) and Sun Tran (Tucson)



Source: National Transit Database. Table TS2.2 - Service Data and Operating Expenses Time-Series by System. ntdprogram.gov/ntdprogram/data.htm.

In addition to the "transit-dependent" riders described above, transit provides an important option to "choice riders," or those who choose bus or rail over driving for a variety of reasons. Many factors play into this choice for each individual person and trip. Factors related to driving include the costs of owning, registering, insuring, maintaining, and fueling a car, parking, travel time, traffic congestion, variability of travel times, and the need to make stops along the way (trip chaining). Factors for transit include the bus or rail ride itself (i.e., transit frequency and speed, the price of fares or monthly passes, and station and vehicle attractiveness) as well as the distances, mode options, and walkability for getting to and from the first and last transit stops. For Metro light rail, stations tend to be about a half-mile apart except in the lower-density areas. Bus lines tend to be spaced about a mile apart, with stops every ¼ mile or so. While Phoenix and Tucson are making steady progress in increasing ridership, initiating major capital projects, obtaining federal funding, and passing sales-tax measures to support continuing operations and service expansion, both cities continue to struggle to attract automobile travelers to public transit.

Table 2.1 Selected Transit Performance Measures for Arizona, 2013

Performance Measure	Operating cost per revenue-mile	Operating cost per boarding	Farebox recovery
Fixed-route*	$7.02	$3.36	23.3%
Paratransit	$4.62	$33.00	5.3%

*Fixed-route includes all bus and light rail services. It should be noted that light rail is about twice as expensive to operate as bus on a given route. Source: Arizona Transit Association, "2013 Arizona Transit Performance Report."

Compared to the national average for all transit modes, Arizona's public transit systems operate more efficiently but have a slightly higher cost per boarding and lower farebox recovery due to lower ridership per vehicle.[24] Table 2.1 shows average operating costs for fixed route and paratransit type services in Arizona. Local funding sources cover the largest share of operating subsidies, generally followed by state and federal assistance. Federal assistance is quite limited for Phoenix and Tucson, but plays a much larger role for medium-sized urban areas and for small transit systems.[25]

BUS RAPID TRANSIT

BRT IS A "HIGH QUALITY, HIGH CAPACITY RAPID TRANSIT SYSTEM THAT, IN MANY WAYS, IMPROVES UPON TRADITIONAL RAIL TRANSIT SYSTEMS. VEHICLES TRAVEL IN EXCLUSIVE LANES, AVOIDING TRAFFIC. PASSENGERS WALK TO COMFORTABLE STATIONS, PAY THEIR FARES IN THE STATION, AND BOARD THROUGH MULTIPLE DOORS LIKE A TRAIN. SERVICE IS FREQUENT AND FAST."

» ACTRANSIT.ORG/PLANNING-FOCUS/YOUR-GUIDE-TO-BUS-RAPID-TRANSIT/351-2/

"BRT SYSTEMS CAN EASILY BE CUSTOMIZED TO COMMUNITY NEEDS AND INCORPORATE STATE-OF-THE-ART, LOW-COST TECHNOLOGIES THAT RESULT IN MORE PASSENGERS AND LESS CONGESTION."

» NBRTI.ORG (SEE ALSO VTPI.ORG/TDM/TDM120.HTM OR WWW.APTA.COM/RESOURCES/STATISTICS/PAGES/GLOSSARY.ASPX#8 FOR DEFINITIONS OF OTHER MODES OF SERVICE)

A number of major initiatives have been made possible in the Phoenix metropolitan area through Proposition 400 (passed in 2004), which extended the half-cent sales tax for 20 years. About one-third of this revenue is allocated to transit. Projects include support for light rail and bus operations throughout the county, as well as light rail or bus rapid transit (see box) extensions and new transit centers. ADOT also administers programs to support public transit, especially in rural areas and small towns.

Similarly, Tucson's Regional Transportation Authority (RTA) was funded in 2006 by a half-cent sales tax, local and regional sources, and developer impact fees. The RTA has funded 450 projects, including the new streetcar project as well as expanded transit services across the county.

Various ideas have been proposed for new public transit services in the Phoenix and Tucson metro areas that would meet existing demand and reach new markets. These include flexible routing, route deviation, integrated paratransit and fixed-route services, and freeway and arterial bus rapid transit (BRT) services. The effectiveness of public transit can also be enhanced by land-use and development policies, such as transit-oriented development zoning, which support use of transit, biking, and walking (see next chapter) and bring economic development benefits to urban areas (Chapter 4). In rural areas, flexible routing, route deviation, integrated paratransit, and public dial-a-ride are all used to improve service even where use is very low.

NON-MOTORIZED TRAVEL

WITH RAM PENDYALA, KARTHIK KONDURI, AND JOSEPH PLOTZ

Non-motorized transportation (NMT) modes such as bicycling, walking, and skateboarding are important components of a multimodal transportation system. Although NMT comprises a small portion of total travel, it is important to the well-being of communities, cities, and society. After a long decline over the past century, NMT is up by 25% since 2001.[26] Cycling to work is up 61% since 2000.[27] The advantages and disadvantages of NMT stem from the simple fact of being human-powered.

On the positive side, NMT is inexpensive (or free) to the user; promotes healthy and active living; emits negligible amounts of pollution and greenhouse gases (GHG); is extremely energy efficient (on the order of 100 to 500 miles per gallon, depending on how energy use is accounted for); can reach or traverse locations with limited road access (e.g., parks and college campuses); is often able to bypass gridlocked traffic; and fosters a sense of connectivity and community. On the negative side, speeds are slower than motorized modes; people are more exposed to weather conditions and traffic; and a general lack of direct, safe connectivity for bikes and pedestrians is a disincentive and a safety hazard. Niches for these modes are heavily influenced by travel speeds, depending on the individual. For instance, walking tends to dominate short distances while biking offers a greater range.

In 2011-2012, 2.8% of American workers walked and 0.6% biked to get to work (Table 2.2). For all types of trips (not shown), the shares rose to 10.9% for walking and 1% for biking in 2009.[28] For non-work trips, people participating in the National Household Travel Survey reported walking and bicycling predominantly for social and recreational purposes: 63% of respondents had made at least one walking trip in the previous week and 12% had bicycled.[29] Walking is roughly equal between men and women, but the male-female ratio for biking is more than 3 to 1.

Table 2.2 Percent of Workers Bicycling and Walking to Work, 2009-2011

Jurisdiction	% Walk	Rank	% Bike	Rank
Arizona	2.2	35	1.0	7
Phoenix	2.0	38	0.7	27
Tucson	3.7	20	2.5	6
Mesa	1.8	44	1.0	20
United States	2.8	n.a.	0.6	n.a.

Source: Alliance for Biking and Walking (2014). "Bicycling and Walking in the United States 2014: Benchmarking Report."

Tucson ranks highly among all cities in percent of workers bicycling to work, and is "Gold Rated" for its support of cycling by the League of American Bicyclists (bikeleague.org/community). Scottsdale also received a gold rating, with Flagstaff and Tempe at silver, and Chandler, Mesa, Phoenix, Sedona, Gilbert and Cottonwood at bronze.[30] Bicycling Magazine recently rated Tucson, Phoenix, Tempe, and Scottsdale in the top 25 cities for cycling in the United States.[31] See prevention.com/fitness/fitness-tips/best-us-cities-walkers for rankings of cities for walking.

By the numbers II: Gender Differences in Use of Non-Motorized Transportation at Least 30 Minutes per Day

	Male	Female
Walk	7.7%	8.2%
Bike	1.5%	0.4%

Source: Pucher, J., R. Buehler, D. Merom, and A. Bauman (2011). "Walking and Cycling in the United States, 2001–2009: Evidence From the National Household Travel Surveys." American Journal of Public Health 101: S310-S317.

In terms of terrain and weather, Arizona's metro areas are hospitable to bicycle and pedestrian modes of travel. The terrain, particularly in the Valley, is relatively flat, while our climate is both a blessing and a curse for NMT. Arizona has few wet days and most of Arizona does not experience extremely cold or snowy weather. However, extreme summer temperatures discourage bicycling and walking, especially in cities. Despite these attributes, Arizona is decidedly inhospitable to NMT in terms of safety, ranking 45th worst among states in bike and pedestrian fatalities. Phoenix, Tucson, and Mesa rank 49th, 32nd, and 20th, respectively, among 52 large cities nationally.[32]

ADOT'S BICYCLE & PEDESTRIAN PROGRAM

ADOT ISSUED ITS FIRST STATEWIDE BICYCLE & PEDESTRIAN PLAN IN 2003, FOLLOWED BY A 2012 PLAN UPDATE TO ADDRESS THE MOST CRITICAL BICYCLE AND PEDESTRIAN TRANSPORTATION PLANNING NEEDS ON THE STATE HIGHWAY SYSTEM. THE UPDATE ESTABLISHES A GOAL "TO DOUBLE THE PERCENTAGE OF WALKING AND BICYCLING TRIPS STATEWIDE OVER THE NEXT 10 YEARS, REDUCE MOTOR VEHICLE CRASHES INVOLVING PEDESTRIANS BY 20% AND THOSE INVOLVING BICYCLISTS BY 12%, AND IMPROVE BICYCLE AND PEDESTRIAN INFRASTRUCTURE ON STATE HIGHWAYS," AND ESTABLISHES STRATEGIES TOWARDS ACHIEVING THESE GOALS.

» SEE AZBIKEPED.ORG/INDEX.ASP.

BACK TO THE LECTURE HALL 2.2

COMPLETE STREETS

"Complete Streets" have emerged as a new paradigm for roadway design, which would "enable safe access for all users, regardless of age, ability, or mode of transportation." Such designs would vary depending on rural or urban context, right of way dimensions, adjacent land uses, and community preferences, among others. These might include "sidewalks, bike lanes (or wide paved shoulders), special bus lanes, comfortable and accessible public transportation stops, frequent and safe crossing opportunities, median islands, accessible pedestrian signals, curb extensions, narrower travel lanes, roundabouts, and more" (SGA 2013).[33] See also Section 9d for an example of the Grand Avenue Complete Street project.

smartgrowthamerica.org/complete-streets/complete-streets-fundamentals.

There is great interest in the US in promoting bicycle- and walking-friendly communities, or pedestrian-oriented development (POD). Many cities and counties have or are developing comprehensive pedestrian and bicycle transportation plans to create NMT networks that are safe and usable for a wide range of activities. In 1990, the FHWA characterized biking and walking as "the forgotten modes" in terms of federal policy.[34] Federal funding for NMT infrastructure has since risen from $6 million nationally in 2009 to over $1.2 billion. Still, this funding represents only 2% of federal surface transport funds and 2.1% of state funding, despite the fact that NMT accounts for nearly 12% of all trips and 14.7% of traffic deaths.[35]

Types of Bike Infrastructure

- Bike Lane – an exclusive lane for cyclists.
- Bike Path – a completely separate right of way exclusively for bikes.
- Cycle Track – a protected bike lane for cyclists, separated from car traffic by a median of some kind.
- Multi-use Path – a separate right of way for all non-motorized modes.
- Shared Lane "Sharrows" – a painted marker in a lane of traffic consisting of a bike with arrows indicating that bicycles have the same rights to the lane as cars.
- Bus-Cycle Lane – a lane shared by bikes and buses only.
- Bike Box – a painted box just behind the crosswalk of an intersection that allows cyclists to make lane changes ahead of cars.
- Bike Boulevard – pleasant low-volume, low-speed street with traffic calming measures (e.g., traffic circles, speed bumps) and prominent bicycle signage for wayfinding.
- Bike Parking Options – include racks, corrals, valets, underground automate garages, and oases.
- HAWK Signals – High Intensity Activated crosswalk pedestrian beacons for mid-block crossings (e.g., where canal paths cross arterial streets).
- Showers, Underpasses, Overpasses – no explanation needed!

For photos, see cascade.org/explore-commuting/bicycle-infrastructure, cicle.org/local-resources/bicycle-infrastructure; and bostonbikes.org/infrastructure/types-of-bike-lanes/.

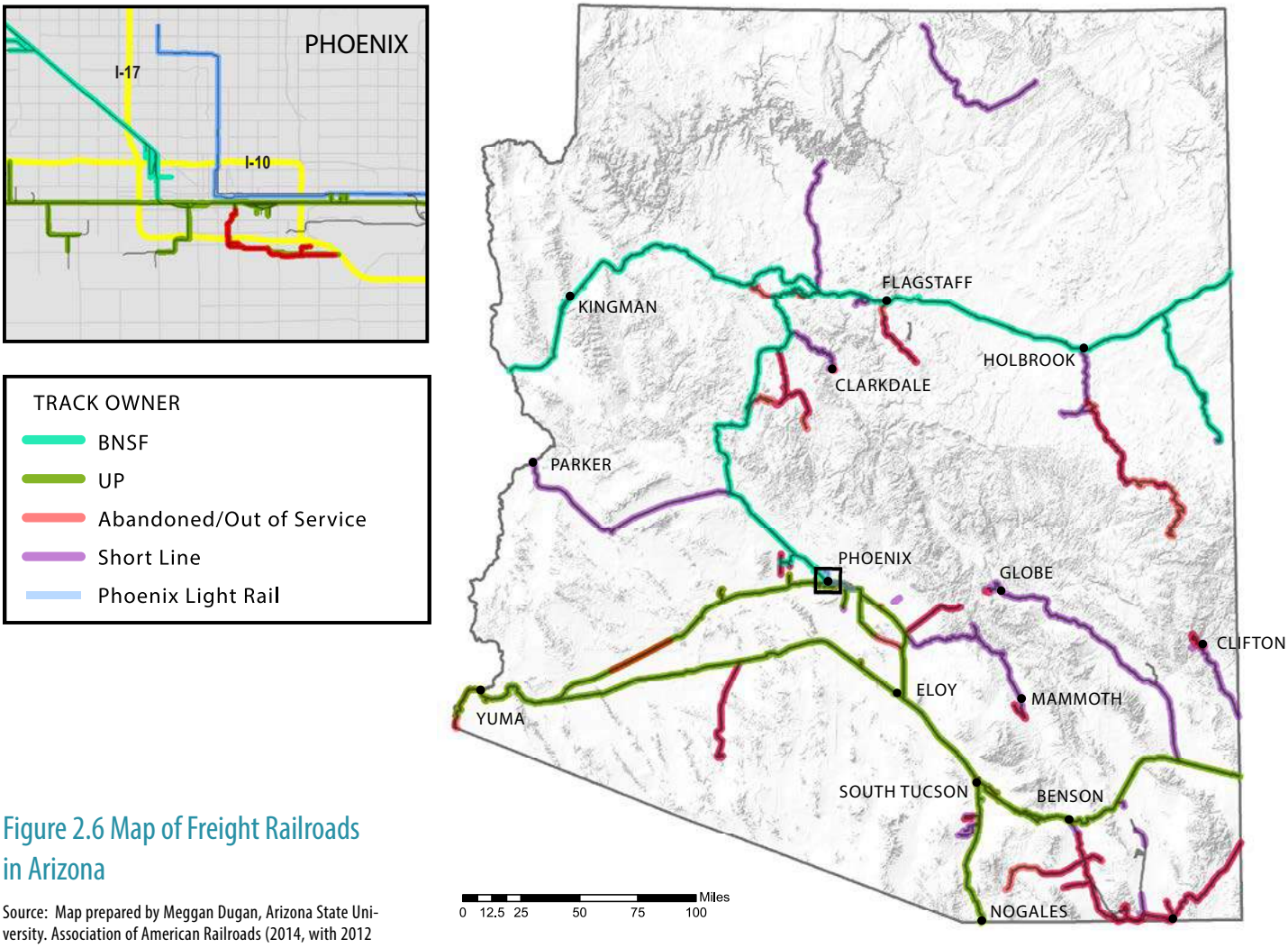


Figure 2.6 Map of Freight Railroads in Arizona

Source: Map prepared by Meggan Dugan, Arizona State University. Association of American Railroads (2014, with 2012 data). "US Freight Railroad Industry Snapshot: Arizona." aar.org/data-center/railroads-states#state/AZ.

FREIGHT RAIL

WITH ARNOLD MALTZ

Freight rail costs more per ton to load and unload than truck freight, but once loaded each mile costs less per ton. Thus, it is generally less efficient than truck for most short hauls but more efficient at moving large volumes of freight over medium and long-distances. Rail is particularly efficient at moving bulk commodities such as grain, coal, and fertilizer. Rail's cost advantages for longer distances and heavier loads stem from much higher capacity, less labor, and much higher energy efficiency. Further economies of scale are gained by double-stacking containerized trains.[36] Rail is also significantly safer, especially where at-grade road-rail crossings can be avoided via overpasses and underpasses.

By the numbers III: Freight Modes: Rail vs. Truck

Mode	Typical Capacity (tons)	Energy Efficiency (ton-miles per gallon)	Fatalities per billion ton-miles
Rail	10,000	455	0.61
Truck	26	105	1.45

Source: Arizona State Rail Plan (2011).

The Association of American Railroads estimates that 6.9 million trucks would have been needed to handle the 124 million tons of freight that moved by rail in Arizona in 2012.[37] Most of the rail traffic (95 million tons) simply passed through Arizona, with 26 million tons moving to our state and only 3 million tons originating from it. Coal by itself accounts for 58% of the tonnage shipped by rail to Arizona, while building materials (stone, sand, and lime) are the main commodities originating from Arizona, followed by metallic ores, cement and primary metals.[38]

A major limiting factor of freight rail is the length and extent of the network. Arizona has 1,643 miles of rail in 2012.[39] Arizona has nine freight railroads, including two major (Class 1) railways. The Union Pacific (UP) Railroad is adding a second track to its entire Sunset Corridor connecting the Los Angeles area with Texas via Yuma and Tucson. The double-track Burlington Northern Santa Fe (BNSF) Railroad mainline crosses northern Arizona through Kingman, Flagstaff, and Winslow. Seven active short lines exist to transport specific commodities such as copper (Magma Arizona) or coal (Black Mesa & Lake Powell RR). The BNSF and UP railroads rely on their routes through Arizona to carry merchandise imported through the Los Angeles/Long Beach port complex and destined for the eastern and central United States. In 2011, ADOT completed the state's first comprehensive Rail Plan, initiated in response to ADOT's increasing involvement in both passenger and freight rail issues.[40] The Plan highlighted four potential "corridors of opportunity" for expanded passenger and freight service to create a viable alternative to road transport. They are the north-south "Arizona Spine;" the "Canamex Corridor" from Nogales to Las Vegas; the "Route 66 Corridor" which includes the existing BNSF line; and the Union Pacific's "Sunset Corridor."

LONG-DISTANCE PASSENGER RAIL

WITH TIMOTHY JAMES, EVA MADLY, AND MATTHEW CROUCHER

Passenger rail mirrors the advantages and disadvantages of freight rail. Its higher capacity, ticket pricing that covers higher loading and unloading costs, and efficiency per mile make it ideal for medium distances on high-volume corridors. It also makes it much less cost-effective when underutilized. For passengers, comfort and the ability to read, work, socialize, and sleep must be weighed against the inflexibility of schedules and routes and the challenge of getting to and from the rail stations at either end of the trip. In addition, the cost per ticket is usually greater that the marginal cost of driving (fuel, tolls, and wear and tear on the vehicle).

For over a century spanning the mid-1800s to mid-1900s, rail was the primary form of long-distance passenger transport in the United States. With the rise of car ownership in the 1920s, rail passenger traffic began declining although regulation continued. The decline accelerated after World War 2, resulting in line closures, service curtailment, underinvestment, and eventually bankruptcies of the remaining inter-city passenger railways. Congress in 1970 created a public-private National Railroad Passenger Corporation (later Amtrak) to prevent extinction of passenger rail service, which began service in Arizona in 1971.[41]

Amtrak operates three intercity rail services in Arizona,[42] paying track owners (including freight operators UP and BNSF) for use of the track. The routes are:

- The Southwest Chief from Chicago to Los Angeles, which runs parallel to I-40 on the BNSF in Northern Arizona, stopping daily in Winslow, Flagstaff, Williams Junction, and Kingman.
- The Sunset Limited from Los Angeles to New Orleans, which runs on the Union Pacific Railroad Sunset route, stopping three times a week in Benson, Tucson, Maricopa, and Yuma
- The Texas Eagle connects Chicago and San Antonio, with through-car service to Arizona and Los Angeles on the Sunset Limited.

Amtrak ridership on these routes has increased slightly during recent years,[43] but remains low, as Table 2.3 illustrates.

Table 2.3 Annual Amtrak Station Ridership in Arizona

City	Ridership FY 2008	Ridership FY
Benson	1,064	1,833
Flagstaff	39,723	40,390
Kingman	10,322	10,523
Maricopa	6,393	12,945
Tucson	14,780	25,921
Williams Junction	8,199	6,944
Winslow	4,767	4,625
Yuma	3,057	3,891
Total, Arizona	88,305	107,072

Source: Amtrak Fact Sheet, State of Arizona, Fiscal Year 2008, 2013.

Amtrak has no public plans to alter its existing pattern of long-distance passenger routes. However, the feasibility of establishing a passenger rail service between Tucson and Phoenix has stimulated considerable debate. ADOT continues to study the matter and in 2013 narrowed the list of alternative corridors to three (see spotlight in Chapter 9). There is currently no construction schedule and no funding has been identified. Arizona includes no congressionally designated high-speed rail corridors at this time, although the State Rail Plan explores the potential for linking to southern California, Las Vegas, New Mexico, and Texas.[44]

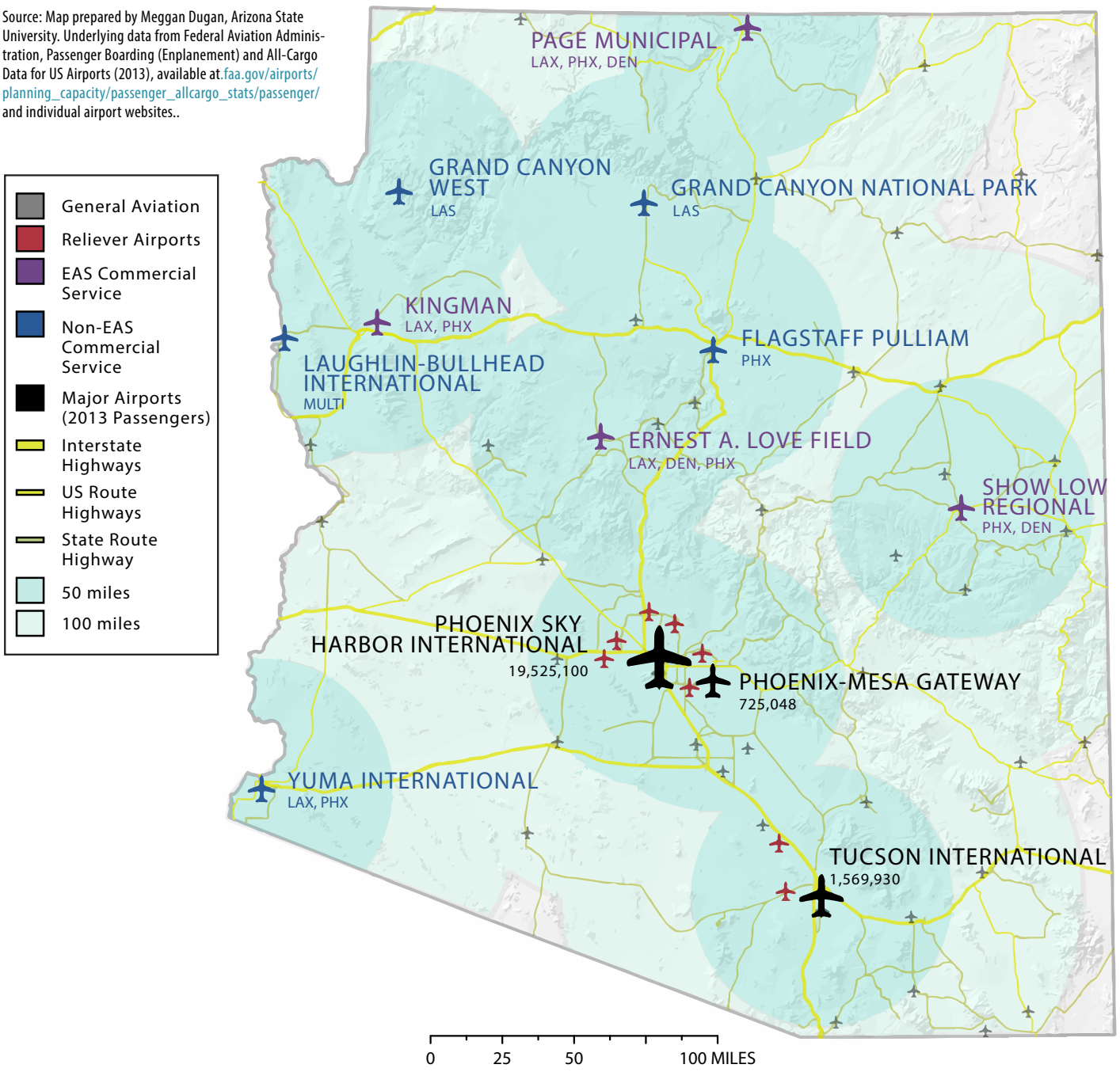
Phoenix—a regional rail cul de sac

Arizona's largest metropolitan area is poorly connected to the US railroad network. A north-south BNSF branch line connects Phoenix with the east-west BNSF mainline, but it dead ends in Phoenix in the south. The UP used to operate a connection from the Sunset line near Yuma to Phoenix that reconnected to the main line near Picacho. With part of the Yuma-Phoenix segment closed, freight trains from Southern California have to go more than halfway to Tucson, double back to Phoenix, and then reverse course back towards Tucson again.

Meanwhile, the closest Amtrak gets to Phoenix is Maricopa, 35 miles away by bus.

Figure 2.7 Airports of Arizona

Source: Map prepared by Meggan Dugan, Arizona State University. Underlying data from Federal Aviation Administration, Passenger Boarding (Enplanement) and All-Cargo Data for US Airports (2013), available at.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/ and individual airport websites..



Greyhound Lines provides scheduled intercity bus service primarily along the Interstate highway corridors, with stations in Phoenix, Casa Grande, Tucson, Flagstaff, Kingman, Yuma, Douglas, and Nogales and out-of-state routes to Los Angeles, Las Vegas, Albuquerque, El Paso, and San Diego.[45] Low-cost competitors such as GotoBus.com connect Chandler, Phoenix, Tempe, Tucson, Kingman, and Wickenburg to each other, to out-of-state destinations, and to Sonora, Arizona through its partner, Tufesa. Airport shuttles such as arizonashuttle.com fill other niches from Prescott and Sedona or van.

AIR

WITH LAURENCE GESELL

As the fastest passenger transportation mode, air transport specializes in long-distance movement. It is not, however, fastest for all trips. The time it takes to get to the airport, go through airport security, wait, load, and take off can be substantial. As a result, short to medium distance trips by car or train can be faster. Air travel is also less affordable, especially for groups and families traveling together, so even for longer trips, travelers face a tradeoff between time and money.

Airline Hubs and Focus Cities

Airport terminology can be confusing. When we talk about a "hub and spoke" network, the term "hub" implies an airport that functions as a switching center for connecting traffic. Pioneered for freight by Federal Express, flights leave a large number of "spoke" airports and arrive at the hub in a "bank" of flights in a small time window. At the hub, packages are sorted onto the flights to their destinations, while passengers sort themselves to the proper gate. By combining all passengers going to other airports from a spoke city onto a single flight, airlines can operate fewer flights using larger planes, offer more frequent service, and fill their flights mostly to capacity (achieving economies of scale and utilization).

The Federal Aviation Administration (FAA), on the other hand, classifies airports into large, medium, and small "hubs" and "non-hubs" based solely on the volume of traffic they carry, not whether they function as switching centers for connecting traffic. The FAA considers Tucson a small hub even though no airlines use it as a connecting hub.

To further confuse matters, airports can be "focus cities" for an airline. Unlike spokes, focus cities have some direct flights to airports that are not hubs. Unlike hubs, the flights do not arrive in coordinated banks designed to facilitate connecting traffic. Connections for through travelers are possible at focus cities, but more by default than by design. Sky Harbor is a hub for American Airlines and a focus city for Southwest Airlines.

When the federal government deregulated the airline industry in 1978, companies became much freer to set their own routes, schedules, and fares; start new airlines or merge existing ones; and add and drop service among airports and change their network structure. Many airlines developed hub and spoke systems with multiple hubs (see box). Smaller regional airlines such as Allegiant, United Express, Great Lakes Airlines, and Horizon offer service from smaller airports in Arizona to Phoenix, Tucson, and a handful of other destinations (see Figure 2.7).

In the US, airline-passenger traffic grew steadily from 275 million passengers in 1978 to 765 million in 2007, fell in 2008-09, and recovered somewhat to 740 million by 2013. In Arizona, there were 22.6 million passengers in 2013, or 3% of all US enplanements, down substantially from 6% in 2007. Arizona's two principal air terminals are trending in opposite directions, though both are falling behind their peers. Between 2000 and 2013, traffic at Phoenix Sky Harbor grew 7.9% to 19.5 million passengers but slipped from 7th to 10th among large hub airports.[46] Traffic at Tucson International Airport fell 13% to 1.57 million as airlines reduced service to Tucson, forcing more passengers to travel to Phoenix by road to catch a flight. As a result, the FAA has downgraded Tucson to small hub status. Sky Harbor's location just minutes from downtown Phoenix and Tempe offers exceptional convenience, but it comes with the costs of airport noise impacts, limitations on expansion and the height of surrounding buildings, and added road traffic in central Phoenix.[47]

The closing of Williams Air Force Base in Mesa in 1993 created an opportunity to take some pressure off Sky Harbor, and it was reopened in 1994 with expanded runways as Williams Gateway Airport. The FAA designated it a "reliever airport" to relieve congestion at Phoenix Sky Harbor and in 2004 Ryan International Airlines began offering charter flights. Las Vegas-based Allegiant Air started scheduled commercial jet service in October 2007. It enplaned 9,500 passengers by July 2008 and Mesa is now a focus city for Allegiant. With 725,048 enplanements in 2013, Gateway now serves half as many passengers as Tucson, garnering FAA small hub status. It is rapidly growing into a substantial resource for Arizona's air travelers, especially in the East Valley, and has put the controversy over the possible addition of a fourth Sky Harbor runway (noise, neighborhood opposition, etc.) on the back burner.

In addition to its three FAA-hub airports, Arizona has six non-hub airports (Grand Canyon National Park (Tusayan), Grand Canyon West (Peach Springs), Laughlin-Bullhead, Yuma, Flagstaff Pulliam, and Page) and three non-primary commercial-service airports (Grand Canyon Bar Ten in Whitmore, Prescott, and Show Low). For the smaller Arizona airports with commercial non-leisure service, flights are infrequent. Sierra Vista once had air service as well, but no longer does.

In addition to the commercial-service and reliever airports, there are a number of primary general-aviation (including reliever) airports and Native American airports (Figure 2.5), as well as secondary general-aviation airports (not shown).[48] General aviation covers all types of civil flying other than the scheduled air carriers. General aviation provides access by air to nearly 100 communities statewide too small to support scheduled commercial service. General-aviation and Native American airports are important for tourism and business, as well as for delivery of health care and social services to rural areas, especially emergency "medevac" flights. While data are scarce, it is estimated that about 2 in 10 passengers travel by general aviation.

Airline deregulation in 1978 gave airlines nearly complete freedom to determine the markets they would serve and the fares they would charge. Because it is less profitable to serve smaller markets, the Essential Air Services (EAS) program was created "to guarantee that small communities that were served by certificated air carriers before deregulation maintain a minimal level of scheduled air service."[49] Kingman, Page, Prescott, and Show Low receive EAS subsidies. Currently, all EAS contracts in Arizona are awarded to Great Lakes Airlines, which provides service in 19-seat twin-turboprop aircraft to PHX, DEN, and LAX. Subsidies are capped at $200 per passenger unless the community is more than 210 miles from the nearest medium or large FAA hub—a distance surpassed only by Page.[50] Currently, Great Lakes is subsidized $7,873,533 for serving EAS airports in Arizona.[51]

Each year, ADOT produces an air transportation capital improvement program for the next five years (visit azdot.gov/

planning/airportdevelopment/development-and-planning/five-year-program). Federal funds come from taxes on airline tickets and are allocated to local airports by the FAA. State funds come from a variety of taxes and fees on property, aircraft, and fuel. The most recent airport program calls for $1.2 billion of capital improvements from 2014 to 2018, with the FAA providing $935 million, ADOT $168 million, and local governments $76 million.[52] Over $240 million of that will go to design and construct a new 300,000 sq. ft. East Terminal building at Phoenix-Mesa Gateway.

Air freight specializes in moving high-value and time-sensitive goods fast over long distances. Nationally, air handled less than 0.04% of freight by weight in 2011, but 2.3% by value. Transport of air cargo has fallen dramatically in Arizona. From 2000 to 2013, air-cargo landed weight decreased by 25% in Phoenix and 44% in Tucson, respectively.[53] Phoenix Sky Harbor handles 90% of Arizona's air freight, with Tucson being the only other major air-freight operation in the state. There are other possibilities in Yuma, Mesa Gateway, etc. but these airports are not utilized for freight to any significant extent. A significant amount of freight tendered to air-freight companies for California and other "close" markets actually travels by truck.

WATER

Water transport is slow, the vessels are large, and the loading and unloading costs are high, but the cost per ton-mile is very low. These factors give water a cost advantage for long-distance movements of low-value bulk commodities. Since Arizona lacks any seaports or navigable rivers, it forces Arizona to rely on truck, rail, air, and pipeline for moving commodities, and on seaports in other states. Additionally, our roads and railroad lines are heavily impacted by traffic passing through our state to and from these ports. On the upside, Arizona is closer to the Pacific ports serving major Asian markets, giving our exporters an edge over the Midwest and East Coast. Opportunities exist for Arizona to be the main US gateway for seaports being developed on the Pacific coast of Mexico and to serve as an inland port to relieve congestion at California ports.

PIPELINES

Pipelines move 5.3% of freight in the US by value, 10.9% by weight, and 17.5% in terms of ton-miles. More important is what pipelines carry: the oil, natural gas, refined products, ethanol, and industrial gases on which so many industries—and almost all of our transportation system—depend. Because there are no oil refineries in Arizona, we depend entirely on just two pipelines—from Southern California and El Paso—to bring refined petroleum products into the state. Should these pipelines rupture, as the Kinder Morgan pipeline did between Tucson and Phoenix in 2003, Arizona residents, businesses, and emergency services are suddenly at risk of shortages and higher prices. In addition, pipeline leaks can contaminate groundwater and soils. In the future, new types of pipeline networks may be needed in Arizona to move hydrogen from centralized production facilities, desalinized seawater from coastal plants, or CO2 from power plants and cement factories to geologic sequestration sites.

AN INTERMODAL SYSTEM

While we presented in this chapter an overview of the most important modes of transportation, we need to emphasize that most trips—nearly all in fact—use multiple modes. Even when we drive from place to place, we may also walk within or around our destinations. Transit users need to walk, bike or be dropped off at their stop to board their vehicle. Freight is packaged in a standard-size container that can be loaded on a flatbed truck, rail car, or ship, and transferred quickly by crane from one mode to another.[54] While "intermodalism" makes sense, transportation experts increasingly recognize that every movement is a door-to-door journey. We still struggle with the

MOST TRIPS USE MULTIPLE MODES: EVERY MOVEMENT OF FREIGHT OR PASSENGERS NEEDS TO BE RECOGNIZED AS A DOOR-TO-DOOR JOURNEY

"last-mile" problem, getting people from the end of their bus trip to their final destination, or a package from the nearest warehouse to the final destination, someone's doorstep.

In Arizona, transportation planners and entrepreneurs are innovating to meet the challenges of intermodal passenger transport and solving this last-mile problem. Transit centers are mini-hubs for transferring between bus lines or bus to rail. Valley Metro light rail has over 3,600 park-and-ride spaces at nine stations, and opened the rubber-tired, driverless Sky Train for connecting from the Metro to the airport in April of 2013.[55] Tucson's SunLink streetcar website has detailed maps of parking, connecting bus and shuttle routes, and connects to the city's Greyhound bus station.

Other solutions include installing bike racks on the front of buses or in a compartment of each Valley Metro light rail car. For those who do not want to hassle with bringing a bike on a train, bike-sharing programs like the new Phoenix-Tempe-Mesa GR:D system offer an alternative solution. These programs provide bike stations near the light rail and many other locations where a bike can be picked up and ridden to one's destinations then left for the next user. Another way to solve this last mile problem, which we discuss in the next chapter, is to coordinate where people are going with their transportation options, an emerging planning paradigm called transit-oriented development.

NEW TECHNOLOGIES

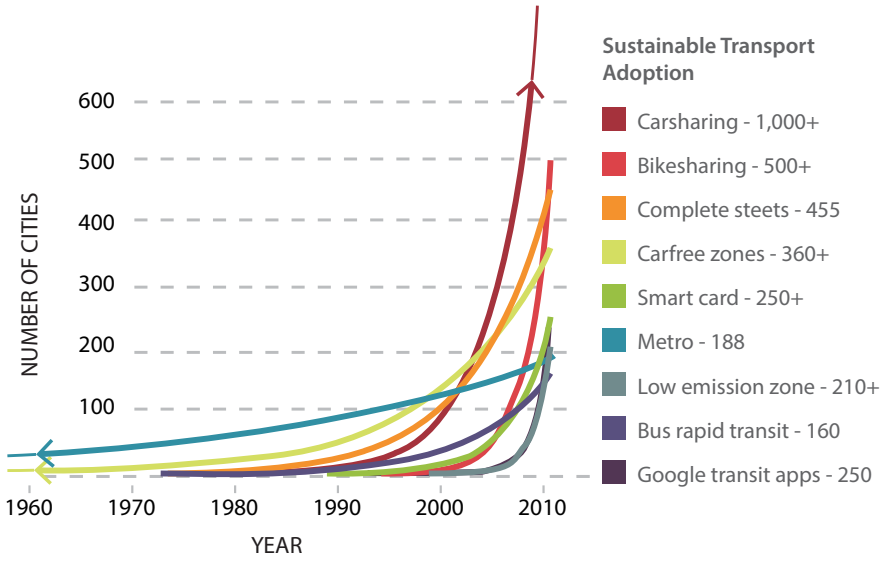
Transportation is one of those industries in which ideas that once seemed futuristic can someday become commonplace and change not just how we get around but how and where we live. Paved roads, railroads, motor vehicles, and airplanes were disruptive technologies—and subsequent innovations have driven relentless increases in speed and reductions in labor costs, making people more mobile and the world "smaller" and "flatter." In addition to speed, transport revolutions affect how far things and people can move, which affects land use, city structure and size, energy and cost efficiency, how different modes interact, geographic accessibility, and individual mobility.[56] As we survey the transportation landscape in 2015, a number of potentially revolutionary technologies might be on their way.

- **Autonomous Vehicles (AVs):** Recently, new car buyers have come to expect features such as rear-view cameras, lane-change detection, and parking assistance. Over time, we can expect sophisticated features like these to become standard in a gradual evolution towards self-driving cars. Next, we will see cars that take over braking or steering when imminent crashes are detected. Later, AVs will brake and steer simultaneously, and include a highway mode for fully automated cruising that would enable AVs to form bumper-to-bumper convoys, maximizing highway capacity utilization and reducing the need to add lanes. Imagine the societal savings if we did not need to own a vehicle at all but could simply summon an AV to pick us up. Our cars would no longer sit and do nothing for most of the day while we aren't using them. Of course, there are technological complications to overcome, including adverse weather and road conditions, road obstacles, and the need for error-free digital maps.[57] See Preparing a Nation for Autonomous Vehicles: enotrans.org/wp-content/uploads/wpsc/downloadables/AV-paper.pdf.
- **Drones:** Another emerging transportation mode is drones, or unmanned aircraft systems. Drones have been authorized for military, law enforcement, and scientific research purposes since the 1990s, but they are now proposed for civilian purposes. Such uses are still considered experimental by the FAA, and currently a special airworthiness certification is needed from the agency

Explosion of Transportation Innovations Worldwide

A global view of transportation planning and policy changes reveals an explosion of innovations beginning around 20 years ago. Measured by the numbers of cities adopting these innovations, the figure below shows that car and bike sharing, complete streets, and bus rapid transit, among other things now define the innovative city. Some of these indeed are found in Arizona, such as car and bike sharing in the Phoenix area, and some are being planned, like BRT in Flagstaff.

Source: WRI Ross Center for Sustainable Cities (2014). EMBARQ. On the move: Advancing sustainable transport – getting from here to there. thecityfix.com/blog/on-the-move-advancing-sustainable-transport-getting-from-here-to-there-holger-dalkmann/.



while rules governing commercial usage are developed.[58] Final regulations could be issued sometime in 2015. While some see great potential for cheaper home deliveries and less congestion, others see risks such as startled drivers, injuries and crashes, and the difficulty of enforcing regulations with thousands of small aircraft hovering in the airspace. See cnet.com/news/why-our-drone-future-is-for-real-someday.

- **Maglev**: An alternative to traditional rail, magnetic levitation technology uses magnets to create both lift and propulsion. Nearly frictionless operation saves on maintenance and potentially on energy use. Maglev, however, requires new tracks and high capital costs. At high speeds, maglev can be efficient but the electrical energy required to travel at low speeds through urban areas and to accelerate might be higher than traditional rail. The first commercially operated maglev train was built in China in 2004 between the Shanghai Pudong International Airport and the financial district. Japan has completed some test runs with speeds reaching 311 miles per hour.[59] For a US maglev proposal, see northeastmaglev.com.

- **Personal Rapid Transit (PRT)**: Somewhere between owner-operated private vehicles, autonomous vehicles, and mass-transit lies PRT. The system consists of small automated vehicles (pods) that run on tracks costing roughly 75% less per mile than light-rail tracks. Riders summon cars to stations and program in their destination. The small size, point-to-point non-stop trips, and schedule flexibility make PRT similar to cars. To date, only a handful of PRT systems operate around the world, generally confined to airports (including Heathrow in London), campuses, and exhibition centers. Challenges include cost, feasibility, geographic coverage, and regulatory requirements that fail to differentiate between mass rail transit and PRT.[60] Autonomous vehicles may offer many of the features of the PRT vision without the need for new networks. See cprt.org.

- **The Hyperloop**: This radical concept proposed by the founder of Tesla Motors would repurpose the vacuum-tube technology currently used for drive-through banking for long-distance passenger transport. Elon Musk envisions small groups of people whizzing from Los Angeles to San Francisco in pressurized pods at near supersonic speeds for as low as $10 per trip. While still in the concept stage, the Hyperloop has generated much interest and enthusiasm.[61] See spacex.com/hyperloop.

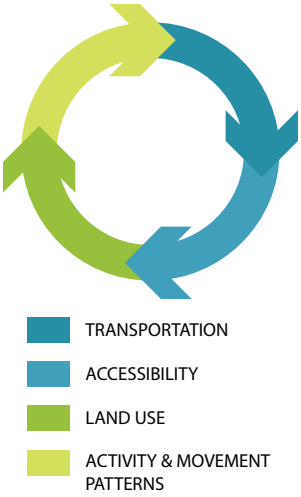
- **Hydrail**: Chapter 6 on Energy introduces alternative fuels and technologies for cars and trucks, but rail transit and rail freight may be the lower-hanging fruit. Traveling on a fixed route, the number of refueling stations needed is minimal, and with only a single carrier involved, the transition can be managed under one roof rather than coordinating countless manufacturers, vehicles, drivers, fuel stations, mechanics, and regions. Electric traction is by far the most efficient propulsion for rail, and hydrogen fuel-cells railways ("hydrail") offer electrification without costly and unsightly overhead wires. Hydrogen can be the sole source of power or extend battery range in a hybrid-type system with regenerative braking. Germany, Dubai, Doha, and Aruba are now building hydrail light rail and streetcars, while companies and agencies in the US, the UK, Denmark, Japan, and South Africa are developing prototypes and bringing systems to market.[62] See hydrail.org and tig-m.com/hydrogen.html.

CHAPTER 3

LAND USE AND TRANSPORTATION

How easily one can access a piece of land shapes how it may be used. Land that is remote and inaccessible will likely be left alone as part of the vast wilderness and perhaps rarely visited, if ever, by humans. The development of transportation connections to lands potentially opens them up for use by humans. As those connections improve, the extent and diversity of human uses expands. Rural roads offer connections to agriculture, mining, tribal lands, parks, and small- to medium-sized towns. Within the urban areas of the state, transportation improvements like roads, freeways, buses, and light rail shape and re-shape both the central city and suburban expansion. It is difficult, therefore, to separate discussions of how Arizona should grow from how transportation systems should develop because transport networks shape our use of land and land use.

Figure 3.1 Land Use Transportation Interactions



The most elemental relationships between land use and transportation create a cycle of investments and feedbacks (Figure 3.1). Following the arrows clockwise, investments in transportation improve access to an area, which makes it a more attractive location for new activities. The new activities that locate there because of the improved accessibility create new traffic flows that cause congestion around them or somewhere "down the road," which, in turn, creates a need to relieve that congestion. This prompts a new set of transport investments, which improves accessibility, and adds activities and traffic flows, and the cycle begins again.

This cycle can also work starting from land use. Land-use patterns and trip lengths dictate to a large extent how one must travel. Land uses that form in concert with particular transportation investments create certain kinds of movement patterns, which then place constraints on the possibilities for transportation. For example, developments along freeways and arterials, which favor driving and lower-density, suburban areas, create long distances to destinations. This form of land use significantly hinders the prospects for someone to be able to walk, cycle, or take public transit, since they are at a distinct disadvantage for these longer trips. They may take a very long time, be unsafe, or generally unattractive. On the other hand, denser developments offering a mix of land uses (housing, work, and shopping) may encourage biking and walking because of shorter distances between destinations. For this reason, people concerned about diversifying the way people travel are increasingly turning to land-use design as the starting point in the cycle, hoping to leverage the system from a different angle.

Throughout history, our settlement patterns have been shaped largely by accessibility. Before mechanized transportation, cities in the United States were not much more than large, compact villages and travel was on foot or by horse. In the 19th century, East Coast and Midwestern cities developed dense, star-like arms along horse-drawn and later electrified streetcar lines that brought workers and shoppers to an all-powerful central business district. Then, thanks to the automobile, our cities exploded. Suburban shopping malls, suburban factories, warehouses, office parks, full-fledged suburban downtowns, and shrinking central business districts followed residential-heavy suburbs. As suburbs matured, they became both more interconnected to the rest of the region and more independent.

KEY POINTS

- There is a powerful synergistic relationship between transportation investments and land use; investments improve access to land and spur new investments, while land use constrains which modes we use to go to work, to school, to shop, etc.
- Population growth drives a lot of land development in Arizona and growth is projected to continue; Arizona's population is expected to grow to more than 10 million.
- Land development and transportation connections in central Arizona have created the beginnings of a single megapolitan area stretching from Nogales to Prescott, though it will be decades for the area to truly unify.
- Land use planning is an important tool to shaping how we travel, and vice versa; new land-use planning ideas such as jobs-housing balance and transit-oriented development create more complete communities which reduce the need to travel far for important destinations.

Phoenix and Tucson were small villages in the pre-automobile 1800s, and thus largely missed the eras when other US cities developed thriving downtowns that contained most jobs and commercial services served by radial streetcar networks. While Phoenix did have an extensive streetcar network in the early 20th century, the population was so small that those lines left a very limited lasting imprint. The explosive city building of Phoenix and Tucson came during the automobile era and as a result, most of our two largest cities have land-use patterns that originated around the automobile and that continue to make it easier for people to reach their destinations by car rather than public transportation. Zoning regulations, highway access, higher car ownership, and the desire to live in single-family dwellings with open space have greatly increased the distance from home to work, shopping, and play and make it more challenging to serve those neighborhoods by public transportation.

From 2000 to 2014, Arizona's population grew by 26.7%—the second-fastest rate in the country, behind Nevada. Rapid growth is expected to resume after the current economic recession. The factors driving that growth, such as warm winters, affordable housing, good quality of life, and job growth will likely continue to stimulate migration to Arizona in coming decades. Figure 3.2 shows population estimates for Arizona counties through 2030. The growth of our population in urban, small town, and rural locations will continue to demand investment in transportation connectivity throughout the state.

Forty years of transportation and land-use planning based primarily on automobile accessibility has resulted in metropolitan areas that are highly dependent on cars for almost all travel needs. Though Arizona travelers depend strongly on the automobile and may have a reputation for their love of cars, freeways, and suburban living, they are actually not different from most states. In fact, Arizona is more urban and dense than the US average. Table 3.1 shows how Arizona and its cities rank nationally in

THE DEVELOPMENT OF TRANSPORTATION CONNECTIONS TO LAND OPENS THEM UP FOR USE BY HUMANS; AS THOSE CONNECTIONS IMPROVE, HUMAN USES DIVERSIFY

BACK TO THE LECTURE HALL 3.1

INDUCED DEMAND

Economists use the term "induced demand" to describe how an increase in the supply of a good leads to an increase in the demand for it. In transportation systems, all trips have a cost that includes fuel, tolls, and the value of the user's time. Congestion raises the user's time costs and causes some people or companies to drive at less-convenient times, take alternative routes or modes, change destinations, or forego trips entirely.

When investments in transportation facilities are made (e.g. road capacities are expanded), congestion drops. In the short-term, trips that were moved off-peak, to public transit, or to a less-convenient route or destination can return and trips that were completely avoided can be made. As a result, the new capacity may be quickly filled by "latent demand." In the longer term, adding transport capacity can alter people's choices of where they live or work, and attract new development designed to take advantage of the new capacity. In short, new capacity added to serve existing demand soon faces much higher demand.

Induced demand has become important in debates about road and freeway construction and urban sprawl. Road expansion can be inefficient to the extent that it just fills with "low-value" trips that people were previously willing to shift or forego. In a region with rapidly growing population, new roads can open up new lands needed for development. In the end, the expanded road becomes as congested as the road was before expansion, but it is now carrying more people.

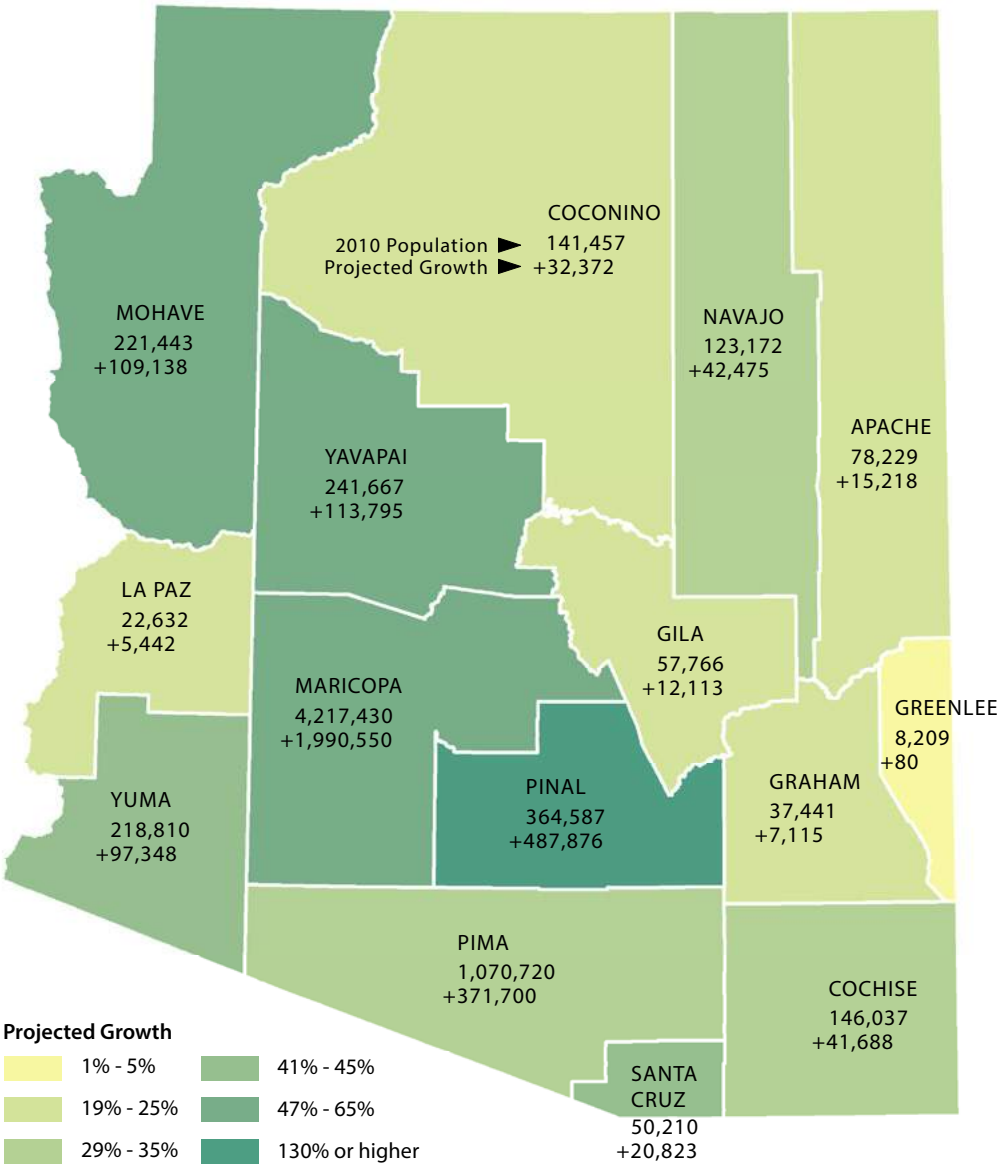
Figure 3.2 Projected Population Growth in Arizona, 2010-2030

Source: Map prepared by Meggan Dugan, Arizona State University. Underlying data from the Arizona Department of Administration, Office of Employment & Population Statistics, 12/07/2012.

Projected 2030 Total Population:

Apache:	93,447
Cochise:	187,725
Coconino:	173,829
Gila:	69,879
Graham:	44,556
Greenlee:	8,289
La Paz:	28,074
Maricopa:	6,207,980
Mohave:	330,581
Navajo:	165,647
Pima:	1,442,420
Pinal:	852,463
Santa Cruz:	71,033
Yavapai:	355,462
Yuma:	316,158

Total projected 2030 population of Arizona: 10,347,543



various measures of travel supply and demand. Though Arizona is expansive in total land area, its human settlement is heavily concentrated in a few large cities. Consequently, its passenger transportation activities and infrastructure are concentrated there as well.

Table 3.1 Urbanization Rate & Travel, Arizona vs. US, 2008

Indicators	Arizona	US Average	Arizona's Rank
Percent Urban	78.7%	78.5%	15
Urban Density (pop. per square mile)	1,988	1,454	10
Urban annual vehicle miles per capita	8,484	8,261	25
Urban lane miles per capita	10.37	9.96	37

Source: Calculations by author, based on data from: FHWA Selected Measures for Identifying Peer States - PS-1 fhwa.dot.gov/policyinformation/statistics/2008/ps1.cfm.

URBAN AND "MEGAPOLITAN" GROWTH IN ARIZONA

There are two overarching and opposing trends in metropolitan land use—growing density in most existing urban areas, and leapfrogging and sprawling growth on the fringes. Both have major implications for Arizona's travel demand and regional planning. The densities of centrally located cities such as Phoenix, Glendale, Mesa, and Tempe have been steadily rising over the past decades.[63] Meanwhile, the fastest-growing areas are in low-density fringe developments on the peripheries of the larger metropolitan areas, including Casa Grande, Coolidge, Florence, Maricopa, and Surprise. Growth in these areas, which tend to be job-deficient, adds to peak-hour demand on regional freeways as residents commute to the metropolitan areas. Figure 3.2 shows how the counties containing or near the large metropolitan areas (Pima, Pinal, and Maricopa) are projected to absorb most of the state's future population growth.

BACK TO THE LECTURE HALL 3.2

MOBILITY AND ACCESSIBILITY

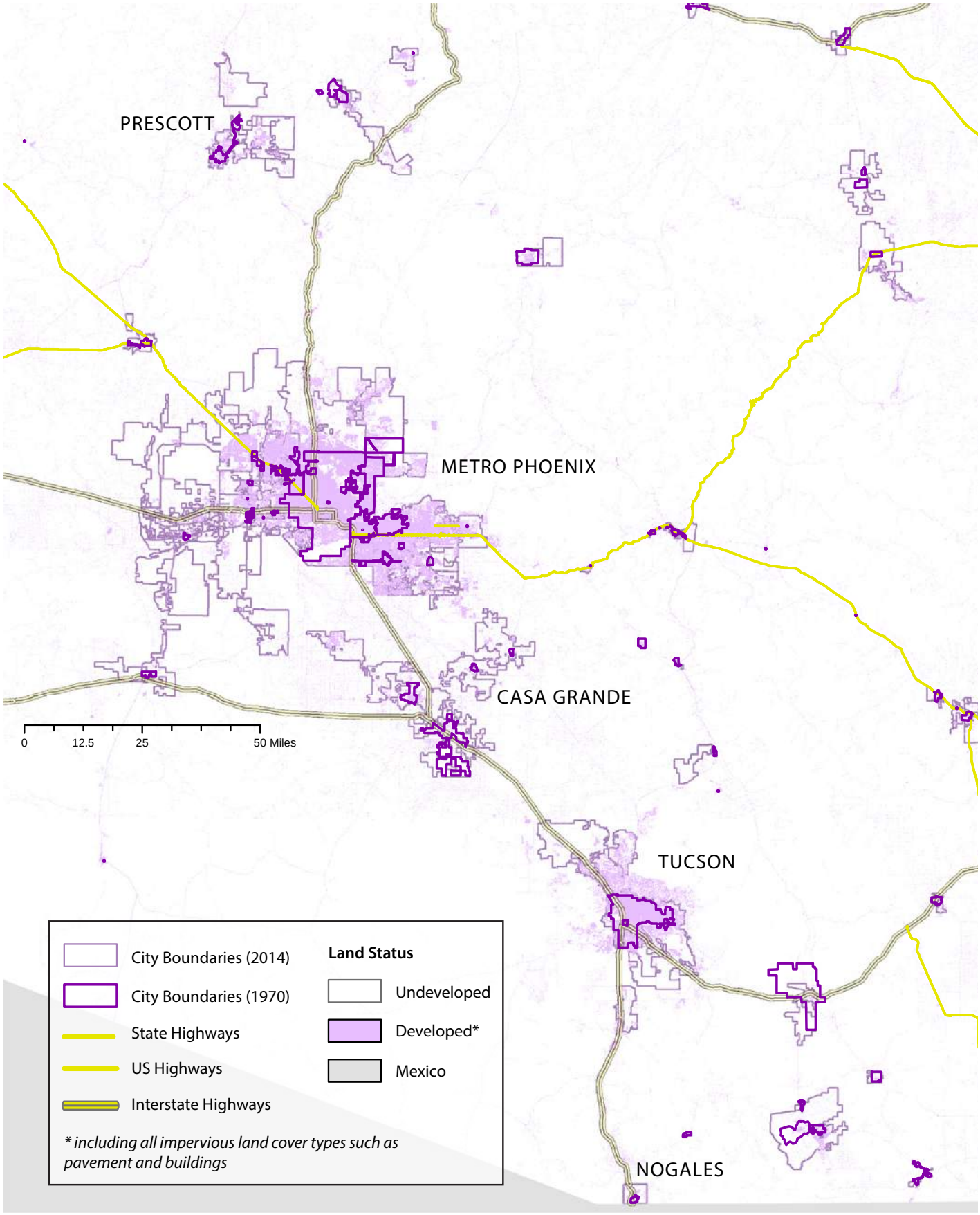
Mobility refers to ease of movement, which is a function of our age, health, and the vehicles we use to get around. Accessibility refers to the number and types of activity sites within reach, which is a function of destination locations and networks for reaching them. The two concepts are distinct but overlapping, Transportation and land use act as an integrated system to provide access. Depending on their configuration, however, we may be required to be more or less mobile. A dense city with mixtures of housing, work, and recreation affords access to its dwellers without requiring everyone to be very mobile. A spread-out suburb full of only housing requires all dwellers to be very mobile to access activities outside of the home. In the late 20th century, transportation planning assumed that by providing mobility by car, everyone would have accessibility. As the costs of mobility continue to rise, however, and concerns over health, pollution, energy independence and climate change, planners are increasingly trying to provide accessibility without demanding as much mobility.

As metro areas expand farther and farther, once-separate regions begin to merge into a single "megapolitan" area exhibiting overlapping cross-region commuting patterns and economic interdependence.[64] As early as the 1970s, the separate cities of the Valley of the Sun—Phoenix, Mesa, Tempe, Scottsdale, Glendale, and others—had effectively merged into a single functional metropolitan area. The artificial boundaries between these cities are now barely noticed by residents as they crisscross them to work, shop, go to college, and socialize. Today, some experts recognize an emerging megapolitan region that could stretch almost continuously from Prescott, through the Phoenix and Tucson metropolitan areas, all the way to Nogales. This "Sun Corridor" occupies only 10% of land area of Arizona, but has 80% of the population growth and produces 88% of state GDP. However, as Figure 3.3 shows, the megapolitanization of the Sun Corridor is not yet a done deal.

ASU's Morrison Institute for Public Policy has noted the harsh realities of the region's continued growth, the lack of coordinated Corridor governance, and challenges in funding the necessary infrastructure.[65] These issues have direct implications for transportation. The lack of strong coordinated governance in the Corridor presents challenges for a regional perspective on transportation planning, while infrastructure investments continue to lag far behind actual development. Furthermore, one-third of undeveloped land in the Sun Corridor is privately held and with much of that land located on the urban fringes and already permitted for construction, existing patterns of car dependence and energy consumption may continue. According to the Morrison Institute Report, Arizona's Sun Corridor, infrastructure in the Sun Corridor will need to go beyond simply building highways to include "smart" infrastructure and denser smart-growth planning approaches, renewable fuels, efficient vehicles, creative transit options, and commuter rail. To pay for these investments, new funding mechanisms may be needed (see Chapter 9). The ability of the Sun Corridor to successfully meet these challenges will determine its ability to compete with other emerging megapolitan areas.

THERE ARE TWO OVERARCHING AND OPPOSING TRENDS IN METROPOLITAN LAND USE — GROWING DENSITY IN CORE URBAN AREAS, AND LEAPFROGGING AND SPRAWLING GROWTH ON THE FRINGES

Figure 3.3 Developed Land along the Sun Corridor, 1970 vs. 2014



Source: Map prepared by Meggan Dugan, Arizona State University. Underlying data from Arizona State University School of Geographical Sciences and Urban Planning, USGS, NLCD 2011 Percent Developed Imperviousness, mrlc.gov; 1970 Arizona Places, Chris Kollen, 2007 atlas.library.arizona.edu; and Arizona State Land Department for the 2014 city boundaries.

BACK TO THE LECTURE HALL 3.3

LOCATION AND PLACE

To the general public, the terms location and place are almost interchangeable ways of saying "where." To urban geographers and planners, however, they have very different meanings. Location refers to where something is and what it is near, while place refers to what it feels like to be there. Both concepts play pivotal roles in the land use-transportation system.

Planners refer to place as having a distinct identity and not merely a location. People get excited about places – they create a sense of community, history, and identity. Consequently, how transportation investments and land use plans can create a distinct sense of place is an important concern for planners. Place-making has become an important element of planning.

LOOKING FORWARD: LEVERAGING LAND USE FOR TRANSPORTATION PLANNING

Land-use planning is an essential tool to facilitate more diverse travel options for communities. Generally, high population density and mixed land uses make trips shorter and thus increase use of public transit, bicycling, and walking. Communities and the governments and planning staff that work for them can apply transit-oriented development and new-urbanist principles to foster density and diversity in their central urban areas. For example, Phoenix has developed an "Interim Transit-Oriented Zoning Overlay District" as part of its zoning code and embarked on a three-year planning process called "Reinvent Phoenix" to rezone and reshape the neighborhoods surrounding its light rail stations. Tucson lacks similar transit-oriented zoning, but does have standards for pedestrian- and transit-friendly development, particularly for downtown infill projects. Both regions are still learning about how to apply these kinds of land-use regulations.

BACK TO THE LECTURE HALL 3.4

LAND USE PLANNING FOR ACCESSIBILITY: THE 5 D'S

Communities and their planners have a few key tools to help improve travel choices for residents. Planners refer to these as the "5 D's"—density, diversity, design, destination accessibility, and distance to transit. Together, these principles make a place—a downtown, a suburban center, an area near a transit station—more amenable to travel by means other than automobile. Density and land-use diversity increase the number and types of destinations nearby, and offer more opportunity for someone to walk or bike between locations. Good design—meaning nice sidewalks, plazas, shade, and landscaping—is important to encourage people to walk, cycle, and wait for public transit. Accessible destination planning makes a place more than just an assembly of stores by adding the right mix of land uses and amenities while also making them accessible by multiple travel modes, from bikes to buses. Finally, locating important destinations near public transit or adding public transit connections to important destinations increases the convenience and competitiveness of transit. These principles come in various planning "packages" within transit-oriented districts, new-urbanist planned communities, or "complete streets" projects.

PART II

WHY TRANSPORTATION MATTERS

The Arizona Town Hall focuses on issues that matter to the lives of people in Arizona. Leaf through almost any recent Arizona Town Hall report and you are likely to find the word "transportation" frequently. Transportation moves people and goods from one place to another and thus facilitates our economic (AZ Town Hall, 2014), social (2014), education (2013), energy (2011), housing (2008), and land use (2007) systems. Its links are part of the fabric that holds our economy, society, and families together. Its reliance on energy from oil affects our country's international relations and impacts our natural environment in significant ways. In this sense, Part II of our report is our answer to the question, why transportation matters? Specifically, it explores transportation's relationships with the Economy (Chapter 4), Society (Chapter 5), Energy (Chapter 6), and the Environment (Chapter 7).

CHAPTER 4

TRANSPORTATION & THE ECONOMY

This chapter emphasizes the impact of transportation on household budgets, economic growth, and job creation. For those more interested in these issues, we recommend checking out the online lecture series from the Volpe National Transportation Systems Center featuring leading thinkers exploring key issues in the transportation–economy connection at www.volpe.dot.gov/events/transportation-and-economy.

Transportation represents a sizable share of the US and Arizona economies. The US Bureau of Transportation Statistics estimates that it accounted for almost $1.5 trillion of spending in 2011, or 10% of US Gross Domestic Product (GDP).[66] While this is a smaller share of the national economy than housing (18%) or health care (16%), it is similar to the percentage spent on food.

Not surprisingly, a significant share of employment is in transportation-related jobs. In 2011, the for-hire transportation sector accounted for 4.3 million jobs out of 131.5 million total jobs nationally, with trucking being the largest employer by far.[67] Attempting to account for employment in "transportation-related" industries—such as manufacturing of transport equipment, transportation-related services such as car repair, postal service, and federal/state/local government jobs related to transportation—yields a much higher estimate of 12.3 million jobs, or 9.4% of the labor force. Arizona is on par with the nation as a whole for the private, for-hire transportation sector, with 3.72% of the workforce, compared to 3.65% nationally (see endnote for details).[68]

Despite its prevalence, transportation has been steadily shedding jobs. From 2001 to 2011, transportation-related industries lost almost 1.5 million jobs, or 10.5%, while the entire US labor force lost only 400,000 jobs, or 0.3%. Employment statistics in all transportation-related industries are not available at the state level.

KEY POINTS:

- Transportation accounts for about 10% of jobs and gross domestic product nationally, and around 17% of household budgets.
- The average driver in Phoenix and Tucson loses 35-38 hours per year in congestion delays.
- Congestion, however, is also a problem in rural areas, on arterial streets, and in off-peak hours.
- Other modes besides road also stimulate the economy and create jobs.
- Tourism and international trade depend heavily on good transportation systems, which is important to our metropolitan, rural, tribal, and border regions.
- The proposed I-11 "super-corridor" could have broad economic impacts, especially if planned in a multi-modal and multi-purpose way, but could also promote sprawl.

TRANSPORTATION IN ARIZONA'S ECONOMIC BASE

A state's economic base is the subset of economic activities that "drive" the rest of the state's economy. These basic industries sell most of their goods and services to out-of-state buyers, bringing money into the state. They purchase goods and services from other companies, which employ workers and other companies themselves. They also hire workers who spend most of their salaries within the state on food, clothing, housing, medical care, and transportation, in turn supporting a wide variety of population-serving or non-basic jobs. Non-basic industries, such as restaurants or printing shops, recirculate this money among different people and businesses within the Arizona economy, multiplying income from each basic job several times over.

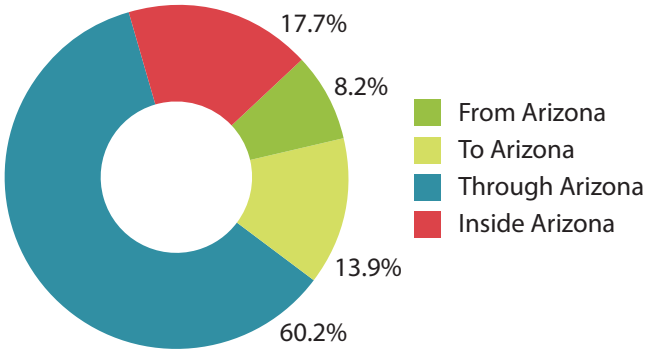
In Arizona's early days, mining, farming, and ranching provided much of our economic base, and their products brought dollars into Arizona. However, our economy is very different today. The 2014 Arizona Town Hall Report on Arizona's Economy identified high-tech manufacturing, tourism, telemarketing, back-office operations, and seasonal residents, and to a lesser extent mining, agriculture, military bases, and other federal government activities as Arizona's most important basic industries. The report characterized wholesale trade and transportation services as serving both basic and non-basic functions. While Arizona can point to some prominent examples where transportation companies contribute to our economic base, transportation is not considered as important an economic driver as the industries listed above.

An example of an Arizona transportation industry that is basic is air transportation. Southwest and American Airlines hub and focus city operations at Sky Harbor serve

millions of passengers who fly in and out of or change planes in Phoenix. These operations generate airline and airport jobs at Sky Harbor and surrounding businesses. Additional examples are major air-freight forwarders (e.g., Mach One) and regional distribution centers for Wal-Mart, Target, Dillard's, and others, which distribute goods across the Southwest.

One reason Arizona has fewer basic transportation industries is that it's a "pass-through" state for freight. Over 60% of the freight moved in Arizona originates from outside Arizona and just passes through on the way to another state. Arizona gains relatively little from the majority of this freight. Therefore, a continuing challenge is determining how to improve the economic yield from this traffic, either by value-added processing of goods and/or leveraging this activity to attract new business. Of the remaining 40%, almost half is intra-state freight that also does not bring money in from outside of Arizona (Figure 4.1). The development of the "inland port" in Tucson could help capture more freight that would otherwise just pass through Arizona from Mexico or ports in Southern California (see Spotlight in Ch. 9), modeled after the inland port in Alliance, TX near Dallas.

Figure 4.1 Freight in Arizona (based on weight)



Source: Arizona Multimodal Freight Analysis Study, Technical Memorandum #1.

While transportation itself may not be a backbone of Arizona's economic base, good transportation infrastructure is vital to attracting and keeping the basic industries that do drive our economy. According to the 2014 Town Hall report on Arizona's Economy, good transportation infrastructure is the second-most important factor in site location decisions, ranking only behind the quality of the workforce.[69] Depending on the industry, air, rail, or road transportation can be critical factors when a business is deciding whether to relocate or expand here. Various types of office employment such as law, accounting, engineering, advertising, or sales may need close airport access and frequent direct flights for employees, while high-tech industries may need to ship valuable parts by overnight air freight. Manufacturing companies moving large volumes of bulk or containerized freight may require rail service, while many others rely heavily on trucking and put a premium on highway access and quality, and low congestion levels.[70] For companies and cities trying to attract creative workers in knowledge-based and artistic professions (see Box), the desired transportation infrastructure is quite different. It often focuses on local mobility, emphasizing modes other than single-occupant private vehicles.

BACK TO THE LECTURE HALL 4.1

KNOWLEDGE WORKERS AND THE CREATIVE CLASS

Author Richard Florida coined the term "the Creative Class" to describe workers whose job is to produce new ideas, technology, or art.[71] The category groups science, engineering, finance, architecture, medicine, law, academia, and advertising with music, arts, and entertainment. These "creative professionals," it is argued, drive the 21st century economy, and are attracted to cities like Seattle, Portland, San Francisco, Boston, New York, and Austin. Researchers, planners, and economic development professionals have generated a long checklist of attributes that supposedly attract the young and talented: a local arts and music scene; historic neighborhoods; waterfronts; local rather than chain businesses; coffee shops; tolerance and diversity; dog parks; farmers markets; outdoor wireless internet; social interaction; authenticity; amenities; and above all a sense of place.[72] Transportation figures prominently on the list of things that knowledge workers supposedly want: not only good transportation service, but also an environment with numerous transportation options, including attractive (even picturesque) public transport service and urban pathways where creative workers can see and be seen.[73,74] Planning for the creative class is not without controversy, as cities have made such investments with no discernable uptick in their high-tech employment, and poorer residents who depended on the good transit access of their inner-city neighborhoods have been forced out of gentrifying areas because they can no longer afford to live there.[75]

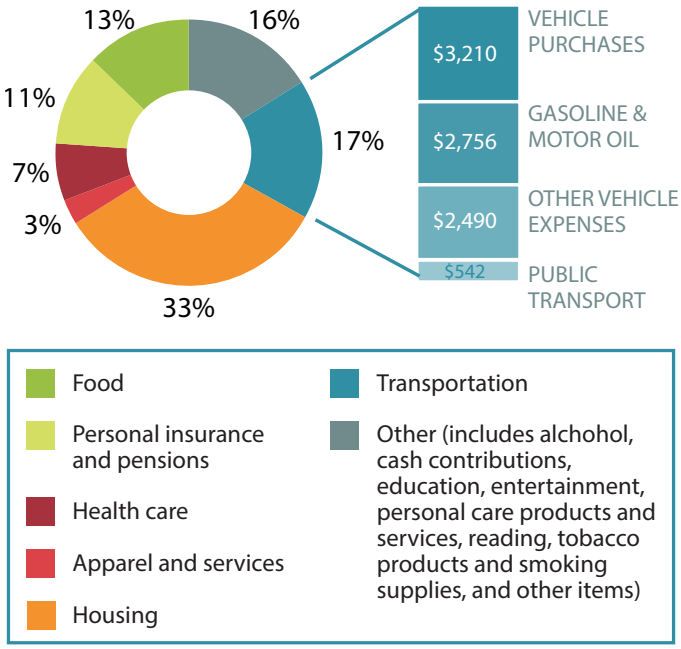
TRANSPORTATION IN HOUSEHOLD BUDGETS

Transportation also affects the business climate in a second way. It adds to employees' cost of living, which affects companies' labor costs and their ability to keep their best employees. According to the Bureau of Labor Statistics (BLS), the average US household spent $8,998 of their income on transportation in 2012—17% of their expenses (Figure 4.2). Public transportation (including air and other travel that can be purchased with a ticket) accounted for only 6% of average household spending on transport. The other 94% were spent on owning, operating, fueling, maintaining, licensing, and insuring personal vehicles.

According to the Center for Neighborhood Technology (CNT), the Phoenix-Mesa-Scottsdale region ranks 25th out of 51 large urban regions for average annual transportation costs. These average costs come in substantially higher than the BLS statistics because they are estimated for the "regional typical" household of median income with the average number of commuting household members. At $13,582 per year, Phoenix ranked far worse than New York, the city with the lowest costs at $10,158. The CNT Transportation Cost Index is based on an area's auto ownership, auto use, and transit use. It is not surprising that New York's transportation costs are low because their auto ownership and use are low, while their transit use is high and the cost of monthly transit passes is far less than the cost of owning, insuring, registering, maintaining, and fueling automobiles. Perhaps more surprising is how Phoenix ranks against some other western cities. Though not as inexpensive as New York for getting around town, San Francisco (2nd, $11,980), Los Angeles (3rd, $12,154, Denver (7th, $12,662), and San Jose (10th, $12,914) all are cheaper than Phoenix (cnt.org/repository/2012-Fact-Sheet-Rankings.pdf). For medium-sized urban areas, Tucson ranks 9th out of 43 at $14,047 per year for a typical household, behind Colorado Springs, Albuquerque, and El Paso and ahead of Stockton, Fresno, Bakersfield, Boise, and Tulsa.

When transportation costs are combined with home-ownership, it can place a heavy burden on a typical working family. Home-ownership affordability is usually viewed in terms of mortgage costs relative to income, with 30% of income often used as the measure of affordability. By this standard, about ¾ of US neighborhoods are deemed affordable to a median-income household. If instead we apply a benchmark of roughly 45% of income as an affordable amount to spend on housing plus transportation,[76] the percentage of affordable neighborhoods drops to 28% nationally. When median incomes of neighborhoods are compared with their combined cost of housing plus transportation (htaindex.cnt.org/map), huge differences can be found across Arizona and within its cities and towns.

Figure 4.2 Household Expenses by Category, 2012 (Percent of Average Annual Household Expenses)



Source: US Department of Labor, Bureau of Labor Statistics. "Consumer Expenditure Survey," October 2013. bls.gov/cex.

While the geographic pattern is complex, one generalization that holds up fairly well is that the more central areas of Phoenix, Tucson, Prescott, and Flagstaff tend to have more neighborhoods where housing plus transportation costs less than 45% of the median income. This is largely because of lower transportation costs due to more public transportation options and shorter automobile trips, which offset higher housing costs. Given that the same housing square footage typically cost less on the urban fringe, where auto ownership and use tends to be higher, the 30% rule for qualifying for a mortgage creates a bias to "drive until you qualify."

Prior to the housing collapse, subprime mortgages were most prevalent in farther-out, new-build areas of the Phoenix area,[77] placing more residents farther away from services and core areas and at the mercy of gasoline price fluctuations. These places—typically the far North, Southeast, and far West areas—had the highest rates of foreclosures (archive.azcentral.com/business/foreclosures/index.php),[78] as residents were subjected to both the housing price collapse and higher gasoline prices in 2007-08. Subsequently, these twin impacts were seen in new construction, which dried up in new-build areas following this period as well.[79]

Arizona's households also depend on efficient movement of freight for essential goods. Without efficient freight operations, we would pay more for food, energy, and all kinds of materials. Businesses depend on timely and low-cost deliveries of their inputs and outputs.

BACK TO THE LECTURE HALL 4.2

TRANSIT > DENSITY > AGGLOMERATION > PRODUCTIVITY

Recent research suggests that investment in public transportation leads to higher wages and productivity through several intermediate steps.[80] Transit investment is associated with increased population and higher employment densities downtown and metro-wide. This creates a larger and more diverse cluster of labor and companies, which creates agglomeration economies for the region. Agglomeration economies are cost savings resulting not from a company itself being bigger but from the geographic cluster of companies being bigger. These cost savings result from reduced costs of making transactions within the cluster, including hiring labor, working with suppliers and customers, and spinning off businesses. Research has shown that agglomeration leads to higher productivity, with higher per capita wages and gross metropolitan product.

CONGESTION

As noted, Arizona residents rely on driving for most of their trips, and Arizona businesses rely heavily on road transport for freight. Traffic congestion is ubiquitous in modern urban society and has large negative economic impacts. According to the 2012 Urban Mobility Report, Americans in 498 urban areas lost 5.5 billion hours and 2.9 billion gallons of fuel in 2011 just by sitting in traffic jams, resulting in $121 billion worth of delay and waste.[81] The cost to the average commuter was a staggering 38 hours and $818 per driver per year.

In 2011, the Phoenix metropolitan area was the 14th largest urban area in terms of population (4.3 million) and ranked 40th in terms of yearly delay per auto commuter (35 hours) and 30th in congestion cost per auto commuter ($837).[82] Tucson, with 990,000 people, ranked 52nd in terms of population but 30th in terms of delays per commuter (38 hours) and 21st in congestion cost ($921).[83] The total congestion costs, including drivers' time, fuel lost, and delivery delays, was estimated at $1.97 billion for Phoenix (14th overall, and 2nd best among the 15 largest urban areas) and $466 million for Tucson (48th). Congestion delays and costs had been rising steadily in our two largest cities until the recession hit and they began to level off (see Figure 4.3).

For truck delays, Tucson ranks dead last among medium-sized cities, with over 2 million annual hours of delay, more than double the national average. Many manufacturing operations today have reduced their inventory of parts and rely on "just-in-time-manufacturing" in which trucks serve as mobile warehouses delivering inputs as needed. When congestion delays the arrival of trucks, production lines might be stopped, which would dwarf the economic losses from the truck delays alone.

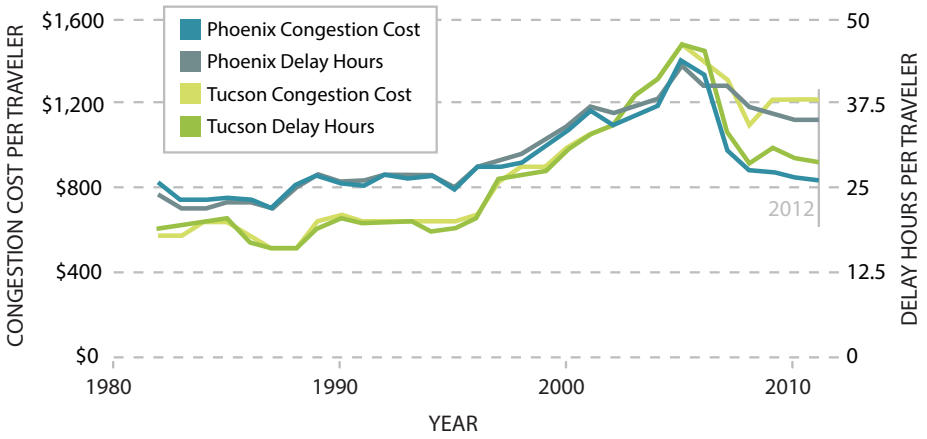
Congestion is no longer purely a rush-hour phenomenon. Nationally, 37% of all delays occur midday or overnight. This is a growing problem for freight transport, which is often scheduled outside of peak hours when free-flow conditions are expected.

In some ways, the impact of congestion is actually worse than these statistics imply because they leave out the effect of the variability and uncertainty of travel times. For the first time ever, the 2012 Urban Mobility Report estimated how much margin for error drivers have to plan for to have confidence that they will not be late more than 5% of the time. For commuting at peak hours in Phoenix, drivers would have to allocate 3.2 times more time than the free-flow time (64 minutes for a 20 minute trip). Congestion is less variable in Tucson, so travelers need to plan for just over twice as much time as in free-flow conditions. Congestion also increases air pollution and thus health care expenditures and lost productivity.

CONGESTION IS NO LONGER PURELY A RUSH-HOUR PHENOMENON

IN SMALLER URBAN AREAS WITH MAJOR INTERSTATE HIGHWAYS, SUCH AS FLAGSTAFF, KINGMAN, AND CASA GRANDE, THROUGH TRAFFIC ADDS GREATLY TO LOCAL CONGESTION

Figure 4.3 Congestion Costs and Delay Hours in Phoenix and Tucson, 1980-2012



Source: Data from Schrank, D., B. Eisele, and T. Lomax (2013). "TTI's 2012 Urban Mobility Report." Texas A&M Transportation Institute.

Although congestion is worse in larger cities, delays also affect residents of smaller cities. Nationally, streets account for more total delays than freeways.[84] In cities and towns with no freeways or interstates, all traffic—including through traffic—is funneled onto main streets and state highways. In smaller urban areas with major interstate highways, such as Flagstaff, Kingman, and Casa Grande, through traffic adds greatly to local congestion.

Recurring congestion is a problem driven by an imbalance of supply (in lane-miles) and demand (in vehicle-miles traveled) at a given time and place (see Figure 2.1). According to a 2005 FHWA report,[85] bottlenecks account for 40% of the congestion, traffic incidents (including crashes) and stalled vehicles for 25%, weather for 15%, and work zones for 10%. Poor traffic-signal timing and special events each account for 5% of congestion. These percentages may vary depending on the region and season, but these causes are fairly universal. Because of this, managing congestion calls for comprehensive strategies that tackle both supply and demand.

Supply-side measures include expanding road capacity in critical corridors to alleviate bottlenecks, but are not limited to adding lane miles. It is also important to get as much service as possible from existing roads by improving roadway operation. Management mechanisms include ramp metering, signal timing, crash removal, improved intersection designs, and traveler information among others. Many of these measures are more cost-effective and can be implemented faster than new roads and lanes.

Demand-side measures include policies that change the usage patterns of roads and provide alternatives to driving. Any strategy that reduces the number of vehicles or the miles driven at the most-congested locations and times is considered demand side. Peak-hour travel can be reduced by flextime, telecommuting, carpooling, land-use planning for smart growth, and transit-oriented development (see Chapter 3) as well as mode-shifting to biking, walking, and mass transit. In fact, the 2012 Urban Mobility Report estimates that if public transportation were discontinued and riders had to switch to private vehicles, the US would suffer 865 million hours of additional delay, adding $21 billion in time and fuel costs. In Phoenix, public transport saved 2.5 million hours and $61 million in congestion costs. In Tucson, savings were 606,000 hours and $14.8 million.[86]

Besides reducing congestion and related costs, spending on public transit systems are also great investments in a local economy. According to the American Public Transit Association, every billion dollars spent on public transportation produces more than 16,000 job-months—twice that produced by the same spending on highways. Furthermore, every dollar invested in public transportation generates four dollars in economic returns overall.[87]

AIR TRAVEL

WITH LAURENCE GESELL

In 2013, ADOT completed a study on The Economic Impact of Aviation in Arizona, 2012,[88] which estimated direct and indirect aviation-related employment at 409,000 jobs (16.8% of Arizona employment) and $58 billion of economic activity. Of this amount, direct employment in aviation itself accounted for 185,000 jobs and $32 billion of activity. The remainder is in aviation-related activity, including aerospace manufacturing, airline and airport operations, tourists who arrive by air, flight training, and Air Force bases. Arizona's excellent flying conditions give it an advantage for flight and military training, and we have the 4th most flight instructors in the US. Almost 10 million out-of-state visitors arrived by air in 2011. The ADOT report breaks these totals down further by airport and industry. While not all aviation-related activity brings in money and thus jobs from out-of-state customers, a substantial portion of it does.

The basic infrastructure, runway capacity, and the level of service at most of the state's airports are generally good.[89] In 2008, the FAA predicted Phoenix to be one of 15 metropolitan areas that could become "capacity locked" by 2025,[90] but the development of Phoenix-Mesa Gateway Airport seems to have allayed that threat, and the most recent report does not highlight Phoenix.[91] Concerns about future capacity, however, remain. The third Sky Harbor runway has limited utility in poor weather conditions, and is shorter than the two main runways. Additionally, there is an airspace conflict with Gateway, which makes its utility limited as well because Sky Harbor must trade off some of its airspace capacity in order for airplanes to use Gateway. Moreover, connectivity between Gateway and Sky Harbor is poor. Another parallel runway is the most effective way to add capacity, but construction of a fourth runway faces major political, financial, and environmental obstacles. Meanwhile, Tucson International Airport no longer offers any direct flights to international destinations, which hurts Tucson's economic competitiveness, especially for conducting business with Mexico.

PARK-RELATED TOURISM

WITH DAVE WHITE AND JESSICA AQUINO

Tourism is the state's largest economic sector in terms of employment.[92] Arizona's remarkable landscapes include many outstanding examples of our natural and cultural heritage that have been preserved for present and future generations. There are 22 National Park System (NPS) units in Arizona—more than in any other state. Included among these jewels are Saguaro National Park, Petrified Forest National Park, and the crown jewel, Grand Canyon National Park (GRCA). A number of Arizona towns serve as gateway communities for park visitors. Their economies are dependent on them, and they are influenced in positive and negative ways by park-related travel.

By the numbers IV: National Park Tourism, 2012 or 2013

Total National Park Visitors in Arizona	10.1 million[a]
Economic Benefit of National Park Tourism in AZ	$774 million[a]
Visitors to the Grand Canyon National Park	4.4 million[b]
Grand Canyon Shuttle System	
Boardings	6.1 million
Income	$6 million[b]
Grand Canyon Railway Passengers	130,191[e]
Vehicle Miles Traveled in National Parks, US Total	2.4 billion[c]
Maintenance Backlog of NPS Transportation Facilities, US Total (the low estimate)[d]	$9.1 billion

Sources: (a) NPS, Working with Arizona: By the Numbers, 2013. (b) NPS Grand Canyon National Park, Park Profile 2013. (c) NPS, Final NPS Alternative Transportation Program, Strategic Action Plan, 2012-2016. (d) DOI Grow America Fact Sheet, (e) NPS, NPS National Transit Inventory, 2013.

Outside of our designated parks and monuments, our cities, towns, Indian reservations, and forests are major tourist attractions. Golfing, resorts, spas, art galleries, and conventions are a major attraction within and near the Phoenix and Tucson areas. These tourist activities also depend on transportation to move visitors to and within them. In the Santa Catalina Mountains north of Tucson, for instance, flooding has repeatedly washed out the road into Sabino Canyon, and the scenic Mt. Lemon Highway suffers from stop-and-go traffic congestion and seemingly endless construction. In rural areas, skiing, horseback riding, boating, all-terrain vehicles, the arts, the old west, casinos, and simply getting out of the heat are popular activities that draw in-state and out-of-state visitors. The fabulous red rock scenery of the Sedona area, which attracts close to 3 million tourists annually,[93] is located in a mix of national forest, state parks, municipal, county, and federal land.

In addition, seasonal visitors flock to Arizona each winter—an estimated 300,000 in 2002-2003.[94] These visitors spend money in Arizona that was earned elsewhere, which makes hosting them a basic economic activity for Arizona. The 106th Town Hall Report on Arizona's Economy notes that quality of life—which includes traffic congestion as well as walkability and bikeability—are a greater influence on the number of visitors a state receives than on the number of businesses it attracts.[95]

Today, the automobile is the dominant mode of travel, not only to and through our parks and monuments, but also to casinos, rural attractions, and urban resorts. The conflict between preservation of the parks and visitor expectations about automobile access has been a persistent issue for the NPS and other land managers. Parks, small tourist towns, and rural attractions have experienced traffic congestion, crowding, parking shortages, air and noise pollution, and impacts to wildlife and roadside vegetation since automobiles use expanded in the post WWII era.

Economic Impact of Bicycling in Arizona

In 2012, ADOT's Multimodal Planning Division completed a study of out-of-state bicycle tourists and exports. The study covered manufacturing, wholesaling, retail and service, and events such as organized tours and triathlons. The study found over 250 annual events attract 14,000 participants from outside Arizona plus another 24,500 visitors who travel with the participants. Bike tourists tend to be more educated and have higher incomes. The study estimated the direct and indirect economic benefits at $31 million and 404 jobs.

Source: ADOT Multimodal Planning Division. An Economic Impact Study of Bicycling in Arizona: Out-of-State Bicycle Tourists and Exports Executive Summary, June 2013: ntl.bts.gov/lib/47000/47700/47739/Economic_Impact_Study_of_Bicycling-Executive_Summary-1306.pdf.

Tradeoffs also exist for tourists. Recent research on transportation in national parks identified three dimensions of the transportation experience—freedom and access, environmental responsibility, and stress and conflict.[96] Visitors more strongly associated freedom and access with private automobiles than with park shuttles. Visitors valued their cars for many of the same utilitarian reasons that they value their cars when traveling around home and work, including convenience, safety, ease of movement, and access. Park tourists, however, also associated traveling by car in the national park with stress, parking difficulties, crowding, conflict, and delays. Visitors also strongly associated park shuttle bus systems with affordability, connection with the natural environment, lower environmental impact, and less congestion.

Designated a national park in 1919, the Grand Canyon has experienced congestion and parking problems since the 1920s. By 1974, the park had introduced an optional, free shuttle-bus service to reduce the traffic congestion caused by nearly 3 million annual visitors entering the park annually.[97] The NPS reported that the large majority of visitors come through the South Entrance Station, and of those, approximately 75% traveled by private vehicle, 19% by tour bus, and 6% by the Grand Canyon Railway. A voluntary park-and-ride shuttle bus offered in the summer from Tusayan enables visitors to leave their vehicles outside the park.

In addition to on-road congestion, off-road transportation also impacts parks. Recent research estimates that approximately 20% of adults in the state (over 1 million people) participate in motorized recreation on trails in Arizona.[98] Land managers are concerned about off-highway vehicle (OHV) impacts such as damage to vegetation, soil erosion, impacts to air quality, habitat fragmentation, lack of law enforcement, and vandalism.

There is a growing market for non-motorized adventure travel or ecotourism. Sedona has become a mecca for mountain biking and road biking in addition to traditional pursuits of hiking, golf, galleries, and restaurants. The main highway into Sedona, AZ-179, was redesigned with biking in mind (see Chapter 9).

INTERNATIONAL TRADE

WITH STEPHEN BLANK, RICK VAN SCHOIK, AND ERIK LEE

Arizona is part of the North American economic system and its transportation system can be viewed as part of a telescoping local-to-continental system. It is therefore essential that the state addresses transportation issues not only in the context of Arizona and the nation, but also in a comprehensive North American context.

The North American Free Trade Agreement (NAFTA) was signed by the United States, Canada, and Mexico in 1992. There is more to the "North American economic system," however, than traditional trade, or the exchange of finished goods among independent actors. We don't trade with each other as much as we make things together. For example, there is no separate Canadian, Mexican, or even US auto industry. Instead, companies that manufacture parts and components, and those that assemble the final vehicles, are sited in all three countries and linked by supply chains that cross national borders. Parts, components, and systems move up and down these international supply chains until the final assembly stage. The finished autos may move across borders again to be sold. The same is true in other industries.

By the numbers V: NAFTA

"NAFTA created the world's largest free trade area, which now links 450 million people producing $17 trillion worth of goods and services."

Source: Office of the United States Trade Representative: ustr.gov/trade-agreements/free-trade-agreements/north-american-free-trade-agreement-nafta.

The volume of goods moving across our borders increased dramatically after NAFTA was signed. From 1993 to 2012, trade of goods among the NAFTA nations nearly quadrupled, from $289 billion[99] to $1.1 trillion (including shipments among establishments within the same company). Another $100 billion of services were traded among NAFTA partners.[100] Canada ($300 billion) and Mexico ($226 billion) were the top two destinations of US exports, and the second- and third-ranked sources of US imports (Canada $332 billon, Mexico $281 billion).

Near-shoring

In contrast with "off-shoring" manufacturing to low-wage countries mostly in Asia, near-shoring is the current trend of moving manufactured goods production closer to the USA in Mexico. While wages in China were 24% lower than in Mexico as recently as 2002, Chinese wages have risen steadily and had closed the gap to 14% by 2010.

Source: Nevada DOT and ADOT (2014). I-11 and Intermountain West Corridor Study Business Case." i11study.com/wp/wp-content/uploads/2012/12/Business_Case_v21_with-UpdatedAppendixA.pdf.

Arizona's exports in 2011 were valued at $17.9 billion, up 25% since 2000, but still recovering from the recession.[101] Mexico is Arizona's leading export partner, as shown in Table 4.1. The Trade Benefits America organization estimates that Arizona's foreign trade is responsible for 711,000 jobs, and that the share of Arizona jobs related to trade has doubled from 11% to 22% since 1992.[102]

Table 4.1 Value of Exports with Arizona's Leading Trade Partners, 2012

	Goods	Services Exports	Total
Mexico	$6.1 billion	$418 million	$6.5 billion
Canada	$2.0 billion	$1.1 billion	$3.1 billion
China & Japan	$2.2 billion	$1.4 billion	$3.6 billion

Source: Trade Benefits America. How Arizona's Economy Benefits from International Trade and Investment.

Arizona plays various roles in the transportation of imports and exports, such as:

- An origin and destination
- A land bridge—the rail and road conduit from seaports and airports elsewhere into the interior of US
- An inland port—a multi-modal, container-transfer station located away from the congestion of actual ports
- A North American trade corridor, e.g., CANAMEX.

Good transportation infrastructure is critical for facilitating international trade, starting at the border. Arizona's border with Mexico has nine land ports of entry (LPOE). For goods crossing over from Sonora, Arizona was the destination for 23% of the followed by Michigan (17%) and California (6%).[103] Most goods imported through our LPOEs are from maquiladora factories, but Arizona is also the leading state for fresh produce entering the US from Mexico.[104] Nogales is by far our busiest LPOE, and the only one that connects directly to an interstate highway or currently operational railroad. Yet Nogales ranks only 5th for land trade with Mexico, with $23 billion (5.8%) of trade in 2012, far behind Laredo (40.4%) and El Paso (16.2%).[105] Following Nogales, the ports of San Luis, and Douglas consistently rank 2nd and 3rd in crossings by trucks, passenger vehicles, and pedestrians. Buses are the only exception to this 1-2-3 ranking, with Nogales followed by Douglas and Lukeville (Table 4.2). For AZ-Mexico Interactive Statistics, see: azmex.eller.arizona.edu/about/az-mex-map-gallery.

By the numbers VI: Border Crossings

23 million	people crossed the Arizona-Sonora, Mexico border in 2010
30%	the proportion who crossed on foot

Source: ADOT, Arizona-Sonora Border Master Plan, azdot.gov/docs/default-source/projects/azsb-executivesummary.pdf?sfvrsn=4.

Borderlands

Borders are artificialities of treaties and wars. Originally intended to be frontiers and dividing lines, they are increasingly populated and increasingly crossed by people, produce, products, resources, ideas, investment, pollution, and wildlife, via pathways regulated or not. Borders are the organizing mechanisms for trade and other flows between sovereign countries, but they also hinder trade, tourism, and transportation because of the necessary infrastructure and security activities. Unfortunately, prosperity for the nation's interior imposes congestion costs at the borders. Inspections, clearance activities, and processing at land ports of entry regularize flows but are inadequately designed and staffed, creating congestion for both vehicles and people.

Many industries and jobs in Arizona depend on unimpeded flows in and out of entry ports—and minutes matter to businesses that depend on just-in-time logistics systems. Our 2009 Town Hall report on transportation expressed serious concern about Arizona's border-crossing and security infrastructure, which had reached or exceeded capacity. Following 9/11, border wait-times increased after security was tightened, adding significant costs to trade, especially at Nogales. Since then, thanks in part to the federal ARRA stimulus package, over $450 million in state and federal funding has been invested in improvements to border infrastructure, including a $225 million project to modernize and expand the port at Nogales-Mariposa.[106] With double the number of lanes, inadequate staffing of lanes is now the main impediment. In San Luis, a new entryway (San Luis II) was constructed for commercial traffic only, but congestion remains at San Luis I, which is used by cars, bikes, and pedestrians. ADOT is partnering with FHWA and Texas A&M to pilot test a system using intelligent transportation systems technology to make wait-time information available in real-time.[107]

Table 4.2 Northbound Crossings at Arizona Land Ports of Entry (2013)

Port	Truck & Bus Crossings Commercial Lanes	Passenger Vehicle Crossings and Lanes	Pedestrian Crossings and Lanes
Nogales	311,669 trucks	3,162,4511	2,912,077
San Luis	33,402 trucks	2,948,504	2,315,369
Douglas	32,497 trucks	1,470,933	1,804,110
Naco	3,947 trucks	284,677	81,146
Lukeville	53 trucks	289,997	40,699

*Rail data are for 2010.

Source: Bureau of Transportation Statistics, http://transborder.bts.gov/programs/international/transborder/TBDR_QuickSearch.html.

ADOT completed an Arizona-Sonora Border Master Plan in 2013, developed with the Federal Highway Administration (FHWA) and Mexico's Secretaría de Comunicaciones y Transportes, and the state government of Sonora, Mexico.[108] This report considered bottlenecks and mismatched capacity on both sides of the border. The highest-priority projects were two projects on the Sonoran side where matching improvements are needed in response to recent improvements at Mariposa and Lukeville on the Arizona side. Next highest were additional facilities to process pedestrians and passenger vehicles at San Luis II on both sides of the border. Full modernization of Douglas and Agua Prieta LPOEs were next. The report also recommends that an Implementation Monitoring Committee be formed representing the highest levels of all affected governments and other key stakeholders. In addition, ADOT has partnered with the Arizona-Mexico Commission, the Arizona Commerce Authority and Office of Tourism on a Transportation and Trade Corridor Alliance (azttca.org/index.aspx).

Upgrades of existing port-of-entry infrastructure will eventually have to contend with increased traffic expected at the Mexican port of Guaymas, a deepwater port on the Gulf of California connected by rail to Nogales (see Spotlight on Guaymas in Chapter 9). However, because current needs are considered pressing, the Arizona-Sonora Border Master Plan ranked Guaymas and potential new LPOE facilities elsewhere aimed at serving future demand as the lowest priority.[109]

Border security issues—such as illegal immigration, drugs, and terrorism—are also transportation issues. The Arizona-Mexico border comprises 351 of the approximately 7,000 miles of remote borders the United States shares with its two neighbors. The post-9/11 security paradigm of tightened border security is enormously difficult to achieve and has had negative consequences for cross-border trade. This paradigm has been imposed on an already highly complex post-NAFTA context of greatly expanded North American trade and a problematic security situation in Mexico. The Department of Homeland Security (DHS), with its Customs and Border Protection (CBP) Administration, has become the de facto border czar for infrastructure, displacing both the US Department of Transportation and the Government Services Administration. Nevertheless, no single agency is formally charged with the primary responsibility for monitoring use, developing scenarios for port usage requirements, or identifying infrastructure problems at the border or on the roads on either side of the border.

THE PROPOSED I-11 CORRIDOR

A number of the issues discussed in this and previous chapters—congestion, trade, border ports, the Sun Corridor megapolitan—coalesce around the proposed Interstate-11 corridor from south of Phoenix almost to Las Vegas with potential extensions south to the Mexican border and beyond and north to Canada (i11study.com). This concept has been discussed for several decades, and was originally a key part of the CANAMEX corridor, which the 1995 National Highway Systems Designation Act defined as a "High Priority" trade corridor immediately after the passage of NAFTA. CANAMEX was a collaborative project of Arizona, Nevada, Idaho, Utah, and Montana "with the goals of stimulating investment and economic growth in the region and enhancing safety and efficiency within the corridor."[110]

A number of justifications are offered for I-11:

- Fill in a gap in the original interstate highway system. Traveling from Phoenix to Las Vegas currently requires traveling on US 60 and US 93, with short stints on of I-10, AZ 303, and I-40.
- Connect Arizona and Las Vegas better to our trading partners in Mexico and Canada, so we can integrate our manufacturing processes and strengthen other economic ties.

THE I-11 CORRIDOR IS BEING ENVISIONED AS MORE THAN JUST ANOTHER HIGHWAY;

IT COULD ALSO INCORPORATE FREIGHT AND PASSENGER RAIL, POWER TRANSMISSION, AND TELECOMMUNICATIONS

- Relieve congestion on other north-south interstate highway corridors, such as I-5 on the Pacific Coast or I-15 from Los Angeles to Las Vegas.
- Relieve congestion at the Port of Los Angeles and Long Beach by shipping Asian traffic through Guaymas and Nogales to the proposed I-11.
- Enhance inter-linkages among the three Southwest megapolitan regions—Arizona's Sun Corridor, the Las Vegas area, and Southern California—with a population approaching 30 million. The other two legs of this "Southwest Triangle" are served by I-10 and I-15.
- Capture more of Mexico-US throughput at Arizona land border ports, which currently handle less than 10% by value of such border crossings.

The 2014 Arizona Town Hall on the economy recommended going forward with I-11.

The I-11 corridor is a long-term proposal that will likely take well over a decade to plan, evaluate, finance, and construct, although certain pieces of it could be put into place earlier and produce immediate benefits of smoother passenger and freight travel. The exact alignments are not set yet, especially between Casa Grande and Wickenburg and near Las Vegas, but you can zoom in to view the recommended alternatives (Figure 4.4) in more detail at: i11study.com/wp/wp-content/uploads/2014/09/Figure7RecommendedAlternatives.jpg.The study also identifies eight "segments of independent utility" between Nogales and Las Vegas that would produce dividends, even if done separately from the other seven.

ADOT and Nevada DOT (NDOT) have developed exploratory plans and a business case for the I-11 project.[111] The studies were conducted in consultation with the Federal Railway (FRA) and Highway (FHWA) Administrations as well as Maricopa Association (MAG) and the Regional Transportation Commission of Southern Nevada. The report includes a traditional Benefit-Cost Analysis that analyzes the cost of capital, acquiring land (right-of-way), and then operation and maintenance (O&M) costs over the lifetime of the project. The "travel benefits" are typically computed as travel cost savings in time, money, and safety relative to "business as usual" traffic.

The study estimated costs of $12-13 billion versus travel benefits of $26-39 billion, for a benefit-cost ratio between 1.2 and 3.0 (Figure 4.5). Ratios above 1.0 indicate an economically beneficial project. The ADOT/NDOT study views this as a conservative estimate of the benefits, as it does not account for "the wider economic benefits that are usually associated with major infrastructure investments."[112] For an upper bound, they conducted macroeconomic analyses of several scenarios of "induced economic activity derived from other activities, such as releasing pent-up demand, enhancing land values by improving access, and transforming the regional economy by improving competitiveness and attracting new classes of industry that would not have occurred without the Corridor."[113] These analyses estimated $4-24 billion of wider economic benefits, although the report cautions against adding the induced economic benefits and the travel cost savings benefits together because some benefits would be double-counted.

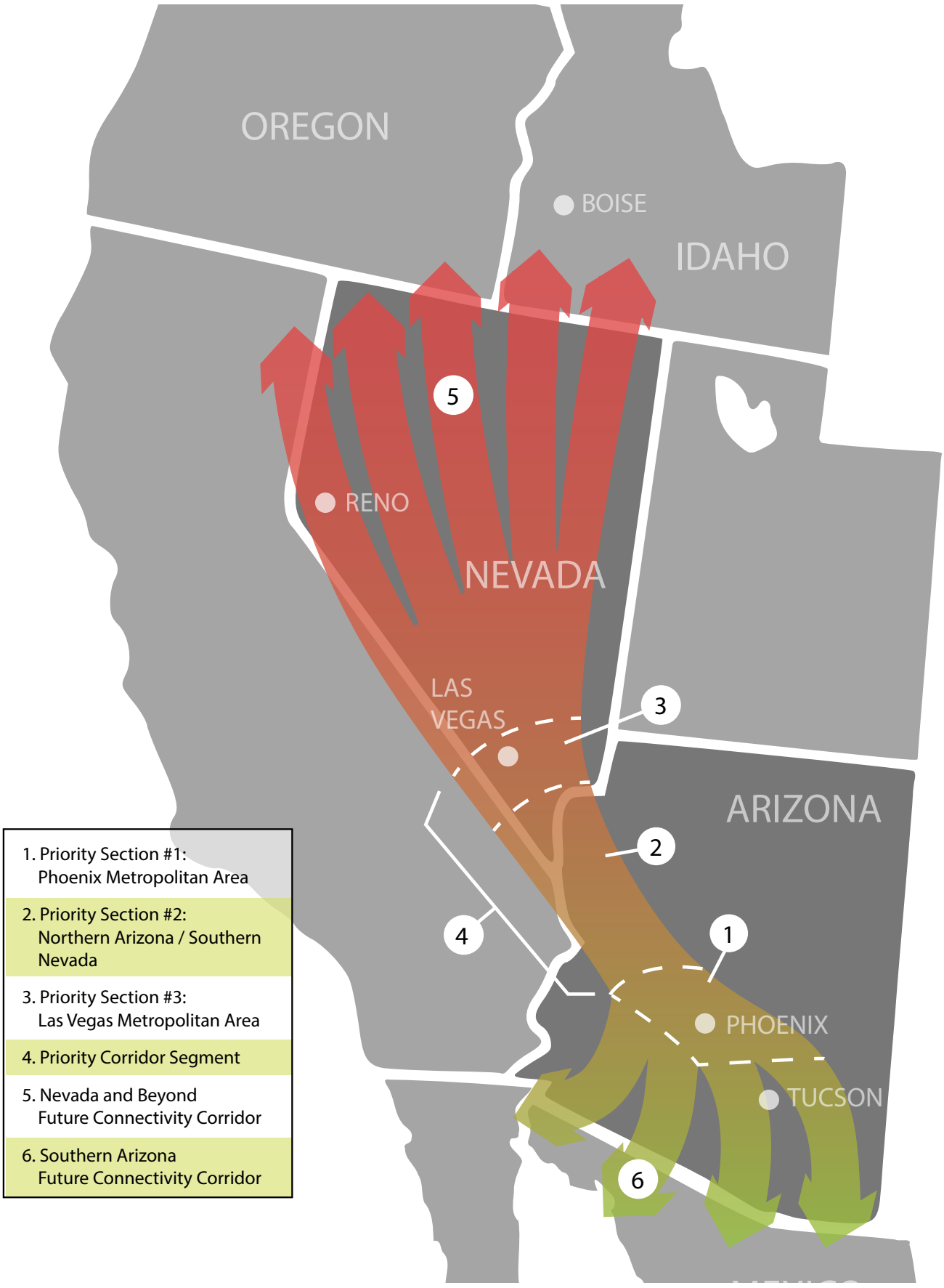
Some opponents of I-11 point to the omission of environmental costs (local/regional air pollutants, greenhouse gases) from the benefit-cost analysis, although there will be some offsetting environmental benefits from reduced stop-and-go traffic and idling of vehicles.[114,115] In addition, many transportation and land-use experts do not view all induced development and traffic as a good thing, and are concerned that, like most interstates developed primarily for through truck traffic, they will be quickly taken advantage of for extended commuting to Tucson and Phoenix, promoting urban sprawl and impacting existing rural areas.[116,117]

ECONOMIC BENEFITS OF INTER-CITY PASSENGER RAIL

- Productivity - Enables people to work on their laptops, read, or simply rest during the train ride.
- Employment - Promotes access to jobs, which are clustered in Phoenix and Tucson, and economic growth.
- Cultural and Economic Centers – Promote access to major governmental, educational, cultural, medical, recreational, and financial institutions many of which are housed in Arizona's two metropolitan areas.
- Tourism - Improve tourist access to Maricopa and Pinal counties, where 75% of tourism dollars are spent.
- Air Travel Substitute –Enable air passengers between Phoenix and Tucson to switch to rail if it fits their travel plans and budgets.
- I-10 Congestion - Reduce traffic on I-10 between Phoenix and Tucson and make widening the freeway less imperative, thus avoiding problems with bridges and environmental impacts. ADOT's Phase II report estimates the cost for widening I-10 to 10 lanes (5 northbound and 5 southbound) between Phoenix and Tucson at $2.6 billion.
- Environment - Decrease CO2 emissions by thousands of tons each year.

Source: Croucher, Matthew, Timothy James, and Eva Madly. Long-Distance Passenger Rail, From Here to There: Transportation Opportunities for Arizona, 94th Arizona Town Hall, Ch. 12, 2009.

Figure 4.4 I-11 Recommended Alternatives

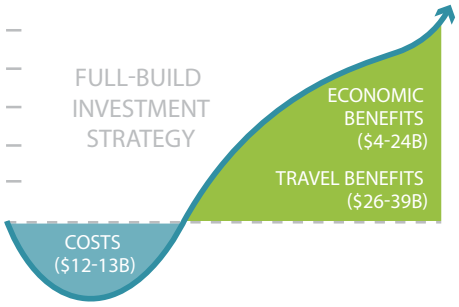


Source: i11study.com

The I-11 corridor is being envisioned as more than just another highway. The ADOT/NDOT study mentions the potential for co-locating multimodal infrastructure, such as freight and passenger rail, power transmission, and telecommunications. Ten or twenty years ago, these elements would likely not have been considered part of the design and planning, but the idea of multipurpose, more sustainable, "next generation infrastructure" projects is gaining momentum (see Chapter 8), including within the National Academy of Engineering.[118] The transformative potential of the I-11 mega-project or "supercorridor" has been studied by the Sonoran Institute (sonoraninstitute.org/where-we-work/southwest/interstate-11-analysis.html) and students and faculty at the major state universities of Arizona and Nevada (i11supercorridor.weebly.com/).

The Sonoran Institute study similarly decries the current infrastructure model that usually involves "parallel yet distant" corridors for rail, electricity transmission, and telecommunications that "exponentially increase the harm to natural landscapes and wildlife," and discourage clustered and attractive development alongside it.[119] It recommends an "Energy Preferred Alternative" that "avoids impacts on environmental resources, provides maximum value to renewable energy development opportunities, [and] accommodates multiple modes," while also satisfying the freight needs identified in the ADOT/NDOT studies.[120]

Figure 4.5 Estimated Costs and Benefits of I-11



Source: ADOT I-11 Business Case. i11study.com.

CHAPTER 5

TRANSPORTATION AND SOCIETY

This chapter evaluates issues concerning transportation and the advancement of Arizona residents of various ages, backgrounds, and abilities. The chapter strives to represent the diversity of Arizona's constituents. We pay attention to changing demographics, needs, and attitudes as baby boomers retire and millennials join the workforce. We inform the readers that transportation plays a critical role for both urban and rural residents of the state, as well as residents of varying socio-economic backgrounds.

KEY POINTS

- Mobility is a challenge for many members of our society, especially workers, seniors, children and the disabled.
- Arizona is not prepared for the coming age wave of senior citizens, most of whom grew up driving
- How we travel has a significant impact on our health, especially for children.
- On average, rural households earn lower incomes, drive farther distances, and have fewer transportation choices.
- Tribal areas face concerns about safety, rights of way through and alongside their reservations, and the impacts of those rights of way on air quality and cultural resources.
- Arizona's roadways remain some of the most dangerous in the country; our fatality rate is double that of the safest states, though it has been declining in recent years.

COMMUNITIES

In this section, we present quick snapshots of different social groups whose daily lives depend on transportation investments and policies. Clearly these groups overlap, as do their travel patterns and needs. Still, we hope that these snapshots can highlight particular issues important to the Town Hall's discussions as they impact these different populations.

COMMUTERS

"Commuting" is the term used to describe the daily trips to and from work. Facilitating a faster and more efficient commute is often the central focus of transportation investments and policies. This is the case in the United States, even though commuting's share of travel has fallen from 26% of all trips in 1969 to 16% in 2009.[121] Its small and shrinking share of travel notwithstanding, commuting is important because most of it occurs in two small time windows—the morning and afternoon rush hours. This rush places large demands on transportation infrastructure as the system must be equipped with enough freeway lanes, buses, trains, etc. to carry everyone traveling in these very compressed time periods. If those same trips were spread over a longer time period, streets and freeways could be narrower and transit companies could own and maintain fewer buses and trains. Our current patterns of living and working in different places and with broadly uniform work times beginning around 8 to 9 am and ending around 5 to 6 pm adds a huge stress to our transportation system. Work trips are also slightly longer than the average trip, with the effect that commuting accounts for 19% of person-miles traveled compared with 16% of trips.

Commuters therefore have particular needs when it comes to travel, including travel speed and dependability. In addition to their efforts to maximize throughput capacity via freeway, street, intersection capacity, and public transit system investments, public agencies also work to improve the dependability and information available to the commuter to reduce their stress while traveling. Intelligent transportation system applications such as smarter intersection signal timing, ramp metering that evens out traffic flows, and variable message signs that give travelers information about expected delays and travel times, all aim to improve performance during important peak hours (See box on Intelligent Transportation Systems on page 25). Also, slow but significant changes to technology and business practices allow more people to telecommute and alter the traditional "work week," adding more and more jobs to weekends and around-the-clock shifts.

Improving peak-hour travel conditions benefits not only commuters, but also the entire economy dependent on workforce punctuality. The nation counts on nearly 137 million workers; the most mobile group of residents compared to the unemployed, children, and retired people. The 53% of the population that is employed accounts

for more than 65% of all person-miles traveled.[122] To be clear, these are not all commuting trips, which account for only 19% of person-miles traveled. Commuters make many other kinds of trips because they are in an active stage of life. They may have children, requiring the need to go many places. In addition, they are generally in good health and have disposable income that enables them to do many things.

Historical trends, which have added considerably to the overall size of the workforce, are showing signs of changing. A significant reduction in growth of total workers is expected over the coming decades.[123] Exactly how this will affect the role of commuting in our transportation planning and infrastructure is hard to predict at this point.

In Arizona, key commuting issues arise in the larger metropolitan areas where major daily flows of commuters strain the transportation infrastructure. In the Phoenix area, 71% of peak hour travel miles are in congested conditions. Congestion on area roads and freeways typically totals 5 hours per weekday exhibiting congested conditions. For Tucson, those measures are 61% and 2.5 hours, respectively.[124]

AGING ARIZONANS

In 2013, roughly 15% of the population of Arizona was over 65; almost 70,000 Arizonans were older than 85. These figures will likely grow as an age wave is expected to hit Arizona in the next three decades, driven by aging of the existing population as well as a continuing influx of retirees. By 2050, the over-65 population of Arizona is expected to expand to 2.4 million people, from under 1 million in 2012, accounting for more than 21% of the state's population.[125] Similarly, by 2040 the population aged 45-64 will grow by more than 1 million, ensuring successive and growing waves of Arizonans turning 65 throughout most of the 21st Century.

How might this substantial growth in aging population affect our current transportation planning and investments? In the 2009 Arizona Town Hall report on transportation, planner and gerontologist Sandra Rosenbloom (formerly of the University of Arizona) painted a fairly pessimistic picture of how planning practice in Arizona was addressing the needs of the growing elderly population:[126]

> There is little evidence that Arizona is prepared for the challenge of the coming age-wave, the impacts of so many older drivers on the state's highway system, or older people's needs for mobility and access when they can no longer drive but wish to remain active and independent. The actions of older citizens themselves, and the apparent lack of appropriate responses now on the part of public and private decision-makers, may doom older Arizonans in the future to a life of dependence on others, and ultimately to isolation and illness.
>
> And, if the past is a prologue to the future, few older Arizonans will themselves make the kind of housing and other decisions that would support their lifestyles when they can no longer drive. Over three-fourths of all Americans over 65 live in suburban or rural areas; and Arizonans are no exception. University of Arizona and ASU studies show why: most older migrants to the state move to the outskirts of metropolitan areas. (p. 185).

BACK TO THE LECTURE HALL 5.1

QUALITY OF LIFE

Transportation systems create benefits and burdens that can have significant impacts on quality of life. Time lost in congestion; traffic and safety risks in neighborhoods; noise and air pollution; and the blight and barriers created by transportation infrastructure can create significant burdens on certain locations and neighborhoods. On the other hand, transportation creates accessibility by connecting locations to the rest of the region. Transportation infrastructure, such as transit stations or canal paths, can become positive amenities that attract business and make them pleasant places to spend time. Governments and planners that work for them should consider carefully how their transportation plans contribute to quality of life.

By the numbers VII: The Elderly Are Heavily Reliant on the Automobile

Licensing rates among older adults in the United States are very high, but are falling as younger groups with lower licensing rates age into adulthood (see also Figure 13 in Ch. 1):

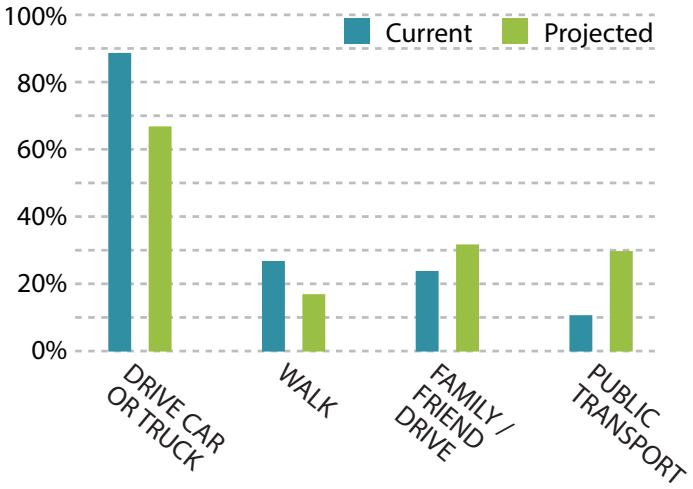
- In 2012, 83% of those over 65 were licensed drivers, down from 85% in 2010
- In 2012, 59% of those over 85 were licensed drivers, down from 61% in 2010

There is a great disparity between Men and Women licensing rates in these older age groups:

- In 2012, 95% of men over 65 are licensed, compared to 76% of women
- In 2012, 81% of men over 85 are licensed, compared to 48% of women

Source: FHWA Table DL20. fhwa.dot.gov/policyinformation/statistics/2012/dl20.cfm.

Figure 5.1 Current vs. Ten Year Projected Modes of Transportation for Aging Adults



Source: Maricopa Association of Governments (2012) Municipal Aging Services Plan - Planning for the Next 100 Years, p. 23.[127]

To plan for growing and potentially unaddressed needs for aging adults, MAG's Municipal Aging Services Project[128] identified key challenges and solutions to address the mobility needs of older adults. Figure 5.1 shows the expected changes in travel according to their surveys of seniors in Maricopa County. Many of the key recommendations are relevant to our discussion of transportation priorities more broadly, some of which we highlight here:

Support people aging in place

- Integrate aging in place into planning processes
  - Add action/elements that support aging in place to general plans and other municipal planning documents
  - Conduct studies utilizing community engagement to ascertain how proposed services will impact people age 65 and older
  - Include specific elements for Request for Proposal (RFP) processes that support people aging in place
- Make it possible for people to age in place through program and service options
  - Provide ways of serving seniors in their homes and close to their homes
  - Ensure safety through fall prevention
  - Promote preventative health services
  - Meet caregiver needs

Promote transportation options

- Provide alternatives to the car
  - Utilize taxi-cab voucher programs
  - Focus on integrated approaches
  - Increase accessible transportation options
  - Increase visibility and awareness
- Promote safe roads and safe drivers
  - Develop complete streets
  - Create walkable communities
  - Support safe driving
  - Conduct road safety assessments

We now turn to some key issues that arise as communities try to implement some of the main solutions mentioned in the MAG recommendations.

Driving. A 2000 MAG Regional Action Plan on Aging highlighted the fact that, unlike previous generations of elderly Americans, today's aging population is "unfamiliar with other modes of transportation. Most grew up driving and are often hesitant or unable to learn new modes at an advanced age. Given current land-use trends and lifestyles, tomorrow's senior citizens, especially those aging in the suburbs, are likely to be even more reliant on their automobiles."[129]

Rosenbloom noted that while many older adults will safely drive for years after they turn 65, driving skills decline as we age. Cost-effective courses are needed to retrain older drivers to keep them on the road safely.[130] Loss of personal mobility can lead to social isolation, depression, and sharp declines in volunteering and health. Making driving safer for aging drivers involves altering the dimensions, marking, and contrast of streets and roads, signs, turn lanes, etc. to make roadways and signage easier to use for older drivers.[131] This will also require technology on the road and in the vehicle that provide real-time congestion information to drivers and lane-change or collision warnings. Car-sharing programs in large residential complexes (independent living centers, trailer parks) and retirement neighborhoods could improve access to an automobile for older adults of limited financial means.

Walking. Walking is the second-most important trip mode for the elderly. Among older people with disabilities, the most significant transportation problems are barriers in the pedestrian environment.[132] Older people are involved in more pedestrian crashes than any group except children and they are far more likely to be seriously injured or die than others. People 65 and over constitute 13% of the population but account for 22% of all pedestrian deaths and 32% of all nonfatal pedestrian injuries. In fact, older people are substantially safer as car passengers or drivers than as pedestrians.

If local jurisdictions provide curb ramps, sidewalks, and/or bus stops, these elements must comply with the Americans with Disabilities Act (ADA). Cities, however, are not required to provide these pedestrian elements at any specific location if they do not already exist. Without enforceable standards, many communities have done only the minimum, or have been lax in maintaining the accessibility pedestrian facilities and fail to retrofit built-up areas without sidewalks.[133] Cities can implement pedestrian-friendly measures such as accessible

curb cuts, lighting, pedestrian overpasses or tunnels at busy intersections, which also benefit from better signalization and pavement markings. Traffic-calming approaches to narrow streets, lower speed limits, raised crosswalks, and medians also make walking safer for the elderly. These measures can facilitate safe walking both as a mode itself and to reach public transit stops and can be implemented through subdivision and zoning regulations and impact or development fees.

Public Transit and Community Transportation. Unlike previous generations of the elderly, the vast majority of people 65 and over today have been driving their entire adult lives and never traveled by transit on a regular basis. According to Rosenbloom, older travelers generally express concerns about safety, personal security, flexibility, reliability, and comfort. In general, measures like expanding hours and routes of public transportation, improving safety and reliability, training drivers, providing trip information, and operating low-floor and smaller buses would make public transit more attractive to older travelers. The long walk to a transit stop can be prohibitively difficult for the elderly, making access a problem even for those comfortable taking transit.

To address these issues, many public agencies and transit operators complement their standard fixed-route public transit (e.g. buses) with demand-responsive paratransit services (sometimes called "dial-a-ride") under the mandates of the ADA, mostly funded through the USDOT Section 5310 and Section 5317 grant programs (which is focused on larger urban areas). Examples include Tucson's Van Tran and Phoenix's Valley Metro Dial-a-Ride. These services, however, are not likely to meet the needs of most aging residents simply because most jurisdictions cannot afford to provide enough of these services compared with the number of older people who need them. In Phoenix, for example, the average operating cost for a bus trip is $2.37 compared with over $35 for a paratransit trip.[134]

Furthermore, eligibility for ADA paratransit services is based on disability, not age—and that disability must be severe enough to significantly interfere with the use of traditional public transit. Even among the 42% of older people with at least one disability, many are not eligible for paratransit services.[135] The lack of transit service is not enough by itself to qualify older people for ADA services.[136] Many Arizona transit systems respond by relaxing service-area constraints or allowing all those over 80 or 85 to ride; but, again, there is simply no capacity to expand services beyond the current demand.

Rosenbloom points out that complementary ADA paratransit was designed to be a temporary alternative for most people with disabilities, until all buses and rail facilities were fully accessible.[137] As more transit vehicles, transit stops, and the pathways to them become accessible, operators will be allowed by federal regulations to substantially reduce the paratransit services that they provide. One solution could be community paratransit systems provided by other governmental agencies, non-profit organizations, faith-based groups, and advocates for the elderly. Other solutions might include expanding the role of taxis, or other for-profit transport providers and subscription services such as Ruby Ride (rubyride.co). New ridesharing services such as Uber (uber.com) or volunteer-based services can utilize excess capacity in cars to provide more services for older people as well.

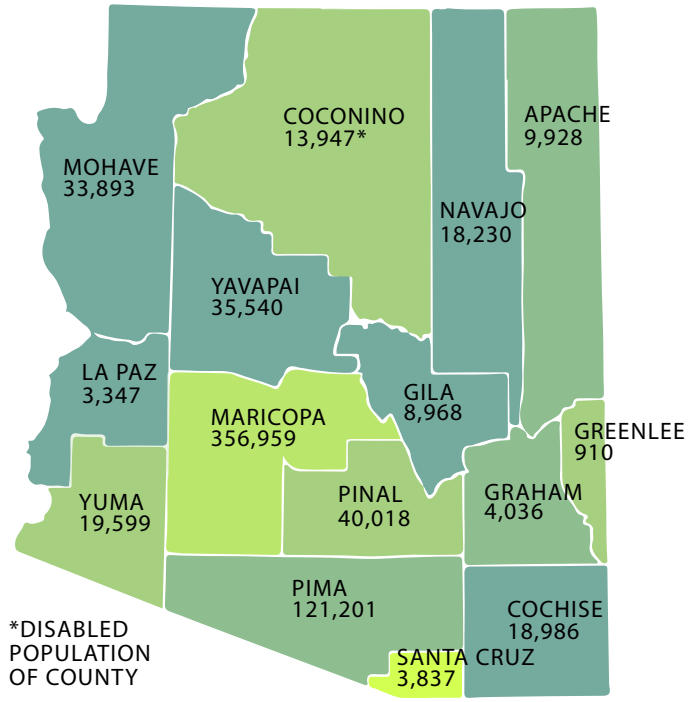
DISABLED ARIZONANS

The US Census Bureau definition of disability combines challenges to vision, hearing, cognitive, ambulatory and independent living—all of which can impact a person's mobility. The scale of this problem is surprisingly large and widespread: disabilities affect at least 10% of Arizonans in every county but one. Services to foster mobility, including dial-a-ride paratransit services and Americans with Disabilities Act (ADA) accessible taxis and fixed route transit services, are thus needed in larger cities, smaller

THERE IS LITTLE EVIDENCE THAT ARIZONA IS PREPARED FOR THE CHALLENGE OF THE COMING AGE-WAVE — THE IMPACTS OF SO MANY OLDER DRIVERS ON THE STATE'S HIGHWAY SYSTEM, OR OLDER PEOPLE'S NEEDS FOR MOBILITY AND ACCESS WHEN THEY CAN NO LONGER DRIVE BUT WISH TO REMAIN ACTIVE AND INDEPENDENT.

towns, and rural areas. Expanding accessible fixed route services are often the most effective means of providing mobility services for disabled residents, as paratransit systems are more than ten times as costly to operate compared to fixed route bus systems. As mentioned earlier in the discussion of aging, there are limited funding programs for paratransit systems through the US DOT under the requirements of the ADA, often funded through Section 5310 and Section 5317 grant programs. Furthermore, eligibility restrictions mean than many who are able to use main-line transit services will not qualify for paratransit services. Many of the solutions mentioned above for aging Arizonans could apply here.

Figure 5.2 Rates of Disability Across Arizona Counties



Source: Map prepared by Meggan Dugan, Arizona State University, using data from the US Census Bureau, American Fact Finder, "Table S1810: Disability Characteristics," 2009-2013, from American Community Survey 5-year estimates. Data reflects imputation of ambulatory difficulty for the civilian non-institutional population 5 years and older.

CHILDREN

Children have special transportation needs. They are dependent on others for travel outside of their immediate surroundings, and also need healthy and safe options for local play and nearby travel. Traditionally, children could walk or cycle locally unaccompanied by a guardian, especially to neighborhood schools or the homes of friends. Unfortunately, wider and faster streets with greater distances have created significant barriers to healthy, safe and independent travel by children.

Even for children who live within one mile of school, walking or cycling to school has dropped by about 60% since 1969 (see By the numbers VIII and By the numbers IX). Distance and traffic danger are the most commonly cited reasons parents give for not allowing their children to walk or cycle to school.[138] As more parents drive their children to school, however, traffic near schools increases. This leads other parents to follow suit, increasing the traffic danger problem.

By the numbers VIII: Walking and Biking to School

Statistics from the 1969 and 2009 National Household Transportation surveys reveal some startling declines over the four decades:

- Children 5-14 years old who "usually" walk or cycle to school: down from 48% in 1969 to 13% in 2009
- K-8 students who live within one mile of school: down from 41% in 1969 to 31% in 2009
- K-8 students living within one mile of school who "usually" walk or cycle to school, down from 89% in 1969 to 35% in 2009

Source: Centers for Disease Control and Prevention (CDC). Safe Routes to School Guide: Introduction. guide.saferoutesinfo.org/introduction/the_decline_of_walking_and_bicycling.cfm.

By the numbers IX: Children and Physical Activity

The percentage of children ages 9 to 13 years who:

Do not participate in any organized physical activity 62%

Do not engage in any free-time physical activity outside of school . . . 23%

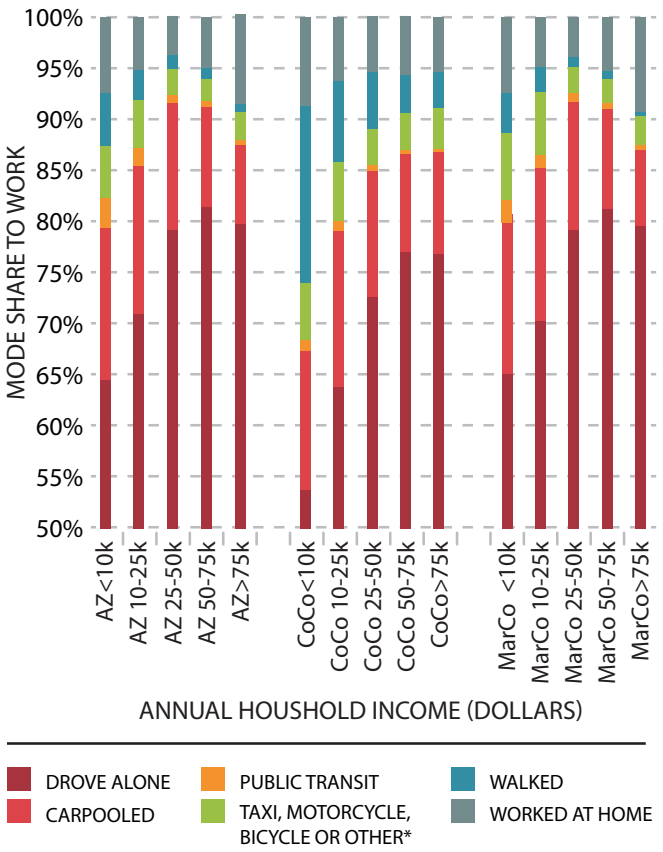
Source: Centers for Disease Control and Prevention (CDC). Safe Routes to School Guide: Health Risks. guide.saferoutesinfo.org/introduction/health_risks.cfm.

Many factors have led to these shifts, from increased real and perceived traffic dangers, to the location of schools on cheaper land on the edge of communities. As more parents drive their children to school, traffic near schools increase and then other parents follow suit, increasing the problem. Distance and traffic danger are the most commonly cited reasons parents give for not allowing their children to walk or cycle to school.[139] National funding programs such as CMAQ (Congestion Management and Air Quality) and TE (Transportation Enhancements) have been developed to assist local governments in improving safety for bicyclists and pedestrians, with benefits for children accessing their school by foot or bicycle. The Safe Routes to School Programs (SRTS), started in the 1990s by grassroots groups across the United States, specifically targets improvements in school access by walking and cycling (saferoutespartnership.org/state/srts-in-your-state/arizona). Congress created a funding program to assist SRTS programs in 2005, now with nearly $1 billion distributed to local governments.[140] See project spotlight in Section 9r for more information about a successful school safety program in Peoria, AZ.

LOW-INCOME FAMILIES

Low-income families face a variety of challenges related to the costs and convenience tradeoffs of different forms of mobility. While relying solely on public transit and forgoing automobile ownership can save households money, the level of service provided by transit in most places is simply not enough for many poorer Arizonans.[141] Figure 5.3 compares the transport mode for commuting for different income levels for Arizona as a whole and for Coconino and Maricopa Counties. It is clear that all income groups in both rural and urban Arizona rely primarily on cars for commuting with nearly 80% of drivers from very-low income (below $10,000) households in Arizona driving alone or carpooling to work. When we focus on commutes made without the automobile, some interesting patterns emerge. Public transit, bicycling, and walking all decline significantly with income. In Coconino County, walking and cycling are more commonly used than in the rest of Arizona, while public transportation is much more commonly used in Maricopa County, especially among the lower-income groups.

Figure 5.3 Commute Mode Share by Income for Arizona (AZ) Coconino County (CoCo) and Maricopa County (MarCo)



Source: US Census Bureau, 2007-2011 American Community Survey, Table B08119: Means of Transportation to Work by Income. (Percentages calculated by author.)

Low-income households that rely on automobiles sacrifice large parts of their budgets to own and maintain them. A recent study of spending by low-income households in California found that those relying on cars spent around 19% of their household budgets on transportation (depreciation, insurance, fuel, maintenance, etc.), third only to spending on housing and food. In contrast, those relatively few households that rely principally on public transportation spent only around 2% of their household budget on transportation.[142]

Being mobile is about being part of the normal ebb and flow of the larger society. Thus, transportation difficulties among low-income households are a significant cause of social exclusion and exacerbate a host of problems from joblessness to poor health to poor education outcomes.[143] Low rates of car ownership and inadequate public transit also keep job seekers in the urban core from reaching many regional jobs:[144]

- The decentralization of jobs away from central cities to lower-density suburbs has shifted job markets farther away from low-income families who remain concentrated in central city neighborhoods.
- Jobs in lower-density suburbs are difficult to access via public transportation, forcing many low-income workers to travel by private vehicle, and excluding those without access to reliable automobiles from a large share of suitable jobs.

Thus, improving public transit connections between low-income residential areas and job centers as well as improving housing affordability throughout the region and especially near job centers could help alleviate the travel burdens on low-income households. Similar issues hold in rural areas, where households are even more dependent on automobile travel to access work and other important destinations.

BACK TO THE LECTURE HALL 5.2

JOBS-HOUSING BALANCE AND AFFORDABLE HOUSING

When jobs are poorly distributed throughout a region, some cities will contain more jobs than housing while others have more housing than jobs. This mismatch causes excessive travel. Improving jobs-housing balance within subareas can shorten commute distances and reduce congestion on regional freeways. For suburban municipalities, this can mean attracting more jobs; while for urban locations, it can mean adding more diverse housing options.

Just having balanced amounts of housing and jobs, however, does not ensure that people will—or even can—shorten their commutes. There can still be a mismatch between the types of jobs and the types of housing in each sub-area. Suburban areas often lack housing affordable to the service workers who work in suburban shopping malls and restaurants. This makes affordable housing a transportation issue.

RURAL COMMUNITIES

WITH ETHAN RAUCH, JENNIFER TOTH, AND JOHN MCNAMARA

Rural communities face many transportation challenges. Because of the generally longer distances between origins and destinations, non-motorized transportation is often not an option except within towns. Due to lower population densities, public transit services are expensive, and therefore, infrequent in most areas or lacking altogether. Rural households tend to be more car-dependent as a result, but have lower incomes on average, making car ownership less affordable. Rural residents also have to drive farther to get to schools, shopping, and services, some of which are only available in larger cities and towns.

Compared to just 8,400 for urban Arizonans, rural VMT per capita averaged more than 13,100 miles per year.[145] Transportation costs related to driving are therefore a substantial burden on many rural households, and place unique constraints on rural commuters, elderly, and schoolchildren. With population growth and demographic shifts in rural parts of the state, demand could grow significantly which would require additional funding.

A 2008 ADOT report analyzed the public transit needs in rural parts of the state and concluded that only a small fraction of the total transit demand is being met, mostly because of funding limitations and high costs to provide transit in spread-out communities.[146] Rural Arizonans make up over 20% of the state's population, but in 2012 took only 2.3 million transit trips—only 2.5% of the entire state's ridership. With population growth and demographic shifts in rural parts of the state, demand could grow significantly, which would require additional funding. Rural transit systems need more cost-effective and innovative service concepts to meet travel demands (see Small Urban and Rural Transit Center: surtc.org).

As Chapter 2 illustrates, rural Arizona has very limited commercial air service, which is often more expensive despite depending on federal subsidies for survival. Rural Arizonans often travel long distances to Phoenix, Tucson, Las Vegas, or Albuquerque for air travel by costly shuttle services. Heavy freight traffic on rural interstate and state highways also impacts rural Arizona in negative ways.

TRIBAL COMMUNITIES (ADAPTED FROM THE 2009 REPORT)

WITH ESTHER CORBETT, NORM DEWEAVER, AND PATRICIA MARIELLA

There are 22 federally recognized tribal governments within Arizona's boundaries. Their lands vary in area, population, accessibility, and cultural traditions. They include large Navajo, Apache, Hualapai, and Tohono O'odham reservations, and the San Juan Southern Paiute Tribe. Some Tribes in Arizona are among the most isolated in the country. The Havasupai people occupy a side canyon of the Grand Canyon with no road access to their community. It is the only place in the United States where mail is still delivered by mule. Communities on the Navajo, Hopi, Tohono O'odham, San Carlos, Hualapai, Kaibab, and Fort Apache reservations are many miles from any city of even moderate size. Tribal governments across Arizona operate 20 airports that they depend on to overcome this remoteness. At the opposite extreme, several Indian reservations share boundaries with urban areas in the East Valley of the Phoenix region and Tucson.

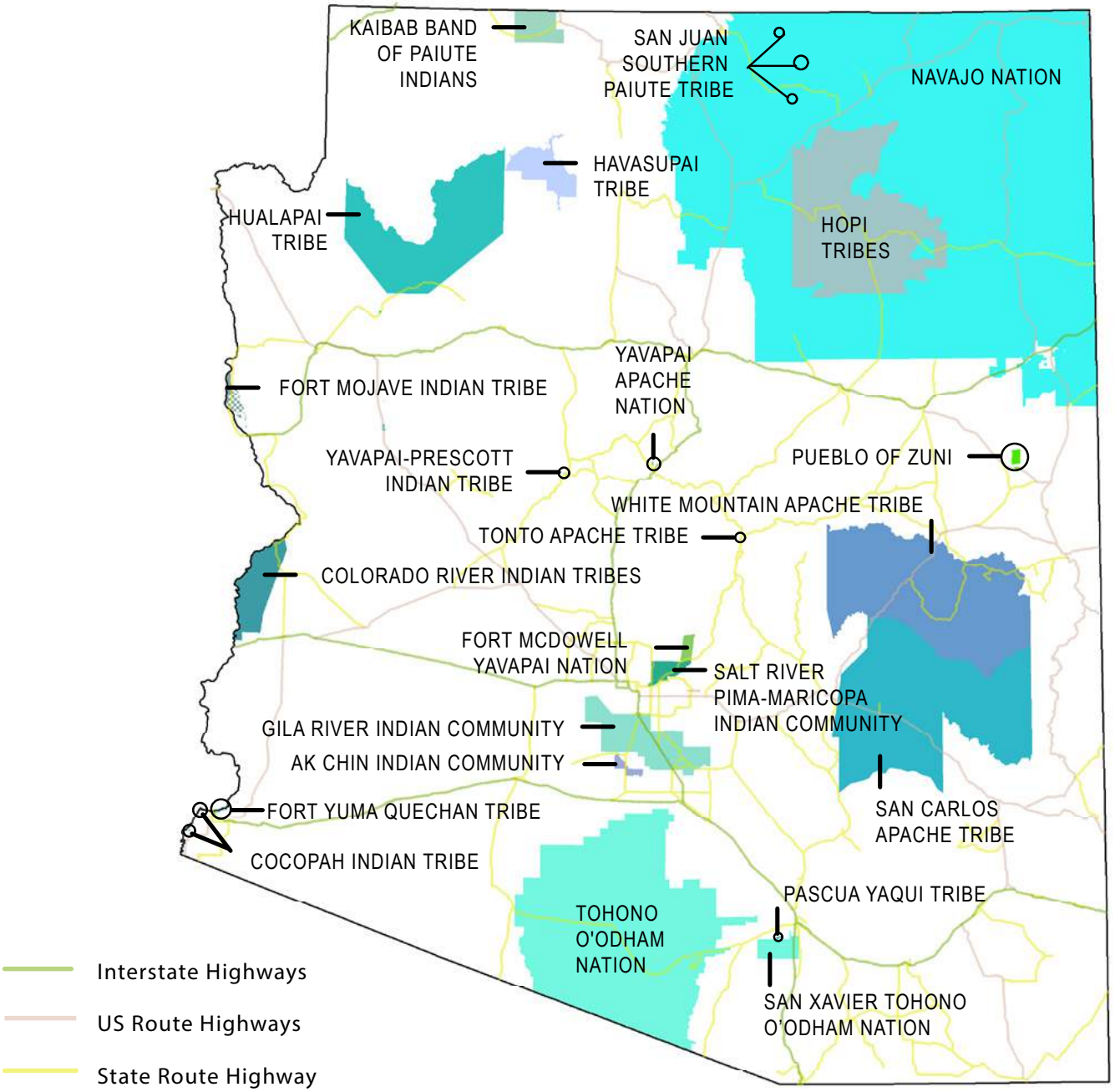
Rights of Way. Traveling Arizona highways is, for many, a trip through Indian Country. Tribal lands make up 28% of the land area of Arizona,[147] and many of Arizona's major transportation corridors cross or go near tribal lands (Figure 5.4). The State Highway system contains 1,219 miles of roads on tribal land, nearly 20% of state mileage.[148] Authorizing rights-of-way for roads across tribal land almost always requires tribal consent.[149] As tribal governments grant these rights-of-way, they are key stakeholders in the transportation arena. Moreover, American Indian people who live on tribal land are a vital part of the Arizona transportation picture. Like other Arizonans, they need access from home to work, education, health, and other services as well as to shopping and recreational opportunities.[150]

A Tribal Transportation Facility (TTF) is a public road that is located within or provides access to an Indian reservation or to Indian trust land that is not subject to sale or transfer without the approval of the federal government or the tribal government involved.[151] The most recent National Tribal Transportation Facility Inventory, for federal Fiscal Year 2015, includes almost 15,000 miles of existing and proposed roads on the Indian reservations of tribes whose main land bases are within Arizona borders.[152] About 66% of total TTF mileage consists of dirt roads; gravel roads account for another 4%.[153]

New roads generate economic opportunities, but also cause environmental concerns. For example, the development of a commercial corridor along Route 101 in the East Valley has provided opportunities for the Salt River Pima-Maricopa Indian Community. However, the traffic volume on interstates and major state roads that cross reservation land can block movement from one community to another and to nearby agricultural areas, degrade air quality, and constrain land use. Although tribal governments have repeatedly given their consent to allow state roads to cross their land, they expect benefits in return for allowing use of their limited land bases and for tolerating traffic and health impacts in their communities.

Safety. Safety around roads is a central concern in Indian Country. Remoteness, lack of public transit, poor road conditions, heavy amounts of freight traffic, and lack of roadside lighting all contribute to high crash rates. Here are some alarming statistics illustrating the urgency of traffic safety improvements in Arizona's tribal areas:[154]

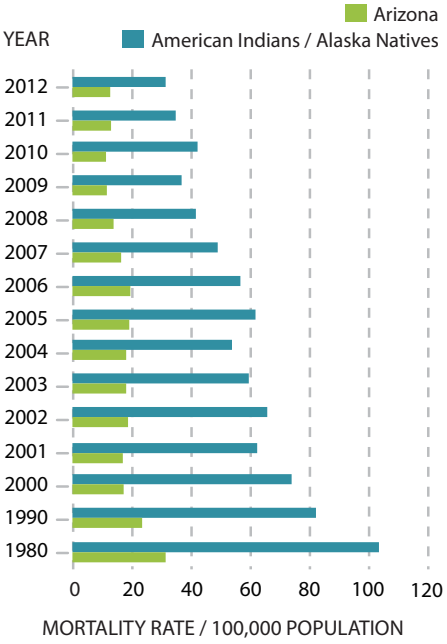
Figure 5.4 American Indian Reservation and Transportation District Boundaries



- The motor-vehicle-crash mortality rate for American Indian people, on and off reservation, is more than twice the rate for the general population (Figure 55).
- Injuries from motor-vehicle crashes are the third-leading cause of death for American Indian people, and the leading cause of death for those aged between 1 and 54.[155]
- The motor-vehicle-related fatalities suffered by American Indian peoples in 2004 in Arizona, on and off reservation, were more than twice the number as those suffered by American Indians in any other state.[156]
- While American Indian people are only 5% of the state's population, they account for nearly 25% of the pedestrian fatalities.[157]
- Tractor-trailer trucks were involved in five times more lane departure crashes, five times as many speed related crashes and four times more young driver crashes, compared to the rest of the state.

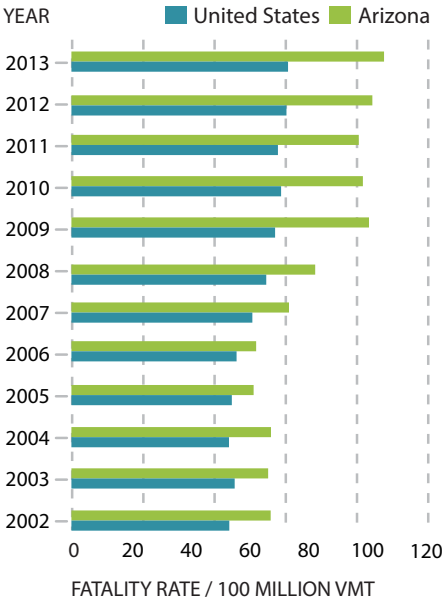
Tribal governments have responded to their serious transportation safety issues in many ways, including road safety assessments (RSAs), seatbelt education, and sobriety-checkpoint programs.[159] Several units inside US DOT and the Indian Health Service are important on the federal side. At the tribal level, coordination among law enforcement, emergency medical services, transportation, behavioral-health services, and education personnel are essential. Regardless, the fragmentation of responsibility among agencies is an impediment to safety improvements.

Figure 5.5 Motor Vehicle Collision Mortality Rates for American Indians/ Alaska Natives in AZ 1980, 1990, 2000-2012



Source: Data combined from Corbett and Mickelson (2007) and Arizona Crash Facts, 2005 to 2012, and Arizona 2014 Strategic Highway Safety Plan and Arizona Health Status and Vital Statistics Report.

Figure 5.6 Historical Vehicle Crash Fatality Rates



Source: 2006, 2009 and 2013 Arizona Motor Vehicle Crash Facts. azdot.gov/mvd/Statistics/arizona-motor-vehicle-crash-facts.

Public Transit Needs. Public transit is often missing in the small communities of rural Arizona, including tribal communities. A 2008 ADOT study found that 82% of the need for public transit in rural Arizona is unmet.[160] The study, which combined needs on tribal lands with those of other rural areas, identified services to the elderly, disabled, and low-income populations as the most serious needs. Though several tribes have received federal Tribal Transit Grant funding through the FTA, only a few receive operating funding and there remains a significant deficit in services.

Mobility services are provided only for a narrowly defined population by health, education, and human services programs. Transportation services to medical facilities are fairly common in tribal communities, although they have a difficult time reaching the most remote areas. School systems on Indian reservations have their own transportation services, as do many tribal Head Start and childcare programs. Tribal employment and training programs sometimes provide transportation as a component of their main activities. Transportation is one of the most important support services needed to move individuals from welfare to work. In Indian Country, transportation is especially critical to employment because work opportunities are often a long distance from home.

Air Quality. Air quality is also a concern in tribal lands and is discussed in greater detail in Chapter 7.

PUBLIC SAFETY

Transportation systems affect how safe we are walking in our neighborhoods, driving in our cars, and even while sleeping as hazardous waste passes through our communities. This section address issues related to transportation safety and security.

PERSONAL SAFETY

WITH SIMON WASHINGTON AND KANGWON SHIN

Over the past five years, Arizona has averaged 105,849 motor vehicle crashes, 811 fatalities, and 71,561 injuries[161] per year. These rates have stabilized over the past few years and are down significantly from the mid-2000s.

By the numbers X: Arizona Traffic Crash Fatality and Injuries for 2013

- One person was killed every 10.39 hours and one person injured every 10.46 minutes on Arizona roadways.
- Alcohol-related crashes accounted for 4.83% of all crashes and 31.53% of all fatal crashes.
- Single-vehicle crashes accounted for 17.75% of all crashes and 39.25% of all fatal crashes.
- Motor vehicle crashes resulted in $2.993 billion in direct economic losses to Arizona, with indirect costs roughly double this number.

Source: 2013 Arizona Motor Vehicle Crash Facts. azdot.gov/docs/default-source/mvd-services/2013-crash-facts.pdf.

Decreases in total VMT since 2009 have contributed to a slight increase in crash rates per mile driven (Figure 5.6). The 2013 rate of 1.39 fatalities per 100 million vehicle-miles traveled is more than 20% higher than the national average of 1.11, but significantly lower than rates 10 years ago. Even with the lower rates, Arizona ranks as the 33rd worst state in the country for traffic safety and more than twice as dangerous as the safest state, Massachusetts (Figure 5.7). The United States overall is much more dangerous than most similarly developed countries; the United Kingdom has the safest roads in the world, with about ¼ the fatality rate of Arizona.[162]

The 2007 Arizona Strategic Highway Safety Plan identified strategies for reducing fatalities on Arizona roads. The first milestone on that path was to achieve a 12% reduction in fatalities by 2012, which was surpassed and a 23% overall reduction was achieved. Indeed, in each of the emphasis areas below, substantial reductions were made. (Note that categories can overlap. For example, a fatality could involve an unbelted and impaired driver, adding to the count in both categories.)

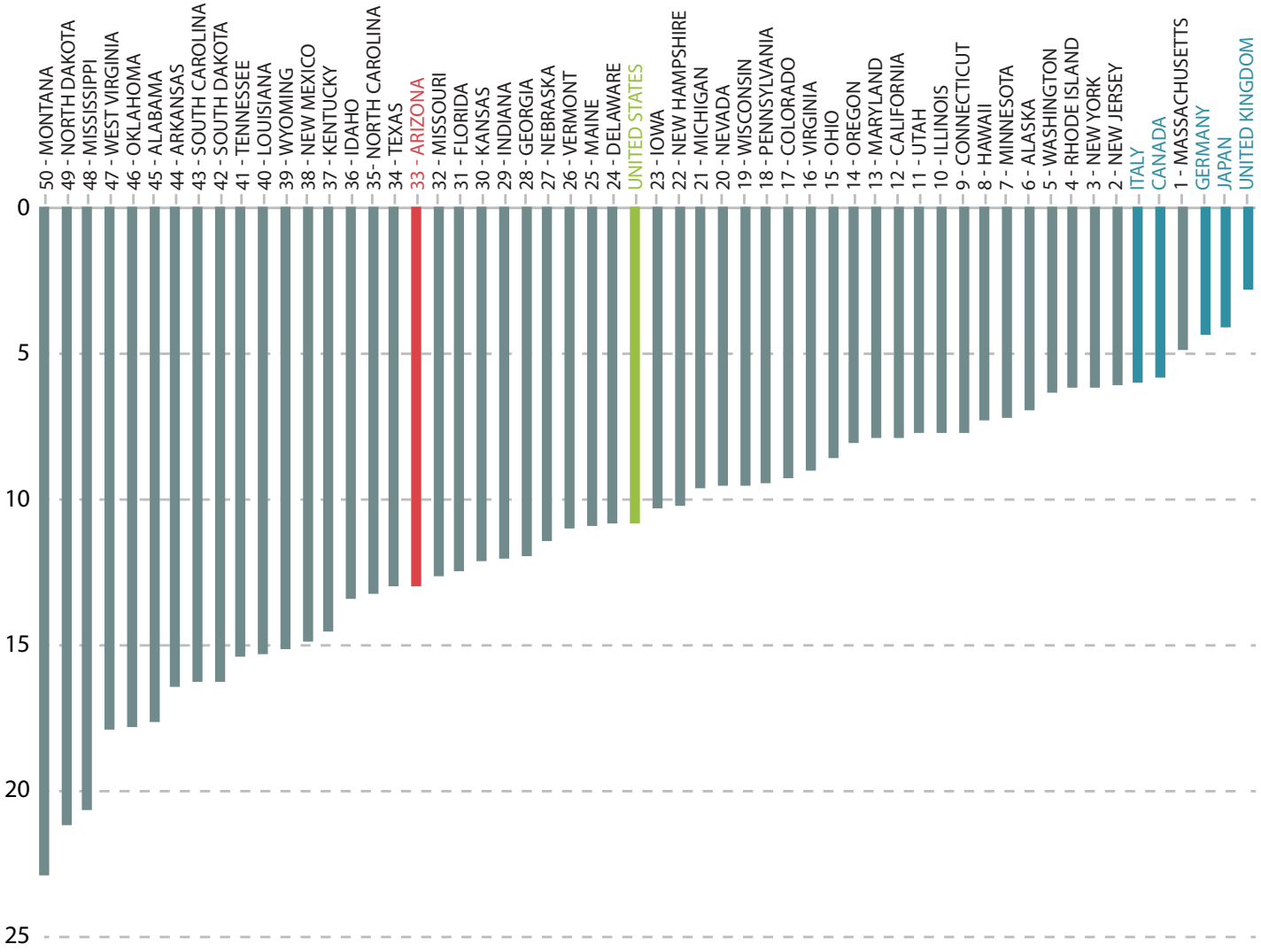
- Speeding
- Impaired drivers
- Restraint use
- Roadway lane departures
- Roadway and intersection crashes
- Young drivers
- Improving the quality of Arizona's safety data

Table 5.1 Changes in Arizona Fatalities by Emphasis Area

	2005	2012	% Change
Speeding	482	281	-42%
Impaired Driving	321	303	-6%
Restraint Use	583	376	-36%
Roadways - Lanes	625	449	-28%
Roadways - Intersections	261	184	-30%
Young Drivers	425	237	-44%

Source: Arizona Strategic Highway Safety Plan, 2014.

Figure 5.7 Comparative Traffic Fatality Rates Among the 50 United States and Selected Peer Countries



Note: The red bar represents Arizona, the green bar is the United States, and the blue bars correspond to peer countries.

Sources: National Highway Traffic Safety Administration (2014) Traffic Safety Facts Research Note: 2013 Motor Vehicle Crashes Overview. www-nrd.nhtsa.dot.gov/Pubs/812101.pdf. OECD/ITF, ed. (2014). "Road Safety Annual Report 2014" Paris: International Traffic Safety Data and Analysis Group, International Transport Forum. internationaltransportforum.org/Pub/pdf/14IrtadReport.pdf.

Considering the success of on-going efforts to improve safety from the 2007 plan, the 2014 Strategic Highway Safety Plan identified the following new issues to focus on going forward:

- Speeding
- Impaired Driving
- Restraint use
- Motorcycles
- Distracted Driving

Distracted driving is a newer issue that was not mentioned in our 2009 Town Hall report, but one that is of major concern. The 2014 Strategic Safety Plan implicates distracted driving in over 20% of serious injuries, slightly more than for impaired driving, although impaired driving leads to far more fatalities.[163] ADOT recommended aggressive public information campaigns, increased use of hands-free technologies, increased enforcement of existing laws, and research into effective state, local, and tribal policies to discourage distracted driving. In response, the Arizona DPS launched a distracted driving enforcement campaign in 2014. The campaign includes a new Arizona Crash Report form initiated on July 1, 2014 collects more detailed data on types of distracted driving.

Achieving significant reductions in motor-vehicle crashes requires both behavioral and engineering countermeasures. As the vast majority of motor-vehicle crashes are caused entirely or in part by human error, behavior modification is fundamental to improving safety. Behavioral approaches are aimed at modifying driver behavior and typically include measures such as graduated driver licensing programs for young drivers, traffic-law enforcement, photo speed enforcement (intersections and road segments), sobriety checkpoints, educational and community awareness programs, and click-it-or-ticket (buckle-up) educational campaigns. Many of these measures require the support of appropriate laws and adjudication procedures. For example, a primary seat-belt law is needed for an officer to pull over and cite someone for failing to wear a safety restraint.[164] Arizona currently has a secondary seat-belt law for adults (an officer must have another cause for pulling a driver over, before citing a restraint-use violation). Drunk-driving and graduated-driver licensing laws are adopted through legislative changes, depending on the support of elected officials and their constituents.

Engineering countermeasures are focused on improving the safe operation and design of transportation facilities. Some countermeasures are focused on easing the impact of a motor vehicle going off from the road (roadside-clearance programs, safety barrels, etc.). Others increase visibility (nighttime lighting, improved signal-head visibility, sign reflectivity, etc.) or minimize conflict points (left-turn bays to an intersection, cable median barriers on highways, etc.). For example, speed enforcement cameras on the Scottsdale 101, which threatened drivers with a ticket if they surpassed 76 miles per hour, successfully reduced the number of crashes in the photo-enforcement zone.[165] The program ended in 2008 because roadway construction necessitated the removal of the cameras. A statewide photo enforcement system administered by DPS was introduced in 2008 but ended in 2010 due to pressure by opponents citing privacy concerns.[166]

Distracted Driving Laws

The Governors Highway Safety Association (GHSA) tracks distracted driving laws by state: www.ghsa.org/html/stateinfo/laws/cellphone_laws.html.

The GHSA website includes a table tracking seven types of legislation. Other than a ban on cell-phone use by school bus drivers and collection of crash data, Arizona's row in the table of state laws is emptier than that of any other state besides Montana's (and tied with Missouri).

According to drivinglaws.org, which also tracks municipal legislation, only Phoenix and Tucson prohibit texting while driving, with fines of $100, or $250 if the cause of an accident: www.drivinglaws.org/arizona.php.

Pedestrian and Bicycle Safety. Non-motorized travel (NMT) faces unique safety and security concerns compared with motorized mobility. The National Highway Traffic Safety Administration (NHTSA) reports that 4,743 pedestrians were killed in traffic accidents in the United States in 2012—basically unchanged since 2003.[167] Persons aged 65 years or older, who make up 14% of the total population, accounted for 20% of pedestrian fatalities. The fatality rate for this group was 2.17 per 100,000 people, higher than of any other age group.

Alcohol is involved in 48% of pedestrian fatalities, and more often it is the pedestrian who is under the influence than the driver. For other road fatalities (drivers or passengers in vehicles), alcohol is only involved in 19% of crashes.

Most pedestrian fatalities (70%) occurred at non-intersection locations (with 44% on roadways without crosswalks). Visibility seems to be a factor, since more than two-thirds of pedestrian fatalities occurred between 6 pm and 6 am, about one-fifth involved hit-and-run crashes. In 2013, 122 pedestrians died in the Arizona, a fatality rate of 1.86 per 100,000 people and the seventh highest pedestrian fatality rate in the country.

By the numbers XI: Bicycling on the Sidewalk or Against Traffic (by Donna Lewandowski, ASU Bicycle Coordinator)

- Bicycling against traffic increases accident risk by 3.6X
- Bicycling on the sidewalk in either direction increases accident risk by 2.5X if you are 17 or younger, and 2.3X if you are 18 or older.
- Bicycling the wrong way on the sidewalk increases accident risk by 4.5X
- If you are 17 or younger, bicycling the wrong way on the sidewalk increases accident risk by 6.6X

Source: Wachtel, A. and D. Lewiston. "Risk Factors for Bicycle-Motor Vehicle Collisions at Intersections." Institute for Transportation Engineers Journal, September 1994, pp. 30-35. bicyclinglife.com/Library/Accident-Study.pdf.

The NHTSA also provides bicycle-safety statistics.[168] In 2012, NHTSA reports that 726 cyclists were killed in traffic crashes, accounting for 2.2% of all traffic fatalities. The number of fatalities has not improved at all over the past decade. The cyclist fatality rate is 2.75 per million people in Arizona, the eighth worst in the country. While these rates have improved over the past decade, they are still alarmingly high compared to the national average.

Security is primarily related to the potential of an individual to become a crime victim during the travel experience. Crime of all kinds is a major deterrent to the use of NMT modes. It is therefore of utmost importance to provide good lighting, secure bicycle-parking facilities, emergency-contact information, and frequent patrols to ensure that NMT users feel safe and secure in their surroundings.

Freight rail and truck safety. Safety as it pertains to freight transportation on roads and railways is a key concern of ADOT and other jurisdictions. Operating larger and heavier freight trucks in mixed traffic and at-grade crossing between railways and roadways create obvious safety concerns for freight delivery systems. The ADOT Multimodal Freight Analysis Study (2009)[169] focuses considerable attention on safety for freight systems. It makes five central recommendations to address and improve safety for freight systems:

1. Target improvements at crash hot spots using existing crash data through the Arizona Accident Location Information Surveillance System (ALISS), which highlights the most dangerous roadway segments in the state.
2. Expand parking opportunities for commercial vehicles drivers.
3. Focus attention on dangerous at-grade rail crossings. Three of the most dangerous in the country are found in the Phoenix area (the 27th Ave UP crossing is the most dangerous in the country, while crossings of the BNSF at 27th Ave at Thomas and 35th Ave and Indian School are in the top 20).
4. Improve enforcement of size and weight regulations. Overweight trucks cause $12-$53 million of damage to roadways annually, and are also unsafe.
5. Improve oversight of air freight cargo screening in accordance with Transportation Security Administration rules.

TRANSPORTATION OF HAZARDOUS MATERIALS

States are required to adhere to various Federal Hazardous Materials Regulations as well as EPA's Emergency Management Program, and each state is encouraged to assume primary responsibility for implementing its own hazardous waste program. In Arizona, the Emergency Management Division (EMD) is the designated lead agency for developing and implementing a state hazardous emergency management program. The Arizona DPS is responsible for establishing a special HAZMAT emergency response unit as an initial response element of the program. The Arizona Department of Environmental Quality (ADEQ) is responsible for the registration of and fee collection from transporters of hazardous waste. ADOT is responsible for rules governing safety operations of motor carriers, shippers and vehicles transporting hazardous materials and wastes on all highways and designated routes, and Arizona State Emergency Response Commission monitors and reports flows of hazardous materials on public roadways.[170]

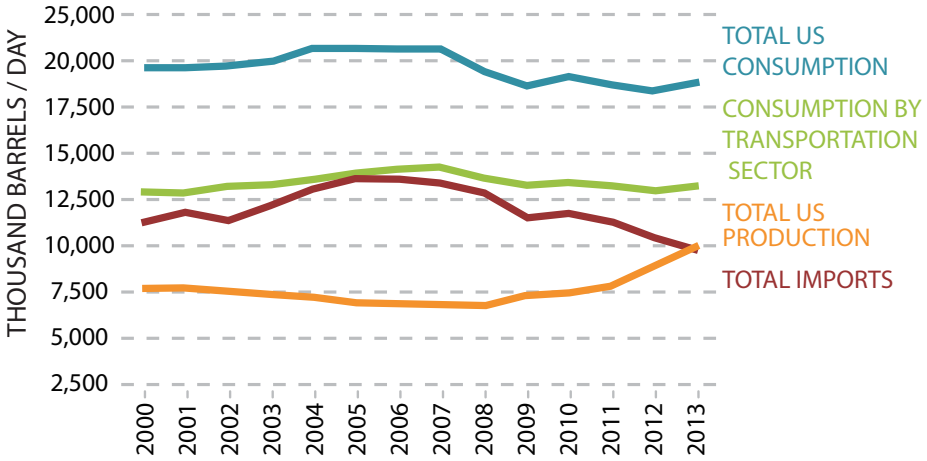
Current monitoring of flows by the commission does not encompass the entire state; areas lacking in coverage include I-10 from the intersection with I-8 west to the California border, I-15 in the northeast corner of Arizona, and multiple border crossings. Since 9-11, emphasis has been taken off of hazardous materials and turned to terrorist threats. As truck transport of hazardous materials on public roadways is the largest safety concern, such materials could be transported via rail as a safer alternative. Commonly transported waste in the state includes gases, flammables, and corrosives, with 72% of hazmat spills in Arizona in 2010-2013 occurring in Maricopa County.[171] In Arizona, some of the factors commonly involved in incidents involve improper training, improper maintenance, and lack of appropriate emergency response plans.[172] A complete analysis of the current handling of hazmat transport and recommendations to improve Arizona's practice are found in the Hazardous Materials Transportation in Arizona, Final Report 624 (ntl.bts.gov/lib/34000/34500/34507/AZ624.pdf).

CHAPTER 6

TRANSPORTATION AND ENERGY

Petroleum (oil) products provide 93% of the energy used in the transport sector in the US, most of which is consumed by light-duty vehicles (LDVs) (63% in 2012).[173,174] No other sector of the economy is remotely as dependent on a single source of energy as transportation is on gasoline, diesel, and jet fuel derived from oil. Our vehicles and infrastructure are built almost entirely around the technological advantages of using liquid fuels derived from oil. The uncertainty about future oil sources, and as a result future gasoline prices, has major implications for how we plan for different transportation modes and land-use patterns, as these decisions affect how resilient our economy will be to major changes in oil prices.

Figure 6.1 US Crude Oil Trends, 2000-2013



Source: Imports of crude oil and use of petroleum products by the transportation sector from the US Energy Information Administration (US Imports by Country of Origin. eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbblpd_a.htm and the Monthly Energy Review Table 3.7c eia.gov/totalenergy/data/monthly/pdf/sec3_21.pdf). Total US consumption of crude oil and domestic production figures from the BP Statistical Review of World Energy, 2014. bp.com/statisticalreview.

The cost of crude oil is the main driver of retail gasoline prices. Since 2008, refining, taxes, and distribution and marketing have comprised roughly $1.20 of the cost, with crude oil fluctuating substantially and making up the balance.[175] Refining costs can rise during times of refinery capacity constraints, and local distribution and marketing costs can also vary.[176] However, these components generally constitute a smaller and more stable part of gasoline prices. Taxes levied at the state and federal levels have been very stable and their relative contribution to the retail price of gasoline has been falling with rising crude oil prices. Arizona's gasoline taxes total 37.4¢ per gallon (19¢ per gallon in state taxes and fees, plus 18.4¢ per gallon federal tax), and are below the US average.[177] Figure 6.2 shows the distribution of costs that consumers pay at the pump.

It is useful to take a long view of gasoline prices and consider them in real terms (i.e., after accounting for inflation). As Figure 6.3 shows, on an inflation-adjusted basis, recent gasoline prices have been on par with those experienced in the US during the supply-constrained periods of the late 1970s and early 1980s. It is too soon to tell whether another low-price period like the 1990s is in store or not.

Crude oil is a global commodity and oil prices are determined in the worldwide marketplace by supply and demand as well as expectations about supply and demand. The direct impact of increasing US domestic output will be limited, and the price of gasoline may increase due to fast-growing demand for oil in other countries, even if

KEY POINTS

- Transportation in the US relies on oil for 93% of its energy—far more than any other sector (e.g., residential, power generation, industrial) relies on a single fuel.
- Gasoline prices are mainly driven by the global supply-demand balance.
- US oil production has risen dramatically in recent years, but our new sources of oil are costly to produce and demand in the rest of the world keeps growing.
- Vehicles that run on electricity and alternative fuels have penetrated the US marketplace, but adoption is constrained by the sparse refueling infrastructure.
- The Valley of the Sun leads all other US urban areas in replacement of oil consumption by a large margin, but this success is mostly limited to commercial, government, and emergency vehicle fleets.
- Fleets save on fuel and maintenance costs and refuel at pumps installed at their home base, other fleet depots, and public stations.

US demand is stable. Indeed, since 2005, crude oil prices have not fallen below $50 per barrel except for two brief periods: during the height of the economic crisis in early 2009, and recently in early 2015. Mostly, this price floor reflects the growing global demand for oil stemming from countries like China and India as well as the high cost of producing shale oil and offshore oil here in the US.[178] However, past experience has shown that the price of crude oil is volatile and highly sensitive to OPEC production decisions, supply disruptions, economic recessions, and geopolitical tensions in almost any part of the world, which explains the extreme highs and lows that prices occasionally reach.

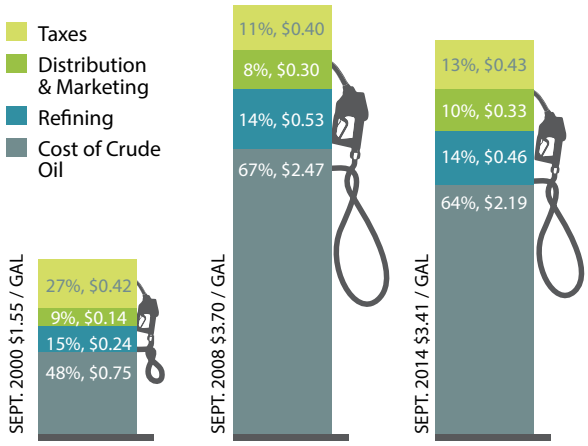
Three crude oil trends have emerged in recent years. First, the US demand for crude oil has moderated somewhat since peaking in 2005, and has not gone back up to pre-crisis levels. Second, recent additions to domestic production in the US have caused the share of oil consumed in the US imported from other countries to fall under 50% for the first time since 1992.[179] Much of increased domestic production, however, depends on unconventional sources like shale oil that are extracted at much steeper production and environmental costs (especially in terms of water use). New shale oil supplies from the US notwithstanding, imports have been and will remain a critical component of the US oil supply, even as the mix of import sources has changed. While OPEC members Saudi Arabia and Venezuela remain two of the largest oil suppliers to the US, imports from OPEC have been declining since 2000 and now account for less than 40%. Mexico, Russia, and increasingly Canada (up 74% since 2000) are the top three non-OPEC suppliers to the US.[180]

Recently, oil prices fell from $115 to $45 from June 2014 to January 2015, due to weak economic growth, booming US production, and the fact that instability in Libya, Syria, and Iraq has not substantially disrupted oil flow from those countries. In response to these conditions, Saudi Arabia decided not to cut production to induce a shortage, preferring instead to keep prices low to maintain their market share and undercut US shale oil producers, many of whom cannot make a profit below $60 per barrel.

ASU's John Hofmeister, former president of Shell Oil, recently made national news by predicting that "the next round of high prices is likely to start later this year, as crude rebounds to the $80s and $90s, perhaps pushing to the $100 level by late in the year or early next," citing deferral of capital investment and continued demand growth.

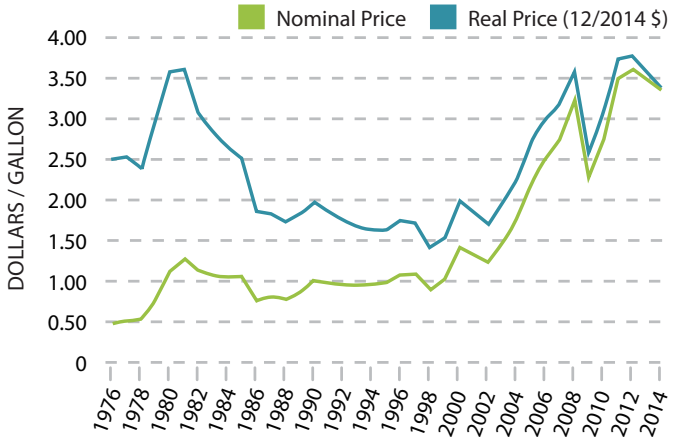
Source: usatoday.com/story/money/2015/01/19/gas-oil-five-dollar-gallon/21865975/.

Figure 6.2 Components of Average US Gasoline Price at the Pump



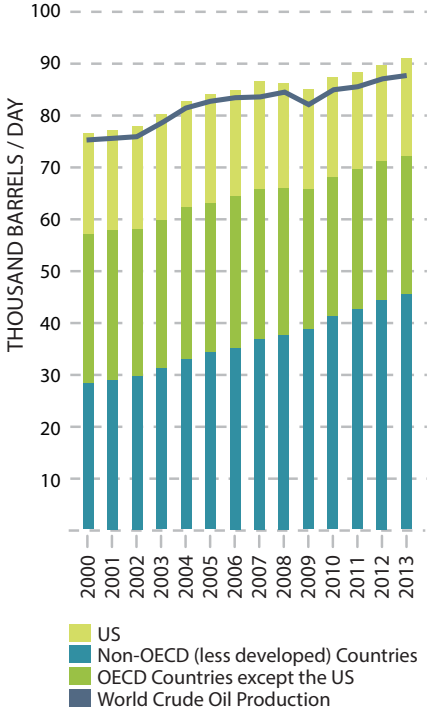
Source: US Department of Energy, Energy Information Administration. Gasoline Pump Components History. eia.gov/petroleum/gasdiesel/gaspump_hist.cfm. Nominal monthly national average of retail gasoline prices with percentages indicating the share of each price component: cost of crude oil, refining costs, marketing and distribution costs, and taxes.

Figure 6.3 Annual Retail Price of Gasoline, Real and Nominal, 1976-2014



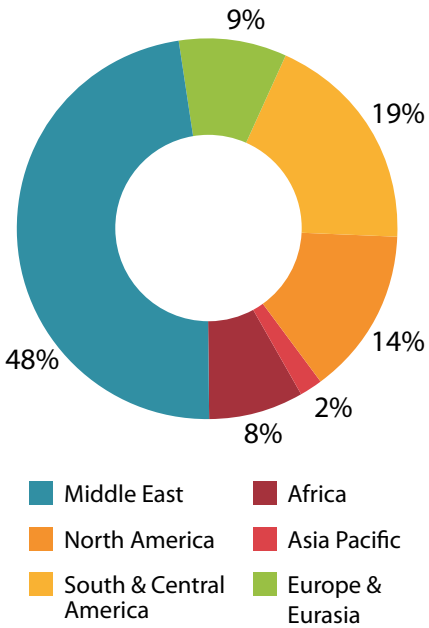
Source: US Energy Information Administration. Short-Term Energy Outlook, December 2014. eia.gov/forecasts/steo/realprices/. Prices correspond to average grade motor gasoline. Real prices calculated by using consumer price index (CPI).

Figure 6.4 World Crude Oil Consumption and Production



Source: BP Statistical Review of World Energy, 2014. bp.com/statisticalreview.

Figure 6.5 Distribution of Proved Reserves of Crude Oil, 2013



Source: BP Statistical Review of World Energy, 2014. bp.com/statisticalreview.

BACK TO THE LECTURE HALL 6.1

PRICE ELASTICITY OF OIL SUPPLY AND DEMAND

Both oil supply and demand are highly inelastic with respect to price in the short run. Production and consumption cannot respond quickly or sizably to even large changes in oil prices, whereas prices change dramatically in response to small changes in supply and demand. On the supply side, it takes many years of large investments to bring new oil supplies into the market. On the demand side, consumption barely budges because oil is a necessity with few substitutes in the short run. People still need to get to work and shop for groceries, and companies need to use their vehicles, and neither consumers nor firms can quickly replace their oil-fueled vehicles with something else. Both consumers and firms can cut back more easily on other budget items than on transportation, which is powerful evidence for why transportation matters.

In Arizona, the transportation sector is the largest energy user (33% of total energy in 2012, above the national average of 28%). Transportation uses 88% of the petroleum products coming into the state. Arizona does not have any measurable crude oil production, has no oil refineries, and depends entirely on two privately owned pipelines for all of its refined petroleum products like gasoline and diesel.[181]

In the short run, when fuel prices rise, the main option available to firms is to switch to another transport mode that uses oil-based fuels more efficiently (e.g., rail instead of truck). Individuals can switch to public transit, which uses alternative fuels in many parts of Arizona. They can also use non-motorized transportation, carpool, telecommute, shop or take classes online, reduce or "chain" trips, and even drive more efficiently. In practice, people's ability to switch to transit is highly constrained by where they live relative to where they need to go, the transit service available, and their family and time constraints (see Price Elasticity Box). For example, during a period of rapidly rising gas prices (e.g., the 21% increase from April 2007 to April 2008), average miles driven fell 2.1%. Americans drove 5 billion miles less, yet transit use increased by only 50 million miles, meaning people made fewer or shorter trips rather than making the same trips by transit.[182]

By the numbers XII: Top Three Ways to Improve Your MPG (percent fuel savings)

Drive less aggressively	5 - 33%
Observe the speed limit	7 - 14%
Avoid cargo storage on roof	2 - 17%

Source: fueleconomy.gov/feg/driveHabits.jsp.

The medium-run solution to conserving fuel is to replace aging vehicles with newer, more efficient ones, possibly using alternative fuels. Smaller vehicles, diesels, hybrid, or plug-in electric vehicles improve mileage compared to conventional vehicles of similar size. New federal rules for vehicle fuel economy also encourage manufacturing of more fuel-efficient vehicles.

Finally, in the longer-term, higher energy prices and energy scarcity will induce changes in where people live and work, where firms locate their production, and how we plan our cities and towns. Our current planning reflects an assumption of unlimited cheap energy, and while that may seem likely over the coming decade, that reality may change over the longer term.

By the numbers XIII: Corporate Average Fuel Economy (CAFE) Standard

Required average fuel economy for each US auto manufacturer's fleet in 2025:

- 54.5 mpg –for passenger cars (up from 27.5 mpg in 2010).
- 40.0 mpg - for light trucks (up from 21 mpg in 2010).

Source: National Highway Traffic Safety Administration (NHTSA), nhtsa.gov/fuel-economy and nhtsa.gov/About+NHTSA/Press+Releases/2012/Obama+Administration+Finalizes+Historic+54.5+mpg+Fuel+Efficiency+Standards.

ALTERNATIVE-FUEL AND ELECTRIC VEHICLES

WITH WILLIAM SHEAFFER

As we have noted, transportation in American cities revolves around the automobile. While more and more Americans are switching to non-motorized and public transportation, it is important to consider the emerging alternative energy sources for cars and trucks if we want to make a bigger dent in America's oil dependency. Adoption of alternative fuel (AFV) and electric vehicles (EV) requires fewer changes in existing lifestyles or land use than switching to mass transit or non-motorized transport.

The AFV industry offers a wide range of options to compete with the gasoline/diesel internal combustion engine. Table 6.1 outlines several key parameters of the main contenders to replace gasoline and diesel. While there is no clear-cut best AFV technology overall, different technologies may be preferable based on geography, a household's or business's driving patterns, vehicle load, and infrastructure availability and cost.

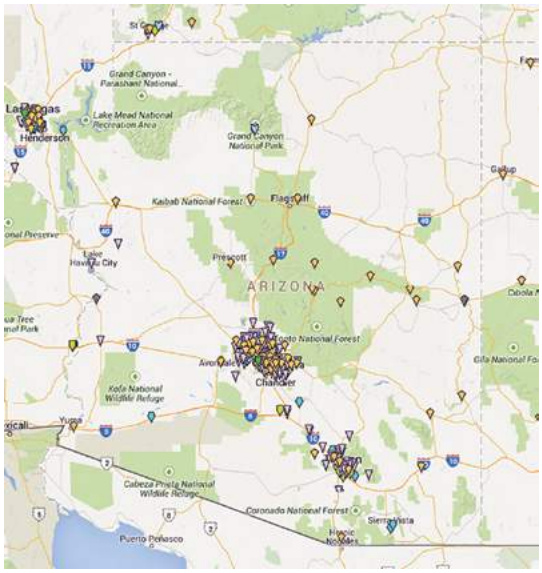
The cost, energy efficiency, and environmental impact of AFVs depend on how the fuels are produced and distributed. Fuels and electricity are energy "carriers," as we do not drill for hydrogen or electricity—we make them from other forms of energy. Recognition of the "wells to wheels" lifecycle costs of fuels is important for understanding the real effectiveness of alternative fuels. For example, electricity made from burning coal has drastically different impacts than electricity made from wind energy. Similarly, production and replacement of battery packs used in many hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and EVs contribute to the total lifecycle cost of these technologies. To compare between fuels, therefore, we need to compare apples to apples and make sure we are taking the complete lifecycle impacts into account.

In general, AFVs cost more upfront than their petroleum-fueled counterparts, although maintenance costs and energy savings can make up for that difference over time. The higher up-front cost is partly due to lower scale of production. As carmakers ramp up the production of alternative and flex-fuel vehicles, however, their prices drop. Of course, some AFVs have components that simply cost more to produce. Batteries for EVs add substantially to their price, and the flexibility offered by a hybrid vehicle comes at the additional cost of having both a battery and a gas tank, as well as an engine and an electric motor.

It is difficult to estimate the true costs of operating AFVs. Prices for liquid and blended fuel alternatives to gasoline (like E85, diesel, and biodiesel) track with the ups and downs of gasoline prices closely, but tend to be more expensive than gasoline. On the other hand, the cost of natural gas (CNG) and electricity is substantially lower on a gallon-of-gasoline-equivalent basis. While cost and fuel economy are important, other considerations unique to AFVs are driving range (for EVs), charging time (for EVs and PHEVs), battery life (for all HEVs and EVs), and most importantly, the availability of public fueling or recharging stations (for all AFVs).[184]

Rolling out an initial refueling infrastructure is essential to breaking the chicken and egg dilemma that can stop the transition to AFVs before it even gets started. In Arizona, electric charging and propane stations are more widely available than ethanol. Natural gas and biodiesel are available at only a handful of stations, and we have no operating hydrogen[185] stations as of 2014 (Figure 6.6). The geographic distribution of stations is also important. Compared with other states, the distribution of alt-fuel stations in Arizona is highly concentrated in Phoenix and Tucson, with little connectivity to other cities or states except for propane.

Figure 6.6 Alternative Fuel Stations in Arizona



Source: Map adapted from Alternative Fuels and Advanced Vehicles Data Center, National Renewable Energy Lab: maps.nrel.gov/transatlas. See also: afdc.energy.gov/locator/stations/.

Alternative Fuel Type	Number of Alt. Fueling Stations per million residents	
	U.S.	Arizona
Electric	61.40	41.04
Propane	9.35	9.81
LNG	0.26	0.30
Hydrogen	0.17	-
Biodiesel	2.39	0.60
CNG	4.00	1.81
E85	8.35	3.62

Table 6.1 Alternative Fuel Comparisons

	Gasoline	Hybrid Electric Vehicle	Plug-in Hybrid Electric	Battery Electric	Nat. Gas Comprss'd (CNG) or Liquefied	85% Ethanol / 15% Gas Blend (E85)	20% Biodiesel / 80% Diesel Blend (B20)	Propane (LPG)	Hydrogen Fuel Cell (FCV)
Examples	Most cars	Toyota Prius	Chevy Volt	Nissan Leaf	Honda Civic Natural Gas	Many Choices	Most Diesels OEMs	Ford E-350 van	Hyundai Tucson FCV Toyota Mirai
Fuels	Gasoline only	Gasoline only	Electric only	Electric only	Natural Gas only	E85 or Gasoline	Biodiesel or diesel	Propane or Gasoline	Hydrogen only
Refueling/ Recharging Time	ϟ	ϟ	ϟϟϟ	ϟϟϟϟ	ϟϟ	ϟ	ϟ	ϟϟ	ϟϟ
Driving Range (miles)	300-500	400-600	10-38 (elec.) 450-650 (gas)	80-265	200-250	300-500	400-750	400-500	250-300
No. of Public Stations in Arizona	2,027†	2,027†	275	275	12 - CNG	23	4	37	0
Original Energy Source	Oil	Oil	Oil, Grid	Grid	Natural Gas	Corn (now) Cellulose, Algae (future)	Vegetable Oil Animal Fats	Oil	Natural Gas Reforming or Electrolysis of water
Domestic Sources	⚑	⚑	⚑⚑	⚑⚑⚑	⚑⚑⚑	⚑⚑⚑	⚑⚑⚑	⚑⚑⚑	⚑⚑⚑
Carbon Footprint*		🍃	🍃🍃	🍃🍃🍃+	🍃🍃	🍃🍃+	🍃🍃🍃🍃	🍃🍃	🍃🍃+
Vehicle Cost	$	$$	$$$	$$$	$$	$	$$	$$	$$$$++
Fuel Costs	$$$$	$$$	$$	$$	$$	$$$$$+	$$$	$$	$$$$$
Maintenance Costs	$$$$	$$$	$$	$	$$	$$		$	$$?
Ideal Commercial and Govt Uses	Up to Class 6 vehicles	Taxi, light-duty vans	Ideal for consumers	Light-duty vans with light cargo (bread, flowers)	Bus, shuttle trash (CNG) trucking	Vans, light-duty pickups	Any diesel vehicle	School bus, shuttle vans, pickups	Rail now - later consumers when stations exist
Safety/ Pollution	⚠⚠⚠⚠	⚠⚠⚠	⚠⚠	⚠	⚠	⚠⚠	⚠⚠	⚠	⚠

Note: Symbols should be interpreted as ranking (more, less), not quantitatively (i.e., $$$ is not 3 times as expensive as $), except for driving range, where length of bars is proportional to maximum range.

† Gas station counts are for 2012. Source: Alternative Fuels Data Center.

* Depends on production and distribution (well to wheels) pathway, See Argonne National Laboratory, the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model: greet.es.anl.gov.

+ Means expected future improvement with mass production and/or cleaner electric grid (more renewables).

§ LNG will leak from sporadically used vehicles. Best for long-distance trucking.

AFV Catch Phrases

Chicken-and-Egg Dilemma – The vicious cycle in which automakers won't mass produce AFVs until consumers can refuel cars conveniently, and energy companies won't build stations until reasonably priced vehicles are on the market. Breaking out of this cycle is the biggest challenge in the transition to AFV.

The Valley of Death – The decade-long struggle for start-up companies of all kinds in going from research to development, product launch, and full-scale mass production. See www.downtowntucson.org/2013/02/10-ways-for-startups-to-survive-the-valley-of-death/.

Range Anxiety – Trademarked by General Motors to tout the back-up gas tank and engine of the Chevy Volt, this refers to concern about being stranded with no station nearby.

Well to Wheels – Analysis of all steps from natural resources to driving an AFV, usually divided into well-to-pump and pump-to-wheels. The term "well" implies any natural resource, including crops, wind, and solar. Can be extended to full lifecycle analysis including car manufacturing.

See apep.uci.edu/3/Research/pdf/SustainableTransportation/WTW_vehicle_greenhouse_gases_Public.pdf.

Relatively obscure just a decade ago, many of these AFVs can now be seen on our streets. If we include hybrid vehicles (which consume only gasoline but generate electricity from braking) and flex-fuel vehicles (which can burn E85 or gasoline), AFVs account for approximately 5% of the 15.5 million[186] of new light-duty vehicle sales in the US in 2013. Excluding those, CNG-fueled cars and PHEVs and EVs account for less than 1% of vehicle sales, but these are the fastest growing sub-categories.[187]

In 2011, more than 52,000 AFVs were registered in Arizona, and the state has consistently ranked among the top five in the nation in terms of AFV sales, alongside heavyweights like California, Texas, and New York.[188] This success, however, is mainly limited to fleet operations of municipalities, transit agencies, utilities, taxis, shuttle companies, and airport operations—penetration of the consumer market lags behind.[189] Commercial and government fleet vehicles are easier to convert to alt-fuels than private cars, for many reasons, including:

- Commercial vehicles tend to be larger and consume more fuel
- Commercial vehicles are driven far more hours per day and miles per year
- Many fleet vehicles drive regular routes or within a limited area, reducing range anxiety
- Larger fleet bases can install their own fuel pumps. Fleet vehicles can be refueled when they return to base, providing guaranteed demand to the station
- Additional unmanned pumps can be installed outside the fence where fuel can be sold to other fleets and the general public using a swipe card, providing additional revenue
- Larger fleets have fleet managers and maintenance staff to help with the transition

Stations at fleet bases are essential for seeding the refueling infrastructure and breaking the chicken-and-egg cycle. There are many alt-fuel success stories for fleets across Arizona. For example, Valley Metro operates one of the largest alternative-fuel bus fleets in the US with natural gas buses displacing about 10 million gallons of gasoline equivalent every year. Waste Management (waste collection company) is collecting methane from its landfills, opening stations, and converting their refuse trucks to CNG.

Long-haul freight transportation is one of the most energy-intensive activities in the United States. Golden Eagle, in partnership with Ryder System, Inc., has converted its entire heavy-duty truck fleet in Tucson to CNG. They built two CNG stations, including one in Casa Grande that is the first public CNG fuel station in that community.

ROLLING OUT AN INITIAL REFUELING INFRASTRUCTURE IS ESSENTIAL TO BREAKING THE CHICKEN AND EGG DILEMMA

Golden Eagle Distributors Inc. Converts Entire Tucson Truck Fleet to CNG

"We are always looking for ways to reduce our carbon footprint, and with diesel fuel prices continuing to rise, the timing was right to convert our Tucson fleet to natural gas vehicles." - Christopher Clements, CEO, Golden Eagle

Source: www.gedaz.com/index.php/who-we-are/sustainability .

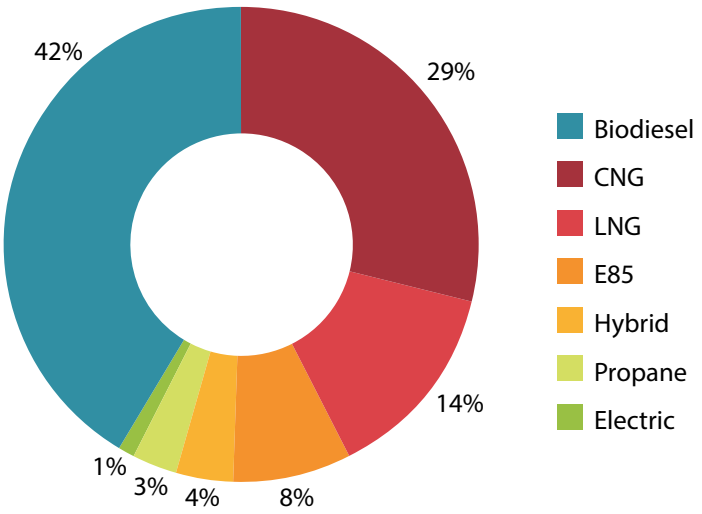
Advice for Fleet Managers and Stakeholder Engagement

- Valley of the Sun Clean Cities: cleanairaz.org/
- Tucson Clean Cities: pagnet.org/Programs/EnvironmentalPlanning/CleanFuels/tabid/180/Default.aspx
- Electric Vehicle Arizona: evaz.org.

Alt-Fuel Incentives and Programs

What are Arizona and other states doing to promote use of alternative fuels in transportation? See: www.afdc.energy.gov/laws.

By the numbers XIV: Avoided Petroleum Use



Valley of the Sun's rank among metropolitan areas in the US 1st

Through the efforts of the Valley of the Sun Clean Cities Coalition, the Phoenix metro area avoided using 60.7 million gallons of gasoline in 2013, almost as much as the next two metro areas (Southern California and New York) combined.

Clean Energy Fuels is building a nationwide network of LNG truck stops, with two open and another planned in Arizona. Freightliner is introducing a line of long-haul trucks designed from the ground up for natural gas combustion.

In addition to selling LNG at truck stops, electrification can reduce fuel consumption and emissions due to idling. Nationwide, there are about 100 electrified truck stops, including two in Arizona.[190] Inside of warehouses, freight-handling equipment is well suited to alternative fuels. With large warehouse operations for companies such as Amazon, Target, FedEx, and major grocery chains, Arizona is a good candidate. Hydrogen-fuel-cell forklifts are being introduced that emit only water vapor and don't require time-consuming recharging. Electric propulsion is considered viable for airport ground support equipment, such as pushback tractors,[191] while hybrids are ideal for vehicles that make hundreds or thousands of stops per day, such as taxis.

Essential and overdue regulations to reduce diesel engine emissions have impacted school district budgets. Buses equipped with these new engines are more costly and more expensive to maintain. New technologies in natural gas and propane engines now deliver the necessary power and range as well as lower maintenance and fuel costs. This combination has been a boon in reducing school bus operating costs—even below previous levels.

Conversion of emergency vehicles to flex fuels could provide insurance against high oil prices or ruptured pipelines in the future. Although Arizona has no oil refineries, ethanol and biodiesel are blended in Pinal County using supplies shipped to Arizona by rail, and millions of gallons of both are stored at the plant. In a pinch, ambulances and fire trucks could run on 100% biodiesel (B100) for several weeks until diesel supplies are restored, and most police cars and light vans could run on 85% ethanol (E85). The Arizona Department of Emergency Management has developed a program for the Greater Phoenix area to press into service a pool of 800 buses, 100 school buses, and a variety of work vehicles running on CNG and propane.

As we said earlier in this section, no sector of the economy is as dependent on a single source of energy as is transportation. It is difficult for other fuels and vehicles to gain traction in competition with our system of petroleum-based vehicles because of the widespread gas station availability, mass production of vehicles, and familiarity. In recognition of the difficulty and importance of reducing petroleum dependency, most states and countries offer a variety of incentives and programs to help the industry cross "the Valley of Death."

Arizona offers reduced license taxes, a home recharging tax credit, and most importantly, a High Occupancy Vehicle (HOV) lane exemption. Other states and the federal government offer a range of incentives on fuel production and sales, station construction, and vehicle purchasing. Incentives, however, have to be constructed carefully. Those that immediately reduce the initial purchase of vehicles have been found to have greater influence on consumer decisions,[192] but there are risks associated with incentives that are not specifically tied to purchasing the alternative fuels.[193]

CHAPTER 7

TRANSPORTATION & THE ENVIRONMENT

Transportation systems create significant impacts on the environment at local, regional, and global scales. Vehicles burn huge amounts of fuels and emit air pollutants as they move through neighborhoods and along major roadways, which impacts human health. Environmental impacts do not stop at state or even international borders, as air pollution can travel great distances. Transportation infrastructure and the associated expansion of human settlements has impacts on land, habitat, water, and endangered species. In addition, transportation is a major contributor of greenhouse gases causing climate change, and climate change is already having impacts on transportation systems. This chapter summarizes some of the key environmental challenges we face in making our transportation system healthier for humans and the larger environment.

- Air pollution from transportation causes various harms to society and the economy, including hundreds of thousands of early deaths, millions of asthma attacks and lost work days nationally; the Clean Air Act rules reduce these harms significantly.
- Many areas within the state of Arizona are out of compliance of National Ambient Air Quality standards and must follow strict clean air act rules in their transportation plans
- Air pollution from nearby urban areas and unpaved roads cause serious air quality problems on tribal lands
- Human-caused climate change is a scientific fact and is happening already, and many cities, states, and countries are preparing not only to reduce transportation emissions of carbon dioxide but also to deal with the effects that higher temperatures, sea-level rise, and an increase of extreme storms will have on our transportation systems

Transportation systems create significant impacts on the environment at local, regional, and global scales. Vehicles burn huge amounts of fuels and emit air pollutants as they move through neighborhoods and along major roadways, which impacts human health. Environmental impacts do not stop at state or even international borders, as air pollution can travel great distances. Transportation infrastructure and the associated expansion of human settlements has impacts on land, habitat, water, and endangered species. In addition, transportation is a major contributor of greenhouse gases causing climate change, and climate change is already having impacts on transportation systems. This chapter summarizes some of the key environmental challenges we face in making our transportation system healthier for humans and the larger environment.

KEY POINTS

- Human-caused climate change is a scientific fact and is happening already, and many cities, states, and countries are preparing not only to reduce transportation emissions of carbon dioxide but also to deal with the effects that higher temperatures, sea-level rise, and an increase of extreme storms will have on our transportation systems.
- Air pollution from transportation causes various harms to society and the economy, including hundreds of thousands of early deaths, millions of asthma attacks and lost work days nationally; the Clean Air Act rules reduce these harms significantly.
- Many areas within the state of Arizona are out of compliance of National Ambient Air Quality standards and must follow strict clean air act rules in their transportation plans.
- Air pollution from nearby urban areas and unpaved roads cause serious air quality problems on tribal lands.

AIR QUALITY AND AIR POLLUTION

WITH ALEX KARNER

Air pollution comes from a combination of natural processes, such as wildfires, tornadoes and volcanic eruptions, and human activities, such as fireplaces, construction sites, factories, electricity generation plants, and the burning of fossil fuels. For some key pollutants, like CO or nitrogen oxides, transportation is the main culprit. It is important to keep in mind that the same air quality will affect different people in different ways and to different degrees. The Environmental Protection Agency (EPA), which regulates air quality and pollution emissions throughout the country, in conjunction with the ADEQ regulates the level of six "criteria" air pollutants that are considered very dangerous to public health. The criteria pollutants most related to transportation activity are found in Table 7.1.

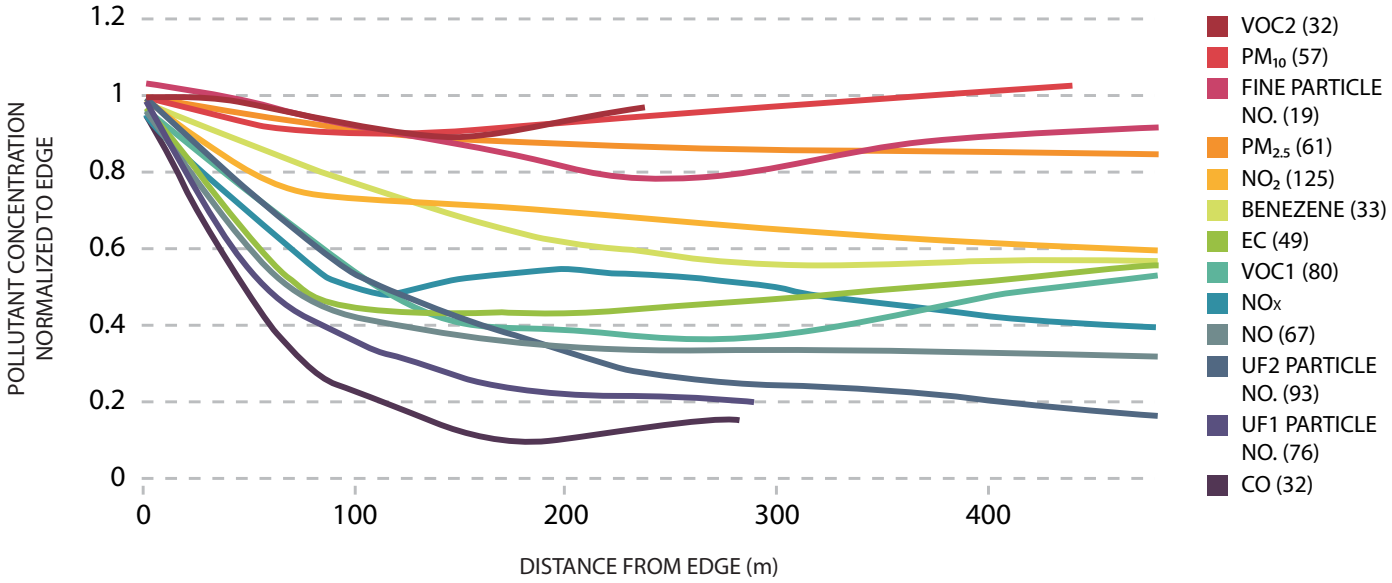
One particular issue with air pollution from transportation is that some pollution can form linear "hot zones" alongside roads. Figure 7.1 shows how some pollutants, such as CO, are highly concentrated near roadways, while others disperse into the surrounding air. Near-road air quality is an issue brought up by opponents to the South Mountain Freeway, who highlight the numerous schools that would be within ½-mile of the new freeway: protectazchildren.org/hot-zones.pdf.

Table 7.1 Major air Pollutants from Transportation Activities

Air pollutant	Description & Health Impacts
Particulate Matter	Consists of many different substances suspended in air as particles, which are categorized by size.[194] Particulates are caused not only by emissions from combustion but also by tire wear and driving on dirt roads. Effects of inhaling particulates include cough, phlegm, wheezing, shortness of breath, bronchitis, increased asthma attacks, and aggravation of lung or heart disease.
Ozone	Is a colorless, but pungent gas that occurs naturally in the upper atmosphere where it serves as a protective element. At ground level, however, it is a pollutant.[195] Ground-level ozone is the primary constituent of smog and causes respiratory illnesses such as pulmonary edema, asthma, emphysema, chronic bronchitis, coughing, sneezing, and chest pain. It also makes plants more susceptible to disease and reduces crop and forest yields.
Nitrogen Oxides	Consist mostly of NO_2, a reddish-brown gas that contributes to ozone formation, haze, and acid rain. Motor vehicles are a primary source. Lung infections, bronchitis, and eye and nose irritation are the worst health effects. Excess nitrogen from the atmosphere may also get deposited at the mouths of rivers, stimulating excessive algae growth, which reduces dissolved oxygen and creates large dead zones.
Carbon Monoxide	Is an odorless, colorless, and poisonous gas emitted mostly by motor vehicles. However, CO levels have not exceeded federal standards in Arizona since 1996.

Source: Information on the six major air pollutants can be found at epa.gov/airquality/urbanair. Two of the six, lead and sulfur dioxide, are not reviewed here because they are mainly caused by activities other than transportation.

Figure 7.1 Pollution Levels Near Roadways



Source: Karner, A. A., D. S. Eisinger, and D. A. Niemeier (2010). "Near-roadway air quality: synthesizing the findings from real-world data." Environmental Science & Technology 44(14), pp. 5334-5344.

Since the relationship between pollution from transportation and public health was first recognized nearly 70 years ago, federal and state agencies have made significant efforts to monitor air quality and reduce the pollution emitted from transportation systems. These efforts are guided by the rules and regulations stemming from the 1990 Clean Air Act amendments. The EPA estimates that these requirements cost the national economy around $50 billion in compliance costs in 2010. In contrast, the benefits amount to more than $1.1 trillion. In 2010, the rules prevented 160,000 Americans from dying prematurely, averted more than 1.7 million asthma attacks, and avoided 13 million lost work days.[196]

Pollution control for transportation takes three basic approaches:

1. Regulate the emissions from new vehicles sold in the United States through tailpipe emissions standards
2. Insure vehicles remain clean throughout their lives by periodically checking the vehicles as they age (smog checks)
3. Encourage shifts from solo driving to carpooling, public transit, and NMT by funding projects that make those alternatives more attractive.

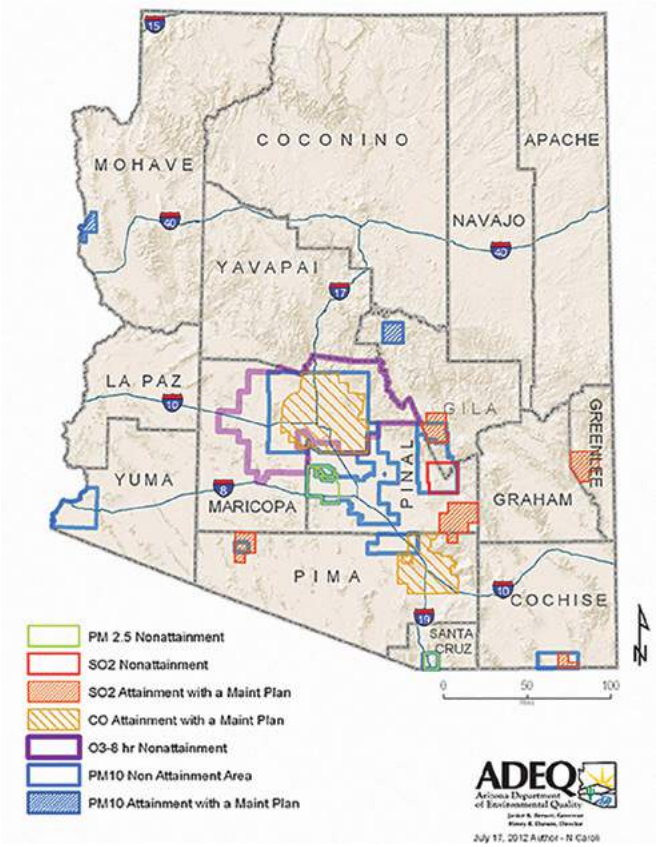
Emissions regulation over the past several decades has reduced total emissions tonnage (of all six criteria pollutants) by 62%. For some automobile tailpipe emissions, such as CO, emissions have been reduced by nearly 99% from levels before emissions rules were enacted. Unfortunately, total driving has increased so much that even with the substantial reductions made, more than 70 million Americans still live in counties violating at least one of the National Ambient Air Quality Standards in 2013.

TRANSPORTATION PLANNING REQUIREMENTS FOR AIR QUALITY CONFORMITY

The EPA classifies regions where air quality does not meet one or more standards as "non-attainment" regions. This classification places specific requirements on metropolitan planning organizations (MPOs) to include a set of policies in their Regional Transportation Plan (RTP) for reducing emissions (described more fully in the next chapter on planning). These policies, known as Transportation Control Measures (TCM), may include High-Occupancy Vehicle (HOV) lanes, improved public transit, rideshare programs, and express buses, among others. The RTP must be updated every three years and MPOs must show that projected emissions from the total package of transportation improvements in the RTP and Transportation Improvement Program (TIP) will not cause emissions to rise above the allowable limit. Even after consistently meeting air-quality standards, "non-attainment" regions remain classified as in "maintenance" status for some time and must continue to meet conformity requirements.

States and counties in non-attainment must submit a plan for approval by the EPA as to how it will work to meet the standards. For example, due to past violations of CO standards, Maricopa County and parts of Pinal and Yavapai Counties are required by the EPA to sell Arizona Cleaner Burning Gasoline (CBG) during the winter gasoline season. Arizona CBG is oxygenated by the addition of ethanol or MBTE, and reformulated by chemical removal of impurities. It has substantially reduced ozone and CO concentrations in the atmosphere, but adds an estimated 9-17 cents per gallon to gas prices.[197] Even though the EPA re-designated the MAG region as an "attainment" area for CO (since 2005), Arizona CBG is still required during months when there is a risk of exceeding those standards. For updates on the program, see: azdeq.gov/environ/air/plan/download/052113sip2.pdf.

Figure 7.2 Current Air Quality Status for Regions of Arizona



Source: Arizona Department of Environmental Quality. azdeq.gov/environ/air/plan/images/notmeet.jpg

Conformity requirements are particularly important for Arizona, because the three largest metropolitan areas are all either in non-attainment or maintenance for at least one transportation-related pollutant. Figure 7.2 shows that the MAG area is in non-attainment for ozone and PM-10, the PAG and MAG areas are "maintenance" areas for carbon monoxide, and the Yuma area is in non-attainment for PM-10. This means that projects proposed for the RTP or short-term TIP must meet conformity requirements and not contribute to worsening pollution—or risk losing federal funding.

AIR POLLUTION ON TRIBAL LANDS

Transportation corridors that increase traffic through reservation communities increase air pollution risks for community residents. The National Air Toxics Assessment and the Joint Air Toxics Assessment Project, a multi-jurisdictional monitoring effort of the Salt River Pima-Maricopa Indian Community and Gila River Indian Community and the Arizona Department of Environmental Quality, determined that hazardous air pollutants from vehicle emissions are highest adjacent to high-volume roadways, such as those on or near those reservations (epa.gov/ttnamti1/files/20032004csatam/fyo4pho.pdf).

Emissions from vehicles traveling on roadways near tribal lands can also have adverse effects. Ozone is created by sunlight and heat acting on pollutants from vehicle emissions as they move through the airshed. Some of the highest readings in the Valley of the Sun are on or near the Salt River Pima-Maricopa Indian Community and the Fort McDowell Yavapai Nation, both of which are downwind of the Phoenix metro area.

The significant number of miles of unpaved roads in tribal communities also poses potential health risks from particulates (dust) to residents of those communities. Children are particularly vulnerable to respiratory health effects from particulate air pollution when they wait on a daily basis for school buses on unpaved roads.

AIR POLLUTION FROM FREIGHT TRANSPORTATION

Freight transportation by truck and rail burns about 46 billion gallons of fuel per year, or roughly 17% of all the petroleum-derived fuels used in transportation (2012).[198] Freight operations, particularly rail, also require large amounts of land.[199] Finally, commercial trucks account for as much as half the traffic on rural Arizona interstate highways, reinforcing their significant negative effect on the State's air quality. The major trucking companies headquartered in Arizona could be excellent partners in developing new technologies for cleaner engines, and instituting policies aimed at lowering emissions, such as less idling.

TRANSPORTATION AND CLIMATE CHANGE

The basic science behind global climate change is now well established and accepted. Human-caused climate change is already occurring, is accelerating, and is beginning to cause impacts for which we must start planning. While there are still uncertainties regarding the pace of climate change, tipping points, feedback effects, and effects on some regional weather patterns, the overall picture has become more and more evident. This section looks at the relationship of climate change and transportation in Arizona in both directions—how emissions from transportation contribute to climate change, and how climate change is impacting transportation systems.

The fundamental mechanism behind climate change is increasing human emission of heat-trapping GHGs, primarily carbon dioxide (CO2) but also methane, nitrous oxides, and water vapor, which are building up in the atmosphere and raising global temperatures. The concentration of CO2 in the atmosphere has risen from about 280 parts per million (ppm) at the beginning of the Industrial Revolution to 386 ppm in 2008 (reported in the last Town Hall report on transportation), to 396 ppm in 2014,[200] with daily concentrations above 400 ppm recently recorded for the first time ever (see box).

The Intergovernmental Panel on Climate Change concluded that, "warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen."[201] Furthermore,

EMISSIONS FROM TRANSPORTATION CONTRIBUTE TO CLIMATE CHANGE,AND CLIMATE CHANGE IS IMPACTING TRANSPORTATION INFRASTRUCTURE

ARIZONA CLIMATE CHANGE INITIATIVES

"GOVERNOR [BREWER]'S POLICY ON CLIMATE CHANGE RECOGNIZES THE IMPORTANCE OF REDUCING GREENHOUSE GAS EMISSIONS WHILE MAINTAINING ARIZONA'S ECONOMIC GROWTH AND COMPETITIVENESS. THE GOVERNOR'S POLICY SUPPORTS ARIZONA'S CONTINUED COLLABORATION IN REGIONAL AND NATIONAL ENDEAVORS TO ADVANCE CLEAN ENERGY AND IMPLEMENT COST-EFFECTIVE SOLUTIONS TO CLIMATE CHANGE WHILE SAFEGUARDING ITS UNIQUE STATE INTERESTS."

» SOURCE: AZCLIMATECHANGE.GOV

increased emissions are "extremely likely" to have been "the dominant cause of the observed warming since the mid-20th century."[202] The 1980s, 1990s, and 2000s have each been warmer than the previous decade.[203]

That's what has already happened, but what about the future? The Third National Climate Assessment published in May 2014 estimated temperature increases of 3-6°F and sea-level rise of 1-4 feet as the most likely scenarios for the 21st century.

By the numbers XV: Evidence that Climate Change is Already Happening

Surface Temperature Increase, 1880-2012	=>	1.5°F
Sea Level Rise, 1900-2010	=>	7.5 inches
Arctic Sea Ice Decrease since 1979	=>	3.5% to 4.1% per decade

Source: Intergovernmental Panel on Climate Change. Climate Change 2014 Synthesis Report Summary for Policymakers, pp.1-2. ipcc.ch/report/ar5/syr/. For graphical presentation of observed changes, see nca2014.globalchange.gov/report/our-changing-climate/observed-change#narrative-page-16564

Transportation accounted for 34% of all Arizona GHG emissions in 2012,[204] well above the national share of 28%[205] and trailing only electricity generation both in Arizona and nationally. Road transportation, which is dependent almost entirely on petroleum, accounts for 65% of transportation emissions.[206] Mitigation efforts to reduce GHG emissions from transportation in Arizona will need to concentrate on reducing emissions from cars and trucks. Numerous strategies are available, including:

- Increasing efficiency of cars and trucks
- Reducing single-occupant vehicle travel
- Reducing the average length of road trips through increased density, smart growth, transit-oriented design, and mixed use development
- Switching to alternative fuels with lower carbon footprints
- Trip chaining (making more stops along the way rather than separate trips)
- Increasing telecommuting, online shopping and education, and social media to replace work, shopping, school, and social trips
- Mode switching to bus, rail, bicycling, and walking

Assessing the carbon footprint of alternative fuels depends greatly on the well-to-wheels pathway by which they were produced. Hydrogen fuel cell and electric vehicles are considered zero-emission vehicles because they do not produce any tailpipe carbon emissions. Both, however, generate carbon emissions "upstream" because both electricity and hydrogen are still generated mostly from fossil fuels. As the cost of renewable electricity falls and the electric grid shifts towards renewables, electric vehicles (EVs) will get greener and hydrogen will be made by electrolyzing water. Thus, there is an argument for investing in electric and hydrogen cars and stations now in order to reach

Passing the "400 ppm" mark

"Passing the 400 mark reminds me that we are on an inexorable march to 450 ppm and much higher levels. These were the targets for 'stabilization' suggested not too long ago. The world is quickening the rate of accumulation of CO2, and has shown no signs of slowing this down. It should be a psychological tripwire for everyone."

Dr. Michael Gunson, Global Change & Energy Program Manager, Project Scientist, Orbiting Carbon Observatory-2 satellite mission, NASA Jet Propulsion Laboratory

ppm = parts per million.

Source: NASA, Global Climate Change, Vital Signs of the Planet: climate.nasa.gov/400ppmquotes/.

Mitigation vs. Adaptation

Mitigation and adaptation are the two main kinds of response to climate change. Mitigation refers to reducing emissions of greenhouse gases to lessen its future impacts. Adaptation means preparing to deal with those impacts that are likely to affect our future transportation system.

a critical mass in those industries and infrastructure systems in anticipation of the greening of electricity generation and the eventual imposition of carbon regulations on transportation.[207]

Under former Governor Janet Napolitano, Arizona developed a Climate Action Plan that counted on transportation and land-use changes to provide 20% of emission reductions. Napolitano asked ADOT to inventory options for mass transit, including commuter and light rail,[208] and to define a smart-growth development process to "direct future discretionary funding to applicant communities that agree to participate in and abide by this smart growth and development process."[209] Most of these efforts ended with the Brewer administration. EPA has a website that links to climate action plans developed by states and metro areas to reduce GHG emissions. Currently, the only plan listed for Arizona is Pima County's August 2008 Sustainable Action Plan for County Operations (epa.gov/statelocalclimate/local/local-examples/action-plans.html#az).

Advance planning is necessary not only for mitigating emissions but for adapting to the likely effects of climate change. Transportation infrastructure systems are being planned today that will not be operational until the 2020s or 2030s, and will remain in use for much of the 21st century, if not beyond. Efforts are underway all over the United States and the world to prepare for the likely effects of climate change. The US military, for instance, produced a 2014 Climate Change Adaptation Roadmap that begins with the sentence, "Climate change will affect the Department of Defense's ability to defend the Nation and poses immediate risks to US national security." Also in 2014, the US Global Change Research Program published its Third National Climate Assessment (NCA), which details how climate change is likely to impact every region of the country and every sector of the US economy (nca2014.globalchange.gov/).

The NCA Transportation chapter points out that climate change will have both direct and indirect effects on transportation systems. Direct effects include damage to vehicles and infrastructure, and temporary closure of networks and terminals due to higher temperatures, increased intensity and frequency of extreme storms, flooding of coastal assets from storm surge, and other weather effects. The indirect effects include shifts in trade flows, agriculture, energy supply and demand, where people live, and human behavior. The report advocates a risk-management approach to adaptation and characterizes the impacts in terms of their likelihood of occurrence and magnitude of impacts. Luckily for Arizona, the transport risks with the highest magnitude of impact and virtual certainty of occurrence are inundation of coastal transportation networks and airports lying below 10 feet above sea level. While Arizona lacks ocean coastline, we are likely to feel the ripple effects of airport, rail, road, and port flooding in places like San Francisco, New York, Boston, Miami, Houston, and other highly vulnerable cities, and our economy will suffer losses from the resultant delays.

The NCA Southwest chapter identified the most likely major impacts on our region as decreasing water supply reliability, increasing temperatures, and associated drought, fire, and insect outbreaks.[210] The urban heat island effect will amplify the effect of higher temperatures, and along with potential disruptions of urban water and electricity supplies, put our population at risk.

In 2014, ADOT completed an Extreme Weather Vulnerability Assessment.[211] This pilot study concentrated on the I-10/I-17 corridor because it is a major statewide artery that passes through the four major climate zones of the state—desert, grassland, chaparral, and forest. All regions of the state will see a dramatic increase in the number of days over 100°F (Figure 7.3), which will increase risks from pavement deformation, thermal expansion of bridges, increased tire debris on roads, and construction worker safety and schedules. Extreme heat is also likely to have a disproportionate impact on the state's most vulnerable populations (see 2014 Arizona Town Hall report on that topic) because of the impact on non-motorized transportation and access to public transit. Dust storms in desert areas are expected to increase. On the other hand, snowstorm risks and freeze-thaw damage to roads are expected to lessen in the state's higher elevations. One major area of uncertainty in Arizona is whether 100-year rainfall events will increase or decrease, as climate change effects on the southwest monsoon are not fully understood.

Figure 7.3 Extreme Temperature Days

Average Annual Days >100°F	Past (1950-1999)	2040	2080
Desert	68	108	143
Grassland	9	30	69
Chaparral	7	28	64
Forest	2	9	26

Source: ADOT (2014). Extreme Weather Vulnerability Assessment.

The NCA Transportation chapter suggests two types of adaptation to transportation risks.[212] First, local and state authorities can begin to retrofit and relocate facilities, improve stormwater drainage systems, and build new facilities to climate-ready standards. Second, some facilities are going to be impacted regardless of our attempts to protect them. The flexibility to re-route passenger and freight flows to other routes and modes is crucial, as well as traveler information systems to warn travelers of the risks, and strategies to rapidly bring damaged facilities back on line and evacuate areas that are threatened.

WATER, NOISE, LAND, AND SPECIES IMPACTS

Additional transportation impacts include water and noise pollution, land use, and habitat destruction. Storm-water runoff from impervious roads and parking lots into rivers, lakes, and groundwater is a serious problem. The Environmental Protection Agency (EPA) estimates that 30% of water pollution is due to runoff, including runoff from farms, construction sites, and landfills.[213] Runoff from paved surfaces includes oil and grease, toxic compounds from brake dust, debris, chemicals, sediment, and bacteria. There are emerging urban planning standards around minimizing runoff from urban roads and parking lots called "low impact development" (LID). These include requiring swales and diverters so rain water can flow into areas with trees and seep into the soil, rather than into storm-water drains (see Figure 7.4). Studies show that this reduces pollution levels in nearby streams and supports vegetation, which can lower temperatures and improve aesthetic environments. Visit the EPA LID site water.epa.gov/polwaste/green or Arizona's Watershed Management Group watershedmg.org for more information.

Trucks, motorcycles, and airplanes are the worst sources of noise, although they are quieter now than several decades ago. Traffic noise is related to traffic speeds. The federal Noise Control Act first regulated noise pollution in 1972, which required noise analysis of all federal projects. Noise barriers are now standard features of urban highways and ADOT provides the opportunity for communities to add more sound protection with additional funding when it is available.

Figure 7.4 Bioswale on Arizona State University Campus to Capture Rainwater Runoff from a Parking Lot

Source: A. Golub

Highway planners typically look for the cheapest and easiest routes for constructing new infrastructure corridors. Not surprisingly, these corridors often go through lands that are undeveloped because they are ecologically sensitive lands that have been protected by previous conservation efforts. The Arizona Chapter of the Nature Conservancy has published a report, Growing by Design, which identifies alternative growth corridors with less impact on Arizona's "natural infrastructure."[214]

Natural habitats are often disturbed by transportation projects. Roads, railroads, bridges, airports, and pipelines can drain wetlands, divide animal territories, disrupt animal migration, and reduce the wilderness quality of various habitats. Wetlands are especially ecologically valuable, particularly in Arizona. Exposure to traffic is a significant cause of mortality for endangered species. Under- or overpasses for animal crossings are sometimes included as a part of new highways in major wildlife corridors. The movement of wildlife will be affected by the South Mountain Freeway construction, for example, and specific features are planned in the design to assist with animal crossing (see Project Spotlight in Chapter 9).

Away from normal roadways, managing off-highway-vehicle (OHV) use on public lands is a significant concern. Recent research estimates that approximately 20% of adults in the state (over 1 million people) participate in motorized recreation on trails in Arizona.[215] Land managers are concerned about OHV impacts to the environment such as damage to vegetation, soil erosion, impacts to air quality, and habitat fragmentation. On High Pollution Advisory days for particulate matter within Maricopa County, OHV activities are not permitted.[216] The US Forest Service (USFS) completed an extensive travel-management rulemaking process to designate OHV routes on its lands in 2008.[217] In the Sedona area, which attracts close to three million tourists annually,[218] the primary travel corridor and the developed OHV routes parallel Oak Creek Canyon, providing recreation access but also putting pressure on sensitive riparian resources.

PART III

STEERING THE SYSTEM

In this part, we lay out for our readers how transportation planning takes place and how transportation related decisions are made and executed on the ground, in Arizona. We also explain to our readers how existing planning, policy and decision-making structures, and ways and means have evolved in the state.

TRANSPORTATION POLICY
Q&A WITH **JOSEPH LARUE** & **TARA JACKSON**

TO SET THE STAGE FOR THIS FINAL SECTION OF THE REPORT, WE INCLUDE A Q&A BETWEEN TARA JACKSON, PRESIDENT OF THE ARIZONA TOWN HALL, AND JOSEPH LARUE, ON WHAT HE SEES AS THE MOST PRESSING TRANSPORTATION POLICY ISSUES FACING OUR STATE.

Tara Jackson
Town Hall President

Joeseph LaRue
Town Hall Board
Sun Health Executive Vice President

Tara: Why does transportation matter to Arizona's economy?

Joe: Transportation is an essential component of a healthy economy and an essential building block for future economic growth. Transportation enables trade and commerce by connecting workers to jobs, business to businesses, and Arizona communities to the global economy. Transportation infrastructure impacts the efficient movement of people, goods and services, which directly impacts the economy.

Tara: What are the most important policy issues relating to transportation?

Joe: The single most important policy issue to resolve is how to pay for the transportation system we need. Funding for transportation infrastructure is complex and requires long-term planning for major projects. Funds are needed to expand the transportation system, to respond to population growth, and to enhance connectedness to the global economy. However, maintaining the existing system is consuming more and more of the allocated transportation dollars, which are stagnant and in some situations declining. This means that policymakers have to choose between using limited resources to preserve and maintain existing systems or expanding those systems to improve economic opportunities.

The tension between the urban and rural transportation systems is another important policy issue. Currently, rural areas are funded differently than Arizona's urban centers, and often feel they are not getting their fair share of transportation improvements. We need to explore how to support transportation systems that help the entire state.

Tara: What are the greatest challenges in solving these policy issues?

Joe: Arizona's transportation governance, planning, funding, and responsibilities are complex and varied. Local, county, regional, state, tribal and federal governments have a responsibility to plan and decide for the common good of their constituents. However, the common good for one area is often in competition with that of another area.

Tara: What actions would have the greatest return on investment for Arizona's future transportation needs?

Joe: Additional revenues to fund transportation infrastructure are required to meet Arizona's future needs. Revenue generation in other states has come in the form of gas tax increases, sales tax increases, or—in Oregon—a new VMT tax. These forms of revenue establish some baseline funding mechanisms that are systemically built into the budgets for transportation systems.

CHAPTER 8

PLANNING & POLICYMAKING FOR TRANSPORTATION

PLANNING BASICS

The transportation system you used today does not exist by accident. It was imagined, planned, and financed years ago by various teams of planners, engineers, and elected officials in close collaboration with the public and other stakeholders. Planning is, in essence, the act of leveraging resources and decisions towards achieving some outcome in the face of estimated future demands for some service. Planning for transportation needs takes place at nearly all levels of government and includes activities by the private sector, households, and civil society as well. The private sector plans as it applies investments to develop and deliver goods and services. The public sector applies its budgets and leverages its control of land uses, public rights of way, and policing and taxing abilities to achieve socially desirable outcomes. In this chapter, we review the important steps that take place in the transportation planning process, much of which is dictated by legal directives at various levels of government. As such, we first review some basics of planning processes then proceed in rising order of governmental level.

GENERAL PLANNING PROCESS

PREDICTING DEMAND, BUDGETS, PROJECT NEED, LOCATION

It is impossible to know the number of trucks that will cross the I-40 next year, how many parking spaces will be needed for the Christmas shopping rush in 2020, or how many people will ride Bus Route 72 in 2030. Planners rely on best estimates of these and many other variables based in turn on estimates of the underlying forecasts driving transportation demand—population, land use change, economic growth, income, employment, tax revenue, costs of fuel, materials and labor, etc. These projections are made by a variety of institutions such as the US Department of Energy, the Arizona Department of Administration, municipalities, airports and regional governments. For instance, the Maricopa Association of Governments (MAG) produces regional projections for land use and population change, which allows partner agencies, such as ADOT, Sky Harbor, and cities within the MAG area to understand where they should expect land use and populations to change over the coming decades.[219] These estimates are then used to model future traffic congestion, light rail ridership, and other transportation related issues.

Transportation projects are strongly affected by these estimates because they shape where the project is located (e.g., where the road should go), how much demand the project must satisfy (e.g., how wide should the road be), and how much it will likely cost. Estimates may also determine that a project is not needed or that it should be changed (say from road to light rail).

PROJECT EVALUATION

Federal and state regulations dictate how projects and plans are to be evaluated before they are implemented or adopted. These evaluations are based on the National Environmental Policy Act (NEPA) of 1969 and various US DOT regulations. These evaluations insure that relevant laws, such as those protecting endangered species,

KEY POINTS:

- Various federal and state laws govern how transportation projects are planned; these rules govern population forecasting, environmental impact evaluation, public involvement, and adherence to civil rights and environmental laws.
- Transportation planning activities occur across the state, from small towns to mega-regions, and from tribal communities, national parks, to statewide plans.
- The preliminary planning and evaluation process can take over a decade for larger projects with complicated impacts.
- Smart growth has emerged as a popular approach to leverage the underlying synergy between transportation and land use.
- Engaging the public in project planning is always a challenge.

water quality, or public health are adhered to as projects are planned. All projects are evaluated under such regulations with rare exceptions for projects that are too small or likely to have no effect (say a bike path on an existing road).

Figure 8.1 Basic Steps in NEPA Review of Transportation Projects

1. Determine jurisidiction, permitting, and funding needs
2. Define purpose and need
3. Public scoping of important impacts
4. Develop project alternatives
5. Analyze alternatives
6. Draft environmental impact statement
7. Public review
8. Final environmental impact statement
9. Public review
10. Final record of decision
11. If project is needed, proceed with engineering, design and construction

Source. Adapted by author from ADOT NEPA Process Guidance for Federal Aid Projects, azdot.gov/business/environmental-planning/environmental-guidance-documents/nepa-process-guidance/overview.

Projects are evaluated through a series of steps that allow: 1) the public and relevant agencies (local, state and federal) to give input to the project, 2) different project alternatives to be evaluated and compared (including not building the project at all), 3) defining any adverse impacts from the project, and finally, 4) mitigating (reducing or offsetting) any unavoidable negative impacts from the project.[220] These basic steps are shown in the Figure 8.1.

These steps insure the project is widely supported by both the public and is approved by other agencies responsible for overlapping issues, such as land, water, housing, or civil rights. In the first step, the responsible agency announces that it will be preparing the project and is seeking public and other agency inputs. It then produces a "purpose and need" statement and proposes several different project alternatives that respond to the need. It then prepares a draft environmental impact statement (EIS) analyzing those alternatives, followed by a comment period to allow the public and other agencies time to review the alternatives and respond with their questions and comments. A final EIS is then prepared defining the preferred alternative and its likely adverse impacts on local communities and the environment as governed by various federal laws regarding endangered species, water and air quality, and civil rights (see further discussion on civil rights below). The public and other agencies have a second comment period in which they can comment on the Final EIS, after which the recommended project and any recommendations to mitigate its adverse effects go into a final record of decision. The project is then approved to obtain funding, conduct detailed engineering, and be constructed.

PUBLIC INVOLVEMENT

Public input into the project planning process as described above is an important part of most planning and project evaluation processes. During comment periods, planners run a series of public meetings, surveys, or other public events to gather public sentiment about the project or other needed information. The public can also come forward with information or questions for the agency. For most projects, considerable time and effort is being spent gathering commentary on design and redevelopment preferences. For example, the transcript of public comments on the proposed South Mountain Freeway Draft EIS contained over 8,000 comments (see Box).[221] Though all are addressed by law, the mechanism by which specific comments are translated into design guidance is not clear.

At the federal level, the drive for public involvement began with Title VI of the 1964 Civil Rights Act, which mandated equal rights to projects and participation where federal funding was involved.[222] This was followed by the National Environmental Policy Act (NEPA) of 1969, which mandated public involvement in all evaluations of federally funded projects. Many states followed NEPA with their own state mandates for public involvement in similar cases.

The Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991 made public involvement a more formal and prominent mandate in legislative documents.[223] Most recently, the 2012 US DOT Environmental Justice mandate strengthened and codified Title VI specifications,[224] causing new rules to be adopted by both FHWA and FTA.[225] Still, language about public involvement is often couched in broad terms and lacks specificity about process objectives, outcomes, or quality criteria.

Legally, public involvement must be executed by the agency overseeing the project planning. Often, private-sector firms are hired to facilitate the process. The mandated form of public involvement is limited under Arizona law. For example, in terms of public input into large-scale processes such as highway surveys, Arizona Revised Statute §28-6952 only requires "a public hearing held at the office of the board to review the program and hear objections and protests from an individual or group." The Pima Association of Governments (PAG) developed a public involvement plan to guide its regional planning process.[226]

Public involvement in transportation decision making in Arizona, and elsewhere, is a complex, often contested undertaking because of diverging stakeholder interests. With sizable populations of households where a language other than English is spoken, Arizona's public agencies need to tailor their outreach and communication approaches to serve these communities.[227] Projects can range widely in transport mode and scale, and from rather nebulous visioning questions to hard criteria such as specific design alternatives for structures such as noise walls. Resource constraints put pressure on the sponsoring agencies to gather input in a short time, using as few meetings as possible.

The US DOT produces a range of guides for public involvement processes.[228]

The fact that a variety of agencies and governmental levels collaborate on planning and constructing transportation projects further complicates the public-involvement process. One successful example of intra-agency collaboration on public involvement was the Route 179 project near Sedona (see Project Spotlight). A key to their success was the proactive approach of regional and local stakeholders, including Metropolitan Planning Organizations (MPOs) and city transportation departments. The ADOT Local Public Agencies Manual contains procedures for enhancing inter-agency cooperation in public involvement.[229]

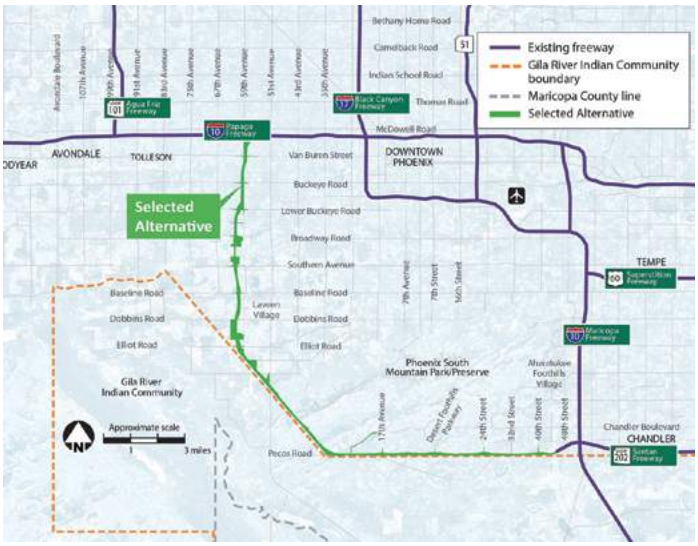
While most of the concerns raised during public comment periods involve the environmental and social impacts of the projects, sometimes the legitimacy of the planning process is questioned. Many transportation researchers have noted how stakeholders refuse to participate in, or do not believe in the legitimacy of, public-involvement processes.[230] Given the enormous sums of public money being spent, taxpayers are increasingly intolerant of "tokenism" in public involvement. The "silent majority" that declines to participate in public forums means that input from public meetings often does not represent the full range of stakeholder views. This erodes confidence in the legitimacy of actions undertaken on the basis of such input. To overcome civic detachment, the public involvement process needs to be seen as legitimate.

Practical, methodological, and educational steps can improve the public-involvement process. State DOTs such as Utah's are beginning to introduce indicators for public involvement and decision quality that are tied to contractors' payments. States are requiring use of best-practice methods for designing large-scale public-involvement processes, such as techniques for managing meetings and eliciting meaningful valuations from large numbers of stakeholders, and using face-to-face, remote, or online survey methods. Training for civil engineers and project managers on public involvement is also essential, and the stipulation for project managers to be present as the "public face" of the project, for example, is certainly helpful.

South Mountain Freeway (SMF)

AZ Loop 202 or the South Mountain Freeway (SMF)

For decades, regional freeway plans have included a high-capacity roadway connection between the I-10 West in Phoenix and Loop 202 in Chandler running south of South Mountain. It was included in the plan approved by Maricopa County voters in Proposition 300 in 1985 and by voters again in 2004 through Proposition 400. Voter-approved plans, however, contain many different pieces, all of which still need to pass federally required NEPA reviews. The SMF has been subject to such a test and appears it will gain final approval sometime in 2015. While the transportation benefits of such a connection may seem obvious, a significant group of Ahwatukee residents have complained about significant negative impacts relating to the ecology of South Mountain Park, sacred native sites, mountain views, traffic noise, and neighborhood air quality. After 14 years and millions of dollars spent in planning, the process has been anything but smooth, and even upon final approval this year there may be additional legal and administrative challenges made by parts of the community.



For more information on the project, see azdot.gov/projects/phoenix-metro-area/loop-202-south-mountain-freeway and for details on the complaints about the project visit: protectazchildren.org.

Source: Loop 202 South Mountain Freeway Fact Sheet. azdot.gov/docs/default-source/loop-202-south-mountain/13-148_factsheet_v10_092314.pdf?sfvrsn=2

BACK TO THE LECTURE HALL 8.1

CONTEXT SENSITIVE SOLUTIONS (CSS) IN TRANSPORTATION PLANNING

CSS principles encourage planners, developers and stakeholders to consider land use, transportation, and infrastructure needs in an integrated manner. The core principle of CSS is "balanced" decision making when planning efforts reflect community input and take into account the impacts on both natural and human environments. This also promotes partnerships. See fhwa.dot.gov/planning/csstp/integrating. ADOT's context-sensitive upgrade to state route 179 from I-10 through Oak Creek Village to Sedona involved an extensive outreach process with frequent regular meetings that incorporated input from a range of stakeholders (see related spotlight project discussion in section 9a). Stakeholders initially defined a set of "core values" that served to guide many of the ensuing discussions and charrettes–collaborative sessions in which a group of designers drafts a solution to a design problem. Dozens of meetings with the community produced a range of design options. The outstanding outcome and support from the community won the project the International Best Project Award from the prestigious Institute of Transportation Engineers 2005 Transportation Planning Council and a Best Practices in Context Sensitive Solutions award from the American Association of State Highway and Transportation Officials.

PLANNING PROCESSES AT DIFFERENT JURISDICTIONAL SCALES

LOCAL AND CITY

Local land use control

Land-use planning, in effect, translates community goals into controls on the use of land. These goals may include health or environmental quality, historical or cultural preservation, creation of affordable housing, and promoting economic growth, among other things.[231] The separation of land uses, such as zoning industrial uses away from residential, may help to meet health or environmental goals, while density or height limits may influence housing costs and affordability or preserve vistas. An emphasis on retail or commercial land uses may help raise sales taxes in a municipality dependent on them for revenues. These various goals can have profound impacts on the relative mixture, proximity, and intensity of land uses, all of which affect transportation demand.

Municipalities also directly influence transportation through their land use controls and development permitting, which dictate characteristics such as parking requirements, access by motorized vehicles from the street and sidewalks, etc. These design characteristics impact how easy it is to move around and park by automobile, and in turn, how attractive it is to walk, cycle, and take public transit. Evaluating proposed developments for transportation impacts involves estimating the future traffic impacts of the project. Depending on the extent, the developer may be asked to change minor aspects of the design to mitigate impacts, make major infrastructure improvements, or pay additional fees. These impacts are only measured on local facilities—additional traffic on freeways is not normally included in the developer's responsibility.

Because of the unavoidable relationship between land use and transportation (see Chapter 3), effective transportation planning must involve local land use planning. The common "predict and provide" process, predicting future land use and transportation demand based on myriad local decisions and then scrambling to meet that demand, is technically not planning. Most land developments are permitted before the transportation capacity exists to handle the traffic they create, meaning that localities and developers are speculating on future regional investments in capacity to make the development viable.

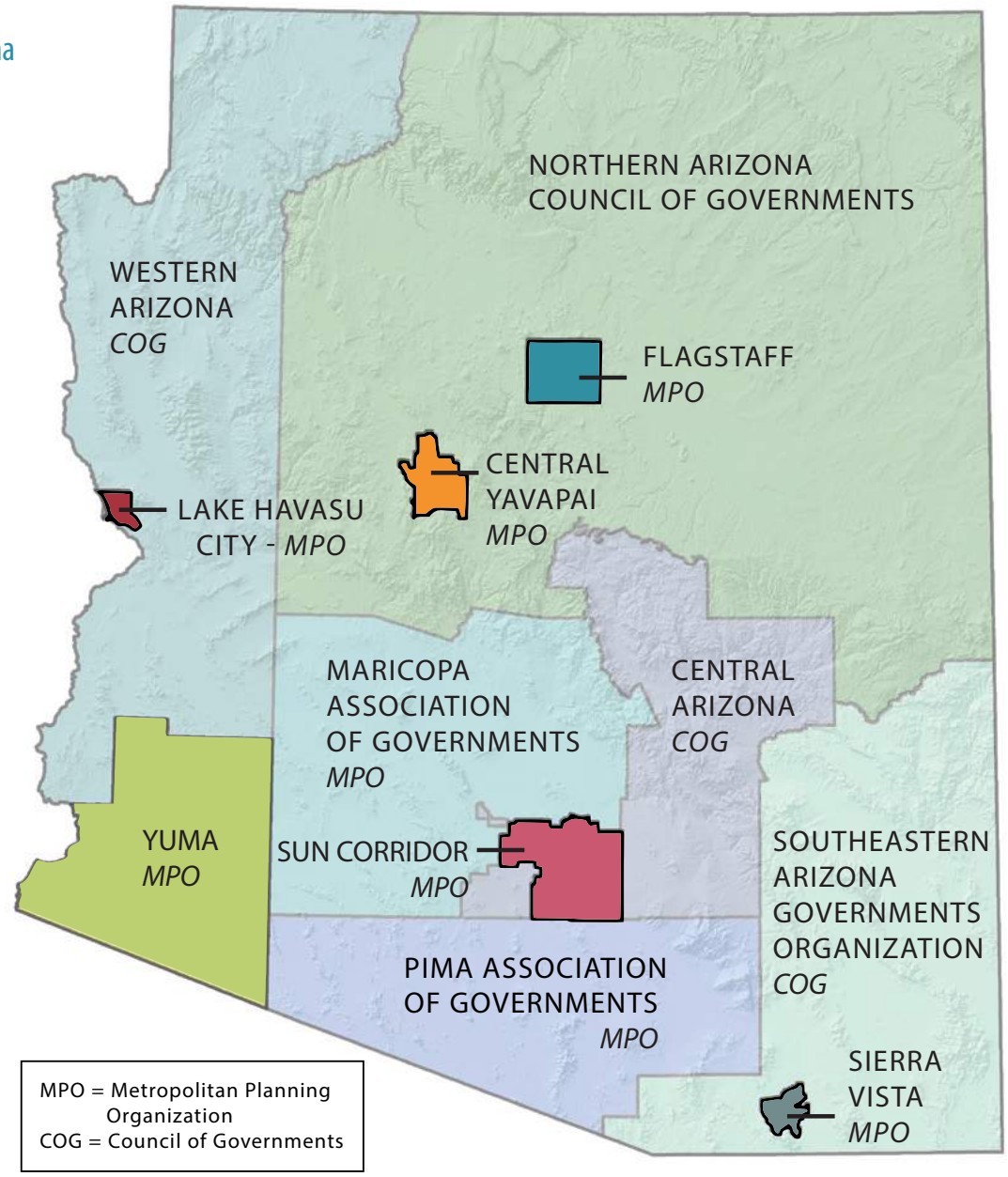
In Arizona, another issue with local land use planning is Proposition 207, which limits what local governments can do to control land use and limit development.[232] Quoting from a key passage in the 2007 Arizona Town Hall report on Land Use: Challenges and Choices for the 21st Century:[233]

> Problems with advance permitting are both private and public. In private hands, land serves as a vehicle to make money. Land near high-growth regions rises in value, as development gets closer, even without any action on the part of the landowner. If the owner gets permitting for development, again without any actual development, the land can rise in value dramatically. From there, whether the same owner develops or sells the land, the problem of speculation is locked in because of Proposition 207. Passed in 2006 and called the "Arizona Private Property Rights Protection Act," Prop 207 created a new Arizona statute stating: "If the existing rights to use, divide, sell or possess private real property are reduced by the enactment or applicability of any land use law enacted after the date the property is transferred to the owner and such action reduces the fair market value of the property, the owner is entitled to just compensation from this State or the political subdivision of this State that enacted the land use law."[234]

An attempt to shape growth may include limiting or restricting development in certain areas, thereby reducing the market value for some property. This could be potentially costly under Prop 207, although there has been no such litigation brought forth to date.

Figure 8.2 Planning Jurisdictions in Arizona

Source: Map prepared by Meggan Dugan, Arizona State University, based on data provided by ADOT.



Local planning

Depending on the scale of a potential new transportation project, local government may be directly involved in, or assist another agency such as ADOT, in project proposal and evaluation. Larger projects that receive federal funding need to be closely overseen and certified by ADOT or the regional MPO, so local involvement may be quite limited during project development. The ADOT Local Public Agency manual covers all aspects of project development for the local government to consider.[235] Local transportation planning, although focused on local issues, affects the larger metropolitan system.

Still, major differences exist from city to city in terms of programs, planning processes, and financing methods and levels. Each locality follows a different planning schedule, and may revise plans at different time intervals. The City of Tempe, for example, recently updated its Transportation Master Plan (tempe.gov/city-hall/public-works/transportation/transportation-master-plan-). Such a master plan would undergo a thorough process of public engagement around specific issues within the plan, such as the balance between public transit, NMT, and road investments.

METROPOLITAN

Metropolitan planning process[236]

Various overlapping jurisdictions plan transportation and land use in metropolitan areas, including the ADOT, tribal governments, councils of government (COGs), metropolitan planning organization (MPO), and other local bodies such as county and municipal governments and transit agencies. Arizona has six areas with designated councils of governments—Central Arizona Association of Governments (CAAG), Northern Arizona Council of Governments (NACOG), Southeastern Arizona Government Organization (SEAGO), Western Arizona Council of Governments (WACOG), Maricopa Association of Governments (MAG) and Pima Association of Governments (PAG). MPOs are designated in urban areas with populations above 50,000 to govern transportation planning in coordination with both member jurisdictions like cities and transit agencies as well as ADOT and the federal government. Arizona has eight MPOs—Flagstaff (FMPO), Central Yavapai (CYMPO), Yuma (YMPO), Lake Havasu City (LHCMPO), the Sun Corridor (SCMPO) and the Sierra Vista (SVMPO), along with MAG and PAG.

By federal law, an MPO maintains a work calendar of the studies and plans it is undertaking, convenes technical review committees, manages the public-involvement process in all of its planning programs, and oversees the development of the key planning processes at the regional level—the Regional Transportation Plan (RTP) and the Transportation Improvement Program (TIP). The RTP is a long-range plan covering at least 20 years, is updated every five years, and defines a regional vision for transportation development. An extensive public process helps define the RTP and the alternatives within it. Requests for project funding from within an urbanized area are submitted to the MPO for inclusion in the RTP and TIP. MPO staff reviews each project for coordination, conformity (to equity and environmental laws), and fiscal constraint in relation to TIP and RTP objectives. The RTP projects revenues available for capital investments, operations and maintenance, and develops project scenarios over the planning horizon that fit within those available funds. Sometimes RTPs also include a long-term scenario without financial constraints to imagine where investments might go if additional funds could be found.

While some MPOs actually develop and compare holistic regional scenarios embodying truly different visions, most simply assemble a list of projects from municipalities, ADOT, and regional public-transit agencies. For larger regions such as MAG and PAG, federal law requires the RTP to clearly define a congestion management plan. To get a flavor for the regional transportation plan, it is probably best to glance through some examples:

Maricopa Association of Governments. The most recent update of MAG's RTP covering 2014 to 2035 includes expansions of the regional freeway system, arterial roads, arterial bus system, high-capacity transit corridors connected to the light rail system, and other improvements totaling almost $26 billion. (azmag.gov/Documents/RTP_2014-01-30_Final-2035-Regional-Transportation-Plan-%28RTP%29-Executive-Summary.pdf). The plan spends almost 68% on freeway or arterial road expansions and O&M, about 30% on public-transit expansions and O&M, and almost 3% on bicycle and pedestrian improvements, special transportation needs, and other projects.

Central Yavapai Metropolitan Planning Organization. CYMPO's 2012 RTP covers 2011 to 2030 and is much smaller than MAG's. It focuses almost entirely on roadway improvements and new roads, with some attention to cyclist and transit needs: cympo.org/wp-content/uploads/2011/08/CYMPO_Final-Report_06202012.pdf.

Requirements for the regional planning process

There are various requirements made by federal law that influence the regional planning process. Those related to public involvement (discussed above), air quality, and civil rights are probably the most important. Regions where air quality does not meet one or more standards (see Section 7a) are classified by the EPA as "non-attainment" regions and have specific planning requirements as discussed. This classification places specific requirements on the MPO to develop a set of Transportation Control Measures (TCM) that may include High-Occupancy Vehicle (HOV) lanes, improved public transit, rideshare programs, and express buses, among others.

According to Title VI of the Civil Rights Act of 1964 and the President's Executive Order (12898) on Environmental Justice (1994), MPOs must also analyze regional plans for their impact on low-income and minority populations. These "Title VI Analyses" document the location and needs of minority populations (by race or national origin) protected by the Civil Rights Act. Regional plans must take into account and estimate both the costs and benefits of the regional plan on protected populations, insuring that burdens on these communities are not disproportionate to their share of the overall community. See: fhwa.dot.gov/environment/environmental_justice/facts/ej-10-7.cfm.

Regional Transportation Investment Program (TIP)

Every two years, each MPO translates its long-term RTP into a shorter-term TIP containing more specific information about the jurisdiction and location of its next set of capital-improvement projects. The TIP contains all regionally significant projects and is given to ADOT to include in the State TIP.

Arizona Department of Transportation

To oversee statewide planning, ADOT combined its (highway) planning and public transportation divisions into a new Multi-Modal Planning Division in 2007. The division, in turn, contains several sections focused on particular planning

issues such as transit, rail, aeronautics, and research. The Intermodal Transportation Division focuses more on project development and implementation, while the Communication and Community Partnerships Division works with counties, regions, and tribal governments.

State Transportation Improvement Program

Under the existing model, all major Arizona transportation projects are part of the Arizona State Transportation Improvement Program (STIP).[237] Before release of federal funds (which most transportation projects require), the federal government must approve this plan. The projects in the STIP must be consistent with the statewide long-range transportation plan, the ADOT Five-Year Program, and all of the regional transportation-improvement programs (discussed above). In air quality non-attainment areas such as Maricopa County, only "regionally significant projects," which have been determined to conform to air quality restrictions (discussed above) may be included.

Statewide Transportation Planning Framework

The framework study begun in 2008 is a statewide, multijurisdictional effort spearheaded by ADOT, focused on particularly important and growing state travel corridors and regions. These regional framework studies are compiled into the planning process known as "Building a Quality Arizona" (bqAZ): bqaz.org.

State Long-Range Transportation Plan

ADOT produced its long-range transportation plan, called "What Moves You Arizona," based heavily on the results of the analyses carried out under the bqAZ framework. The plan covers the next 25 years of transportation needs in the state and was created in partnership with the MPOs, COGs, and Tribal Governments in the state: azdot.gov/docs/default-source/planning/lrtp-2011-1129.pdf?sfvrsn=2.

FEDERAL

The US DOT oversees the planning and project development activities at the state and regional levels through its various sub-administrations—Federal Highways Administration (FHWA), Federal Transit Administration (FTA), Federal Aviation Administration (FAA), and Federal Railroad Administration (FRA), among others. Numerous funding programs are administered through these agencies and they work closely with regional and transit agency partners and ADOT to insure federal regulations, such as NEPA, are followed for those projects and programs receiving federal funding. The RTPs, TIPs, and STIP must contain any project expected to receive federal funding.

Federal transportation law and funding is renewed periodically in multi-year legislation. The most recent reauthorization bill, called MAP-21, the Moving Ahead for Progress in the 21st Century Act was passed in 2012 and authorized more than $105 billion in transportation spending in 2013 and 2014. The bill continues the series of federal transportation legislation started with ISTEA in 1991. ISTEA strengthened issues like air quality regulations, public involvement, and multi-modal planning. Funding through MAP-21 comes through the various federal DOT administrations. Most surface transportation funding (for roads, bridges, public transit) comes through the Highway Trust Fund (see Chapter 10). There are a variety of funding programs geared towards specific kinds of projects such as the more urban-oriented Congestion Mitigation and Air Quality program or rural-oriented High Risk Rural Roads Program. For a list and description of federal funding programs most used in Arizona, see page 6-24 of the ADOT Local Public Agency Projects Manual: azdot.gov/business/programs-and-partnerships/LocalPublicAgency/lpa-projects-manual and for an overview of all of the programs, see: fhwa.dot.gov/map21/factsheets.

TRIBAL

The tribal transportation planning process is similar to any other part of the state. Tribal transportation officials develop long-range and specific project plans, and apply for funding through federal and state funding programs, just like other jurisdictions (aztribaltransportation.org). There are also a relatively small amount of federal funds available through the Tribal Transportation Program that are specifically for 566 tribal governments and their transportation needs across the country (fhwa.dot.gov/map21/factsheets/ttp.cfm).

To facilitate planning on tribal lands, there are several partnerships between ADOT and tribal governments, including the Arizona Tribal Strategic Partnering Team, ITCA Transportation Working Group, and the Arizona Commission of Indian Affairs. ADOT staff also makes specific connections with tribal governments to coordinate planning issues in ADOT projects, such as right-of -way issues or historic preservation as it may pertain to an ADOT project. Larger tribes such as the Navajo Nation, Hopi Tribe, and San Carlos Apache Tribe convene quarterly their own planning partnerships with ADOT, FHWA, and others. For descriptions of these groups, see page 6-16 of the ADOT Local Public Agency Projects Manual: azdot.gov/business/programs-and-partnerships/LocalPublicAgency/lpa-projects-manual.

Tribal transportation planners deal with many of the same issues as urban and regional transportation planners, such as land use, congestion, and safety issues. An example of a long-range tribal transportation plan is one by the Hualapai Tribe, which includes a roadway design and safety plan that identifies bicycle and pedestrian needs, and explores circulation and congestion issues on the reservation (azdot.gov/planning/CurrentStudies/PARAStudies/hualapai-indian-tribe-long-range-transportation-plan). Like many small communities in rural Arizona, public transit is often missing on tribal lands. Only three tribes currently have public transit systems—Navajo Transit, Hopi-Senom

Transit, and Salt River Pima-Maricopa Indian Community's Salt River Transit. Several other tribes have received Tribal Transit Grant funding to plan and establish transit systems. For example, the Fort Mojave Indian Reservation Transit Study will look more closely at community needs and improvements to transit services on the reservation (azdot.gov/planning/CurrentStudies/PARAStudies/fort-mojave-transit-study).

The first state Road Safety Assessment (RSA) conducted anywhere in Arizona was conducted on the Tohono O'odham reservation. An RSA is a formal safety performance examination of an existing or future road or intersection by an independent multidisciplinary team. The team is designed to be independent of the agencies responsible for designing, constructing, or maintaining the road section being assessed. Intergovernmental coordination between the Tohono O'odham Nation, PAG, and ADOT, was the key to improving a dangerous intersection identified in the RSA. Tribal governments have responded to other serious safety issues identified in a variety of ways, including safety assessments of specific locations, conducting seatbelt education, and establishing sobriety checkpoint programs. National guidance on RSAs are can found at flh.fhwa.dot.gov/programs/ttp/safety/rsa.htm, and case studies of tribal RSAs across the country, including the Navajo Nation can be viewed at safety.fhwa.dot.gov/rsa/tribal_rsa_studies/tribal_rsa_studies.cfm.

One impediment to safety problem improvements has been the fragmentation of responsibility among many agencies. Several federal units inside the USDOT and the Indian Health Service are important on the federal side. At the tribal level, close coordination among medical services, law enforcement, medical services, transportation, behavioral health services, and health education staff are essential. In 2007, the Inter Tribal Council of Arizona (ITCA) created the Comparative Analysis of Motor Vehicle Crashes on American Indian Reservations in Arizona (see itcaonline.com/wp-content/uploads/2013/06/SHSP-Comparative-Crash-Analysis_AZ-Tribal-Lands.pdf) to assist the tribes and ADOT with the initial Arizona Strategic Highway Safety Plan.

Nations within Nations: The Challenges of Intergovernmental Relations

Tribes are sovereign nations within Arizona borders, with inherent powers to govern its people and land. Indian reservations are categorized as federal lands.

Tribes in Arizona cooperate with the State to fulfill the federal requirements to consult with tribes on programs and projects that impact its people and land.

Based on federal funding formulas, Arizona's local match to federal tribal transportation funds is lower than some states because of the large amount of federal lands in AZ, including Indian reservations.

Tribes in Arizona have contributed rights-of-way for major transportation corridors but are excluded from representation on the State Transportation Board.

The Arizona constitution prohibits tribal access to the state Highway User Revenue Fund, however, tribes in AZ are eligible to receive federal transportation funds administered by ADOT.

Annually, the $507 million Tribal Transportation Program funds must be shared with 566 tribes throughout the US; this funds very little of the transportation needs in these large areas.

CDC Grants for Tribal Transportation Safety

In 2004, the Centers for Disease Control funded multi-year grants for seat- belt education programs and sobriety checkpoints. Three of the four national pilot projects were in Arizona, at the Tohono O'odham Nation, the San Carlos Apache Tribe, and the White Mountain Apache Tribe.

RURAL

Rural Arizonans drive significantly more and take far fewer public transit trips than their urban counterparts, even though the need for more affordable transportation is very high. The Rural Transit Needs Study, completed in 2008, identifies rural public transportation needs and serves as an analytical foundation for establishing a long-term strategic direction for rural transit-service provision. While the study projected that transit demand in rural Arizona will grow, deficiencies in service remain (80% of the needs were found to be unmet), mostly because of funding limitations and high costs to provide transit in spread-out communities[238] (azmemory.azlibrary.gov/cdm/ref/collection/statepubs/id/6922).

To facilitate planning in rural areas, ADOT has several important programs. Its LRTP and Statewide Transportation Planning Framework both rest heavily on engagement and dialogue with rural and tribal communities throughout the state. All COGS and tribal governments give input into the STIP and LRTP. To better coordinate these communications, ADOT instituted a Transportation Consultation with Rural Officials policy (azdot.gov/planning/transportation-planning/transportation-consultation-with-rural-officials).

Rural transit systems need more cost-effective and innovative service concepts to meet travel demands. For a review of national best practices and trainings, visit the Small Urban and Rural Transit Center: surtc.org. ADOT administers several programs to fund and assist rural areas and small towns to improve their public transit systems. For example, the Planning Assistance for Rural Areas (PARA) program, offered through the Multimodal Planning Division (MPD), funds local transportation studies across the state to assess the need for roads, public transit, cycling and walking (azdot.gov/planning/CurrentStudies/

PARAStudies). See azdot.gov/planning/TransitProgramsandGrants and especially the federally funded 5311 Rural Public Transportation grant program (azdot.gov/planning/TransitProgramsandGrants/5311-rural-public-transportation-program) for more information.

PARKS

Cars and roadways are integral components of tourism transportation systems, providing access to national parks and other recreation areas. Indeed, the preservation of parks and wilderness areas in America is linked historically to tourist travel by trail, rail, and road.[239] Today, the automobile is the dominant mode of travel to and through the national parks. Park infrastructure, management mindset, and visitor expectations about automobile access are persistent issues for the National Park Service (NPS).[240] Public-land-management agencies such as the NPS are increasingly concerned about the relationship between park transportation systems and quality of the natural environment, as well as about visitors' experiences.[241] Among the concerns are crowding, traffic congestion, parking shortages, increased air and noise pollution, and impacts on wildlife and roadside vegetation.

ISTEA and subsequent renewals of the federal transportation bill have encouraged a transportation-planning framework within the NPS that integrates local, regional, and statewide transportation decision making. The NPS transportation-planning program includes a variety of materials to support park planning, including an emphasis on supporting alternatives to the automobile to and within parks. These "alternative transportation" programs are now implemented in 66 out of 401 national parks with many operated by local transit agencies or through a private subcontractor.[242] See: nps.gov/transportation/index.html.

SPECIAL PLANNING CONCERNS

PLANNING FOR NON-MOTORIZED TRANSPORTATION

There is growing interest in pedestrian and bicycle transportation planning in the United States. A common feature of many cities that are rated among the most "livable" is strong pedestrian and bicycle transportation plans. These cities require that adequate pedestrian and bicycle transportation facilities are included in all roadway projects, and they pay close attention to engineering design to ensure the safety of pedestrians and bicyclists in a multimodal transportation environment.

It is also important to consider the connectivity, integrity, and accessibility of bicycle and pedestrian transportation networks. Policies that encourage or stimulate mixed-use development, jobs-housing balance, high-density corridors, limited parking facilities, and grid-pattern street layouts are conducive to the use of NMT because these shorten trip lengths and allow travelers to do more in a single location. Flexible land use regulations that allow developers and landowners to provide bicycle parking instead of automobile parking, for example, would enhance bicycle use and discourage automobile travel.

The US DOT's 1994 National Bicycling and Walking Study was important in encouraging cities and states across the country to develop long-range bicycle and pedestrian plans. Every state DOT has a Bicycle and Pedestrian Coordinator to promote and facilitate investment in and enhancement of NMT. The Bicycle and Pedestrian Program of the FHWA oversees all state-level bicycle and pedestrian initiatives (fhwa.dot.gov/environment/bicycle_pedestrian/).

ADOT has developed a long-term Statewide Bicycle and Pedestrian Plan for a system of shared roadways, and bicycle and pedestrian facilities. ADOT began implementing the Plan in 2003 and updated it in 2013 (azdot.gov/ADOTLibrary/Multimodal_

COMMUNITIES ACROSS THE COUNTRY ARE RECOGNIZING THE NEED TO PLAN FOR WALKING AND CYCLING AS MORE PEOPLE SEEK SAFE OPPORTUNITIES FOR "ACTIVE TRAVEL" IN THEIR OWN NEIGHBORHOODS AND INCREASINGLY TO GET TO WORK

Planning_Division/Bicycle-Pedestrian/Bicycle_Pedestrian_Plan_Update-Final_Report-1306.pdf). The statewide planning process has developed several projects to enhance education programs, establish a Bicycle and Pedestrian Steering Committee to engage stakeholders, and identify projects in the ADOT work program that can incorporate bicycle and pedestrian facilities.

The MAG recently completed a Regional Bikeway Master Plan to guide member agencies in improving, expanding, and connecting the region's bicycle infrastructure. The City of Phoenix currently has more than 500 miles of bikeways. Tempe has an extensive bikeway system of more than 165 miles and their newly updated master plan includes significant plans for bicycle facilities. The greater Tucson region also has a widespread bicycle network with nearly 600 miles of bicycle lanes, routes, and shared-use paths and trails. ADOT is currently working with the FHWA on a Pedestrian Safety Action Plan, and four cities with high pedestrian fatalities are implementing safety measures to improve pedestrian safety. The City of Phoenix's plan can be found here: safety.fhwa.dot.gov/ped_bike/ped_focus/expedaction/phoenix.

THE SMART GROWTH PARADIGM

The movement in urban planning for "smart growth" seeks to counter scattered and uncoordinated development that leads to inefficient and unsustainable transportation patterns.[243] Smart growth attempts to exploit the underlying synergy between transportation and land use to create more efficient places, which in turn creates benefits like stronger place-making, protection of open space, affordability, diversity of housing, and travel choices. It is a way to reduce total VMT, fuel consumption, pollution, and GHG emissions. Smart growth refers to a group of design, planning, financing, and regulatory strategies that promote proximity and centrality, compactness, existing infrastructure, jobs-housing balances, affordability, and mixed land uses. Smart growth also fosters distinctive, attractive communities with a strong sense of place. By involving both public and private sectors, it aims to make development decisions predictable, fair, and cost effective, and encourages community and stakeholder collaboration in development decision making. Smart growth is a fairly mainstream view in many metropolitan areas in Arizona. ADOT offers a "smart growth scorecard" tool for local jurisdictions to evaluate their planning processes according to the smart growth paradigm (azdot.gov/planning/CurrentStudies/arizona-smart-growth-scorecard).

In 2008, the Urban Land Institute conducted a regional visioning exercise involving 30 groups and 270 community members. The resulting report, AZ One–A Reality Check for Central Arizona, produced the following key recommendations of smart growth principles:[244]

- Preserve open space (100% - 30 of 30 groups);
- Encouraging growth along existing transportation corridors (90%);
- Connect existing and new employment, housing, and urban areas with multi-modal transportation options (90%);
- Create new core urban centers and infill currently developed areas, allowing compact, higher-density development (87%);
- Locate housing near jobs to create employment corridors (80%);

- Protect quality of life by emphasizing safe and livable neighborhoods, education, recreation, and arts (57%);
- Conserve natural resources and create sustainable communities (50%); and
- Provide a diversity of housing options because affordability is important (43%).

NEXT GENERATION INFRASTRUCTURE

WITH LINDA SAMUELS

Independent of smart growth, but consistent with its principles, is the idea of multipurpose, more sustainable, "next generation" infrastructure projects. The concept is gaining momentum in planning, architecture, and engineering. Next-generation infrastructure consists of "multipurpose construction aligned with natural systems, integrated into social context, and designed for a changing climate."[245]

Nine Principles of Next-Generation Infrastructure

Double Duty	Adopt roles beyond their single purpose as a conduit.
Common Ground	Encourage shared terrain as a platform for public life.
Make It Real	Allow people to see how the city works by showing hidden infrastructure above ground.
Give Back	Garner local support by adding, for instance, bike lanes to storm water channels or growing food in public spaces.
Local Adaptation	Disperse and weave infrastructure into local fabric.
Eco-Economy	Prioritize the use of existing (and historic) resources by recycling, reclaiming, and revitalizing.
Design Prototypes	Create functional and aesthetic models of working public architecture.
Innovation and Technology	Include infrastructure for driverless cars, smart phone parking apps, gig-scale data network, and car/house/other sharing.
Cross-Agency Thinking	Ensure cooperation across departments such as transportation, planning, parks, and public works to overcome institutional barriers.

Source: Samuels, Linda C. I-11 Super Corridor: Imagining Infrastructure for the 21st Century. i11supercorridor.weebly.com, and Samuels, Linda C. I-11 Sustainable Supercorridor. Seminar given at Arizona State University, Institute of Transport Engineers Seminar Series, November 21, 2014.

CHAPTER 9

PLANNING SPOTLIGHTS

Arizona has amazing people and organizations working in the transportation field, and one of the new features of this report is a section that spotlights some of the best and most innovative projects they have done across our great state. We hope these success stories will inspire you, and perhaps, at the next Arizona Town Hall on transportation, something you helped make happen will be spotlighted within these pages.

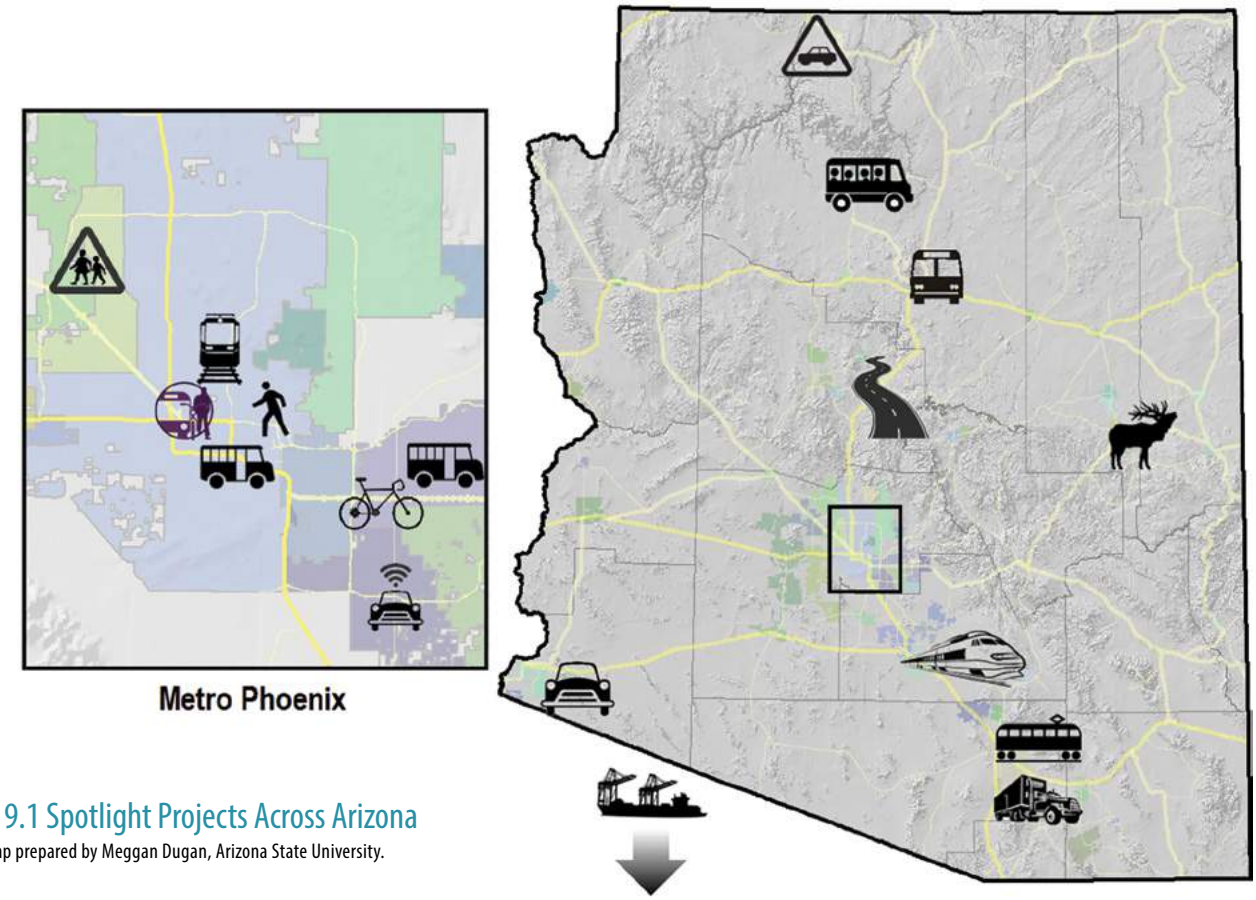


Figure 9.1 Spotlight Projects Across Arizona

Source: Map prepared by Meggan Dugan, Arizona State University.

SPOTLIGHTS

SEDONA STATE ROUTE 179, VILLAGE OF OAK CREEK TO CITY OF SEDONA

AUDRA MERRICK, (DISTRICT ENGINEER, ARIZONA DEPARTMENT OF TRANSPORTATION)
KAREN HOBBS, PE (HIGHWAYS PRACTICE MANAGER, ARIZONA FOR GANNETT FLEMING, INC.)
CARL BURKHALTER, PE (ASSOCIATE ENGINEER/PARTNER, NEWFIELDS)

The greater Sedona area is Arizona's second leading tourist attraction (after the Grand Canyon) and was rated in May 2003 as "the most beautiful place in America" by USA Weekend. Widely recognized as one of the most scenic drives in the country, SR 179 follows a meandering corridor rich with natural beauty, especially the spectacular Red Rocks. Although only nine miles long, the corridor traverses diverse environments, ranging from urban commercial at the north and south ends to developing suburban and forested back country in the middle.

ADOT was able to preserve the scenic beauty of the drive and the values of the communities through innovative

approach called a needs-based implementation plan (NBIP). Through screening workshops and numerous charrettes (see Chapter 8 box), the community screened twelve planning concepts to produce a single preferred plan for a greatly improved two-lane road designed for maximum context-sensitivity through Sedona, the Village of Oak Creek and the highly sensitive Coconino National Forest. Construction began in 2006 and was completed in 2010.

The central goal of the project was to develop a transportation corridor that addressed safety, mobility, preservation of scenic, aesthetics, historic, environmental and other community values and reach consensus on the planning, design and construction of SR 179.

Visit contextsensitivesolutions.org/content/case_studies/sr_179__village_of_oak_creek_to.

THE "INLAND" PORT OF TUCSON

ARNOLD MALTZ, ASSOCIATE PROFESSOR, SUPPLY CHAIN MANAGEMENT, ARIZONA STATE UNIVERSITY

Because most freight flows through Arizona without stopping, the 2009 Town Hall report mentioned the idea of "inland ports" as an opportunity for in-state value-added and support activities by loading and unloading containers away from seaports at less congested inland processing centers. In 2013, the Port of Tucson celebrated two milestones in its efforts to provide true inland port service to the state of Arizona. First, the Port shipped its first export container, which contained pet food, to Japan. The company involved, Azmira, estimated a 20% transportation saving vs. its previous shipping process, which involved trucking a container to the port of Los Angeles. Second, the port received a $5 million Tiger grant to improve throughput at the port and further develop its capabilities. As a

result, the Port of Tucson will be better able to handle, load and unload, and utilize the many empty containers coming from Texas on the Union Pacific Sunset main line to California.

Visit portoftucson.net.

CITY OF MESA BICYCLE MASTER PLAN

JAMES HASH, SENIOR PLANNER (SA), CITY OF MESA

In the spring of 2010, Mark Venti and I set out to begin the task of creating a stand-a-lone Bicycle Master Plan, which would be developed, written, and compiled exclusively by the Transportation Planning Staff at the City of Mesa. The goal of the plan was to create a document that would launch the City of Mesa towards being one of the premier cities for cycling in the United States. The 2012 Mesa Bicycle Master Plan defines a set of goals, objectives, and strategic measures to be completed within the life of the plan, to make Mesa an exceptional community of bicycling. While the plan was written to be visionary, it also lays out a framework that is practical and functional, which will aid in the creation of a finely woven, integrated bicycle network, which include supporting facilities, and programs necessary to make bicycling a viable choice for a wide variety of trips. The Plan will facilitate the programs and built environment needed to increase social interaction along the Mesa Complete Street network, offer alternatives to driving, reduce pollution, and programs that focus on education and awareness necessary to advance the City of Mesa towards achieving Bicycle Friendly "Platinum" status with the League of American Bicyclists.

Visit mesaaz.gov/residents/transportation/bike-pedestrian.

GRAND AVENUE: TRANSFORMATION TO A COMPLETE STREET USING INTERIM MATERIALS

CHRISTINE W. FANCHI, PE, PTP, GRAND AVENUE PROJECT MANAGER, CITY OF PHOENIX
(CURRENTLY CITY OF AVONDALE CITY TRANSPORTATION PLANNER)

Grand Avenue is home to a mix of artists and industrial businesses in a transition zone from the high speed US60 highway into downtown Phoenix. Major concerns about the existing street configuration included high vehicle speeds, lack of parking, and lack of bike lanes. A design process, supported by a US EPA grant, included a 3-day community workshop and produced the "Greening of Grand Avenue" vision for a streetscape design with the following goals:

- Enhancing economic development opportunities;
- Provide a variety of mobility choices; and
- Engage the community through activation of the street and events.

While funds for the full design vision were not available, the existing 5-lane corridor was converted, using striping and concrete planters, into a 3-lane corridor with bike lanes and on-street parking in both directions using just 10% of the projected full costs. The first green bike lanes in Phoenix were installed along the corridor along with numerous bike racks and a new GR:D bikeshare station at Bragg's Pie Factory. Planters have been adopted by local artists and business owners to create unique public artwork. In the first year alone, 10 new businesses have moved into the corridor, average vehicle speeds have reduced from 39 mph to 33 mph, and more pedestrians and bicycles are seen on this street than ever before. This project serves as an example of "Complete Streets" for Phoenix and its success speaks to the commitment of the Grand Avenue merchants and residents.

In 2015, the project won a national award from the American Planning Association.

Visit: azite.org/ITEIMSAspring/SpringConf2014/4BcompSt.pdf.

ARIZONA PASSENGER RAIL CORRIDOR STUDY: TUCSON - PHOENIX

SCOTT OMER, DIRECTOR, MULTIMODAL PLANNING DIVISION, ARIZONA DOT

The project evaluates a passenger rail connection between the two major metropolitan areas in the state that would serve both intercity and commuter needs and which would function as a modal alternative to Interstate 10. Beginning with as many as 142 alternatives, the study considered alignments that follow I-10, the existing Union Pacific rail line and proposed future highway corridors that would be built as multimodal facilities (e.g., North-South Corridor).

The project has completed an Alternatives Analysis (AA) and a preliminary draft Tier 1 Environmental Impact Statement (EIS). Both are presently under review by the co-lead federal agencies, the FRA and the FTA. A Service Development Plan (SDP) is in preparation and will be completed after the Record of Decision (ROD) for the EIS is issued.

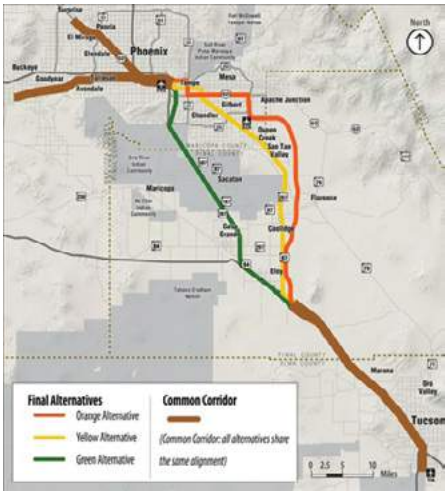


Image Source: azdot.gov/planning/currentstudies/passenger-rail.

Forecast ridership is expected to be between 18,000 and 20,000 riders per day, including both commuter and intercity services. Costs range from $4.5 billion for the alternative that follows the existing UP line (Yellow alignment) and $8 billion for the alternative that follows the North-South Corridor (Green alignment).

The schedule for the project anticipates the draft Tier 1 EIS and the AA to be available for public comment in March 2015 and a Final EIS by summer 2015. The SDP would be completed in summer 2015 following the approval be the federal agencies of the ROD for the Tier 1 EIS.

THE ROLE OF THE PORT OF GUAYMAS IN ARIZONA TRADE

J. RENE VILLALOBOS, SCHOOL OF COMPUTING, INFORMATICS AND DECISION SYSTEMS ENGINEERING
ARIZONA STATE UNIVERSITY

The Port of Guaymas, Sonora is situated on the Gulf of California, a region that has not been heavily exploited for maritime commerce. Traditionally, the main shipments coming in and out of the Port have been petrochemical products and bulk cargo such as grains and cement. In the last 10 years, however, the products shipped from the port have changed to reflect global trends, such as mineral exports fueled by China's impressive economic growth, and container service in the form of feeder service from the Port of Manzanillo.

The growth of freight through Guaymas has stimulated Mexican plans to transform it into a regional economic development pole. Without the congestion of larger, regularly scheduled ports of call, the Port could provide fast and efficient vessel turnaround and smooth flow of inbound and outbound materials through the Port's docks. Situated just 258 miles from the border crossing point in Nogales, Arizona and connected by both rail and road, this ease of flow could be very attractive to shippers located in Arizona and other states within the area of influence of the Port of Guaymas. Guaymas is viewed as a relief port for the congested ports of Long Beach and Los Angeles. It could fill the void left by the now defunct Punta Colonet project, where railroad connectivity issues and unlucky economic timing proved too complex to overcome. Additionally, the Port of Guaymas could be attractive as a site for value added manufacturing to customize merchandise coming from other regions to the North American market and adding Mexican content to merchandise destined for Mexico's free trade partners.

Map by Meggan Dugan, ASU

Visit ilpil.asu.edu/research/supplychainlogistics-projects/logistics-analysis-of-the-port-of-guaymas-in-the-supply-chain-of-regional-companies.

SUNLINK TUCSON STREET CAR

ARLIE ADKINS, PHD, ASSISTANT PROFESSOR, SCHOOL OF LANDSCAPE ARCHITECTURE AND PLANNING
UNIVERSITY OF ARIZONA

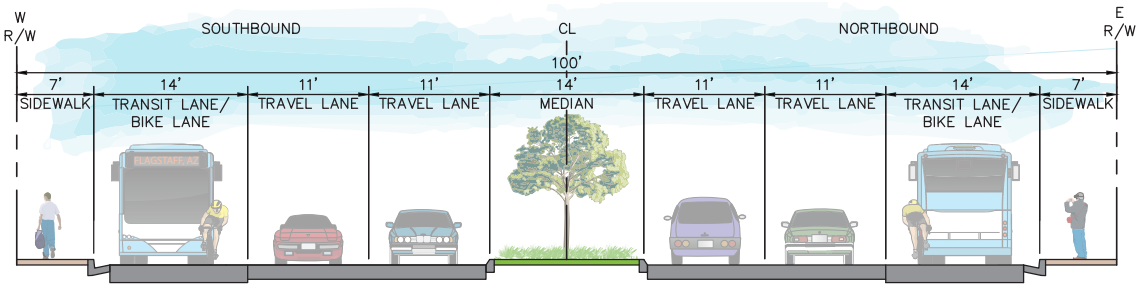
The SunLink streetcar began operations in August on its newly constructed 3.9-mile route linking the University of Arizona Medical Center, the University of Arizona, downtown Tucson, and transit-oriented development currently underway in the Mercado District west of downtown. The $200 million Sun Tran project was funded by $26 million from the City of Tucson, $75 million from the Regional Transportation Authority, a $63 million federal TIGER Grant, and a partnership with the Gadsden Company, which is developing mixed-use transit-oriented development on

land adjacent to the streetcar terminus just west of downtown. Initial ridership estimates have exceeded expectations and nearly $1 billion in private development has occurred along the route since plans were announced, including dozens of restaurants, offices, the first grocery store in downtown Tucson in four decades, and 2,000 units of market rate, student, and affordable housing. In addition to providing a better link between the University of Arizona, central Tucson neighborhoods, and the central business district, the new streetcar also connects to numerous bus lines serving downtown Tucson's Ronstadt Transit Center, Amtrak station, and convention center.

Visit sunlinkstreetcar.com.

FLAGSTAFF BRT MASTER PLAN (TRANSIT SPINE ROUTE STUDY)

ERIKA MAZZA, INTERIM GENERAL MANAGER/DEVELOPMENT DIRECTOR, ADAM LANGFORD, TRANSIT PLANNER,
NORTHERN ARIZONA INTERGOVERNMENTAL PUBLIC TRANSPORTATION AUTHORITY (NAIPTA)



NAIPTA's plan for bus rapid transit (BRT) is a result of the success of Mountain Link, a high-frequency route that began serving downtown Flagstaff, Northern Arizona University (NAU), and Woodlands Village in August 2011. Riders made 715,000 trips on Mountain Link in FY-2014—39% of system ridership. Construction of the 6.8 mile round-trip route was funded by an FTA Section 5309 Very Small Starts Capital Improvement Grant of $6.24 million, which provided about three quarters of the total cost of $8.25 million. This was used to purchase four buses, construct 21 bus stops, and 0.8 miles of dedicated lanes, plus other upfront costs. Operating costs are funded by NAU and city sales taxes, plus a fare of $1.25 (free with an NAU ID).

The proposed BRT will utilize a lane exclusively for bus and bikes for a segment of the route. The proposed Spine Route will connect downtown, Flagstaff Medical Center, the 4th Street corridor, East Route 66, Flagstaff Mall, the Milton Road corridor, Woodlands Village, and Pulliam Airport. The 2013 Flagstaff Regional Five-Year and Long Range Transit Plan received over 1,100 responses from a public outreach campaign, many asking for higher frequency and fixed guideway service. NAIPTA has received ADOT funding for developing a BRT Master Plan, which will identify alternative route alignments, assess NEPA requirements and associated costs, and begin Entry into Project Development with FTA. NAIPTA will then apply for a Small Starts Capital Improvement Grant to fund the BRT.

NAIPTA Transit Plans: naipta.az.gov/news/transit_plans.htm.

Transit Spine Route Study RFP: flagstaff.az.gov/DocumentCenter/View/45417.

Visit mountainlink.az.gov/, with real-time arrival transit visualization.

PHOENIX LIGHT RAIL EXTENSION: BUILDING A HIGH CAPACITY TRANSIT NETWORK IN METROPOLITAN PHOENIX

ABHISHEK DAYAL, AICP, TRANSIT PLANNING MANAGER, VALLEY METRO

In 2004, Maricopa County voters approved a half-cent sales tax to support and expand the region's freeway, streets and public transit systems. In December 2008, the first 20 miles of light rail began operating in Phoenix, Tempe and Mesa. Today, there are an average of 47,000 daily boardings with ridership nearing its 2020 projection. Seven light rail extensions are planned or are under construction that will create a 60-mile system by 2034. The Central Mesa light rail extension will add 5,000 new riders along the 3.1-mile corridor to downtown Mesa. Completion is expected by late 2015. The 3.2-mile Northwest Extension will also add 5,000 new riders operating along 19th Avenue to Dunlap Avenue by early 2016. Valley Metro is also working with Mesa to extend light rail on Main Street by 1.8 miles to Gilbert Road. The project is in the design phase and is expected to open in 2018. Building upon a regional system, Valley Metro is seeking to add the first streetcar line in Tempe. The 3-mile alignment will connect upcoming activity centers along Rio Salado to downtown Tempe and the ASU campus. The project is currently in the planning phase and is expected to begin operating by late 2018. Work continues in various communities across the Valley to develop and expand the region's total transit network including the 11-mile Capitol/I-10 West extension along Interstate 10, 5-mile South Central extension in South Phoenix and the 1.4 mile Northwest extension to Metrocenter Mall.

Visit valleymetro.org/publications_reports/project_report_cards.

REINVENT PHOENIX

AARON GOLUB, SCHOOL OF GEOGRAPHICAL SCIENCES AND URBAN PLANNING AND SCHOOL OF SUSTAINABILITY, ARIZONA STATE UNIVERSITY

"Reinvent Phoenix" was a City of Phoenix planning process funded by a $2.7 million Community Challenge Planning Grant through HUD's Sustainable Communities Initiatives program and carried out in partnership between the City of Phoenix Planning Department, Arizona State University's Global Institute of Sustainability, and Saint Luke's Health Initiative. This HUD funding program specifically strived to "reduce transportation costs for families, improve housing affordability, save energy, and increase access to housing and employment opportunities" and to "nurture healthier, more inclusive communities".* In this spirit, since 2012, the project has implemented a new model for urban redevelopment planning which aspired to improve access to housing, recreation and healthy food near transit for the entire spectrum of incomes, ages, family sizes, and physical and developmental abilities along the light rail corridor. The Reinvent Phoenix project was structured into planning, design, and implementation phases focused on six planning elements: economic development, green systems, health, housing, land use, and mobility. This process was applied separately in each of five "districts" which surround most of the Light Rail stations in the City of Phoenix. The overall effort assessed the current state of each District, facilitated stakeholder input – nearly 3,000 people participated - into each District's vision for the future, and developed detailed plans and land use policies needed to achieve the long-term vision. Finally, motivated stakeholders were asked to join district Steering Committees to implement these strategies in the political process of rezoning and development approval processes.

Visit: reinventphx.org

*Office of Sustainable Housing and Communities. (2012). Guidance on Performance Measurement and Flagship Sustainability Indicator Fact Sheets. portal.hud.gov/hudportal/documents/huddoc?id=OSHCPerfMeasFlagSustInd.pdf.

CANALSCAPE

NAN ELLIN, PHD, DEAN, SCHOOL OF ARCHITECTURE, UNIVERSITY OF TEXAS AT ARLINGTON

Over a millennium ago, the Hohokam Indian civilization built over 600 miles of canals through what is now the Phoenix region. European settlers reestablished the canal system in the late 19th century. Life revolved around the canals once again until the mid-20th century when air-conditioning, suburban tract development, and infrastructure engineering conspired to abandon and neglect the canals. To revitalize the canals, Canalscape introduces hubs of activity where canals meet major streets and transforms canal right-of-ways into non-motorized, energy-yielding, beautiful, and comfortable commuting and recreation corridors.

In January 2009, 22 ASU students from 11 different academic programs participated in the Canalscape Workshop along with 15 additional students at the University of Colorado at Denver. Students researched the history of the canals as well as 121 other canals cities around the world. They also surveyed residents about perceptions and preferences for the canals and introduced a series of planning, policy, and design recommendations for implementation. Just over a year after the student project, the civic organization Valley Forward (now Arizona Forward) elected to steward the canalscape project. Jay Hicks, Chairman of the organization, maintained, "Valley Forward is committed to transforming the canals from eyesores to amenities." Arizona Forward's first project is located in Central Phoenix several blocks

Image by Jens Kolb

from a light-rail stop. The 3.5 acre site would include retail, an indoor/outdoor museum of the canals, a farmers' market, and retail space. Partnering with other entities, Arizona Forward hopes this project will demonstrate the potential of canalscape to the public and private sectors.

Visit www.valleyforward.org/committees/92/.

IMPLEMENTING THE 2008 SOUTH RIM VISITOR TRANSPORTATION PLAN AT GRAND CANYON NATIONAL PARK

DAVID UBERUAGA, SUPERINTENDENT, GRAND CANYON NATIONAL PARK

Although Grand Canyon has utilized shuttle buses for more than 40 years, the NPS prepared the 2008 South Rim Visitor Transportation Plan to better meet the needs of the park and its visitors. Grand Canyon's transit system is critical to park operations and is essential to limiting congestion on park roads and other infrastructure, improving the visitor experience, protecting park resources, and reducing greenhouse gas emissions. The plan addressed many issues, including:

- Construction of more parking areas around the Grand Canyon Visitor Center, so visitors can park their cars and board a shuttle bus;
- Realignment of South Entrance Road, for a pedestrian-friendly, fully-accessible experience at the popular viewpoint, Mather Point;
- Expansion of the Greenway Trail System, for a multimodal experience that reduces visitors reliance on motorized travel; and
- Implementation of a summer shuttle route between the gateway community of Tusayan and the South Rim Visitor Center.

The plan has been 85% implemented. Shuttle ridership has grown by 40 percent since 2009 with more than 6.8 million boardings in 2014. This represents a reduction of 2 million short in-park car trips, which reduces the park's carbon footprint and congestion, particularly in the historic Grand Canyon Village.

Completion of a rim-based trail system makes it possible to walk or bike 13 miles along the South Rim, with a bus stop every one-half to one mile. Visitors can walk or cycle one way and ride the bus back to their point of origin.

Visit nps.gov/grca/parkmgmt/trans.htm.

KAIBAB BAND OF PAIUTE INDIANS—TRIBAL TRANSPORTATION SAFETY PLAN

RONICA SPUTE, TRIBAL ADMINISTRATOR, KAIBAB BAND OF PAIUTE INDIANS

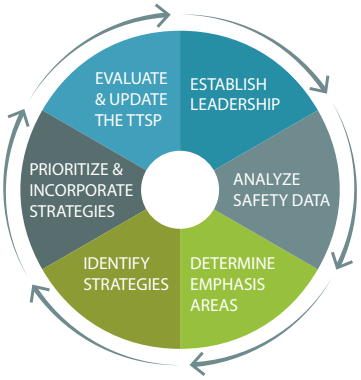
Under the Federal surface transportation funding program MAP-21 passed in 2012, 2% of Tribal Transportation Program funds were set aside for safety programs. A formal Tribal Transportation Safety Plan (TTSP) is a prerequisite to accessing project safety funds. The Kaibab Band of Paiute Indians is one of two tribal governments in Arizona that has prepared a TTSP under this new program.

The Kaibab Band of Paiute Indians is committed to reducing the risk of deaths and serious injuries as a result of transportation incidents within the Arizona Strip region. The TTSP was developed with input from several departments within the Tribe in cooperation with Federal, State, County, and City Government agencies.

The Tribe formed a Working Group to identify and analyze the safety problems facing the Tribe, and to recommend emphasis areas to include. Crash data were collected and analyzed to properly understand the safety risks.

The Tribe has established: a Vision Statement of all transportation users to arrive safely (your life depends upon it!); a Mission Statement of implementing safety strategies through cooperative efforts utilizing the 4 E's (engineering, education, emergency services, and enforcement); and a goal to respond and react to transportation-related incidents. The plan thus incorporates both preventative and responsive measures.

The TTSP incorporates several existing safety efforts. A secondary seat belt law requires child safety seats. The Tribe has a traffic court and uses it to process citations issued by Bureau of Indian Affairs (BIA) Police. The Tribe is pursuing Memorandums of Understanding with



nearby law enforcement agencies to assist on the reservation. Two RSA studies have been conducted along SR389 by ADOT, the ITCA, and the Tribe. Finally, the Tribe upgraded all traffic signs on tribal/BIA roads from 2010 to 2013 to improve reflectivity and standardize all regulatory and warning signs.

Kaibab Paiute Safety Plan: kaibabpaiute-nsn.gov/ANNC/safetyplan.pdf.

US Department of Transportation Tribal Transportation Safety Funds: flh.fhwa.dot.gov/programs/ttp/safety/ttpsf.htm.

HIGH-OCCUPANCY TOLL (HOT LANES)

YINGYAN LOU, ASSISTANT PROFESSOR, SUSTAINABLE ENGINEERING AND THE BUILT ENVIRONMENT
ARIZONA STATE UNIVERSITY

While driving on Phoenix-metropolitan freeways, you may have encountered dedicated lanes high-occupancy vehicles (HOV), restricted to vehicles with two or more people during specified peak hours of the day. Another type of dedicated lane is a high occupancy toll (HOT) lane, which are free to HOVs but charge tolls to regulate access to low occupancy vehicles. HOT lanes are designed to promote carpooling and transit while maintaining travel speeds and reliability as express lanes. Currently, 22 HOT facilities exist or are planned in the US.

Arizona does not have any HOT lanes, but their implementation has been considered. In 2012, the MAG Managed Lanes Network Development

Strategy assessed feasibility, operation, pricing, and recommendations for implementation of HOT lanes in Arizona. A 2014 ASU survey gathered drivers' attitudes towards HOT lanes in the Phoenix-metropolitan area and found that 24% indicated interest in using HOT lanes.

HOV and HOT lanes benefit both drivers and the freeway system. Drivers benefit by the additional travel option of HOV/HOT that provides more reliable travel times and speeds. The freeway system benefits by providing drivers incentives to carpool or pay a small fee, which in turn helps alleviate congestion in the general purpose traffic lanes. The fees collected from HOT are often used to improve the freeway facility and/or subsides mass transit services. For more information, visit:

Visit: www.metro.net/projects/expresslanes/expresslanes_us/

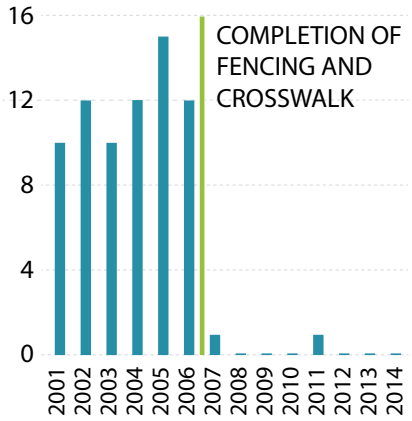
www.azmag.gov/Projects/Project.asp?CMSID=1041&CMSID2=4190

www.usatoday.com/story/news/nation/2012/12/04/controversial-hot-lanes-spread-nationally/1747319/

STATE ROUTE 260 ELK CROSSWALK AND FENCING PROJECT

JEFF GAGNON, STATEWIDE RESEARCH BIOLOGIST, ARIZONA GAME AND FISH DEPARTMENT

Many wildlife species need to cross roads to obtain food, water, access to seasonal ranges or mates. Roadways restrict wildlife movements and can cause collisions with vehicles, creating significant public safety issues and liability costs. Constructing wildlife underpasses and overpasses with funnel fencing has proven a successful method to provide safe passage across roadways for many species. However, they require a large financial commitment and may not be feasible in some cases due to topography, construction timelines, or financial constraints. To overcome these constraints, the Arizona Game and Fish Department (AGFD) and ADOT installed an animal-activated crosswalk to alert motorists to elk and other wildlife crossing SR 260, east of Payson in 2007. Elk and other wildlife are funneled by 8-foot fences to the crosswalk, where a detection system activates a series of signs warning motorists that animals are crossing ahead. The highway fencing is also tied into two large underpasses to provide alternatives for wildlife to cross safely cross under the road. Motorists responded positively to the warning system by reducing their speed by nearly 10 mph when signs were activated. After previously averaging 11.6 collisions/year, only two elk-vehicle collisions have been documented in the 8 years since 2007—a 98% drop. Wildlife crosswalks provide an effective alternative to costly wildlife crossing infrastructure. Both, however, require fencing to funnel the animals to the safer crossing to ensure their success. AGFD and ADOT continue to work together to solve wildlife/highway issues on a statewide level.



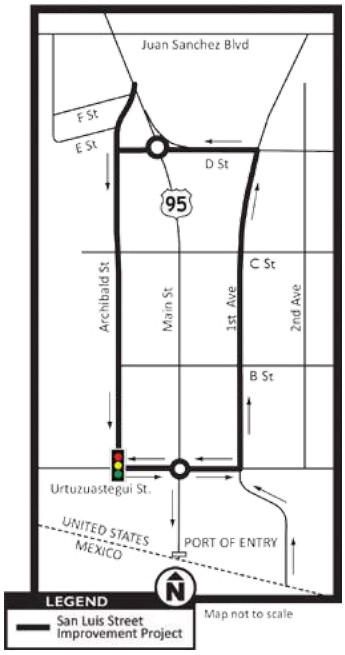
Visit: http://www.azgfd.gov/contracts/files/WFN_V3.pdf

US 95 SAN LUIS IMPROVEMENTS

GABRIELLA (GABY) KEMP, SENIOR COMMUNICATIONS OFFICER, ARIZONA DEPARTMENT OF TRANSPORTATION

The Federal Highway Administration, Yuma County, the City of San Luis, and ADOT are working on an extensive improvement project in downtown San Luis to improve the circulation of vehicular traffic, enhance bicyclist and pedestrian safety, and improve access to downtown businesses. Construction at the second-busiest border crossing in Arizona began in October 2014 and is scheduled for completion in summer 2015. The $11 million project, which is in the Yuma Metropolitan Planning region, will help facilitate the movement of commerce and goods throughout the state by converting several local streets into one-way couplets for US 95 northbound and southbound Port of Entry traffic. Main Street will be converted into a one-way street with additional parking, bicycle lanes and landscaping. The project also consists of installing a new storm drainage system throughout the project as well as two roundabouts. A first for Yuma County, the pedestrian-activated "Highway Hawk" beacon is expected to assist with the safe travels of pedestrians as they exit towards Mexico. ADOT is currently working with the City of San Luis, stakeholders and the general public to overcome unique traffic challenges that are common to the desert southwest during the fall/winter agricultural season. The San Luis community can look forward to a more multi-modal-friendly downtown in the near future.

Visit azdot.gov/projects/far-west/san-luis-improvement-projects/overview.



ARTERIAL TRAFFIC CONDITION MONITORING USING BLUETOOTH/WI-FI READERS IN CHANDLER ('11) & MESA ('14)

JEFF JENQ, PH.D., DIRECTOR OF ITS PLANNING, OPERATIONS, AND RESEARCH, OZ ENGINEERING, PHOENIX

As congestion grows, the public is increasingly interested in travel-time information especially during rush hour. Such information is readily available on most freeways due to technology built into the infrastructure. Travel time on arterial streets, however, has lagged behind due to the lack of a means to collect real-time data—until recently. Travel-time data collection using Bluetooth or Wi-Fi technologies is gaining popularity with transportation agencies around the country for traffic monitoring on all classes of roads, including arterials. "Bluetooth or Wi-Fi readers" are small devices that record the unique Media Access Control (MAC) address of the Bluetooth/Wi-Fi radios built into personal mobile devices and cars. As a vehicle with a Bluetooth/Wi-Fi device onboard passes through and is recorded at two adjacent readers, the travel time between the two locations is calculated as the difference between the two time stamps. In light of privacy concerns, the process typically translates and then discards the MAC address.

Using a map-based interface, this information allows cities to quickly and systematically identify traffic backups caused by incidents, special events, construction, and traffic spilled over from clogged freeways. Remedies such as adjusting traffic signal timing, modifying field traffic control measures, or police intervention can be deployed quickly before conditions worsen. Chandler and Mesa have successfully deployed the technology to provide travel-time information to the general public via dynamic message signs and support arterial traffic monitoring.

Visit OZ Engineering, ozengineering.org; Acyclica, acyclica.com/; Traffax, traffaxinc.com/content/freeway-arterial-travel-times; and ITERIS Vantage Velocity, iteris.com/products/processors/vantage-velocity.

PEORIA SCHOOL DISTRICT SRTS: FRONTIER ELEMENTARY SCHOOL CIRCULATION PLAN

BRANDON FORREY, CITY OF PEORIA

Frontier Elementary School was designed and built using an outdated transportation model. The school's only designated loading area for parents was a short bay on a local street that filled quickly. The queued parent vehicles would spill out onto an adjacent collector street, obstructing two 15mph School Crossings, the bike lane, and the school's two driveways.

Staff determined the average maximum number of parent vehicles to be accommodated – those vehicles in the queue and parked on surrounding streets at the time of the school dismissal bell. The goal was to create a circulation plan that would provide sufficient queuing for

the demand and remove conflicts among the various modes of transportation, especially pedestrian/vehicle conflicts.

Completed in August 2011, the project created a new congregation area for student loading and parking lane for parent vehicle queuing along the collector street. Two crosswalks were relocated and a bulb-out feature was added to one crosswalk to eliminate vehicle queue visibility obstructions. Finally, the bay on the local street was marked with parking stalls to provide short-term parking / loading for kindergarten children.

The new circulation plan reduced congestion and neighborhood intrusion, resulted in safer conditions for students walking and riding bikes, and improved ingress and egress for the buses loading from the parking lot. Though SRTS funding was not permitted to make improvements to student loading, Peoria used local funds for this project, believing a holistic approach is the best method to create an environment more conducive to children walking and riding bikes to school.

SUPER SHUTTLE: PROPANE VANS

ALAN GILDERSLEEVE, GENERAL MANAGER

In 2011, Super Shuttle in Phoenix began replacing standard Ford E-350 vans with a clean-burning version. The most widely used alternative fuel and the world's third most common engine fuel, propane produces 20 percent less nitrogen oxide, up to 60 percent less carbon monoxide, up to 25 percent fewer greenhouse gas emissions, and fewer particulate emissions when compared to gasoline. As a result, it's considered a "clean burning" fuel. In addition to reducing carbon footprint by sharing the ride, every propane van releases 175,000 pounds less CO2 over its lifetime than the gasoline van it replaced. While customers think they're saving a few bucks booking with Super Shuttle, they're also doing their part to save the environment without even realizing it. The adoption of this new vehicle type by the Phoenix team in 2011 set the standard nationwide, and now many other locations are in the process, or have finished, replacing their standard vans for those with clean-burning engines. As of January, 2014, there were 160 vans nationwide running on propane, and making up much of the fleets in Phoenix, Denver, Fort Collins, Las Vegas, and Orlando. The franchise owner-operator in Phoenix saved an average of $3,000 per van compared with using regular unleaded.

Visit supershuttle.com/blog/Blog/ArticleViewer/tabid/1028/Article/308/How-Our-Propane-Vans-are-Changing-the-Game.

CHAPTER 10

PAYING FOR TRANSPORTATION

WITH JEFFREY CHAPMAN AND MARTIN SHULTZ

INVESTMENT NEEDS

Like most states, Arizona faces critical transportation funding challenges. The State's population is projected to reach 10.4 million residents by 2030, 56% more than in 2013. Travel by the additional 3.7 million people will need to be accommodated by the state's transportation system, while major existing sources of federal and state funding for operations, maintenance, and system expansion are declining. The Great Recession was both a crisis and an opportunity for transportation. Government budgets at all levels were devastated by a slump in tax revenues, but the federal stimulus package injected $746 million into the Arizona economy (out about $50 billion nationally). Arizona's share went to 619 transportation projects, with $572 million for highways, $140 million for transit, and $34 million for aviation (see arra-gis.dot.gov for an interactive map). The projects included the Tucson Streetcar, charging infrastructure for electric cars, and routine infrastructure maintenance.

The federal stimulus investment, however, was a temporary respite, and once again we must rely on existing revenues that cannot keep up with road and bridge maintenance needs. The American Society of Civil Engineers (ASCE) considers 238 of the 7,862 bridges in Arizona as structurally deficient and another 721 as functionally obsolete.[246] To address this, the Federal Highway Bridge Fund awarded Arizona just $19.5 million in FY 2011. ASCE also rates 7% of Arizona roads in poor condition. Several factors are expected to exacerbate cost pressure in the future. Highway construction costs have risen faster than inflation, and environmental-mitigation costs may rise as we strive to achieve healthier environmental standards, reduce carbon emissions, and adapt to climate change (see Chapter 7).

In addition to the factors above that are driving up the future costs of road construction and maintenance, we must also consider the need for investment in other modes: rail, airports, transit, bike, and pedestrian. One of the most consistent long-term trends in transportation over the last three decades is towards a multi-modal system and multi-modal planning. Following the decline of streetcars and railroads from the 1920s to the 1980s, most state DOTs functioned primarily as Departments of Road Transportation. Since then, although road transport still dominates both traffic and financing, federal, state, and local transportation planning has become increasingly multi-modal with each passing decade. As gasoline prices, urban form, awareness of environmental and health issues, and culture and behavior evolve, we are seeing greater demand for investment in bicycle and pedestrian infrastructure, more attractive public transportation services, and long-distance higher-speed rail.

The FTA estimates $78 billion is needed to eliminate the maintenance backlog for transit systems across the US.[247] They estimate an annual funding gap of $25 billion per year, which costs the economy $90 billion per year in wasted fuel and lost time. This economic loss is projected to grow to $570 billion per year in 2020 and over $1 trillion in 2040.

Nationally, only about 1.5% of federal transportation dollars go to fund bike paths and walking trails, despite the fact that 12% of all trips to work, school, and shopping are made by bike or on foot, and pedestrians and cyclists account for about 24.2% of annual traffic fatalities in Arizona.[t]

KEY POINTS

- Transportation funding comes from a maze of overlapping federal, state, regional, and local sources.
- Different financing mechanisms have different implications for fairness and for incentivizing users with appropriate price signals.
- Federal and state gas taxes—the leading source of revenue for transportation—have not been raised in decades and are not indexed to inflation.
- The federal highway and transit trust funds have been falling steadily deeper into the red, requiring the federal government to bail out the funds with tens of billions of dollars from the Federal General Fund.
- Meanwhile, at the state level, highway funds that are dedicated legally to roads are being swept into the State General Fund to help fund the Department of Public Safety ($668 million in FY 2010-2012).
- After a temporary respite thanks to injection of $746 million of federal stimulus money for transportation in Arizona, the imbalance between future revenues and infrastructure needs gets worse with each passing year and is reaching crisis proportions.
- The finance gap has real consequences for Arizona residents and businesses, in terms of hours of delay in traffic congestion and waiting for public transportation, higher vehicle maintenance costs, and adverse health and safety outcomes.

(Key Points Continued)

- The growing gap puts pressure on officials to make difficult choices between system preservation and expansion of capacity to meet future growth, as well as between rural and urban areas and across the different modes of transportation.
- A wide variety of potential financing mechanisms are in use around the US that could be adopted in Arizona.
- It remains to be seen whether our leaders and voters have the political will to either modify our existing financing mechanisms or introduce new financing mechanisms.

Meanwhile, the federal Aviation Improvement Program currently allocates $3.35 billion annually, a slight cut from pre-2012, and a drop in the bucket compared with an estimated $80 billion in projects considered essential between 2011 and 2015 for the nation's airports.[249]

Another public concern—safety—must compete for funding with other priorities such as congestion and air quality, which often trump safety concerns. Funds to manage and implement safety programs can be difficult to allocate, and no single agency has broad jurisdiction over safety within a region.

ADOT's Long-Range Transportation Plan, What Moves You Arizona: 2010-2035, brackets our needs and revenues.[250] At the high end, the bqAZ 2050 vision calls for $250 billion over 25 years. Scaling that vision down to essential "needs," ADOT estimates $88.9 billion for capital investment in the State Transportation System, which includes highways, bridges, transit, passenger and freight rail, and aviation, but excludes local streets. At the low end, assuming no new sources are created, ADOT estimates baseline revenues of only $26.2 billion—less than one-third of basic needs.

Even in the face of large projected shortfalls, Arizona has done little to change its transportation financing mechanisms since the last Town Hall on Transportation in 2009. The same three main problems, identified in a national study of infrastructure finance and highlighted in our last report, continue to apply today and generally have gotten worse:[251]

- Revenue is not sufficient to maintain the surface-transportation network and build needed improvements;
- Funding mechanisms and revenue levels are not closely linked to the use of the transportation system, which allows costs to grow faster than revenues and can send inefficient price signals to system users; and
- Politics drives critical components of the current approach to financing infrastructure, and cost-effectiveness is not structurally important.

KEY PRINCIPLES OF TRANSPORTATION FINANCE

There are at least two groups of people who arguably should pay for surface-transportation infrastructure because they benefit from it. Drivers who use the roads obviously benefit, but the non-driving general populace also receives "public-good" benefits from infrastructure. Both pay in the current system in different ways. However, the linkages between those paying and the benefits of the infrastructure are indirect and unclear.

Payment by users (drivers, truckers, etc.) is the most common form of highway finance. Arizona charges an excise tax on gasoline and diesel fuel, and assorted vehicle licensing and registration fees, most of which flows into the aptly named Highway Users Revenue Fund (HURF) that finances road construction and maintenance. While a straight fuel tax charges users for some of the costs of driving, it also misses many costs. For instance, for trucks, the marginal cost should relate to the marginal road damage caused by the truck, which increases exponentially with the total weight per axle, whereas fuel consumption increases linearly with the total weight of the vehicle.[252] The costs of the

Lagging Investment in Transportation Infrastructure: A Broken Record

Over the years, numerous high-profile reports have documented the endemic problem of lagging investment in America's and Arizona's infrastructure. Here are some resources we've drawn from in this and the 2009 Town Hall reports on transportation.

- Arizona Investment Council, Infrastructure Needs and Funding Alternatives for Arizona: 2008-2032, May 2008. arizonaic.org. (See reports, bottom left.)
- National Surface Transportation Infrastructure Financing Commission. Paying Our Way: A New Framework for Transportation Finance, February 2009, financecommission.dot.gov.
- ADOT, What Moves Your Arizona: Long-Range Transportation Plan, 2010-2035, November 2011, azdot.gov/docs/default-source/planning/lrtp-2011-1129.pdf?sfvrsn=2. (This report builds on the earlier Building a Quality Arizona report at www.bqaz.org.)
- Building America's Future: Falling Apart and Falling Behind-Transportation Infrastructure Report 2012, bafuture.org/report. (BAF is a non-partisan effort founded by Former Governors Ed Rendell of Pennsylvania, Arnold Schwarzenegger of California, and Former Mayor Michael Bloomberg of New York.)
- American Society of Civil Engineers, 2013 Report Card for America's Infrastructure, infrastructurereportcard.org. (Annual)

DRIVERS GENERALLY PERCEIVE PARKING AT MALLS, WORK, OR SCHOOLS AS FREE, ALTHOUGH IT OBVIOUSLY COSTS MONEY TO BUILD AND MAINTAIN THAT PARKING LOT

environmental damage caused by increased driving, and the time-dependent costs of congestion, are also usually ignored in the tax-setting process (see Box on the Full Costs of Transportation).[253,254] Electric vehicles use the roads but don't currently pay fuel taxes (plug-in hybrids pay some fuel tax), but their market share is tiny.

Table 10.1 Criteria for Evaluating Funding Sources

Arizona Investment Council Criteria	National Surface Transportation Infrastructure Financing Commission Criteria
Growth Pays for Itself	Revenue Potential
Mechanism Efficiency	Sustainability
Generation of Funds	Political Viability
Sustainability of Funding Mechanism	Promotes Safe and Effective System Operations/Management
Local Economy Effects	Ease of Compliance Ease/Cost of Administration Level of Government Promotes Efficient Use Promotes Efficient Investment Ease/Cost of Implementation Addresses Externalities Minimizes Distortions Promotes Spatial Equity Promotes Social Equity Promotes Generational Equity

Sources: Arizona Investment Council (2008) and the Interim Report of the National Surface Transportation Infrastructure Financing Commission (2008).

BACK TO THE LECTURE HALL 10.1

FULL COSTS OF TRANSPORTATION

Individuals, and society as a whole, must consider costs and tradeoffs when choosing how to invest in and use various modes of transportation. An automobile driver, for example, balances the value of a vehicle trip with the costs incurred by making the trip. The costs perceived by the driver, however, may be quite different from the actual full costs imposed on society. Drivers are likely to be most aware of the marginal costs they personally incur, such as fuel or travel time, for that one trip. Fixed costs, such as vehicle purchase, depreciation, insurance, and registration, may have little effect on a driver's short-term decision about whether to drive or how far to drive. Drivers may perceive parking at a mall, at work, or at school as free. Although it is obviously not free to build and maintain a parking lot, the cost to do so is not paid by the driver and is "externalized" for others to pay. Other external (a.k.a. social) costs include traffic congestion, environmental impacts, costs of securing foreign oil supplies, and noise. Individuals, corporations, and government agencies may not recognize many of these costs in making their daily transportation choices and investment decisions.

Transportation planning and policy analysis typically focus on a limited number of direct costs—those that are easiest to measure, such as construction costs, operating and maintenance expenses, and travel time savings from increased speeds. External costs that are difficult to measure may be considered intangible and therefore excluded from quantitative analysis. Market efficiency, however, is maximized when the total marginal costs are close to the price paid by the user. Underestimating external costs can lead to underpricing of transportation, which leads to over-consumption of resources. Todd Litman, an expert on "full-cost accounting," determined that transportation, particularly private-motor-vehicle travel, is significantly underpriced when compared to the true marginal costs it causes. Estimates of the value of external costs vary, but are substantial. For example, the external costs of driving automobiles in peak-hour congested conditions are estimated to cost society almost 30¢per mile—above the internal time/money costs incurred by the driver.

One policy solution to the underpricing problem is to "internalize" external costs, and incorporate fixed costs and external costs in the marginal costs drivers pay for each trip. For drivers to recognize these costs in their decision-making, an equivalent gas tax of about $6 per gallon would need to be collected. Even the high gasoline taxes collected in Europe only cover a portion of these costs, while the minimal gas taxes collected in the US barely cover the construction and maintenance of the freeway system, and none of the external costs. (Note - local roadways are typically maintained using local taxes, such as sales or property taxes.)

Though uncertainty still surrounds the estimation of external costs, Litman argues that ignoring them in the decision-making process results in even greater inaccuracy because it essentially assumes that external costs are $0.00. Transportation pricing that includes external costs such as charging to park, tolls, or carbon taxes, would help level the playing field among modes and fuels, however imperfectly. The likely result would be to discourage automobile use and encourage alternative transportation modes, particularly for short trips for which bicycling and walking may be viable. In the absence of these policies, the very real external costs on society in terms of congestion, pollution, health, war, urban heat island, and climate change are likely to continue increasing.

To learn more, see: Litman, T. A., Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications, 2nd edition. Victoria Transport Policy Institute, 2009: vtpi.org/tca.

The general public also benefits from transportation infrastructure in that the goods and services they consume rely on labor and freight movement. Transport infrastructure supports economic growth,[255] and since all residents benefit from this growth, all should pay for a portion of this infrastructure. This happens at the national level, because MAP-21, the current federal surface transportation financing program ($105 billion for 2013-14) is financed by general federal revenues in addition to federal gasoline taxes. In Arizona, the HURF is financed entirely by transportation users, rather than by the general public. To supplement that, several Arizona counties and cities have passed a supplemental sales tax, which includes the entire county population in the base for financing transportation. The right balance between user fees and sales taxes, however, is not often addressed directly and openly in public debate.

An additional challenge is to make the funding program equitable, so as not to impose an undue burden on any particular group of Arizonans, geographically, socioeconomically, or generationally. The funding mechanisms also should send appropriate signals to transportation users in terms of incentives and disincentives. While it may not be possible for any single funding program to

BACK TO THE LECTURE HALL 10.2

EFFICIENCY AND EQUITY

In designing policy for financing transportation infrastructure, efficiency and equity are primary concerns. Efficiency refers to the price mechanism at the heart of free-market economics: the way we pay for transportation should send proper price signals to people so they will make choices that maximize economic benefits to ourselves and society. In contrast, equity refers to the fairness of who pays and who benefits, and how much.

For financial efficiency, the prices or fees one pays should roughly equal the costs of society to provide for that travel. These "efficient" prices encourage citizens to demand, and pay for, a level of service that reflects an efficient allocation of societal resources. When prices are efficient, then people generally demand the right amount of transportation – they don't travel too much or too little.[256]

In terms of equity, there are several ways to think about a fair way of spending transportation dollars. We might define fairness as spending the same amount tof money on infrastructure and services for each individual, group, or region. Alternatively, fairness could be providing the same level of service in terms of congestion or transit for each individual, group, or region. Third, it might be fair to spend public dollars proportionally to how much each individual, region, or group pays into the system. These are all equally valid measures of equity and all are used in different parts of our finance system.

There are several major challenges in designing policies for achieving both efficiency and equity. First, transportation infrastructure is a publicly owned and shared resource: Individuals do not build and pay for their own infrastructure. Second, transportation infrastructure is long lasting, so there are intergenerational concerns. Third, transportation generates costs that the user may not pay but that fall upon others in society in the form of pollution, health, safety, sprawl, military conflicts, and congestion (see Box on The Full Costs of Transportation). Only when these costs are integrated into the prices people pay, can we say the price is efficient.

Some infrastructure financing tools are more in line with underlying costs and thus promote more efficient choices. Financing tools such as tolls and congestion charges inspire users to travel more efficiently. Fuel taxes or mileage-based fees, if properly priced, can help filter out trips with negligible benefit. Pay-as-you-go financing saves future generations money, and maintains government's credit capability. Borrowing, on the other hand, allows faster construction (which generates a higher current value of benefits since benefits are recognized earlier in the life cycle), and spreads the financing of the benefits to future generations who will enjoy them.[257]

Efficiency also relates to aligning the responsibilities of federal, state, and local governments. Thus, the case for federal support is strongest for public goods that accrue to broad geographic areas or the nation as a whole, such as interstate highways. Federal grants to state and local governments do not, however, always serve their intended purposes. Increasingly, states have responded to federal highway grants by reducing their own highway funding.[258]

Equity concerns began to emerge 50 years ago as highways were built that demolished and divided low-income neighborhoods while mainly serving suburbanites driving through those neighborhoods. Equity can be an ethnic, socio-economic, generational, or rural-urban issue. For instance, should public dollars be spent more in cities where traffic congestion is worse, or in rural areas where drivers drive longer distances and pay more fuel taxes per person? The sales taxes and gas taxes that Arizona relies on tend to be regressive, meaning that low-income households pay a larger share of their income on these taxes than wealthier households. Of course, if low-income travelers take public transit, which is heavily subsidized, some of this money is recycled back to them and these concerns disappear.

See Wachs, M. (2003). "Improving Efficiency and Equity in Transportation Finance." Brookings Institution, Washington, DC. brookings.edu/research/reports/2003/04/transportation-wachs

achieve all of these goals, they are desirable to keep in mind (see Box on Efficiency and Equity).

In a world of unlimited resources, all transportation projects for which the long-term benefits exceed the long-term costs would be implemented. Given the limits to public funds, however, it is necessary to prioritize funding decisions based on a more comprehensive set of evaluation criteria (see Table 10.1).[259] Like most states, however, Arizona allocates funds to different levels of government based on politically negotiated percentages.

CURRENT STRUCTURE OF TAXES AND FINANCING

The remainder of this chapter focuses on financing and investment challenges of surface transportation including highways, streets, public transportation, passenger rail, bike, and pedestrian. We do not cover freight railroads, Amtrak, pipelines, or electricity transmission. We also do not cover aviation, though many of the ideas presented here apply to it.

Table 10.2 shows the large number of federal, state, and local sources that channel revenues in one way or another through

ADOT, even if ADOT only passes on those funds and doesn't decide how they are used. Nearly all of the federal funds come from MAP-21 revenues, although not all of these funds go to highways. The other major source is Arizona's Highway User Revenue Fund (HURF). The principal source for this fund is state's 18¢ gas tax, followed by the vehicle license tax, fuel taxes on diesel, motor carrier fees and other. The vehicle license tax is split between local governments (55%) and HURF (45%). Some sources of ADOT revenue are not included in Table 10.2.

Table 10.2 Funding Sources That Flow Through ADOT and FY 2014 Actual Revenue (in millions)

State Sources	Amount in FY 2014	Major* Uses
	2014	
Highway User Revenue Fund *(click for more info)* • State Gas Tax $457.4 • Use (Diesel) Fuel Tax $176.4 • Registration $163.7 • Vehicle License Tax ~$344** • Other $95.3	$1,241.3	• State Highway Fund $566.6 » MAG $63.7, PAG $21.3 » Discretionary State Hwy Fund: $474.1 • Transfer to DPS $117 • Cities and Towns $308.6 • Counties $213.2 • Cities over 300,000 Population $33.7
Vehicle License Tax	$433.1**	• County General Funds $190.4 • Cities/Towns $190.4 • Counties (transport purposes only) $45.4
Maricopa County Transportation Excise Tax (Prop. 400 half-cent sales tax)	$365.6	• Public Transportation Fund $121.8 • Regional Area Road Fund » Arterials $38.4 » Freeways $205.4
Local Transportation Assistance Funds	$16.2	Maricopa County (Valley Metro) only
Federal Sources		
Federal Aid Highway Program under MAP-21 (Primarily from federal gas taxes)	$637.5	
Financing Options		
HURF Bonds	$0	But $377.5 in Series 2015
Transportation Excise Tax Regional Area Road Fund (RARF) Bonds	$376.8	Series 2014
Highway Expansion and Extension Loan Program (HELP) State Infrastructure bank	$78.2***	No HELP loans approved in 2014
Grant Anticipation Notes (GAN)	$0	But $43.8 in Series 2012
Board Funding Obligations	$0	

* May add up to less than 100%
**Not including $344 to HURF, which is included above in the HURF total
***Assets, not inflows

Source: ADOT, azdot.gov/about/FinancialManagementServices/transportation-funding

STATE FUNDING SOURCES

State Fuel Taxes. The Arizona state gas tax is 18¢ per gallon, 13% below the average state tax of 20.64¢.[260] The federal tax is 18.4¢. Excise taxes, however, are not the only taxes states levy on fuel. Arizona's total tax on gasoline also includes an underground storage tank tax of 1¢ compared with a national average of 9.25¢ for all other taxes. Thus, Arizona's total gas tax is 19¢—36.4% below the national average of 29.9¢. For diesel fuel, Arizona's 27¢ per gallon is more in line with the national average of 35.4¢.

Note that Arizona has a rebate program that brings the diesel fuel tax down to the level of the gasoline tax for light-duty diesel vehicles.

By the numbers XVI: Gasoline Affordability

Percentage of a day's wages needed to afford 1 gallon of gasoline in the USA 1.95%

Rank of USA on this metric . . . . . 56th out of 61 countries.

Bloomberg.com. "Pain at the Pump: Gasoline Prices by Country." bloomberg.com/visual-data/gas-prices/20144:United%20States:USD:g.

The combined federal and state average of 39.5¢ per gallon in the US is far lower than in other industrial countries such as Canada ($0.96), Japan ($2.26), the UK ($3.95), and Germany ($4.10). Only Mexico's gas tax is lower (afdc.energy.gov/data/10327). In the fourth quarter of 2014, the price of gasoline in Norway was $9.26 per gallon. Taxes comprise a small part of the gasoline price; currently, Arizona's percentage is around 20%, though it fluctuates with the price.[261]

Inflation erodes the purchasing power of the gas tax, while the improving fuel efficiency of automobiles, mandated by much higher federal CAFE standards, simultaneously reduces the number of gallons consumed per mile traveled.

Arizona is one of 32 states with a "fixed rate" gas tax that requires legislative action to raise the tax. While six states with fixed-rate taxes have raised their tax in the last 5 years (Wyoming, Minnesota, Maine, Oregon, Rhode Island, and Washington), most have not. Arizona's excise taxes on gas and diesel fuels have not been increased since 1991. Only nine states have gone longer than Arizona's 24 years since raising their gas tax.[262]

Not only has Arizona not raised the fuel tax since 1991, but the state legislature has been sweeping funds from the HURF to pay for DPS. Article 9§14 of the Arizona Constitution (azleg.gov/FormatDocument.asp?inDoc=/const/9/14.htm) requires that all of these revenues be used only for highway and street purposes. Whether policing should be considered in that category is a political question. The Arizona League of Cities reported that the legislature swept $668 million from the HURF in FY 2010-2012, removing $337 million from the State Highway Fund, $204 million from cities, and $127 million from counties. In FY 2012, HURF funds made up the largest portion of DPS revenues—29%, compared with only 5% in FY 2008.[263] Florida, Kentucky, Minnesota, New Jersey, North Carolina and Wisconsin have also diverted transportation funds to the general fund, notwithstanding existing constitutional restrictions.

Sales Taxes. In 1985, Maricopa County voters approved Proposition 300, a half-cent sales tax for constructing a freeway system. In 2004, Proposition 400 continued the countywide half-cent sales tax for regional transportation improvement. From 2006 to 2013, it generated a total of $2.7 billion, and it should raise about $5.6 billion between 2015 and 2025.[264] Prop 400 allocates 56.2% of revenues to the Regional Area Road Fund (RARF) for freeways and other routes in the state highway system, 10.5% for major arterial-street and intersection improvements, and 33.5% to public transportation, including light rail. Legislative "firewalls" prohibit transfer of Prop 400 funds from one mode to another.

State Transit Funding. Our 2009 Town Hall report on Transportation reported that "the primary source of public transit funding from the State of Arizona is the Local Transportation Assistance Fund (LTAF)." There were two LTAF funds: LTAF I, funded by the Arizona Lottery system, and LTAF II, funded by a combination of multi-state lottery funds (e.g., Powerball) and a portion of Arizona's vehicle-license-tax revenues. From 2001 to 2009, LTAF averaged almost $10 million of transit funding per year. Unfortunately, due to state budget shortfalls during the recent recession, LTAF monies intended for local public transit were swept into the state general fund. A total of $51 million has been diverted since 2010.[265]

In the Arizona legislature, HB 2594 has been proposed to restore the LTAF. So far, it has been restored only in Maricopa County, where the Center for Law in the Public Interest won a court ruling based on the fact that Maricopa County was under a Clean Air Act court order. Starting in September 2011, this ruling restored about $16.2 million per year to the county's cities and towns.[266]

By the numbers XVII: Pay More Gas Tax or Pay Your Mechanic

The American Society of Civil Engineers estimates that driving on poor roads costs Arizona motorists $1.16 billion a year in extra vehicle operating costs and repairs, which comes to $247.10 per motorist. While this figure provides a strong justification for increased investment in maintenance, Arizona actually ranks 5th best in this category—poor roads in many states cost residents 2-3 times more than that per year.

Meanwhile, to match the purchasing power it had in 1990 when it was last raised, Arizona would need to raise gas and diesel taxes by 13¢, which would raise an additional $272 million annually, according to the Institute on Taxation and Economic Policy. A 13¢ increase would cost the average driver $67 per year.

While we are not saying that an extra $67 per year of gas taxes per driver would completely eliminate the extra $247 per year of vehicle operating and maintenance costs, it is worth pointing out that this cost estimate does not include the estimated $837 per year of delay costs (per Phoenix-area driver—see Chapter 4). In any case, the timeless adage, "a stitch in time saves nine," is good advice for investing in roads.

Sources: American Society of Civil Engineers, 2013 Report Card for America's Infrastructure, infrastructurereportcard.org/a/#p/state-facts/arizona and the Institute on Taxation and Economic Policy, Building a Better Gas Tax: How to Fix One of State Government's Least Sustainable Revenue Sources, December, 2011, itep.org/bettergastax/bettergastax.pdf.

Finding stable and growing sources of operating funds for public transit is a challenge. Even before LTAF funds were redirected away from their intended purpose, a 2006 nationwide analysis of federal and state funding for public transit ranked Arizona fifth highest in terms of variability of state funding, and second highest in variability of federal funding from year to year.[267] Local sources of funding can also be volatile.

Borrowing. Arizona has been innovative in borrowing money to accelerate infrastructure investments in the past. For example, in the mid-1990s, using the State Infrastructure Bank, ADOT developed a Highway Expansion and Extension Loan Program (HELP) using board funding obligations. In partnership with local governments, HELP cut seven years off the completion date of the Maricopa Freeway system.[268] Going forward, FHWA cannot add new capital to these banks, but existing infrastructure banks are allowed to continue operation and seek funds from other sources.[269,270] This idea could be extended to tribal transportation funding, as suggested by the Hualapai Tribe to the US Senate Committee on Indian Affairs in 2007.[271]

In the past two years, Arizona has issued over $375 million per year of bonds to accelerate infrastructure investment based on expected state and local revenues. Arizona issues HURF Bonds secured by anticipated future receipts of HURF revenues (state gas taxes, licensing and registration, etc.) and RARF Bonds secured by future receipts from the Maricopa County transportation sales tax. A similar borrowing option is Grant Anticipation Notes (GAN), including Grant Anticipation Revenue Vehicles (GARVEE), with the debt service funded by anticipated receipts of grants from the federal government. Arizona does an admirable job of using available GAN funds.

Other State Funding Programs. Another creative example is the Statewide Transportation Acceleration Needs (STAN) program, which uses appropriations from the State General Fund to expedite new highway construction throughout Arizona. As of 2012, the STAN Account had disbursed $219 million and earned $34 million in interest. STAN monies are distributed by formula: 60% to Maricopa County, 16% to Pima County, and 24% to all other counties combined.[272]

Planning Assistance for Rural Areas (PARA) is an ADOT program that provides federal funds to non-metropolitan communities in order to conduct transportation-planning studies. Eligible counties, cities, towns, and tribal communities may apply PARA funds to planning issues related to roadway and non-motorized transportation.[273]

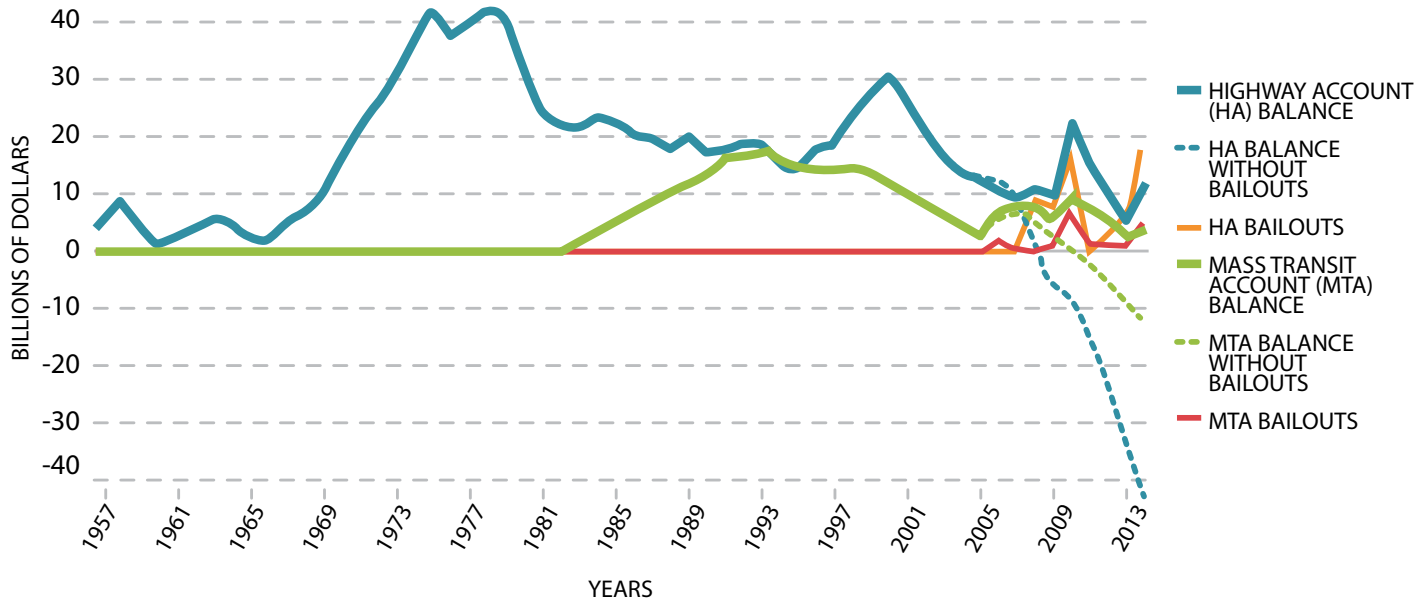
FEDERAL SOURCES

Federal Fuel Taxes (Highway Trust Fund)

Like all states, Arizona depends heavily on federal funding for roads and transit, but the federal trust funds would have been bankrupt several years ago without federal bailouts. Because of declining proceeds from federal fuel taxes, the Highway Trust Fund has been falling short since 2005, and has depended on transfers from the General Fund of the Treasury to stay afloat. These bailouts keep growing larger, reaching $18.4 billion for highways and $5.2 billion for mass transit in 2014. The thick dashed lines in Figure 10.1 show that, without bailouts from the General Fund, the balances of the Highway and Mass Transit Accounts would now be $44 billion and $13 billion in the red.

Arizona received approximately $637.5 million in federal allocations in FY2014 from the Federal Highway Trust Fund for new highways, road expansions and improvements, transit, and a variety of other programs and projects. The Trust Fund comes mainly from federal fuel taxes. Mass transit receives 15.5% of federal fuel taxes on gasoline, ethanol blends, and CNG, and a smaller percentage from diesel, propane, and LNG.

Figure 10.1 Federal Highway and Mass Transit Fund Balances



Source: FHWA Status of the Highway Trust Fund.

TRIBAL TRANSPORTATION PROGRAM

WITH ESTHER CORBETT, NORM DEWEAVER, AND PATRICIA MARIELLA

Although many aspects of tribal transportation are challenging, financing stands out above all. Under the new federal highway bill, MAP-21, the former Indian Reservation Roads (IRR) and the separate IRR Bridge program were rolled together into a combined Tribal Transportation Program (TTP) funding.[274] The money may be used for a variety of activities, including planning, transit facilities, maintenance, safety, and road construction.

The TTP program is, in reality, the only source of funding for BIA and tribal roads in Arizona. MAP-21 kept the TTP funding level ($450 million) for FY 2013 and FY 2014 at the same level as the former IRR program, though it was raised to $507 million in FY 2015.[275] The former Bridge program, a new Tribal Safety Program, and planning funds are funded by 2% set-asides within the TTP. The Bridge funding has been reduced from former levels. The FTA Tribal Transit Grant Program funding has doubled from $15 million to $30 million per year. The Tribal Scenic Byways Program was also folded into other federal transportation programs, and tribes will need to compete with non-tribal needs for this funding now.

TO PRESERVE AND EXPAND 15,000 MILES OF EXISTING AND PROPOSED ROADS (OF WHICH 66% ARE DIRT ROADS), ARIZONA'S TRIBES RECEIVE JUST $72 MILLION IN FEDERAL FUNDING

The $450 million of TTP funding is divided regionally and among all tribes in the US based on eligible road miles and tribal population. This program is grossly inadequate to meet tribal needs. In particular, there is very limited maintenance funding for reservation roads. Tribes are limited to spending 25% but no more than $500,000 of TTP funding on maintenance (excluding road sealing).

A new program, the Tribal High Priority Projects Program, authorizes $30 million per year for the entire US to help Tribes whose annual allocation of funding under the TTP is insufficient to complete their highest-priority project, or to cover disasters or emergencies. Tribes can apply for a maximum of $1 million.[276]

The BIA estimated the unmet need in FY 2007 at over $10.0 billion for the tribes in Arizona, including all of the Navajo Reservation. In contrast, the actual funding allocated has slowly risen from $68 million in FY 2008 to $72 million in FY 2015. At this rate, it would take over 100 years just to meet the need as it existed in FY 2007,[277] let alone future needs that will continue to grow due to inflation and the additional mileage likely to be added to the system.

The Arizona constitution effectively prohibits direct tribal access to state transportation revenue in the HURF.[278] Levying tribal excise taxes on fuel sold on reservation land is a supplementary financing option available to a few tribal governments with commercial gas stations on their land. Tapping this resource could supplement the limited federal funding for tribal transportation improvements, though byzantine state tax law makes it unrealistic for most tribal governments. The Navajo DOT, however, purchased seven state-of-the-art road graders with tribal gas tax funds in 2008.[279]

PUBLIC TRANSPORTATION FUNDING

WITH MARK HICKMAN

Virtually all public transit services in the US depend on public subsidies for both infrastructure and operations. Fares cover only a small fraction of the total cost of transit operations, approximately 23% of the total operating cost (excluding capital costs) for Valley Metro and 25% for Sun Tran. Additional funding for public transit in Arizona comes from a variety of sources that we explain in this section. Some specifically fund either operating or capital expenses, while others are flexible. Sources include the USDOT, FTA, various state funds, and local taxes and general revenues. In 2008, Arizona ranked 13th lowest in the ratio of transit funding that comes from state vs. federal sources, with a 1:14 ratio.[280]

Federal Non-Motorized Travel Programs

Federal programs that help fund non-motorized transportation include the following:

- National Highway System Funds
- Recreational Trails Program
- Surface Transportation Program Funds
- Highway Safety Improvement Program
- Section 402 Funding for State and Community Highway Safety Grants
- Congestion Mitigation and Air Quality (CMAQ) Improvement Program
- Federal Lands Highway Program
- National Scenic Byways Program
- Safe Routes to School Program

For urban areas of over 50,000 people, the FTA provides funds directly to the area's Metropolitan Planning Organization (MPO) to support fixed-route services (Section 5307 funding), divided 2/3 for bus transit and 1/3 for fixed guideway transit. The amount of funding is determined through a federal formula allocation. If the urban area has a population over 200,000 (as do Phoenix and Tucson), the FTA provides funding only for capital expenses, at a ratio of up to 80% federal share to 20% local or state match. Arizona received $73.25 million in capital funding from Section 5307 funds in FY 2014. Valley Metro received $49.2 million; Tucson's Sun Tran received $13.7 million.[281]

For urban areas with populations between 50,000 and 200,000, FTA funds both operations (up to 50% federal share) and capital expenses (80% federal share). This amounted to about $10.3 million split between Avondale, Casa Grande, Flagstaff, Lake Havasu City, Prescott, Sierra Vista, and Yuma in FY 2014.

For areas with fewer than 50,000 people, FTA provides Section 5311 funds directly to the state for distribution (as a pass-through), to cover capital (80% federal share) and operating expenses (up to 50% federal share) of public transit. Arizona received $11.6 million in Section 5311 fund for FY 2014.

FTA funds paratransit services with Section 5310 funds for the elderly and disabled, which can be used to cover capital expenses for vehicles and facilities. This program steered $5.6 million to Arizona in FY 2014. Another FTA-funded initiative, the Rural Transit Assistance Program, enables ADOT to provide support, technical assistance, and training opportunities to all Section 5311 and 5310 grant recipients in Arizona.

The FTA also has discretionary grants for large capital projects, known as New Starts or Small Starts depending on their size. For the initial Phoenix-Tempe-Mesa light-rail line, New Starts contributed $587 million of the total capital expenses of $1.4 billion. An additional $59 million came from USDOT's CMAQ program, bringing the ratio to 46% federal funds vs. 54% local and state matching funds. Valley Metro used the Phoenix regional, half-cent sales tax for transportation to provide the local match for light rail. The City of Tucson completed its modern streetcar system in 2014, which received $63 million in Transportation Investment Generating Economic Recovery (TIGER) funding. The remaining $130 million was provided by the half-cent sales tax for the Regional Transportation Authority in Pima County, the City of Tucson, and other local sources.[283]

CITY PROGRAMS

Local governments may use a variety of funding sources for transportation, but most are hard-pressed to meet their basic needs, including public safety and other vital services. Recognizing the need for capital improvements, some counties and cities in Arizona have enacted a sales tax (typically 0.5%) and development impact fees to pay for transportation improvements. A sales tax, however, is regressive and disproportionately affects low and fixed-income residents of Arizona.

Local governments fund surface transportation through general local government revenues (mostly sales and property taxes) as well as developer impact fees, special assessments, community facilities districts, and local debt (usually bonds that anticipate state motor-vehicle fuel taxes). In the Phoenix area, Tempe, Scottsdale, Mesa, Phoenix, Glendale, and Peoria have each passed sales tax increases ranging from 0.3% to 0.5%, mainly for transit and other transportation improvements.

Because of their size, Phoenix and Tucson are ineligible to receive operating assistance from the federal government. Our two largest urban areas must therefore rely much more on the farebox and state and local funding sources. In metropolitan Phoenix, besides local government funds, the Public Transportation Fund, an account generated from the half-cent sales tax, covers many expenses. For Sun Tran, most of the operating and capital expenses are covered by City of Tucson general revenues. Pima County's Regional Transportation Authority (RTA), funded by the half-cent sales tax passed in 2006, supports new services but does not cover operating costs for existing services.

Both Phoenix and Tucson cut public transit services during the recession because of insufficient funding for operating expenses from sales and property taxes. The maze of funding sources and rules led to the ironic result that operations were being curtailed while at the same time other capital monies were being invested in new infrastructure and additional vehicles.

OTHER FINANCING MODELS

The Government Accountability Office argues that federal surface-transportation programs are not effectively addressing challenges because federal goals and roles are unclear, and many programs lack links to needs or performance.[284] Many of the concerns at the state level are similar to those at the federal level. The last section of this chapter will offer a menu of options to help us develop an efficient, equitable, and comprehensive funding system that will be financially sustainable. Some are traditional, and some require a willingness to face political consequences that might be uncomfortable. All can be part of the solution package.

VARIABLE-RATE GAS TAX

As mentioned above, while Arizona is in the majority in having a fixed-rate gas tax, only nine states have gone longer than Arizona's 24 years since last updating that tax (itep.org/itep_reports/2015/02/how-long-has-it-been-since-your-state-raised-its-gas-tax-1.php). In contrast, 18 states have some kind of variable-rate gas tax that automatically adjusts with inflation or gas prices, and the majority of the US population lives in these states. Most of these states have increased their gas tax in the last year, enabling them to keep up better with growing needs for transportation investment.

The Institute on Taxation and Economic Policy (ITEP) wrote a report in 2011 on Building a Better Gas Tax: How to Fix One of State Government's Least Sustainable Revenue Sources. Four new states have joined the ranks of variable-rate taxes since 2011. Rates can be updated in a variety of ways:

- Ten states (CA, CT, GA, KY, NC, NY, PA, VA, VT, WV) use a tax that varies with gas prices. North Carolina, for instance, charges 7% of the wholesale price averaged over a 6-month period, and resets the tax twice a year. Under this scheme, revenues would fluctuate in concert with the price, though drivers tend to consume a little more quantity when prices drop and a little less when they rise. Theoretically, the tax could also move in the opposite direction of price to try to level out the fluctuations of gas prices and collect more when gas is cheaper.
- Four states (HI, IL, IN, and MI) apply their general sales tax rate to fuel purchases on top of the gas tax.
- Two states (FL and MA) peg their tax to the Consumer Price Index (CPI), which adjusts for the declining value of the dollar (inflation).
- Maryland's tax varies with both gas prices and the CPI.
- Nebraska's tax varies with both gas prices and the legislature's spending decisions. However, ITEP reports that it has had little effect because the legislature has mostly avoided spending over the level that would trigger a tax increase.

There are subtle differences within these state programs described in the ITEP report (www.itep.org/bettergastax). Policy makers can customize their approach by basing a variable-rate tax on a more stable "moving average," limiting maximum rate changes, and imposing floors and ceilings on min and max rates. The report also recommends combining a gas-tax increase with low-income tax relief to make the tax less regressive.

INDEXED ENERGY USE FEE

The idea of a gas tax can be extended to user fees on all forms of commercial energy used for transportation—gasoline, diesel, B20, E85, propane, CNG, LNG, electricity, and H2. A transportation expert at University of Tennessee's Howard H. Baker Center for Public Policy has proposed a user fee on all transportation energy that would also be indexed to inflation and the average energy efficiency of vehicle travel. Indexing would ensure the tax continues to produce adequate revenue as costs rise and vehicles improve in efficiency. Like the gas tax, collection at the wholesale level would make it easy to collect and hard to evade. The cost would be passed on from wholesalers to retailers to drivers, and would send a clear price signal to users to encourage energy efficiency, and better align road taxes to external environmental costs, which rise proportionally with energy use. A disadvantage is that fuel use goes up linearly with vehicle weight while road damage goes up exponentially, so, like the gas tax, it would not by itself address the cost responsibility of heavy vehicles. Also, until smart electricity grids are implemented, it will be difficult to separate the home EV charging from an owner's overall electricity bill. Several ideas have been proposed to address both shortcomings. See: Greene, David L. 2011. What is greener than a VMT tax? The case for an indexed energy user fee to finance us surface transportation, Transportation Research Part D: Transport and Environment 16(6), 451-458.

OTHER SALES TAXES

We can expand the state sales tax (5.6%) to gasoline and diesel. It would generate a revenue stream that would increase as the price of gas increases. To the extent that this tax is shifted to the consumer, it would also have secondary effects such as encouraging a shift to more efficient cars, reducing fuel use and emissions, and slowing global warming. While some Arizona jurisdictions have add-on sales taxes for transportation, others do not. The Transportation and Infrastructure Moving Arizona's Economy (TIME) initiative in 2008 would have added a penny statewide to the 5.6-cent state sales for 30 years.

CONGESTION PRICING

Pricing strategies include tolls by time of day, express toll lanes, tolls based on congestion level, and area-wide charges. Congestion pricing has not been implemented in Arizona but is used elsewhere in the US and in other countries. Although congestion pricing can generate direct revenue, it often faces opposition. Many people consider it double pricing given that they already pay for vehicle registration, insurance, and fuel tax to pay for the roads. Another criticism is that the system favors the rich, who can afford to pay the user fees.

Congestion pricing is not a new idea. The goals of these systems are to allocate road space efficiently, reduce peak-hour congestion by spreading traffic to off-peak times, produce additional revenues for transportation improvements, and reduce emissions.[285] The Congressional Budget Office argues that the demand for spending on highways (at the national level) could be reduced by as much as $20 billion annually if congestion pricing were implemented to encourage efficient use of existing infrastructure.[286]

Other types of more narrowly defined congestion charges can also be adopted. Chapter 9 spotlighted "High Occupancy Toll" (HOT) lanes in which drivers in single-occupant vehicles can pay a toll to use an HOV lane.

A second type of local, area-wide charge is a cordon charge on all vehicles entering the congested central zone. It has been used successfully in London, but was rejected by the New York State Legislature, preventing New York City from adopting it. In addition to raising funds from the users who contribute most to congestion, cordon charges have the indirect effects of reducing the need for new highway construction and encouraging transit use. Of course, for cities that want to stimulate activity in their core, the cordon charge would work against that. A third type of congestion charge can be based on VMT using GPS (discussed below).

TOLLS

Tolls for road maintenance and construction are relatively common along parts of the highway system in many of the eastern states, and bridge and tunnel tolls are common throughout the United States. Many of these are not part of the interstate highway system, but managed through a service contract with a private road operator or toll authority. However, trip length usually determines the toll amount, rather than congestion and time of day. Tolls are often politically difficult to increase, so rates would have to be carefully set, in conjunction with congestion mitigation.[287]

Equity concerns are also relevant to toll roads and have contributed to the failure of many proposals. However, actual equity effects can vary considerably from one project to another depending on user demographics and program design. For example, if low-income travelers take public transit, they do not have to pay congestion tolls. Or if low-income travelers without access to public transit have children in day care, and if congestion tolls reduce commute times, then the savings from the shortened commute (lower child-care costs) may offset the congestion toll. It is also possible to address this equity concern by dedicating congestion-toll revenue to subsidize mass transit or to provide tax credits based on income.[288] In any case, equity concerns are important, but the assumption that tolls are always inequitable may not be correct.[289]

RENTAL CAR FEES

A 2007 report completed for the Arizona Transportation Research Center[290] suggested rental-car taxes could be imposed to help fund public transportation. In Maricopa County, a 3.25% rental car tax was approved in 2000 by voters to repay revenue bonds for building the NFL Cardinal's stadium in Glendale and various Cactus League stadiums. In June 2014, the Maricopa County Superior Court ruled that the tax was unconstitutional because all vehicle taxes need to be spent on transportation issues such as highways, and the Arizona Department of Revenue may be required to refund the tax collections to rental-car companies.[291] While the rental car tax may be unconstitutional for funding stadiums, it would be fine for funding transportation.

OPEN THE HURF TO PUBLIC TRANSIT FUNDING

Current state legislation restricts the statewide Highway User Revenue Fund (HURF) gas-tax monies from being used for public transit purposes. Arizona is one of 23 states with provisions in their constitution (plus three more by statute) preventing state fuel tax revenues from being used for purposes other than highways and roads. Other states allow fuel tax monies to be used for multimodal transportation purposes, which gives officials greater flexibility in solving transportation problems. See transportation-finance.org/pdf/50_State_Review_State_Legislatures_Departments_Transportation.pdf.

PUBLIC-PRIVATE PARTNERSHIPS

Public-Private Partnerships (PPPs or P3) enable private-sector entities to participate in financing and managing transportation projects, such as toll roads mentioned above. PPPs allow flexibility in project delivery.[292] Under PPPs, the private sector may finance,

ELECTRIC VEHICLES AND ROAD FUNDING

As more people buy electric and plug-in hybrid vehicles, concern is growing that they don't equitably pay their share of gas taxes towards the roads they drive on. On the other side of the coin, another school of thought argues for incentivizing early EV adopters, who pay more up-front for their cars, take on added personal financial risk on new technology, deal with the limited charging infrastructure, and contribute to society by helping the EV industry learn and achieve conomies of scale.

A 2015 study estimated the cumulative decrease of transportation funding due to the growing EV market at $200 million through 2025—less than 1% of highway funding. For EV owners to make up this difference would require an increase of $200 to their annual registration fees—a 60%-1400% increase. Alternatively, the shortfall could be covered by a $1 increase per year spread across all vehicle owners.

Some states have enacted compromise solutions. Colorado passed a Plug-in Electric Vehicle Fee of $50, from which $30 goes to Highway Users Tax Fund and $20 goes to an EV grant fund for installing charging infrastructure. A similar bill in Utah did not pass. It is possible to design similar legislation with a sunset provision for the EV infrastructure portion of the proceeds based on when an agreed-upon market penetration threshold is sur-passed. See Colorado Revised Statutes 42-3-304: www.afdc.energy.gov/laws/11486.

Source: Jenn, A., I. Azevedo, P. S. Fischbeck (2015). "How Will We Fund our Roads? The Case of Decreasing Revenue from Electric Vehicles." Paper presented at Transportation Research Board, Washington, DC.

construct, manage, or even operate specific infrastructure, such as a freeway under contract and oversight from a local public agency. Many states have formal legislation that allows some form of PPP under a wide variety of PPP arrangements. Article 9§7 of the Arizona Constitution (azleg.gov/FormatDocument.asp?inDoc=/const/9/7.htm) prohibits "any donation or grant… to any individual, association, or corporation … except … as authorized by law solely for investment of the monies in the various funds of the state."[293] However, with the passage of HB 2396 in 2009, ADOT now has legal authority to pursue PPPs (azdot.gov/business/programs-and-partnerships/Public-PrivatePartnerships(P3)/overview), and is among 13 states with no formal legislative approval requirement.[294]

Common motivations for using infrastructure PPPs are public budget constraints, large upfront proceeds, greater flexibility for using the proceeds, technology transfer, and a transfer of risk to the private sector (assuming appropriate monitoring, strict accountability for service, financial performance, and transparent accounting). PPPs are increasing in the United States; for example, Indiana has leased its portion of I-90 under a 75-year agreement and received an upfront $3.85 billion payment. Chicago leased its Chicago Skyway for $1.82 billion, and its Pocahontas Parkway for $661 million. Chicago used these funds to reduce debt, establish a $500 million "rainy day" fund, allocate $375 million to the annual operating budget, and fund several social-service programs.[295] Texas has used PPPs for inland-port infrastructure, and California is exploring this option as well.

VALUE CAPTURE AND TAX INCREMENT FINANCING

WITH DEBORAH SALON

Successful transport investments generate economic value because they improve accessibility. They increase the value of nearby land, and they support "agglomeration economies" that make cities the engines of our global economy. Value capture is the concept that government may be able to capture part of this location-based value, and use these funds to help pay for transport infrastructure. This idea is sound, but implementation is challenging.

A clear prerequisite to implementing a value-capture strategy to finance transportation is that the infrastructure must create value to be captured. If real-estate values go up, and a well-defined benefit zone or benefit group can be identified, then value capture is appropriate, and contributions will be proportional to benefits received.

Compared to other funding sources, mechanisms based on rising land values can exhibit higher volatility due to large fluctuations in land markets. The equity implications of value-capture strategies have different profiles than funding sources based on use or sales taxes. They can be more or less equitable, depending on the specific provisions of each.

Gas Tax	vs.	VMT Tax
Simple, inexpensive, and nearly impossible to evade		Complex, more costly, and harder to enforce
No connection to when the fuel is used		Can be used for congestion pricing if GPS-based
No privacy concerns		Potential privacy concerns
Pure EVs pay no gas tax		EVs also pay
Proportional to emissions		Can be proportional to emissions

Arizona is the only state in the country that does not have a statute permitting Tax Increment Financing (TIF), a prominent type of value capture.[296] According to Ken Strobeck, Executive Director of the League of Arizona Cities and Towns, "This is something that cities and towns absolutely want in their tool box."[297]

There is no single value-capture system—rather, strategies vary on several dimensions. These dimensions include who is asked to contribute (i.e., property owners, businesses, developers), the timing of the contribution (i.e. one-time, ongoing), and the geographic extent of the benefit zone within which value capture contributions are collected (i.e. immediate vicinity of station, zones within city, whole metro area). See cts.umn.edu/Research/featured/valuecapture and lincolninst.edu/pubs/2026_Value-Capture-and-Land-Policies.new-vmt-charge.[298]

MILEAGE-BASED ROAD USER CHARGES (VMT TAX)

WITH DEBORAH SALON

Given both the political challenge of raising the gas tax and the practical issue that the gas tax will be increasingly less effective with improving fuel economy and increasing use of alternative fuels, interest in paying for roads using mileage-based road user charges has been increasing. The concept of paying for roads according to miles driven (VMT) is not new, but it has only recently become practical with the advent of electronic payment systems and the ubiquity of GPS. Despite much discussion about this option and a general agreement that it is theoretically a good idea (efficient and equitable because it's a direct user fee on all vehicles), the only real-world trial in the US has been in the state of Oregon (usa.streetsblog.org/2013/09/24/ten-questions-and-answers-about-oregons-new-vmt-charge/). Based on their pilot project experience in 2007 and 2012, Oregon will begin a slow process of transitioning from a gas tax-based system to a mileage-based system officially in July 2015 (oregon.gov/ODOT/HWY/RUFPP/Pages/index.aspx).

Proponents tout this solution as providing a more stable source of funds for road maintenance, as well as creating a platform for add-on services such as congestion pricing, automated parking and toll payments, and mileage-based insurance premiums. Challenges include collecting mileage data and payments while protecting the privacy of drivers. Options range from low-tech odometer readings to high-tech smartphone apps and GPS-enabled in-vehicle devices. For a thorough review of this option for roadway funding, see www.rand.org/pubs/tools/TL104.html.[299]

OUTLOOK

It is clear from this review of financing needs, existing programs, and opportunities that the current funding system is inadequate and falling further behind with each passing year. The weak link between the full costs of driving and how we pay for roads does not promote efficient use of the system. The inherited patchwork financing system and politically negotiated percentage distribution of funds is not well designed to meet multimodal transportation needs. Furthermore, these financial resources vary widely and unfairly across the urban, suburban, rural, and tribal areas of the state. There is simply not enough money to preserve the existing system while expanding to meet future needs and keeping up with changing demographic, technological, safety, health, and environmental priorities.

The growing gap between revenues and needs can be addressed by incremental modification of our existing financing mechanisms, or via wholesale reexamination of the entire funding system. We must decide whether to update the existing gas tax, which is easy to implement, transparent, and virtually impossible to avoid, or would we prefer new funding mechanisms such as VMT taxes, tolling, value capture, congestion pricing, public-private partnerships, or indexed energy fees.

As we address these challenges, we will ideally come together as a state to develop a transportation financing system that can address the varying needs of different communities and different regions in a way that is efficient, equitable, affordable, sustainable, predictable, and reliable. What remains to be seen, however, is whether Arizona's leaders and voters have the political will to come to grips with these problems, which otherwise will have increasingly dramatic effects on the daily lives of Arizona residents and daily operations of Arizona businesses.

THE IDEA OF PAYING FOR ROADS ACCORDING TO MILES DRIVEN (VMT) IS NOT NEW, BUT IT HAS ONLY RECENTLY BECOME TECHNOLOGICALLY PRACTICAL

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