94th Arizona Town Hall

April 19 - 22, 2009
Tucson, Arizona

Background report prepared by:
Arizona State University
School of Geographical Sciences
School of Planning
School of Sustainability

From Here to There: Transportation Opportunities for Arizona

Ninety-Fourth Arizona Town Hall
April 19-22, 2009

From Here to There: Transportation Opportunities for Arizona

Background Report Prepared by

Arizona State University
Michael Crow, President

School of Geographical Sciences
Luc Anselin, Director

School of Planning
Luc Anselin, Director

School of Sustainability
Charles L. Redman, Director

College of Public Programs
Debra Friedman, Dean

Editors

Michael Kuby
School of Geographical Sciences

Aaron Golub
School of Planning

Authors

Soyoung Ahn
Jessica F. Aquino
Keiron Bailey
Stephen Blank
Jeffrey Chapman
Esther Corbett
Matthew Croucher
Norm DeWeaver
Laurence Gesell
Aaron Golub
Mark Hickman
Tim James
Karthik Konduri
Michael Kuby
Erik Lee
Eva Madly
Arnold Maltz
Patricia Mariella
John McNamara
Ram M. Pendyala
Joseph Plotz
Sandra Rosenbloom
Ethan Rauch
William Sheaffer
Kangwon Shin
Martin L. Shultz
Jennifer Toth
Sravani Vadlamani
D. Rick Van Schoik
Simon Washington
Dave D. White
Zuduo Zheng

Acknowledgements

This report would not have been possible without contributions from many dedicated people. First, we thank the team from ASU's Global Institute of Sustainability. Kathryn Kyle copy edited, and Cindy Zisner formatted, all 18 chapters, with great patience and skill. From ASU's School of Geographical Sciences, cartographer Barbara Trapido-Lurie designed the cover and advised the student cartographer, Hope Johnston, who produced maps and graphs. Jason Kelley, PhD student in ASU's School of Planning, researched the transportation history timeline and other issues. We thank the directors of our units at ASU for their support: Luc Anselin (Director, School of Geographical Sciences and School of Planning), Wellington Reiter (former director, School of Planning), and Charles L. Redman, (Director, School of Sustainability). We thank Debra Friedman, dean of the College of Public Programs, for recruiting us and maintaining the strong relationship between ASU and the Arizona Town Hall. It was a pleasure working with the team at the Arizona Town Hall, including editorial guru Sharon Flanagan-Hyde, Debbie Stanhope who put the finishing touches on the report and, most of all 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, to our brilliant authors, we thank you for your cooperation and expertise, and for all we have learned from your chapters.

Arizona Town Hall Research Committee Members

Warren Prostrollo, Chair

Jay Kittle, Vice Chair

F. Rockne Arnett
Darryl Dobras
Jessica Fotinos
Debra Friedman
Susan Goldsmith
James Holway
John Hudson
Jack Lunsford
Robert Matia
Elizabeth McNamee
Victor Mendez
Dennis Mitchem
Elliott Pollack
Scott Rhodes
Fred Rosenfeld
Martin Shultz
David Snider
Devan Wastchak
Jim Condo, *ex officio*
Tara Jackson, *ex officio*
Sharon Flanagan-Hyde, *ex officio*

Cover photo credits (clockwise from top)

Freeway map: Arizona Department of Transportation, www.az511.com/hcrsweb/hcrsweb.jsp
Traffic jam: Istock Photo, www.istockphoto.com
Light-rail train: Valley Metro, www.valleymetro.org/metro_light_rail/downloads/progress_photos/
Bicyclist: Istock Photo
Pedestrians: ASU Digital Asset Management
Bus: Sun Tran
Truck: Tennan-Gas, commons.wikimedia.org/wiki/File:Airlift_axles_001.JPG
Amtrak train: Ted Ellis, Desert Rails, algomacentral.railfan.net/AZMisc.htm
US Airways plane: Sander van der Molen, commons.wikimedia.org/wiki/File:US_Airways-01_(xndr).jpg
Gas prices: Istock Photo, www.istockphoto.com

Table of Contents

Chapter 1 INTRODUCTION 1

Chapter 2 GASOLINE PRICES 17

Chapter 3 METROPOLITAN TRANSPORTATION AND LAND-USE PLANNING. 29

Chapter 4 RURAL TRANSPORTATION 45

Chapter 5 INTERNATIONAL TRADE AND TRANSPORTATION 55

Chapter 6 TRIBES AND TRANSPORTATION IN ARIZONA 65

Chapter 7 TRANSPORTATION ISSUES IN NATIONAL PARKS 75

Chapter 8 HIGHWAY TRAVEL AND CONGESTION 85

Chapter 9 PUBLIC TRANSIT 95

Chapter 10 NON-MOTORIZED TRANSPORTATION 103

Chapter 11 AIR TRANSPORTATION 113

Chapter 12 LONG-DISTANCE PASSENGER RAIL 123

Chapter 13 FREIGHT AND LOGISTICS 135

Chapter 14 TRANSPORTATION SAFETY 143

Chapter 15 AGING AND MOBILITY 151

Chapter 16 ALTERNATIVE-FUEL VEHICLES 163

Chapter 17 PUBLIC INVOLVEMENT IN ARIZONA'S TRANSPORTATION DECISION MAKING 175

Chapter 18 TRANSPORTATION FINANCE 183

Appendix 1 TIMELINE OF ARIZONA TRANSPORTATION HISTORY 197

Appendix 2 EXCERPT FROM ARIZONA CLIMATE CHANGE ACTION PLAN .. 202

Appendix 3 LATEST REGIONAL TRANSPORTATION PLAN MAPS FOR ARIZONA'S METROPOLITAN PLANNING ORGANIZATIONS 204

Appendix 4 ARIZONA STATEWIDE TRANSPORTATION INVESTMENT STRATEGY 215

Appendix 5 TRANSPORTATION STIMULUS FUNDING 248

List of Tables

Table 1.1: Arizona Journey-to-Work Mode Shares, 2006 6

Table 1.2: Arizona Population-Growth Estimates 6

Table 1.3: Example Policy Instruments..... 12

Table 2.1: Fuel Economy Savings 25

Table 3.1: Measures of Transportation Supply and Demand for Urban Areas in Arizona 30

Table 3.2: Daily Transit Ridership Projections, 2008-2032..... 40

Table 4.1: Representative Projects and Programs..... 51

Table 5.1: Value of Trade with Arizona's Leading Trade Partners, 2007..... 57

Table 5.2: Northbound Crossings and Lanes at Ports of Entry..... 59

Table 9.1: Selected Transit Performance Measures, 2007 96

Table 10.1: Mode Share for the Journey to Work in the United States 104

Table 10.2: Percent of Workers Bicycling and Walking to Work 105

Table 12.1: Annual Amtrak Station Ridership in Arizona, Fiscal Year 2008 ... 124

Table 12.2: County-to-County Worker Flows..... 125

Table 12.3: Characteristics of Railroad Development Alternatives in Arizona 126

Table 12.4: Characteristics of Comparable Railroad Routes 128

Table 12.5: Financial Analysis of the Phoenix-Tucson Route..... 130

Table 13.1: Freight Carried by Mode of Transportation..... 136

Table 14.1: Trend of Traffic Crashes and Vehicle Miles Traveled in Arizona . 144

Table 14.2: Arizona Fatalities and Injuries by Focus Area 145

Table 15.1: Paratransit Ridership and Costs, 2007 155

Table 15.2: Estimated Paratransit Costs for Servicing All People 65+ with Disabilities 157

Table 16.1: Summary Table of Alternative-Fuel Vehicles..... 165

Table 16.2: Estimated Consumption of Alternative Fuels by Fuel Type, 2006 167

Table 16.3: Alternative Fuel Stations, October 2008..... 168

Table 18.1: ADOT Funding Sources and FY2007 Actual Revenue 187

Table 18.2: Criteria for Evaluating Funding Sources in Two Recent Studies. 188

List of Figures

Figure 1.1: 20th Century National Travel Trends 2

Figure 1.2: Cars per Household, 1983-2007 3

Figure 1.3: Commuting Mode Share by Number of Cars per Household 4

Figure 1.4: Vehicle Miles Traveled, U.S. vs AZ 4

Figure 1.5: Arizona Population Distribution, 2000 ad 2050 (Projected) 5

Figure 2.1: Energy Consumption by End-Use Sector, 1949-2006 18

Figure 2.2: Components of Average U.S. Gasoline Price at the Pump 18

Figure 2.3: World Oil Consumption Trends 19

Figure 2.4: World Oil Production Trends 20

Figure 2.5: U.S. Oil Trends 21

Figure 2.6: Production vs. Reserves, by World Region 22

Figure 3.1: Phoenix Annual Public Transit Trips per Capita Compared to Peer Cities and Roadway Supply Compared to Peer Very Large Urban Areas, 1982-2005 32

Figure 3.2: Tucson Annual Public Transit Trips per Capita Compared to Peer Cities and Roadway Supply Compared to Peer Medium Urban Areas, 1982-2005 32

Figure 3.3: Planning Jurisdictions in Arizona 33

Figure 3.4: A Rough Typology of Planning Responsibilities for the Overlapping Jurisdictions in a Metropolitan Area 34

Figure 3.5: Current Air Quality Status for Regions of Arizona 36

Figure 3.6: Daily Vehicles Miles Traveled per Capital for Arizona Counties 39

Figure 4.1: Regional Framework Study Area Location 48

Figure 5.1: a. Arizona Border Ports and Related Networks. b. CANAMEX Corridor 58

Figure 6.1: American Indian Reservations and Transportation District Boundaries 66

Figure 6.2: Motor Vehicle Collision Mortality Rates for American Indians/Alaska Natives in AZ 1980, 1990, 2000-2007 69

Figure 7.1: National Park Service Units in Arizona 76

Figure 8.1: Vehicle Miles Traveled and Lane Miles per Capita, and Delay Hours per Peak Hour Traveler: 1982 to 2005 86

Figure 8.2: Current (2005) and Projected (2050) Traffic Conditions 89

Figure 8.3: Basic Arizona Parkway Design 91

Figure 9.1: Annual Ridership for Valley Metro and Sun Tran..... 96
Figure 9.2: State Funding through LTAF Distributions 98
Figure 10.1: Trend in Share of Workers Walking to Work 104
Figure 11.1: State of Arizona Primary Airport System..... 115
Figure 12.1: Proposed Phoenix-Tucson Intercity Route 127
Figure 13.1: Inbound, Outbound, Internal, and Through Freight..... 136
Figure 14.1: Trend of Fatal Traffic Crashes and Arizona Population 144
Figure 14.2: Arizona vs. U.S. Fatality Rate 145
Figure 14.3: Fatalities and Injuries Involving Young Drivers, 2001 to 2005.... 146
Figure 14.4: Fatalities and Injuries Involving Speeding, 2001 to 2005 147
Figure 16.1: Alternative Fuel Pathways 164
Figure 16.2: Recent Prices of Some Alternative Fuels 167
Figure 16.3: Alternative Fuel Stations in the United States, 2008..... 168
Figure 17.1: Arnstein Ladder of Public Participation..... 176
Figure 17.2: Stakeholder Evaluation of Public Involvement 177

Chapter 1

INTRODUCTION

Aaron Golub
Arizona State University, School of Planning and School of Sustainability

Michael Kuby
Arizona State University, School of Geographical Sciences

Jason Kelley
Arizona State University, School of Planning

"From here to there" is transportation in its most elemental form: the movement of people and goods from one place to another. Transportation is how we overcome physical separation and create links that hold our society and our world together—links among people, places, regions, companies, industries, cultures, and families. As linkages grow more complex, transportation becomes ever more essential to our way of life. Some observers like to say that transportation is becoming less important—that knowledge and information now drive the world economy, that distance is unimportant, that the world is once again "flat."[1] These pronouncements, however, take smooth, fast, and inexpensive transportation for granted. The world has gotten smaller and our cities have gotten larger *because of* the efficiencies of our transportation systems for people and goods. But this ease of travel may not remain forever; we now confront, for the first time, real limits relating to global supplies of fossil fuels and climate change.

Because transportation is a big topic with diverse geographic settings, technologies, and issues, we have chosen to provide you with 18 short chapters, each one focused on a specialized topic. The chapters were written by some of the leading transportation researchers at Arizona's universities, government agencies, private companies, and consulting firms.

The chapters are organized into four groups. There are two introductory chapters: this one, and one on gasoline prices. Following those stage-setting chapters are five chapters organized by geographical setting: metropolitan, rural, NAFTA, tribal lands, and national parks. These chapters frame transportation needs and solutions for several different spatial scales and in areas with unique issues. The third group consists of five chapters on modes of transportation: roads and highways, public transit, non-motorized transportation, intercity rail, and air. Space limitations prevented us from including chapters on modes such as pipelines and electricity transmission, but they figure prominently in energy transportation to, from, and within Arizona. Since Arizona lacks navigable rivers and ocean coastline, water transportation is excluded, though it does affect Arizona through intermodal connections and is briefly discussed in the NAFTA and freight chapters. The fourth set of chapters features important cross-cutting issues: freight and logistics, safety, aging and mobility, alternative fuels, community involvement, and perhaps most importantly, transportation finance.

Each chapter (excluding this introduction) is organized into the same four sections to help you navigate the material:

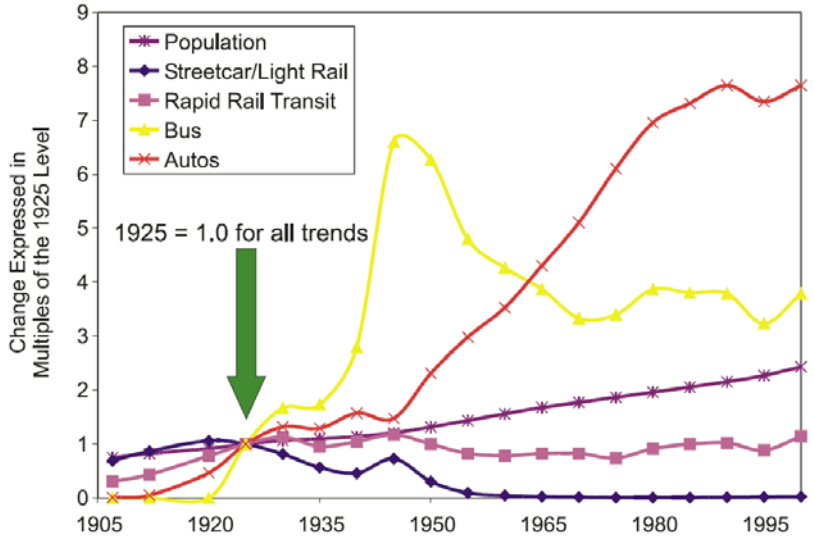
- Current Conditions, which provide you with important background data and the overall picture
- Existing Plans and Programs, which brief you on the main policies relevant to the subject area
- Challenges, which focus on the most difficult problems to solve and barriers to overcome
- Opportunities, which highlight some strategies and solutions that you may wish to consider

In this chapter we present some basic trends, terminology, and themes that are important in chapters that follow. These include economic, environmental, and policy themes, as well as background information on growth. We emphasize the fact that transportation is an interdisciplinary, intermodal system. While we divide this report into chapters, it is important to recognize that each aspect of transportation discussed is a subsystem of the overall system.

Travel Trends

To set the stage for the chapters that follow, we begin with a brief overview of travel trends in Arizona and the United States. Figure 1.1 shows a long-term view of some major travel trends. While the U.S. population has more than doubled since 1925, the number of registered automobiles has climbed eight-fold. During wartime rationing, bus and streetcar ridership peaked, but dropped precipitously afterwards. Rapid rail (subway, elevated, and commuter rail) dipped in the 1950s and 1960s only to recover somewhat in the 1990s, while light rail and streetcars almost completely disappeared, despite the new light-rail systems opened in the 1990s.

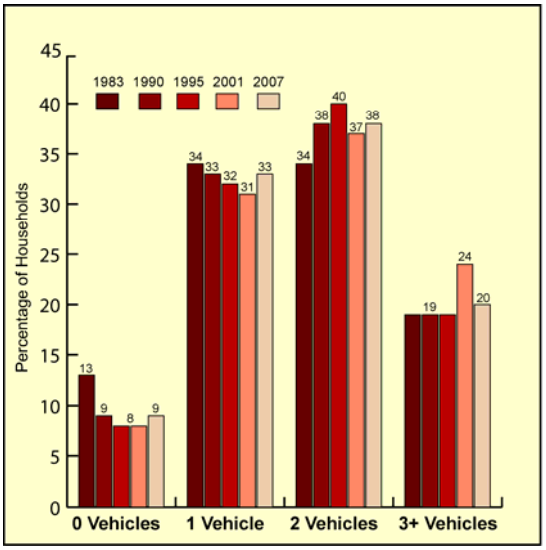
Figure 1.1: 20th Century National Travel Trends



Source: Miller, John S. *Expected Changes in Transportation Demand in Virginia By 2025.* Virginia Transportation Research Council, 2003. virginiadot.org/vtrc/main/online_reports/pdf/03-tar5.pdf.

According to most measures, auto dependency grew from the 1980s to the early 2000s, but there are signs of a possible reversal in this trend. Figure 1.2 shows the share of households with access to various numbers of vehicles. The number of households with no car at all decreased by nearly one-quarter, from 13% of total households to 9%, while the share of households with two or more vehicles grew. However, the trends towards more households with multiple cars and fewer households with no or one car appear to have slowed or reversed themselves in the 2007 survey. Whether the decades-long trend towards auto dependency and suburbanization is reversing, possibly due to higher gas prices and back-to-the city residential movement, is difficult to determine at this time.

Figure 1.2: Cars per Household, 1983-2007



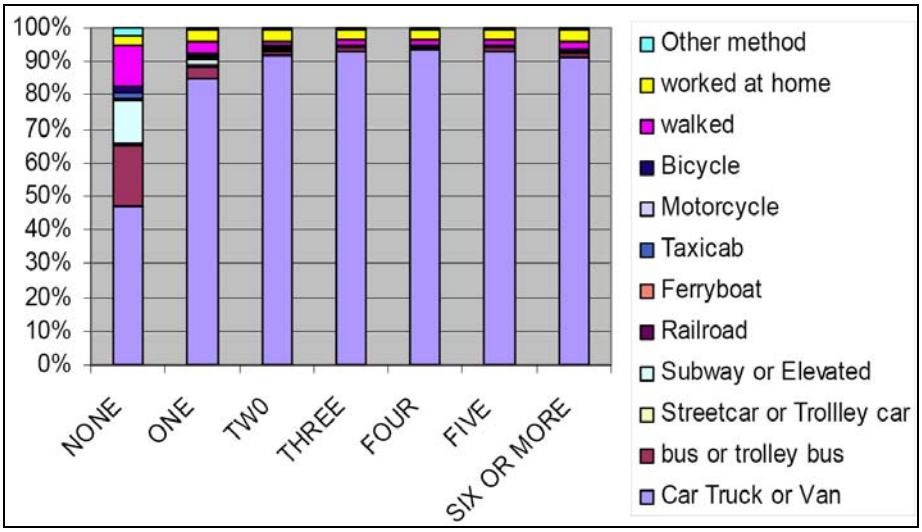
Source: Data from American Community Survey.

Car ownership is significant, because the mode share for public transit in households without a car is over 20%, but drops to less than 0.5% for households with two or more cars (Figure 1.3). When people have access to a car and have paid the substantial fixed costs of ownership, they use it.

The 2007 reversal in the long-term vehicle per household trends (Figure 1.2) is consistent with other findings that auto dependency might finally be slowing.[2] From 1995 to 2008, total vehicle-miles traveled (VMT) grew 50% in Arizona, compared with 21% for the United States (Figure 1.4a). VMT growth, however, has been slowing since 2004, and actually began declining in late 2007—before $4 per gallon gasoline and the mortgage crisis. On a *per capita* basis, Arizona's VMT peaked back in 2004 at 9,980 miles per year, before dropping to 9,134 in 2008 (Figure 1.4b). But even in 2007, VMT per capita in Arizona was below its 1996 level.

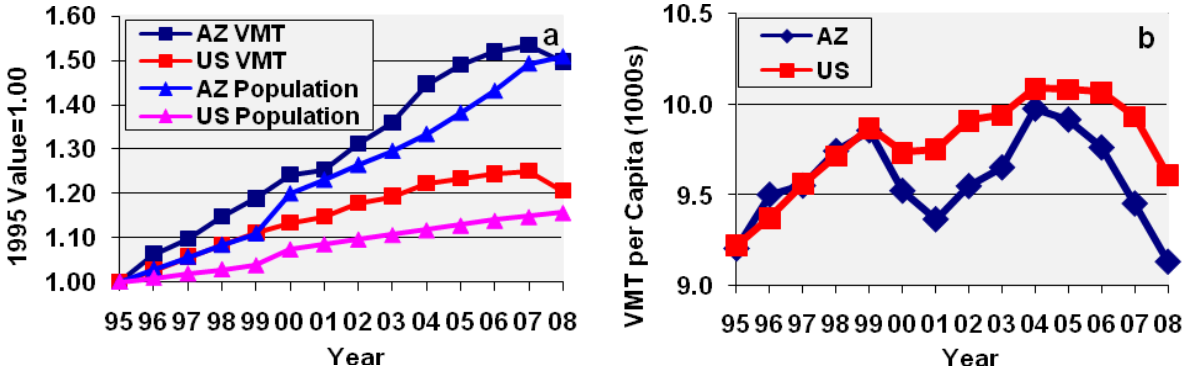
VMT is the best measure of demand for road capacity, so it is important to understand the factors behind it. A recent study indicates that nearly half (46%) of the growth of VMT during the late 20th century was due to an increase in the number of daily trips per person.

Figure 1.3: Commuting Mode Share by Number of Cars per Household



Source: Pisarski, A. A. *Commuting in America III: The Third National Report on Commuting Patterns and Trends.* Transportation Research Board, TCRP Report #110, 2006. www.trb.org/news/blurb_detail.asp?ID=6699.

Figure 1.4: Vehicle Miles Traveled, US vs. AZ



Source: Federal Highways Administration. *Traffic Volume Trends.* www.fhwa.dot.gov/ohim/tvtw/tvtpage.cfm and U.S. Census Bureau, *Population Estimates.* www.census.gov/popest/estimates.php.

Population growth accounted for 28%, people switching from other modes to driving for 16%, and people making longer trips for 10%.[3]

Arizonans are more dependent on driving to work than the nation as a whole, but also carpool at a higher rate (Table 1.1). Adding together the drive-alone and carpool shares, 88.7% or Arizonans drove to work, compared with 87.7% nationally. Arizonans use transit and walk significantly less, but bicycle and work from home more. These patterns vary somewhat among regions in Arizona.

Table 1.1: Arizona Journey-to-Work Mode Shares, 2006

Mode Share Percent							
Region	**Drive Alone**	**HOV Carpool**	**Transit**	**Bicycle**	**Walk**	**Work from Home**	**Other**
Phoenix Metro	74.8%	14.3%	2.3%	0.7%	1.8%	4.5%	1.6%
Tucson Metro	75.2%	12.2%	2.6%	1.2%	2.9%	4.4%	1.6%
Flagstaff Metro	68.3%	13.6%	0.9%	2.9%	7.3%	5.6%	1.5%
Prescott Metro	76.3%	12.5%	0.1%	0.2%	2.8%	6.5%	1.5%
Yuma Metro	74.4%	15.3%	1.8%	0.3%	3.9%	2.7%	1.5%
Arizona	74.8%	13.9%	2.1%	0.8%	2.3%	4.5%	1.6%
United States	76.1%	10.6%	4.8%	0.5%	2.9%	3.9%	1.2%

Source: American Community Survey, 2006.

Another important trend relates to trip purpose. Work trips in 2001 made up only 15% of all trips, and 18% of miles traveled.[4] Work trips per person increased 14% from 1977 to 2001, while family and personal business trips increased 114%. These trends have important implications for congestion, which is spreading to other times of day, and for use of mass transit, because some trips are easier to make by transit than others.

Growth Trends

From 2000 to 2008, Arizona's population grew by 26.7%—the second-fastest rate in the country, behind Nevada. Rapid growth will likely 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. Table 1.2 shows population estimates for Arizona counties through 2030.

Megapolitan Growth. 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 traveled on foot or by horse. In the 19th century, cities developed star-like arms along horse-drawn, and then mechanized, streetcar lines that brought workers and shoppers to an all-powerful central business district. Then, due to the automobile, our cities exploded. Bedroom suburbs were followed by suburban shopping malls, suburban factories and office parks, full-fledged suburban downtowns, shrinking central business districts, and exurban landscapes that look rural but are half-filled with urban commuters or telecommuters functionally tied to the metropolitan area.

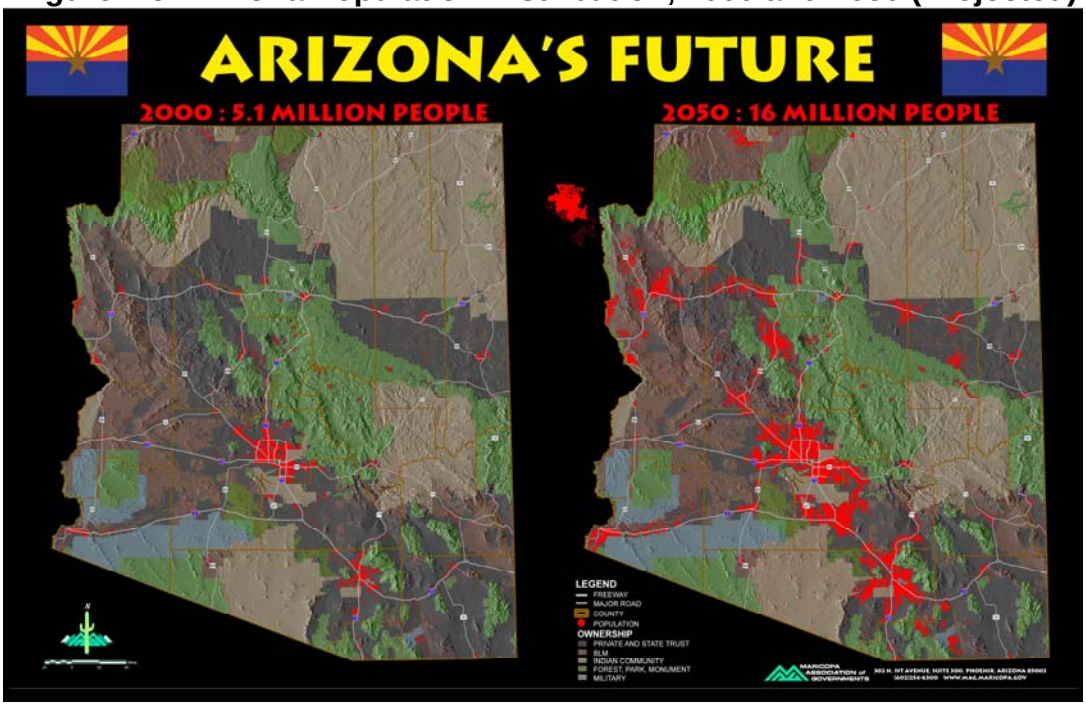
As metro areas expand farther and farther, once-separate regions begin to merge. Experts recognize an emerging *megapolitan* region that will stretch almost continuously from Prescott, through the Phoenix and Tucson metropolitan areas, all the way to Nogales (Figure 1.5). This "Sun Corridor" is among 20 emerging megapolitan areas, including 5 in the Mountain West, with overlapping cross-region commuting patterns and economic interdependence.[5] Arizona's Sun Corridor, which currently occupies only 10% of land area of Arizona, has 80% of the population growth, and produces 88% of state GDP.

Table 1.2: Arizona Population-Growth Estimates

	Population Estimates				Change 2010 to 2020	Change 2010 to 2030
	2008	2010	2020	2030		
Apache	76486	78229	86,533	93,447	8,304	15,218
Cochise	140560	146037	169,717	187,725	23,680	41,688
Coconino	137261	141457	159,345	173,829	17,888	32,372
Gila	56427	57766	64,396	69,879	6,630	12,113
Graham	36666	37441	41,119	44,556	3,678	7,115
Greenlee	8238	8209	8,189	8,289	-20	80
La Paz	22062	22632	25,487	28,074	2,855	5,442
Maricopa	3992887	4217427	5,276,074	6,207,980	1,058,647	1,990,553
Mohave	208372	221443	281,668	330,581	60,225	109,138
Navajo	117971	123172	147,045	165,647	23,873	42,475
Pima	1026506	1070723	1,271,912	1,442,420	201,189	371,697
Pinal	316899	364587	609,720	852,463	245,133	487,876
Santa Cruz	47777	50210	61,658	71,033	11,448	20,823
Yavapai	227468	241667	305,343	355,462	63,676	113,795
Yuma	207305	218810	271,361	316,158	52,551	97,348
Arizona	**6,622,885**	**6,999,810**	**8,779,567**	**10,347,543**	**1,779,757**	**3,347,733**

Source: Arizona Department of Economic Security, Research Administration, Population Statistics Unit.
www.azcommerce.com/econinfo/demographics/Population%20Projections.html.

Figure 1.5: Arizona Population Distribution, 2000 and 2050 (Projected)



Source: Maricopa Association of Governments. http://www.mag.maricopa.gov/maps.cms

ASU's Morrison Institute notes the harsh realities of the region's transportation-infrastructure limitations in the face of such rapid growth.[6] The impacts of continued growth, the lack of coordinated Corridor governance, and concerns about how to fund necessary infrastructure have direct implications for transportation in the Sun Corridor. Of the ten individual urban realms within the Corridor, the Morrison Institute identified six with transportation-related challenges for future growth (including traffic congestion and inadequate infrastructure), and seven with air-quality challenges. One-third of undeveloped land in the Sun Corridor is privately held, and with much of that land already permitted for construction, existing patterns of car dependence and energy consumption may continue. 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, thereby contributing to increased traffic congestion and air-quality problems. According to the Morrison Institute Report, infrastructure in the Sun Corridor will need to go beyond simply building highways to include "smart" infrastructure and 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 18). The ability of the Sun Corridor to successfully meet these transportation infrastructure challenges may very well determine the region's ability to compete globally with other emerging megapolitan areas.

The Full Costs of Transportation

Individuals, and society as a whole, must consider costs and tradeoffs when choosing how to invest in and use the various modes of transportation available. 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 internal* costs they personally incur, such as fuel or travel time, for that one trip. *Fixed* internal 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 as free. Although it is obviously not free to build or 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,[7] and noise. Individuals, corporations, and government agencies may not recognize many of these costs in making their transportation daily 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 time savings from increased travel speeds. Other 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 reflected in the price paid by the user. Underestimating these marginal costs can lead to under-pricing resources and overconsumption. Todd Litman, an expert on "full-cost accounting," determined that transportation, particularly private-motor-vehicle travel, is significantly under-priced when compared to the total marginal costs it causes.[8] Estimates of

the value of external costs vary, but are substantial. For example, the external costs of driving automobiles in peak-hour conditions, when congestion effects are quite large, are estimated to cost society (above the internal costs paid by the driver) almost 30 cents per mile.[9] To recoup these costs, an equivalent gas tax of about six dollars per gallon would need to be collected. Even the high gasoline taxes collected in Europe (see Ch. 2) only cover a portion of these costs, while the low gas taxes collected in the U.S. barely cover the construction and maintenance of the freeway system, and none of the external costs. (Local roadways are typically maintained using local taxes, such as sales or property taxes.)

One response to under-pricing transportation is to attempt to "internalize" external costs, and convert fixed costs to marginal costs, through what is often referred to as marginal social-cost pricing. Techniques for quantifying such costs have improved significantly and various pricing strategies have been proposed or are in use. Though uncertainty still limits the precision with which these costs can be measured, Litman argues that the complete exclusion of external costs from the decision-making process would result in greater inaccuracy, which therefore justifies their inclusion. Due to the uncertainty, however, other experts caution against complete reliance on pricing strategies alone.[10] Social concerns that cannot be accounted for in cost-benefit analyses must still be worked out through the political process. Litman contends, however, that social-cost analysis can help identify important transportation problems, understand tradeoffs, and evaluate alternatives, thereby creating better-informed transportation decisions.

Environmental Impacts of Transportation

Transportation systems create significant impacts on the environment at local, regional, and global scales. Here, we condense this very important issue into a brief subsection. As you read it, keep in mind that environmental impacts have implications for every other subject covered in the report.

Air Quality. It is important to keep in mind that the same air quality will affect different people in different ways and to different degrees. Information on the six major air pollutants can be found at www.epa.gov/air/urbanair/6poll.html. Two of the six, lead and sulfur dioxide, are not reviewed here because they are mainly caused by activities other than transportation. Detailed information on air-quality trends in Arizona is available at www.epa.gov/air/airtrends/index.html.

Particulate Matter (PM) consists of many different substances suspended in air as particles, which are categorized by size.[11] Fine particles less than 2.5 micrometers in diameter, known as PM2.5 pose the greatest threat to health because they can get into the lungs. Particles between 2.5 and 10 micrometers are called PM10, while particles larger than 10 micrometers are referred to as total suspended particulates (TSP). 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 (O_3) is a colorless but pungent gas. Ozone occurs naturally high in the atmosphere and serves as a protective element in the upper atmosphere. At ground level, however, ozone is a pollutant. Ozone is not usually emitted directly into the air, but is created by a chemical reaction between other vehicle pollutants: oxides of nitrogen (NO_x) and volatile organic compounds (VOC). Ground-level ozone is the primary constituent of smog. Ozone causes respiratory illnesses such as lung edema, asthma, emphysema, chronic bronchitis, coughing, sneezing, and chest pain. It also reduces crop and forest yields and makes plants more susceptible to disease.

Nitrogen Oxides (NO_x) consists mostly of NO_2 and is 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. Deposition of nitrogen from the atmosphere also causes water pollution. Nitrogen builds up at the mouths of rivers, stimulating excessive algae, which reduces dissolved oxygen and creates large dead zones.

Carbon Monoxide (CO) is an odorless, colorless, and poisonous gas caused mostly by motor vehicles. CO levels have not exceeded federal standards in Arizona since 1996.

Greenhouse Gases (GHG) include carbon dioxide (CO_2), methane, nitrous oxides, CFCs, and even water vapor, which are building up in the global atmosphere and raising global temperatures.[12] The greenhouse effect is not new and some CO_2 in the atmosphere is essential to life on Earth. What is new since the Industrial Revolution is the amount of CO_2 being emitted into the atmosphere by the burning of fossil fuels and forests. The concentration of CO_2 in the atmosphere has risen from about 280 parts per million (ppm) at the beginning of the Industrial Revolution to 386 ppm in 2008. In conjunction with these atmospheric changes, the mean global temperature has increased by 1.4ºF since 1900.[13] The hottest 10 years on record have all occurred between 1997 and 2008.

The U.N.-sponsored Intergovernmental Panel on Climate Change (IPCC) concluded that "most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations."[14] The 2007 Fourth Assessment Report predicts a 30% to 240% increase in CO_2 concentrations by 2100, with average temperatures increasing between 3.2ºF and 7.2ºF. Warmer sea and air temperatures would partially melt the polar ice caps and increase the volume of existing oceans, causing sea levels to rise and flooding low-lying coastal areas and heavily populated islands.[15] Global circulation patterns would change in ways climatologists don't fully understand, but there is some consensus that storms would increase in number and strength. Agricultural and biotic regions could shift, causing disruption to human, animal, and plant communities.

The Arizona Climate Action Report (Appendix 2) warns of many impacts specific to the Western U.S., including an additional temperature increase of 3° to 9° F by mid-century. The most extreme estimates show southwestern U.S. temperatures increasing by up to 14° F. This would have a profound impact on water cycles, decreasing summer rain but increasing winter rains and flooding. Overall, water supplies will likely decline, along with forest cover. Not surprisingly, considering the population-growth estimates cited above, Arizona is

projected to increase its GHG emissions by 148% from 1990 to 2020.[16] Transportation accounted for 39% of Arizona's GHG emissions in 2000, well above the U.S. average of 26%, and was the largest singe emissions category. The Obama Administration has included revenues from a carbon cap-and-trade system in its projected 2012 budget.

Stormwater 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.[17] Runoff from paved surfaces includes oil and grease, toxic compounds from brake dust, debris, chemicals, sediment, and bacteria.

Noise Pollution was first regulated by the federal Noise Control Act in 1972, which required noise analysis of all federal projects. 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. Noise barriers are now standard features of urban highways.

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. 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. Wetlands are especially ecologically valuable, particularly in Arizona.

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 precisely 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 that* identifies alternative growth corridors with less impact Arizona's "natural infrastructure."[18]

Economies of Scale and Utilization

Transportation is one of the more capital-intensive parts of the economy. Efficient transportation relies on investment in capital goods, from the networks themselves, to the passenger and freight terminals where we access the networks, to the vehicles on the networks. In thinking about the costs of transportation, it is important to distinguish between two terms that even experts often mix up: economies of scale and economies of utilization.

In these two terms, the word "economies" means cost savings. Therefore, economies of *scale* imply savings from a larger scale of operations. These benefits derive from many sources: larger vehicles, volume purchasing, mechanization, and specialization of employees and equipment. A large airport, for instance, can process planes and passengers at a lower cost *per plane* and *per passenger* than a small airport. Similarly, a double-tracked railroad can move more than twice as many trains per day as a single line, yet costs less than twice as much to build and operate. Economies of scale have been a major factor in lowering transportation costs of all kinds.

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, so they try to maximize their use, also known as their *load factor* or *capacity utilization.* Economies of utilization are a short-term phenomenon to achieve lower average costs with one's existing capital stock, while economies of scale are a long-term phenomenon that involves increasing one's capital stock.

Policy Fundamentals and Approaches

Derived Demand. Derived demand is a key concept of demand-side management (see below). 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. 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.

Demand-Side Management. When use of a transportation facility approaches or surpasses the capacity for which it was designed, congestion results. We most often associate this problem with roads, but rail, air, and transit are not immune. For centuries, policy makers have responded to congestion by building more capacity. In recent decades, scientists and policy makers have increasingly recognized two distinct ways to deal with congestion. The business-as-usual, supply-side approach adds to the supply of transportation: more roads, more buses, more rail lines, more runways, more pipelines and canals, and more transmission lines. In contrast, demand-side strategies aim to reduce the demand or spread the demand to less costly times and places. This kind of strategy has been catching on in both the transportation and energy industries. For instance, electric utilities have found it cheaper to invest in energy conservation for their customers (insulation, new appliances, or weather stripping) or to try and steer demand to the nighttime (when there is excess capacity), rather than build new power plants to meet customers' needs.

In the transportation sector, opportunities abound to "manage demand." For instance, the supply capacity of a freeway lane is about 2,400 passenger cars per hour. Demand is a function of VMT in the peak rush hours. Since VMT is a function of both number of vehicles and number of miles, demand-side strategies can aim at either target. Peak-hour vehicle *trips* can be reduced in several ways:

- Flex-time and four-day workweeks
- Carpooling
- Telecommuting, online shopping, distance learning, and online social networking
- Multipurpose trip-making
- Mode shifting to mass transit (including school buses) or non-motorized transportation

Similarly, we can reduce highway demand by shrinking the *miles traveled* by vehicles:

- Jobs-housing balance
- Mixed-use development
- Master-planned communities
- Infill development within central cities
- Urban villages
- Location-efficient mortgages that consider both mortgage *and* commuting costs in calculating a potential buyer's ability to pay, thus eliminating the built-in bias towards cheaper housing on the urban fringe (i.e., the "drive 'til you qualify" phenomenon)

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.[19] 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 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 capacity can alter people's choices of where they live or work, and modify land-use patterns. Induced demand has become important in debates about road widening and urban sprawl. Highway expansion can be inefficient to the extent that it just fills the new capacity with "low-value" trips that people were previously willing to shift or forego and generates more negative externalities, and can be unsustainable in the long-run because it leads to an ongoing cycle of supply and demand expansion. And yet, people change their travel behavior because they perceive a benefit, and therefore induced demand can also be another form of benefit, above and beyond the time and fuel savings of the road's current users.

Policy Instruments: Carrots and Sticks. Policies either encourage or discourage a particular behavior, and can take the form of regulation or pricing. A simple representation is shown in Table 1.3, with a few examples.

Table 1.3: Example Policy Instruments

	Allowing/Encouraging	**Banning/Discouraging**
Regulation	Hybrid vehicles in HOV lanes	Emissions test
Pricing	Hybrid vehicle tax credits	Bridge toll

Regulation places specific limits on the behavior of individuals, firms, or public agencies, while *pricing* strategies raise the cost to users of activities considered undesirable and lower them on desirable choices. *Allowing* hybrid vehicles in HOV lanes is a *regulation* designed to encourage people to purchase hybrids. An emissions test is an example of a *regulation* that *bans* undesirable choices. There's no opting out of the test by paying a fee: every car must pass the test or it cannot be registered. Example *pricing* strategies to *encourage* desirable behaviors include tax credits for purchasing hybrid vehicles. A bridge toll, such as on the Golden Gate Bridge, *discourages* drivers from crossing the bridge when the cost of the

trip, including the toll, exceeds the benefit of the trip. Understanding these approaches is important when considering the effect that policies, regulations, and financing mechanisms may have on demand.

An Intermodal System

For much of the 20th century, transportation research and planning focused on the competition among modes. Rail, air, road, bus, water, pipeline, biking, and walking were viewed as competing ways to make a trip or send goods. But multimodal trips have been common throughout history. Goods have been hauled overland to rivers or ports and transferred to ships, while people have walked, taken a bus, or driven to train stations. Our thinking about transportation modes began to change with the invention of containerized freight transportation. Freight could be packaged in a standard-size container that could be loaded on a flatbed truck or rail car, or stacked on a ship, and transferred quickly by machine from transport mode to another. Containerization provided the muscle, but the intermodal system did not fulfill its potential until information technology provided the brains. Using door-to-door routing, booking, billing, and tracking technologies, freight-transportation modes were integrated into a nearly seamless web that has indeed made the world smaller and "flatter." Containerization moved transportation from loosely linked modal networks to an integrated intermodal system.

Passenger transportation lags behind freight—not surprising since few of us would be willing to submit ourselves to human forwarders who arranged our door-to-door transport to minimize total system transportation costs. Nevertheless, transportation planners and researchers increasingly recognize that every passenger trip is a door-to-door planning process. Automobiles have a built-in advantage because many Americans, and nearly all Arizonans, park in their own driveway or in front of their own house, and are able to park at their destination. Transit planners are aware that it is a challenge to get people from their homes to the nearest bus or rail stop, via walk, bike, or car (the latter via drop-off or park-and-ride). An even more vexing challenge is the "last mile" problem, getting people from the end of the transit trip to their final destination, because even fewer options are available. We have already noted the environmental and congestion problems associated with single-occupancy vehicles (SOV), but we must also recognize the convenience advantage of SOVs over intermodal options for completing door-to-door trips.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 created funding programs to help regional governments address congestion and air quality by combining whatever approaches and modes would work best for them, instead of mandating a particular solution. Prior to ISTEA, each surface transportation mode was treated separately in federal legislation. ISTEA also expanded the requirements for public participation in transportation planning. The act has been renewed twice: in 1998 as the Transportation Efficiency Act for the 21st Century (TEA-21), and in 2005 as the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The act is currently due for reauthorization, and its new contents will have important implications for Arizona's transportation system. ADOT took a major step in 2007, combining its (highway) planning and public transportation divisions into a new Multi-Modal Planning Division. ADOT is in

the midst of developing a multi-modal "framework" study, working closely with other jurisdictions to create long-term visions based on broad and comprehensive analysis. Several recent statewide transportation studies are cited in various chapters within this report. For clarity, we present a brief description of each study, along with a link to their website where you can find more information.

Arizona Investment Council (2008) Infrastructure Needs and Funding Alternatives. This study tallies total statewide infrastructure needs across the energy, water, communications, and transportation sectors. It includes a review of demand and supply estimates, and detailed cost estimates for meeting demand projections. The full report can be found at: www.arizonaic.org/images/stories/pdf/AIC_FINAL_report.pdf.

Statewide Transportation Investment Strategy. The investment strategy is a comprehensive inventory of transportation projects, some of which correspond to current financially constrained regional plans, and some of which remain unfunded. This strategy served as the underlying project proposal to be funded under the failed TIME ballot proposition. TIME proposed to raise $42.58 billion over 30 years, to be allocated 58% to highways, 18% to rail and transit including high-speed intercity rail, 20% to local mobility projects by any mode, and 4% for walking and biking improvements. The maps and lists of projects with projected costs are included in the Appendix 4 and can be accessed at: www.azdot.gov/Statewide_Transportation_Investment_Strategy/Index.asp.

Statewide Transportation Planning Framework. Currently underway, the framework study is a statewide, multijurisdictional effort spearheaded by ADOT, focused on particularly important state travel corridors. The study area maps and report updates can be found at: www.bqaz.gov/index.asp.

We have divided this report into separate chapters for road, rail, air, and non-motorized transportation, and for urban, rural, international, tribal, and national park transportation issues. We encourage you to make connections across these artificial divisions to better plan Arizona's transportation future.

Conclusion

This April 2009 Town Hall occurs at a time when the national economy is slowing at a faster rate than it has at any time since World War II, with especially large impacts on Arizona. Housing prices have dropped and construction starts have ground to a halt. What good can come from this slow-down? It does offer some benefits for planning. The state has been leading the nation in growth rates for decades. Now, pressures to catch up with growth will ease and we can take time for reflection, assessment, and planning. We can identify and correct things that seem to be going wrong, and recognize and build upon things that are going right. This is a time of trouble, but also one of opportunity. (See Appendix 5 for the most current information available on the stimulus funding when this report went to press.)

The report's title, "From Here to There," refers not just to getting from place A to B, but also to transitioning from the transportation system we have now to the system we envision. Our

current system is the result of decades—even centuries—of changes in technology, regulatory structures, resource availability, awareness of environmental issues, and economic and cultural development. There is tremendous inertia in the transportation system because of the huge infrastructure already in place, and the existing built environment that it must serve. While we may be able to envision a more efficient, equitable, and sustainable system, figuring out how to get from here to there—from now to then—is an inherent part of the challenge. It is a challenge for which the Arizona Town Hall is ideally suited.

List of Abbreviations Used

CO	Carbon Monoxide	**NO_x**	Oxides of Nitrogen
CO_2	Carbon Dioxide	**O_3**	Ozone
EPA	Environmental Protection Agency	**PM**	Particulate Matter
GHG	Greenhouse Gases	**SOV**	Single-occupant vehicle
HOV	High-occupancy vehicle	**TEA-21**	Transportation Efficiency Act for the 21st Century
ISTEA	Intermodal Surface Transportation Efficiency Act	**TSP**	total suspended particulates
IPCC	Intergovernmental Panel on Climate Change	**VMT**	Vehicle miles traveled
NAFTA	North American Free Trade Agreement	**VOC**	volatile organic compounds

Aaron Golub is an assistant professor in the Schools of Planning and Sustainability at ASU. He holds a PhD in Civil and Environmental Engineering from the University of California, Berkeley, and a BS and MS in Mechanical Engineering. His research focuses on environmental- and social-equity outcomes of planning processes; travel survey data analysis; transportation policy and finance analysis; public transportation planning; and advanced bus systems and vehicle technologies. He has consulted with public agencies around the world on transportation projects, including the World Bank, United Nations, city governments, and sustainable-transportation advocacy organizations.

Michael Kuby received a Bachelor's degree from The University of Chicago and a PhD from Boston University, both in Geography. He is a Professor in the School of Geographical Sciences at ASU, where he has taught since 1988. His research centers on creating optimization models for facility location and transport-network design, mainly for sustainable energy and transport systems. His work with the World Bank on energy and railway transport in China was a Finalist for the 1994 Franz Edelman Award for Management Science Achievement. Kuby has served as Chair of the Transportation Specialty Group of the Association of American Geographers, and on editorial boards of the *Professional Geographer* and *Journal of Transport Geography*. He is currently Area Editor for Location Science for *Networks and Spatial Economics.*

Jason Kelley is a PhD student in the School of Planning at ASU. He earned a MA in Geography from ASU in 2007, and a BA in Geography from ASU in 2005.

---

[1] Friedman, T. L. *The World is Flat, 3.0: A Brief History of the Twenty-first Century.* Picador, New York, 2007.
[2] Puentes, R., and A. Tomer. *The Road… Less Traveled: An Analysis of Vehicle Miles Traveled Trends in the United States.* Brookings Institution, Washington, D.C., December 2008. www.brookings.edu/reports/2008/1216_transportation_tomer_puentes.aspx. Accessed Feb. 27, 2009.
[3] Polzin, S. E. *The Case for Moderate Growth in Vehicle Miles of Travel: A Critical Juncture in U.S. Travel Behavior Trends.* Center for Urban Transportation Research, University of South Florida, April 2006. www.cutr.usf.edu/pdf/The Case for Moderate Growth in VMT- 2006 Final.pdf. Accessed Jan. 7, 2009.
[4] Pisarski, A. A. *Commuting in America III: The Third National Report on Commuting Patterns and Trends.* Transportation Research Board, TCRP Report #110, 2006. www.trb.org/news/blurb_detail.asp?ID=6699. Accessed Feb. 26, 2009.

[5] The Brookings Institution. *Mountain Megas.* 2008. www.brookings.edu/~/media/Files/rc/reports/2008/0720_intermountain_west_sarzynski/IMW_full_report.pdf. Accessed Feb. 26, 2009.
[6] Morrison Institute for Public Policy. *Megapolitan: Arizona's Sun Corridor.* May, 2008. www.asu.edu/copp/morrison/megapolitan.htm. Accessed Feb. 26, 2009.
[7] A recent paper estimated the wartime and peacetime defense expenditures for protecting United States access to Persian Gulf oil at $27-73 billion per year. See Delucci, M. A., and J.J. Murphy. US Military Expenditures to Protect the Use of Persian Gulf Oil for Motor Vehicles. *Energy Policy,* Vol. 36, 2008, pp. 2253– 2264. The International Energy Agency estimates that the United States spends $150 billion per year maintaining a military presence in the Middle East, primarily to secure oil imports.
[8] Litman, T. Policy implications of full social costing. *Annals of the AAPSS,* Vol. 553, 1997, pp. 143-156.
[9] Delucchi, M. Should we try to get the prices right? *Access,* Vol. 16, 2000, pp. 10-14.
[10] *Ibid*.
[11] U.S. EPA. *Particulate Matter.* www.epa.gov/particles/. Accessed Jan. 7, 2009.
[12] Much of this section on greenhouse gases was adapted with permission from Kuby, M., Harner, J. and Gober, P. *Human Geography in Action* (4th edition). John Wiley & Sons, New York, 2006.
[13] Intergovernmental Panel on Climate Change (IPCC). *IPCC Fourth Assessment Report: Climate Change 2007.* www.ipcc.ch/ipccreports/ar4-syr.htm. Accessed Feb. 23, 2009.
[14] *Ibid.*
[15] While two feet of sea-level rise is the conservative estimate of the IPCC report, assuming no changes in ice floes, a recent study of the possible collapse of the 2,000-ft high West Antarctic Ice Shelf raises the possibility of a rise up to 21 feet. See Mitrovica, J. X. N. Gomez, P. U. Clark. The Sea-Level Fingerprint of West Antarctic Collapse. *Science.* Vol. 323. No. 5915, 6 February 2009, p. 753.
[16] Arizona Climate Change Advisory Group. *Climate Change Action Plan, August 2006.* www.azclimatechange.gov/. Accessed Jan. 7, 2009.
[17] University of Arizona, Non-point Education of Municipal Officials. *Arizona NEMO.* www.srnr.arizona.edu/nemo/index.php. Accessed Jan. 7, 2009.
[18] The Nature Conservancy. *Growing by Design: Choices for a Sustainable Arizona.* www.nature.org/wherewework/northamerica/states/arizona/projects/art25470.html.
[19] Wikipedia contributors. Induced Demand. *Wikipedia, The Free Encyclopedia*. en.wikipedia.org/w/index.php?title=Induced_demand&oldid=268775685. Accessed February 27, 2009. Also Federal Highway Administration. *Induced Travel: Frequently Asked Questions.* www.fhwa.dot.gov/Planning/itfaq.htm. Accessed February 27, 2009.

Chapter 2

GASOLINE PRICES

Michael Kuby
Arizona State University, School of Geographical Sciences

Key Points

- The United States relies on oil for 96% of its transportation energy.
- Recent fluctuations in gasoline prices were driven by changes in crude oil prices.
- World oil consumption is growing rapidly, while global supply peaked in May 2005.
- The United States imports 58% of its oil. Given where world reserves are found, we will grow more dependent on the Middle East over time. We should expect higher, more volatile prices, and even shortages.
- While there is little that Arizona can do to lower gas or diesel prices, there are many things we can do to prepare for higher future prices.
- Federal and state taxes are only 18 cents per gallon each.

Predicting future gasoline prices is a risky business. Even when there is broad consensus about the direction prices will go, the consensus can be wrong. Although the amount of oil contained in the earth is finite, many people are too pessimistic about future oil prices. On the other hand, it is easy to be too optimistic by putting too much faith in the ability of market forces and technological change to overcome geology, geography, politics, and global trends.

Despite the difficulty of predicting gas prices, it is essential that we begin this report with a realistic understanding of the factors involved. Oil provides 96% of the energy used in the transport sector in the United States. 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 (Figure 2.1). Our vehicles and infrastructure are built almost entirely around the technological advantages of using liquid fuels derived from oil. Future gas prices are likely to be higher and more volatile, which has major implications for the competition among transport modes, land-use patterns, and the competitiveness of our industries.

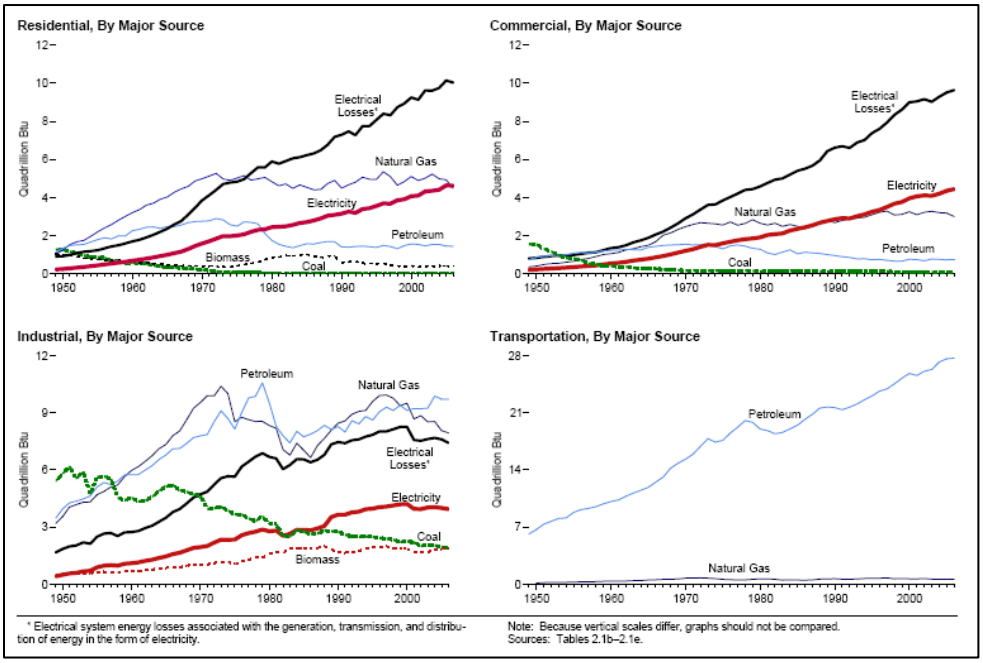
Current Conditions

Let's begin with a breakdown of the retail cost of gasoline at the pump (Figure 2.2). Taxes comprise a small and stable part of the pump price, averaging 41.5 cents nationally. Local distribution and market costs are a small part of the whole, averaging 23 cents per gallon since 2000, but they have fluctuated quite a bit, from 5 to 76 cents. Refining costs have averaged 31 cents, and have spiked as high as 81 cents when capacity has been tight, but were clearly not responsible for the 2008 price surge. But despite the fluctuations in distribution, marketing, and refining costs, it is clear from the graph that the cost of crude oil is the driving force behind retail gasoline prices. At the low point of the graph, in December 2001, the national average price was $1.09 per gallon and crude oil accounted for only 37%

of the cost. Prices peaked in July 2008 at $4.06 per gallon, when crude oil comprised 76% of the cost.[1] In absolute terms, the cost of the crude oil in a gallon of gas went from 40 cents to $3.03 between the low and high points of the graph.

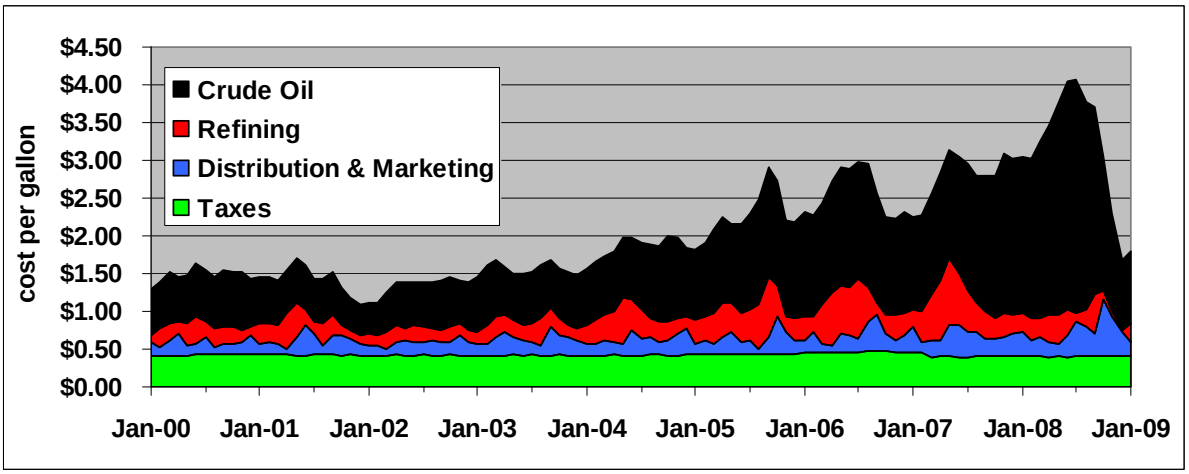
The upward trend in gas prices that dominated the news in 2007-2008 actually began in 2002, and should not be viewed as an aberration (Figure 2.2). Both crude oil prices and U.S. gasoline prices have dropped drastically since July 2008 as the global financial crisis

Figure 2.1: Energy Consumption by End-Use Sector, 1949-2006



Source: *Annual Energy Review.* U.S. Energy Information Administration.

Figure 2.2: Components of Average U.S. Gasoline Price at the Pump



Source: EIA. Gasoline Components History. tonto.eia.doe.gov/oog/info/gdu/gaspump.html.

reverberated throughout the world economy and demand plummeted. In December, 2008, the average U.S. gasoline price was $1.69, with crude oil prices accounting for 56%. Diesel experienced a similar run-up to $4.70 per gallon (65% for crude) in July 2008, and drop-off to $2.45 (39% for crude) by December. Crude prices at the end of 2008 stood at $35 per barrel, down from $147 at the July 2008 peak.[2]

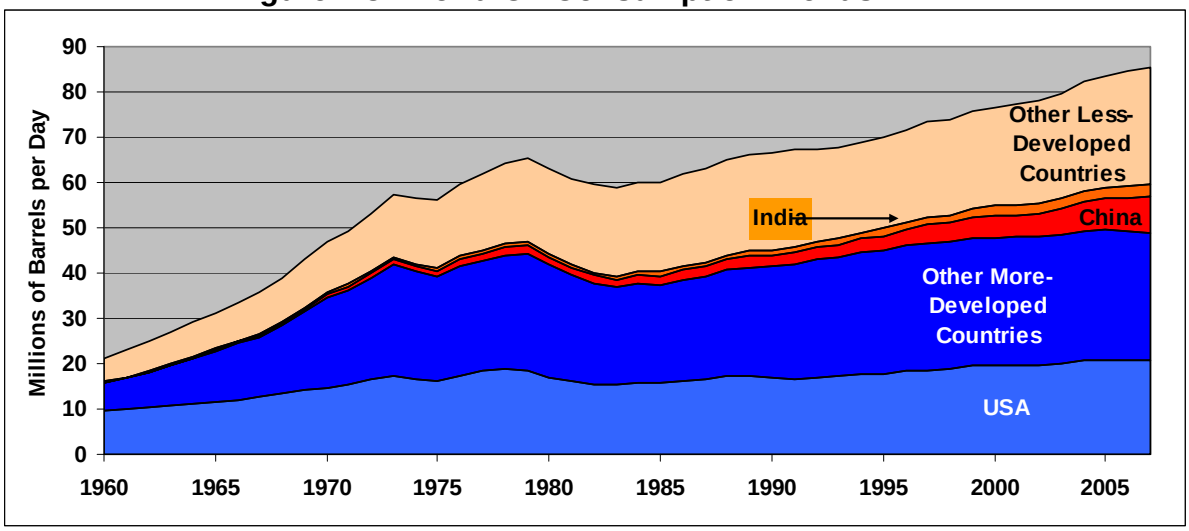
Taxes comprise a small part of the pump price. The Arizona state tax is18 cents per gallon, below the average state tax of 21.5 cents.[3] Federal tax is 18.4 cents. The combined federal and state average of 39.5 cents per gallon is far lower than in other industrial countries such as Canada ($1.19), Japan ($2.29), the U.K. ($5.02), and Germany ($5.12).

Figure 2.2 makes it clear that to understand gasoline prices, we need to understand crude oil prices. OPEC, the Organization of Petroleum Exporting Countries, was formed in 1960. Oil prices quadrupled in 1973 because of the Arab oil embargo, and then doubled again during the Iran hostage crisis of 1979. Many feared the world was entering a new era of dwindling oil resources, but that did not come to pass. Real oil prices declined through the 1980s and 1990s, and many came to believe that geological supply was not a limitation.

Crude prices began rising again in the early 2000s. Although the run-up in prices in the 2000s coincided with the second Gulf War, there were no major supply disruptions like those in the 1970s. Even when such factors as speculation, terrorism, and world politics are taken into account, the latest rise in crude oil prices was mostly due to world demand growing faster than world supply.

To get a better idea of how world supply and demand are likely to evolve after the current recession, it helps to look at past trends (Figure 2.3). In 1960, the United States consumed 9.8 million barrels per day (mbd), or 46%, of the world's oil. By 2007, our consumption had more than doubled to 20.7 mbd, but our *share* of world consumption fell by almost half, to 24%. Since 1995, oil consumption in the United States, Canada, Western Europe, Japan, and Australia has grown by 4 mbd, compared with 11 mbd in the less-developed world. In

Figure 2.3: World Oil Consumption Trends



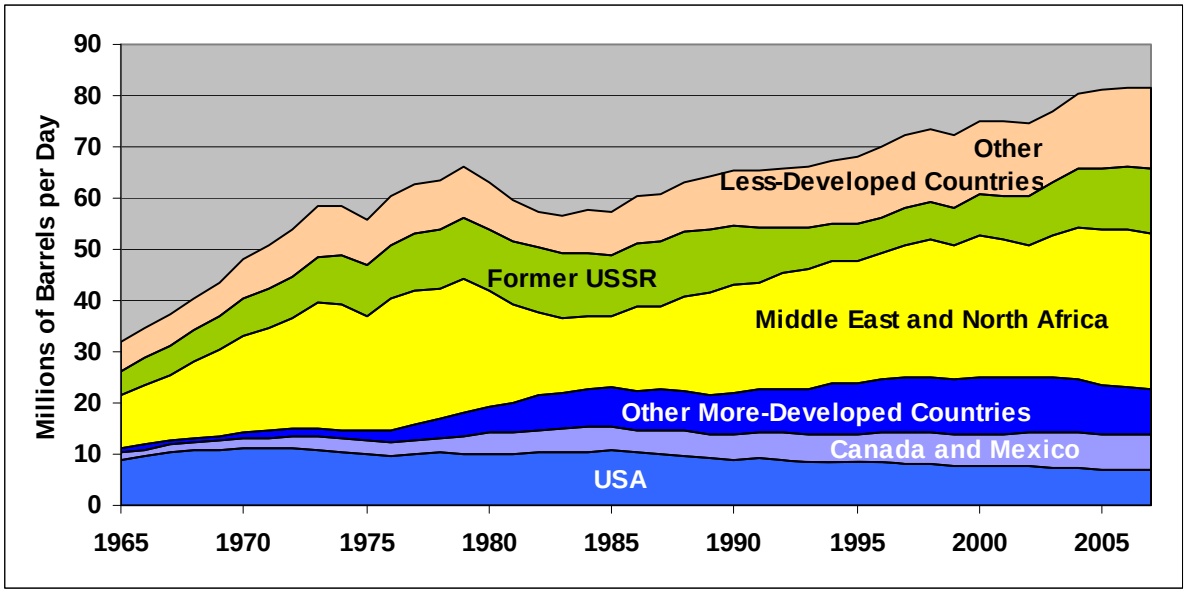
Source: *BP Statistical Review of World Energy June 2008* (original data from U.S. EIA).

particular, from 1960 to 2007, consumption in China and India grew 32 times larger, from 0.33 to 10.5 mbd. China and India together have 2.5 billion people, more than 8 times the U.S. population. Despite their rapid economic growth, they still lag far behind the United States in car ownership. India and China average 18 and 24 motor vehicles per 1,000 people, compared with 787 per 1,000 in the United States.[4] Given these facts, world oil consumption may continue to rise rapidly.

On the supply side, U.S. production peaked in the early 1970s at 11 mbd and has steadily declined to less than 7 mbd (Figure 2.4). Canada and Mexico, our largest sources of imported oil, have not made up the difference. Other more-developed countries, mainly Norway and the United Kingdom, peaked in 2000 at 11 mbd and have since declined to less than 9 mbd, as offshore deposits in the North Sea are depleted. Meanwhile, more than half of the world's oil is supplied by the Middle East, North Africa, and the former USSR.

World crude-oil prices are, of course, a result of the balance of supply and demand on a global level. Compare the height and slope of world consumption and production trends in 2007 in Figures 2.3 and 2.4. Production shows some flattening at 81-82 mbd, compared with the steady increase in consumption from 80 mbd to 85 mbd. This global shortfall in supply relative to consumption has been the primary cause of the price increase since 2003. World daily oil demand rose from 82.4 mbd in 2004 to 87.0 mbd in the fourth quarter of 2007, *without a corresponding increase in supply*, while the sudden recession-related drop to 84.7 mbd in the third quarter of 2008 was primarily responsible for the price decline in late 2008.[5]

Figure 2.4: World Oil Production Trends

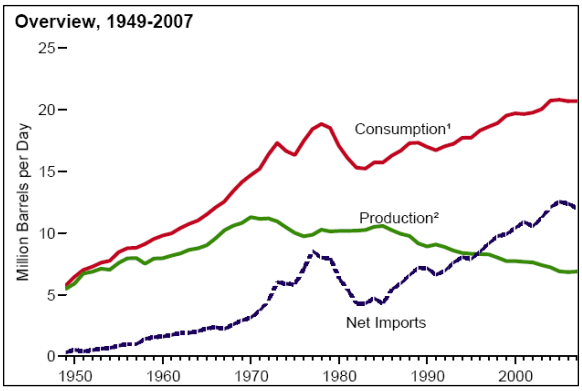


Source: *BP Statistical Review of World Energy June 2008* (original data from U.S. EIA).

Both oil supply and demand are known to be highly inelastic with respect to price in the short run. This means that production and consumption cannot respond quickly or sizably to changes in prices, while prices change dramatically in response to changes in supply and demand. On the supply side, it takes many years and large investments to bring new fields into production. 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 or heat their homes, and companies need to run their equipment, and neither consumers nor firms can quickly replace their oil-fueled equipment with something else. Both consumers and firms can cut back more easily on other budget items than on their transportation needs.

The growing gap between U.S. consumption and production is filled by imports (Figure 2.5). Net imports in 2007 accounted for 58% of U.S. oil consumption. In 2007 our four largest suppliers were Canada (18%) and Mexico (11%), as well as OPEC members Saudi Arabia (11%), and Venezuela (10%). While the rest of the world relies heavily on OPEC, it supplied only 45% of our imports in 2007.[6]

Figure 2.5: U.S. Oil Trends

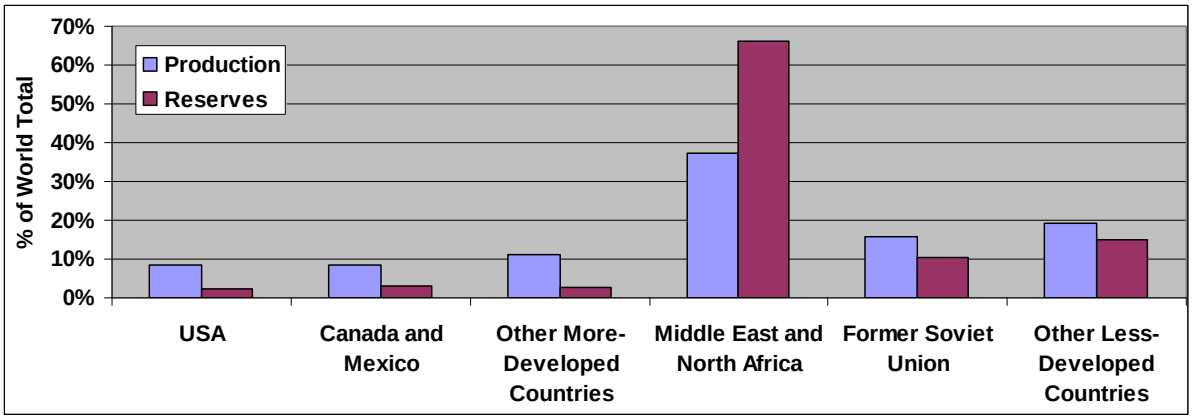


Source: *Annual Energy Review.* U.S. Energy Information Administration.

Are these trends likely to continue? The answer depends heavily on how much oil is left in different regions of the world. The most common measure of oil in the ground is *reserves*: deposits that are geologically proven, and recoverable at a profit using today's technology at today's prices. Reserves shrink mainly by pumping them out, but they can also grow through three mechanisms. Technology can improve or prices can rise, thus making it economically feasible to recover more oil for a profit, and companies can identify deposits that were previously unknown or uncertain. U.S. oil reserves began falling in the late 1960s, rose in 1970 when oil was discovered in Alaska, and have declined ever since. In contrast, our natural-gas reserves keep growing as discovery outpaces production.

U.S. dependence on imports, from OPEC and the Middle East in particular, is likely to increase in the coming years. As Figure 2.6 shows, the United States currently produces 8.4% of the world's oil, but has only 2.4% of the reserves. Canada, Mexico, and other more-developed countries similarly have much higher shares of the world's production than of reserves. The Middle East and North Africa, meanwhile, are producing 37% of the world's oil, but are sitting on an estimated 66% of reserves.[7] Furthermore, the Middle East is the only region with the capacity to increase production in the short term to meet shortfalls.

Figure 2.6: Production vs. Reserves, by World Region



Source: *BP Statistical Review of World Energy June 2008*.

What about less conventional sources, such as oil and tar sands, oil shale, and oil on the outer continental shelf or in the Arctic National Wildlife Reserve (ANWR)? According to U.S. Energy Information Administration (EIA) analysis, the earliest ANWR production could begin would be 2018, in which case it would peak at 0.78 mbd around 2027.[8] Opening ANWR would reduce our oil dependency (by 3% in 2030) and balance of trade, but would have little effect on world oil prices, which are determined by the balance of *global* supply and demand. EIA predicts ANWR would lower crude prices by only 75 *cents* per barrel in 2025. Similar results are found for the outer continental shelf. Tar sands and oil shale hold much larger quantities of oil, but at much steeper production and environmental costs.

As we said at the beginning of this chapter, predicting future oil and gasoline prices is nearly impossible for specialists in the field, let alone local residents and officials. There are, however, agencies, institutes, and companies whose job it is to make such prognostications. The International Energy Agency (IEA) recently doubled its forecast for the price of oil in 2030 to $120 per barrel in 2008 dollars, because of "rising demand in the developing world as well as surging costs of production as oil needs to be sourced from more expensive offshore fields and state-run companies."[9] The IEA called the current trends "patently unsustainable" and said "the era of cheap oil is over." The Association for the Study of Peak Oil and Gas-USA finds even this revised IEA outlook too optimistic: "Years of data from the majority of oilfields around the world show steady or declining production. Most major oilfields were found decades ago, and those reserves were easy and inexpensive to extract. Since then, few new fields have been discovered to replace those reservoirs . . . We anticipate supply shortages and price increases within a few years."[10] A recent presentation by oil

expert Matthew Simmons to the EIA called peak oil "extremely real and extremely risky" and said "there is nothing fuzzy when global demand outstrips faltering supply."[11] While the debate continues about when world oil production will peak and begin a possibly inexorable decline, according to the EIA's own data, the monthly world production record set in May 2005 has not been broken in 48 months.

Existing Plans and Programs

CAFE Standards. In 1975, Congress passed the Corporate Average Fuel Economy (CAFE) standards requiring each manufacturer's fleet-wide average to meet certain miles-per-gallon (mpg) targets. The passenger-car standard reached 27.5 mpg in 1985, was briefly lowered, and then remained at 27.5 from 1990 to 2007. In addition, lower standards for light trucks allowed the auto industry to get around the regulations by producing more pickups and SUVs, which were permitted to average 25% fewer mpg. The United States and Canada have the lowest mpg standards of any industrialized country in the world.[12] In 2007, the Energy Independence and Security Act eliminated the separate standards for cars and light trucks and raised the standard on the combined fleet to 35 mpg by 2020. President Obama has asked the U.S. Department of Transportation to consider even higher standards.

Federal Tax Credits and Disincentives. There is a $3,400 federal tax credit for hybrid and diesel vehicles, but both credits are gradually phased out as each manufacturer surpasses certain sales totals. There is also a federal "gas guzzler" tax on cars with exceptionally poor fuel economy, but it does not apply to light trucks, which include minivans and SUVs.

State Standards and Incentives. Federal law allows states to seek a waiver from the U.S. Environmental Protection Agency (EPA) to set their own, more-stringent emissions standards, which often have the effect of improving energy efficiency. Concerned about their air quality, California received 50 waivers until, in 2007, their attempt to require a 30% reduction in greenhouse-gas emissions in cars and light trucks by 2016 was blocked by EPA. President Obama has ordered the EPA to reconsider California's request. Eleven other states had adopted the standards, and Arizona was one of six states seriously considering them.[13] Arizona offers a "limited number" of high-occupancy vehicle (HOV) lane exemptions to owners of Honda and Toyota hybrids, but not to low-sulfur diesels or efficient small cars.[14]

Strategic Petroleum Reserve. The Federal Government maintains the Strategic Petroleum Reserve (SPR) to safeguard against—and deter—disruptions in oil supply. As of January 2009, the SPR contained 703 million barrels, enough to supply all U.S. needs for 33 days. U.S. Presidents have approved two SPR drawdowns, during Operation Desert Storm in 1991 and after Hurricane Katrina in 2005.[15]

Arizona Cleaner Burning Gasoline. Due to past violations of federal carbon monoxide (CO) standards, Maricopa County and parts of Pinal and Yavapai are required by agreement with 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. Arizona CBG has substantially reduced ozone and CO in the atmosphere. Arizona CBG adds an estimated 9 to 17 cents per gallon to gas prices.[16] Even

though the EPA re-designated the MAG region as being in "attainment" status for CO in 2005, Arizona CBG is still required during months when there is a risk of exceeding those standards. Arizona has requested EPA to reduce the winter gasoline season to 3 months.[17]

Price Gouging. Over half the states have laws against price gouging, usually defined as prices 0-25% above the norm during a declared state of emergency.[18] Arizona does not have such a law, which would not apply to non-emergency price increases anyway. Arizona's Attorney General's Office has the authority to enforce anti-trust laws in cases of price fixing and unfair competition, but not in cases of retailers setting prices at what they think the market can bear. Arizona cooperates with the Federal Trade Commission's Gasoline Price Monitoring Project. The Arizona Department of Commerce's Energy Office analyzes and reports on gasoline supplies and prices.

Challenges

As we said at the outset, the United States relies on petroleum—gasoline, diesel, and jet fuel—for 96% of its transportation energy. While other factors such as labor agreements and shortages, capital costs and interest rates, safety and environmental regulations, taxes and fees, economies of scale, and competition also affect transport costs, none has as much impact on transportation costs as fuel prices. Fluctuations in gas prices over time are largely determined by global supply and demand. Variations from place to place are mainly dictated by fuel taxes, although delivery and blending costs also cause variation.[19]

In the short run, when oil prices rise, the main option available to companies is to switch to another mode that uses oil-based fuels more efficiently (e.g., rail instead of truck). Individuals can switch to transit, which uses alternative fuels in many parts of Arizona (see Ch. 16). They also can use non-motorized transportation (see Ch. 10), telecommute, shop or take classes online, and reduce or combine trips. From April 2007 to April 2008, gas prices rose 21%, yet average miles driven fell only 2.1%, from 250 miles per week to 245.[20] Americans drove 5 billion miles less, yet transit use increased by only 50 million miles, meaning they made fewer or shorter trips rather than making the same trips by transit. 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.

Recently, the National Resources Defense Council ranked Arizona the 7th most vulnerable state to gas price changes.[21] The average Arizona driver spends nearly twice the portion of income on transportation (4.9% vs. 2.5%) as drivers in states with the least vulnerability.

Opportunities

While cities and states can do little specifically to lower gas prices, there are opportunities for actions that indirectly, and over the longer term, can help prepare for higher future prices.

Alternatives. The main thing that state and local governments can do to prepare for higher future gas prices is provide alternatives to driving—alternative modes and alternative fuels. As subsequent chapters will show, the success of alternative modes and fuels depends heavily on

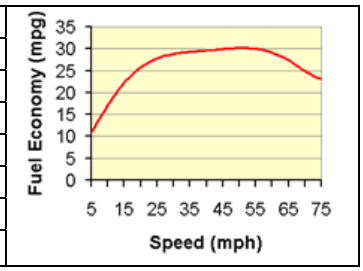
infrastructure. Investing in alternative modes such as transit (see Ch. 9), walking and biking (see Ch. 10), and intercity rail (see Ch. 12) is one solution. (Air transport is omitted from this list because its cost will increase even more rapidly with higher oil prices—see Ch. 11). Promoting "smart growth" land-use patterns that support use of alternative modes is also important (see Ch. 3). The other major alternative to paying high gas prices is to start investing now in the infrastructure for alternative transportation fuels (see Ch. 16).

Conserving Fuel. Even without switching to alternative fuels, Arizonans can replace gas-guzzling cars and light trucks with more efficient vehicles. While the greatest gains result simply from driving a smaller vehicle (several cars cost under $15,000 and get over 40 mpg),[22] hybrid vehicles are about 25% more fuel efficient than a conventional vehicle of similar size. Diesel vehicles get 30-35% better mpg than gasoline vehicles due to improved engine efficiency and higher energy content of the fuel, and they have gotten cleaner in recent years. Federal programs exist to help finance fuel-efficient, "clean-diesel" trucks.[23]

In the short term, Arizonans can take steps to improve the mpg of their current vehicles (Table 2.1). While the Arizona Department of Commerce web site regularly updates fuel-price information and other useful links at www.azcommerce.com/Energy/MotorFuel/, consumers have to seek out this information. A more effective way to publicize these savings would be to require that they be posted on all gas pumps.

Table 2.1: Fuel Economy Savings[24]

Action	Fuel Savings
Driving less aggressively	5-33%
Observing the speed limit	7-23%
Removing excess weight from the car	1-2% /100 lbs.
Keeping engine properly tuned	4%
Replacing air filters	Up to 10%
Keeping tires properly inflated	Up to 3%
Using recommended grade of motor oil	1-2%



Source: www.fueleconomy.gov

Speed Limits. As Table 2.1 shows, slower driving saves gas. During the gas crises of the 1970s, the federal government reduced the national speed limit to 55 mph. Arizona could lower the state speed limit to save energy and money, and reduce pollution and accidents, albeit at the cost of longer travel times.

Refineries and Pipelines. Arizona relies on refineries in El Paso and Southern California for its gasoline and diesel, which are shipped in by private pipelines. Being at the "end of the pipeline," Arizona is at risk of fuel shortages, refinery capacity limitations, and, as we saw in 2003, pipeline ruptures. The new refinery proposed in Yuma, and additional pipelines, could help avoid future fuel emergencies.

Higher and "Net-Zero" Gas Taxes. Average Americans, faced with the transport choices and prices before them, are not irrational. From 1980 to 2000, real personal income in the United States rose over 50%, while real gas prices fell more than 50%.[25] It is no surprise, therefore, that Americans responded to these signals by buying more and bigger cars and driving them more miles. Higher gas prices would likely have the opposite effect over time.

There are proposals by experts from both the left[26] and the right[27] to raise fuel-excise taxes in a revenue-neutral and politically acceptable way by phasing it in gradually and lowering other taxes proportionally. The decrease in other taxes could be calibrated so that individuals who drive an average vehicle an average number of miles would see no net change in their taxes, but all Arizonans would have additional incentive to conserve. The idea has been proposed and has been described as a "win-win-win-win-win" solution.[28]

Another idea being discussed is trying to stabilize gas prices by creating a price floor. At the 2009 North American International Auto Show in Detroit, General Motors CEO Rick Wagoner said taxing gas or providing rebates on fuel-efficient cars "is going to be the most effective way to move the needle fast."[29] Ford Executive Chairman Bill Ford Jr. commented: "It makes life very difficult if the market gyrates wildly over the course of several months, and that's exactly what we've seen happen."[30] Increasing fuel taxes now while prices are low, without adding to citizens' total tax burden, might get Arizona moving earlier to meet its energy future.

List of Abbreviations Used

ADEQ	Arizona Department of Environmental Quality	**EPA**	Environmental Protection Agency
ANWR	Arctic National Wildlife Refuge	**HOV**	High-occupancy vehicle
BP	British Petroleum	**IEA**	International Energy Agency
CAFE	Corporate Average Fuel Economy	**mbd**	Millions of barrels per day
CBG	(Arizona) Cleaner Burning Gasoline	**OPEC**	Organization of Petroleum Exporting Countries
CO	Carbon monoxide	**SPR**	Strategic Petroleum Reserve
EIA	Energy Information Administration (U.S.)	**VMT**	Vehicle miles traveled

Michael Kuby received a Bachelor's degree from The University of Chicago in 1980 and a PhD from Boston University in 1988, both in Geography. He is a Professor in the School of Geographical Sciences at Arizona State University, where he has taught since 1988. His research centers on creating optimization models for facility location or transport network design, mainly for sustainable energy and transport systems. His research has been funded by the U.S. Department of Energy, the U.S. Army Corps of Engineers, and the National Science Foundation. His work with the World Bank on energy and railway transport in China was a Finalist for the 1994 Franz Edelman Award for Management Science Achievement. Kuby has chaired the Transportation Geography Specialty Group, and served on editorial boards for the *Professional Geographer* and *Journal of Transport Geography*, and is currently Area Editor for Location Science for *Networks and Spatial Economics.*

---

[1] U.S. Energy Information Administration. *Gasoline Components History*. tonto.eia.doe.gov/oog/info/gdu/gaspump.html. Accessed March 1, 2009

[2] U.S. Energy Information Administration. *World Crude Oil Prices.* tonto.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm. Accessed Jan. 7, 2009.

[3] American Petroleum Institute. *Notes to State Motor Fuel Excise and other Taxes.* www.api.org/statistics/fueltaxes/upload/MotorFuelNotesJan20092.pdf. Accessed Feb. 28, 2009.

[4] Population Reference Bureau. *World Population Data Sheet, 2008.* www.prb.org.

[5] U.S. Energy Information Administration. *International Petroleum Monthly.* www.eia.doe.gov/ipm/demand.html. In addition, a good 1-minute video on inelastic oil supply and demand curves can be viewed at www.youtube.com/watch?v=T7vGDwGLU7s. Accessed Jan. 7, 2009.

[6] U.S. Energy Information Administration. *Annual Energy Review*. /www.eia.doe.gov/emeu/aer/contents.html. Accessed Feb. 28, 2009.

[7] Estimates of oil reserves in the Middle East and in other OPEC countries might be inflated. OPEC assigns production quotas based on a percentage of a country's reserves, so there is some incentive to exaggerate reserves in order to be allowed to produce more. Oil production is nationalized in many OPEC countries, so independent estimates are not possible. The possibility that their reserves are overestimated could be good or bad for the U.S. If OPEC reserve estimates are inflated, the world would be less *proportionally* dependent on the Middle East, but it would also mean that the world has much smaller reserves than currently believed.
[8] U.S. Energy Information Administration. *Analysis of Crude Oil Production in the Arctic National Wildlife Refuge.* Report #SR-OIAF/2008-03, May 2008. www.eia.doe.gov/oiaf/servicerpt/anwr/results.html. Accessed Jan. 5, 2009.
[9] Porretto, J., and J. Wardell. Energy Agency Warns of Impending Supply Crunch. *USA Today*, Nov. 12, 2008. www.usatoday.com/money/economy/2008-11-12-3143874449_x.htm. Accessed Feb. 28, 2009.
[10] Bowden, D. *World Energy Outlook 2008 Report Details Significant Challenges In Petroleum Production, Agreeing With ASPO-USA's Long-Held Position*. Association for the Study of Peak Oil and Gas-USA. November 17, 2008, www.aspousa.org/index.php/2008/11/patently-unsustainable/. Accessed Jan. 7, 2009.
[11] Simmons, M. The Peak Oil Debate as the EIA Turns 30. April 7 2008. www.eia.doe.gov/conf_pdfs/Monday/Simmons.pdf. Accessed Jan. 5, 2009.
[12] Wikipedia, *Corporate Average Fuel Economy*. en.wikipedia.org/wiki/Corporate_Average_Fuel_Economy. Accessed Jan. 6, 2009.
[13] California Air Resources Board. *Climate Change Emissions Standards for Vehicles.* www.arb.ca.gov/cc/factsheets/ccfaq.pdf. Accessed Jan. 6, 2009.
[14] U.S. Department of Energy, Alternative Fuels Data Center. *Arizona Incentives and Laws.* www.afdc.energy.gov/afdc/progs/state_summary.php/AZ. Accessed Jan. 5, 2009.
[15] U.S. Department of Energy. *Strategic Petroleum Reserve—Profile.* fossil.energy.gov/programs/reserves/spr/index.html. Accessed Jan. 5, 2009.
[16] Arizona Department of Commerce. *Arizona Cleaner Burning Gasoline.* www.azcommerce.com/doclib/energy/az_cleaner_burning_gasoline.pdf. Accessed Jan. 5, 2009.
[17] Arizona Department of Environmental Quality. *Cleaner Burning Gasoline State Implementation Plan Revision: Removal of February and March from the Winter Gasoline Season.* Sept. 27, 2007. www.azdeq.gov/environ/air/plan/download/0707sip.pdf. Accessed Feb. 28, 2009.
[18] Arizona Department of Commerce. *The Law.* www.azcommerce.com/doclib/ENERGY/AZ_The_Law.pdf. Accessed Jan. 5, 2009.
[19] U.S. Energy Information Administration. *A Primer on Gasoline Prices*. www.eia.doe.gov/bookshelf/brochures/gasolinepricesprimer/. Accessed November 10, 2008.
[20] Pendyala, R. *Arizona's Travel Trends and Conditions.* Presentation to Arizona State Legislature Gas Price Summit, June 24, 2008.
[21] National Resources Defense Council. *Addicted to Oil: Ranking States' Oil Vulnerability and Solutions for Change*, 2007. http://docs.nrdc.org/air/files/air_07061901a.pdf. Accessed Mar. 1, 2009.
[22] U.S. EPA. *Fuel Economy Guide.* www.fueleconomy.gov/feg/FEG2009.pdf. Accessed Jan. 5, 2009.
[23] U.S. EPA, Office of Transportation and Air Quality. *Smart Way.* www.epa.gov/smartway/. Accessed Jan. 5, 2009.
[24] See also Edmunds.com. *Fuel Economy: We Test the Tips.* www.edmunds.com/advice/fueleconomy/articles/106842/article.html. Accessed Jan. 5, 2009.
[25] See note 20.
[26] Friedman, T. *Win-Win-Win-Win-Win…* The New York Times, December 27, 2008. www.nytimes.com/2008/12/27/opinion/27sat1.html?_r=1&partner=rss&emc=rss. Accessed Feb. 1, 2009.
[27] Krauthammer, C. The Net-Zero Gas Tax: A Once-in-a-Generation Chance. *The Weekly Standard* 14(16), Jan. 5, 2009. www.weeklystandard.com/content/public/articles/000/000/015/949rsrgi.asp. Accessed Feb. 1, 2009.
[28] See note 26.
[29] Carty, S.S. Carmakers Lean Toward Higher Gas Tax to Fuel Small-Car Sales. *USA Today*. January 13, 2009. www.usatoday.com/money/autos/2009-01-12-gas-tax-automakers-small-car-sales_N.htm. Accessed Feb. 1, 2009.

[30] Associated Press. *Automakers Talk of Stabilizing the Price of Gas*. January 13, 2009. www.msnbc.msn.com/id/28643952/. Accessed Feb. 1, 2009.

Chapter 3

Metropolitan Transportation and Land-Use Planning

Aaron Golub
Arizona State University, School of Planning and School of Sustainability

Key Points

- There is a strong relationship between transportation demand and the density and mix of land uses.
- Metropolitan areas absorb most of the population growth in the state by the dual processes of densification in established cores alongside "sprawl" on the edges of urban areas—therefore special attention should be paid to land-use and transportation planning in both central and outlying areas.
- Many public agencies are involved in overlapping financing, planning, and implementation of metropolitan transportation systems.
- Current metropolitan land-use and transportation plans do little to control demand.
- There is a growing movement, both in the state and nationally, for more comprehensive land-use and transportation planning that controls demand and sustains economic growth.

This chapter reviews the process of transportation planning in Arizona's metropolitan areas across the full scale of jurisdictions—from municipalities to the state and federal Departments of Transportation. It also reviews the systems of land-use planning within the various jurisdictions of the metropolitan areas, and summarizes the results of those processes. Also included are proposals that fall outside of typical planning processes.

Current Conditions

Connection between Urban Land Use and Transportation. There is a strong and fundamental interdependency between the workings of the transportation system and the possibilities for land use in a metropolitan area. The physical extent and performance of its transportation system determine the relative costs of traveling within a metropolitan area, and therefore the possible arrangements of the area's land uses. The history of metropolitan area growth shows that as evolving transportation technologies enable faster travel, cities expand in size, which allows for greater differentiation and specialization of land uses over wider areas (see Ch. 1). Improved transportation enables faster, cheaper, and more convenient travel, and without planned control of growth it can lead to expansion of the metropolitan area. On the other hand, if transportation-system performance degrades or costs rise due to worsening congestion or increasing gasoline prices, land-development pressure may move inwards as more central locations become relatively less costly to access.

This dynamic works in the reverse direction as well. Land-use types can also place constraints on the possibilities for transportation. Low land-use density means that distances between destinations—home, work, shopping—are long. Low density affects slower modes such as cycling or walking, making travel times prohibitive. Public transit is also affected, since the average cost of providing service per rider is related to how many riders can access the system in a given area. Bus service in a dense area yields more riders per unit cost than in a low-density area, and therefore is cheaper to operate. Many metropolitan areas have rules governing the minimum share of operating revenues that must come from passengers, which *de facto* limits the areas where public transportation is viable. Areas with mixed-use development (MUD), such as places with residential and retail uses, can encourage non-automobile modes for trips within the development. When different uses are scattered over several miles, the traveler may prefer to drive. For those without an automobile, choices are limited. Land-use and transportation planning are two sides of the same coin. Land-use plans need to incorporate transportation-system characteristics, while transportation plans need to understand the layout of, and their effect on, land uses.

Current Trends: Transportation Infrastructure and Travel Demand. Forty years of applying a transportation and land-use planning approach based strongly on automobile accessibility has resulted in metropolitan areas that are highly dependent on cars for almost all travel needs. Table 1.1 in Chapter 1 shows that 88.7% of work trips in Arizona are by car.

Table 3.1: Measures of Transportation Supply and Demand for Urban Areas in Arizona

2007 NET LAND AREA (SQUARE MILES)				
RURAL	URBAN	% URBAN	U.S. RANK	U.S. AVERAGE
111,063	2,572	2.3	36	4.5
2007 POPULATION (1000)				
RURAL	URBAN	% URBAN	U.S. RANK	U.S. AVERAGE
1,144	5,195	82.3	12	85.0
URBAN POPULATION DENSITY (POP/SQUARE MILE)				
URBAN	U.S. RANK	U.S. AVERAGE		
2,020	9	1,493		
ANNUAL VEHICLE-MILES OF TRAVEL (MILLIONS)				
RURAL VMT	URBAN VMT	URBAN VMT/CAPITA	U.S. RANK	U.S. AVERAGE
19,586	43,377	8,350	28	8,396
LANE-MILES				
URBAN	LANE-MI/CAPITA	U.S. RANK	U.S. AVERAGE	
52,956	10.2	38	9.9	

Source: Calculations by author, based on data from: Federal Highway Administration: Highway Statistics, 2007. http://www.fhwa.dot.gov/policyinformation/statistics/2007/.

Though Arizona is overwhelmingly rural in land area, its human settlement is heavily concentrated in a few large metropolitan areas. Consequently, its passenger transportation

activities and infrastructure are concentrated there as well: 71% of its vehicle-miles traveled (VMT) (Rank: 13th in the nation) and 40% of its road supply (Rank: 10th in the nation) are packed into these few urban areas.[1] Table 3.1 puts other measures for Arizona's urban areas in a national context. Arizona's urban areas are of higher density, have slightly higher road capacity per capita, and slightly lower travel demand per capita than the average of all urban areas in the United States.

The Phoenix and Tucson metropolitan statistical areas (MSA) contain nearly 75% of the state's population and over 95% of its urban population. Both of these areas were late in developing urban freeway infrastructure.[2] Until 1948, Phoenix relied heavily on streetcars and was connected with neighboring cities by arterial-type roads. There was great skepticism about the various regional freeway proposals because of fear of negative impacts on central Phoenix. For a long time, the region depended on ever-expanding arterial roads and had worse than average congestion. The freeway construction program hit full stride in the 1990s and, as shown in Figure 3.1, by 2002 Phoenix had caught up with the rest of the nation. It now has a typical freeway system and relatively low congestion compared to peer cities (see Ch. 8, Fig. 8.1). Phoenix also has significantly lower public-transit use than its peer cities (Figure 3.1).[3] In the early 1980s Phoenix was ranked 2nd worst for congestion delay per traveler among the 85 largest cities in the nation, but according to the 2007 *Urban Mobility Report*, it has greatly improved to 15th (or 9th of the 14 "very large" U.S. urban areas).[4]

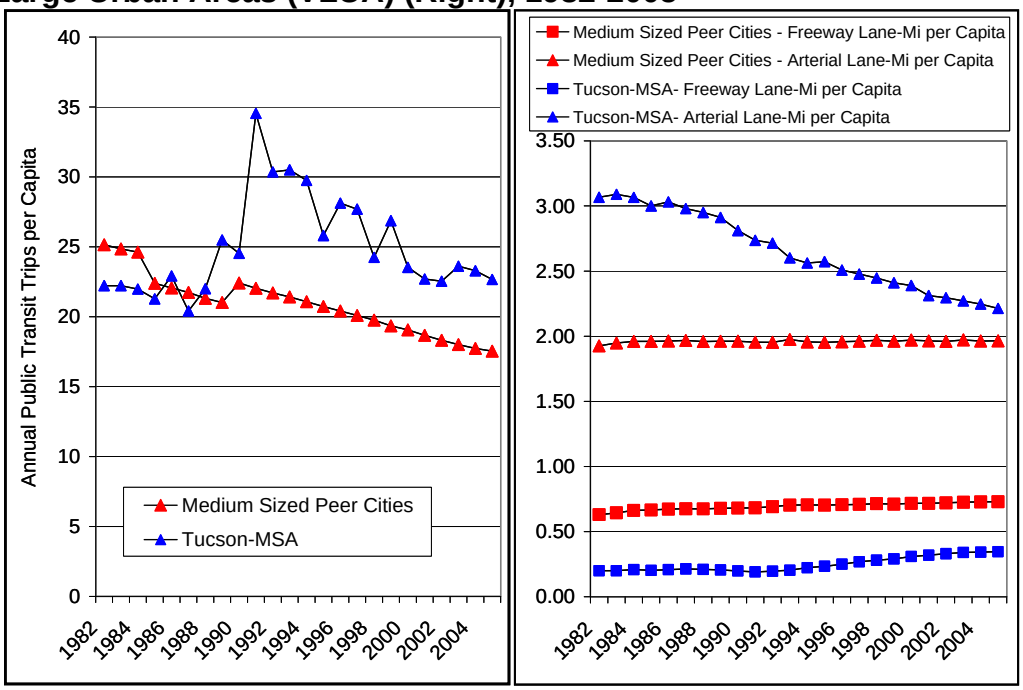
Like the Phoenix area until recently, Tucson has historically relied heavily on arterial capacity for road travel rather than on freeway capacity, compared to the medium-sized peer cities (Figure 3.2).[5] Tucson experiences higher average delay per peak traveler (see Ch. 8). It also has higher public-transit ridership than peer cities (Figure 3.2). According to the 2007 *Urban Mobility Report*, Tucson has steadily increased in congestion delay per traveler compared to medium-sized peer cities, rising from 52nd to 25th.

Current metropolitan population and land-use trends. 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 edges of some urban areas. Both have major implications for 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.[6] Meanwhile, the fastest-growing areas of the state are in low-density fringe developments in or near small towns on the peripheries of the larger metropolitan areas, such as 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. Table 1.2 in Chapter 1 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.

Existing Plans and Programs

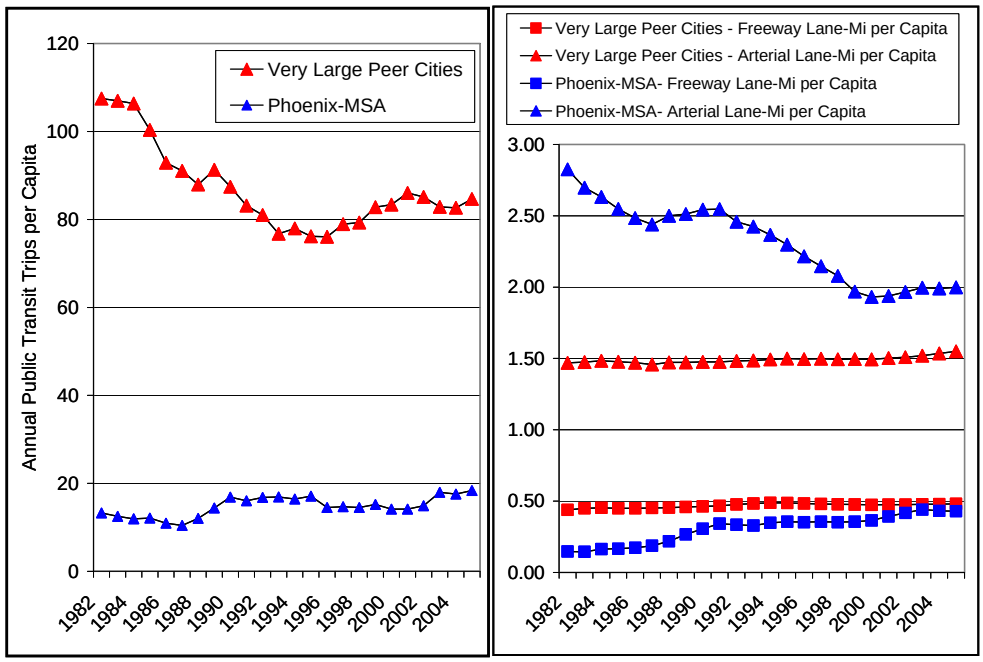
Metropolitan Planning Overview. Various overlapping jurisdictions plan transportation and land use in metropolitan areas, including the Arizona Department of Transportation (ADOT), a metropolitan planning organization (MPO) for that region, and other local bodies such as county and municipal governments. Arizona has five metropolitan areas with designated

Figure 3.1: Phoenix Annual Public Transit Trips Per Capita Compared to Peer Cities (Left) and Roadway Supply (Freeway and Arterial) Compared to Peer Very Large Urban Areas (VLUA) (Right), 1982-2005



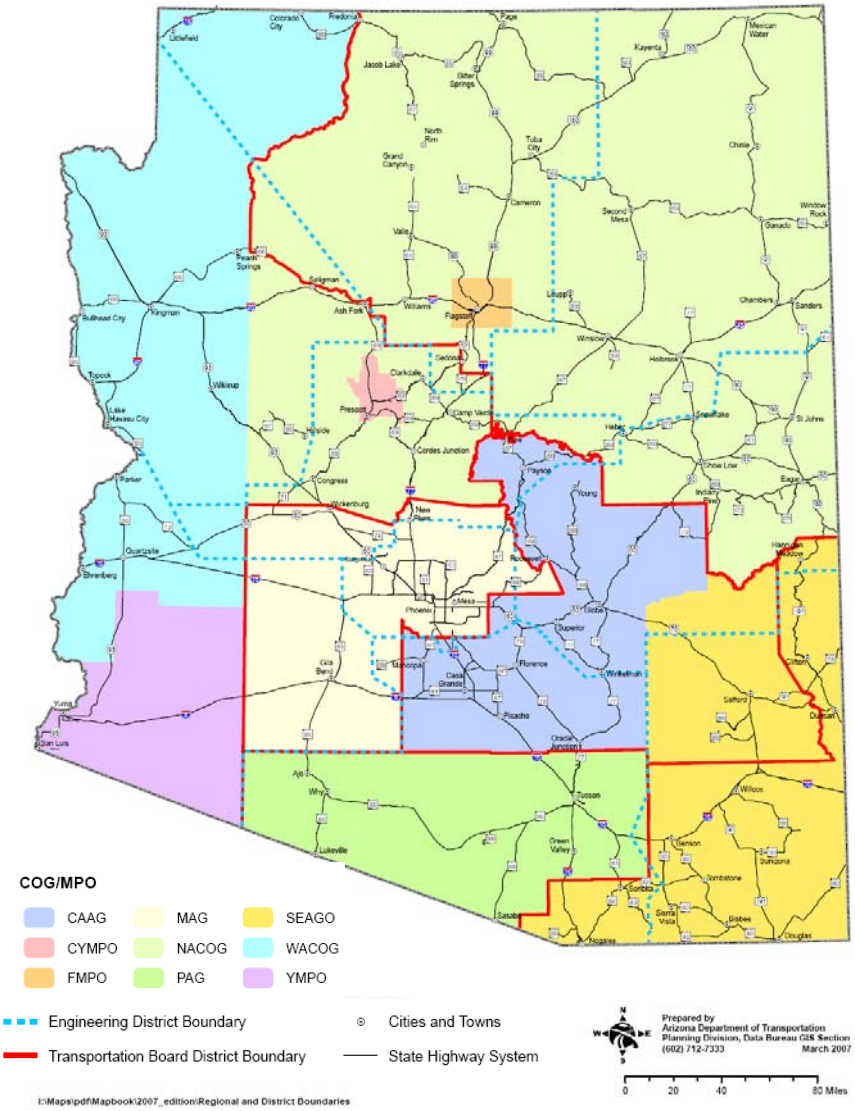
Source: Calculated by author using data from TTI 2007 *Urban Mobility Report.*

Figure 3.2. Tucson Annual Public Transit Trips Per Capita Compared to Peer Cities (Left) and Roadway Supply (Freeway and Arterial) Compared to Peer Medium Urban Areas (MUA) (right), 1982-2005



Source: Calculated by author using data from TTI 2007 *Urban Mobility Report*.

Figure 3.3. Planning Jurisdictions in Arizona



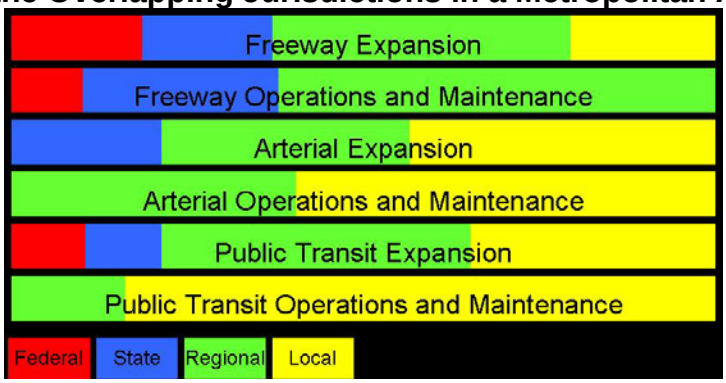
Source: mpd.azdot.gov/planning/Files/index/Cogs_Mpos.pdf

MPOs: Phoenix (MAG), Tucson (PAG), Yuma (YMPO), Flagstaff (FMPO), and Prescott (CYMPO). Planning in non-metropolitan areas is the responsibility of councils of governments (Figure 3.3).

Overlapping metropolitan planning jurisdictions can be difficult to separate, especially for regionally significant issues. While the relative contribution of each jurisdiction differs drastically from project to project and among funding, planning, implementation, and maintenance activities, a rough sketch of relative planning responsibility is shown in Figure 3.4. Freeway projects, because of environmental impacts review and the need for capital finances from federal, state, and regional funds, usually involve all levels of planning, while operations and maintenance rely on more local, county and regional financing and decision

making. Because of particular air-quality issues in Arizona (discussed below), the MPO for that metro area takes a central role in overall planning of any project.

Figure 3.4: A Rough Typology of Planning Responsibilities for the Overlapping Jurisdictions in a Metropolitan Area



Metropolitan Land-Use Planning. Historically, Arizona has a strong philosophy of local control over land-use decisions. Thus, land-use controls are administered and controlled at the municipal level, or at the county level in un-incorporated areas, meaning that *metropolitan* land-use planning is really a patchwork of *local* land-use planning. 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, or promoting economic growth, among other things.[7] 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 determine housing affordability or preserve vistas. An emphasis on retail or commercial 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 have implications for urban travel demand. Since these goals can differ from community to community, outcomes can often conflict and there can be inefficiencies in land use, although sometimes communities work together to make more efficient decisions.

Municipal Transportation Planning. Municipalities play an important role in metropolitan transportation planning in two ways: they evaluate and mitigate project-level transportation impacts, and they maintain and finance local transportation systems, including public transit, roadways, and parking. Evaluating proposed projects for transportation impacts involves estimating the future traffic impacts of the project. Depending on the extent of impact, the developer may be asked to provide minimal traffic mitigations or fees, or even major infrastructure improvements. These impacts are only measured on local facilities—additional traffic on freeways is not normally included in the developer's responsibility. A single project may not only impact local streets, but may add to peak-hour congestion and significantly degrade the level of service on regional facilities, depending on demographics, location, and other factors. Cities are responsible for building and maintaining road infrastructure outside of each development, and for providing a portion of the funding for public transit.

Municipal transportation planning, although focused on local issues, affects the larger metropolitan system. Major differences exist from city to city in terms of programs, financing methods and levels, and planning processes. Each city follows a different planning schedule, and may revise plans at different time intervals. The differences in public-transit support among Tempe, Mesa, and Phoenix mean that bus services end earlier in Phoenix and Mesa and bus riders are left stranded. Tempe, Phoenix, and Glendale all have special sales taxes dedicated to transportation. Tempe supports the region's best free neighborhood-shuttle network, a new transit center, and an excellent bikeway program. Some cities develop specific area transportation plans, such as Scottsdale's Downtown Plan. Local transportation plans may include approaches that conflict with regionally defined needs. Even plans that do not end up being implemented can help focus discussion on needs, guide future proposals, and reveal support for regionally significant projects such as freeways or light rail.

Regional Transportation Planning. In metropolitan areas with a population over 50,000, MPOs manage regional transportation planning by federal law. The 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 Regional Transportation Plan (RTP) and the Transportation Investment Program (TIP).

The RTP is a long-range plan covering at least 20 years, is updated every 5 years, and defines a regional vision for transportation development. An extensive public process helps define the RTP and the alternatives within it. TIPs are the short-term implementation of RTP projects, are updated every two years, and include specific funding for five years. 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 pollution restrictions), and fiscal constraint in relation to TIP and RTP objectives.

While some MPOs actually develop and compare holistic regional scenarios embodying truly different visions, most merely assemble a list of projects from municipalities, county transportation departments, and regional public-transit agencies. For large regions, there are specific requirements for the RTP to clearly define a congestion management approach.

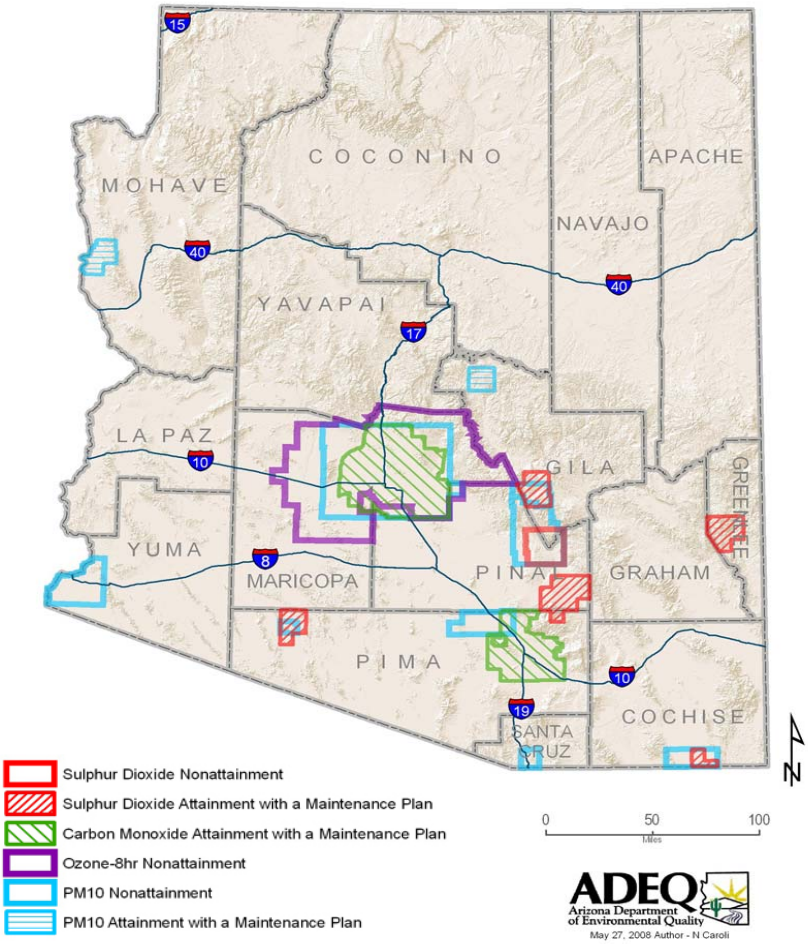
For financing, regional planning is highly interdependent with state and federal agencies. In Arizona, state-managed gas taxes, vehicle license fees, federal funds based on population, and grants for specific projects all account for a large part of the regional transportation budget. Regionally collected, transportation-dedicated taxes, such those in the MAG, Pinal County, and PAG regions, are also significant.

Regions where air quality does not meet one or more standards (see Ch. 1) are classified by the EPA as "non-attainment" regions. This classification places specific requirements on the MPO to develop a set of policies in the RTP to reduce emissions, called Transportation Control Measures (TCM); these 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 it must be shown that projected emissions from the total package of transportation improvements in the RTP and TIP will not cause emissions to

rise above the allowable limit. Even after consistently meeting air-quality standards, "non-attainment" regions remain classified as "maintenance" for some time, and still must meet conformity requirements.

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 3.5 shows that the MAG area is in non-attainment for ozone and PM-10, the PAG area is a "maintenance" area 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. According to Title VI of the Civil Rights Act of 1964 and later DOT orders, MPOs must also analyze plans for their impact on low-income and minority populations.

Figure 3.5: Current Air Quality Status for Regions of Arizona



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

As regional visions and needs or specific region-scale projects are defined, either at municipal or agency levels, through regional planning processes, or even by non-public actors, the regional transportation plan takes shape. Below we review the main elements of the regional plans from the five MPOs in the state, as well as two state-level planning

process: the Statewide Transportation Investment Strategy, and the Statewide Transportation Planning Framework. Appendix 3 includes summary maps from each of the MPO's RTPs.

Maricopa Association of Governments. The 2007 update of MAG's RTP 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.[8] The plan spends almost 70% on roadway expansions and operations and maintenance (O&M), about 30% on public-transit expansions and O&M, and almost 2% on bicycle and pedestrian improvements and other projects. Tables A-3.1 and A-3.2 in Appendix 3 show the breakdown of financing for the MAG RTP, along with maps of the freeway, arterial, and high-capacity improvements.

Pima Association of Governments (PAG). PAG is currently updating its RTP for a horizon to 2040. Its last RTP, from 2005, covered planning to 2030. Its plan includes freeway, transit, and bicycle-system improvements, and even a modern streetcar proposal.

Yuma Metropolitan Planning Organization (YMPO). YMPO's RTP focuses primarily on roadway improvements, with some transit route reorganizations.

Central Yavapai Metropolitan Planning Organization (CYMPO). CYMPO's RTP focuses on roadway improvements, new commuter bus routes, and a possible high-capacity transit corridor.

Flagstaff Metropolitan Planning Organization (FMPO). FMPO's current RTP is underway but incomplete, so no information is included here. A review of its TIP for 2008 to 2012 showed a mixture of roadway, transit, and bicycle-way improvements.[9]

Statewide Transportation Investment Strategy. The investment strategy is a comprehensive statewide inventory of transportation projects, some of which correspond to current financially constrained regional plans, and some of which remain unfunded. The maps and lists of projects with projected costs are included in Appendix 4.[10]

Statewide Transportation Planning Framework. Currently underway, the framework study is a statewide, multi-jurisdictional effort led by ADOT, focused on important travel corridors in the state. Areas in the urbanizing MAG and PAG regions, such as Hidden Valley and Hassayampa Valley, are particularly important in the study.[11]

Challenges

Fragmented Planning Process. Because of the strong and unavoidable relationship between land use and transportation, effective transportation planning must involve land-use planning. The common "predict and provide" process, predicting future land use and transportation demand based on disparate local decisions and then scrambling to meet that demand, is technically not planning. Most developments are permitted well before the transportation capacity exists to handle the traffic they create, meaning that localities and developers are speculating on future regional investments in capacity. They assume that the rest of the

region will bail them out. Quoting from a key passage in the 2007 Arizona Town Hall report on *Land Use: Challenges and Choices for the 21st Century*:[12]

> The horse is already out of the barn in terms of population growth because of the sheer amount of land that has been set aside for future development. Development areas are defined as parcels that are either planned or approved for future development. They are, in turn, divided into three types: active areas that are experiencing infrastructure development, entitlements that are not yet active but have gone through the planning process and have received official approval, and proposed areas that are at an early point in the planning process but have not yet received approval. In the six-county region, including Yavapai, Maricopa, Pinal, Pima, Santa Cruz, and Cochise Counties, which includes 35% of the state's land area and 86% of its 2000 population, the Maricopa Association of Governments (MAG) estimates that in early 2007, there were 1.6 million existing residential units, 0.7 million units under active development, and 1.2 million units that were entitled or planned, for a future total of 3.5 million housing units. Assuming an average of 2.6 persons per household, this area now has enough housing built, under construction, or planned to accommodate more than nine million residents. Thinking about this another way, there are as many housing units entitled, planned, or under construction today as there are in the current housing stock.[13]

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."[14] An attempt to shape growth may include limiting or restricting development in certain areas, thereby reducing the market value for some property which would be potentially costly under Prop 207, though there has been no such litigation brought forth to date.

The implications of Proposition 207 for controlling growth and coordinating land-use and transportation planning at regional levels are numerous. In Chapter 4 of the 2007 Arizona Town Hall report on land use, Grady Gammage, Jr. comments:

> It is also important to note that Prop 207 affects state laws as well as city ordinances. Historically, Arizona has not had extensive land-use regulation at the state level, and Prop 207 will make any additional regulation difficult. Any state statute regulating rural lot splits (for example), as has been proposed in several recent legislative sessions, is likely to result in widespread claims under 207. Even recent legislation dealing with the authority of counties to consider water supply in making planning and zoning decisions

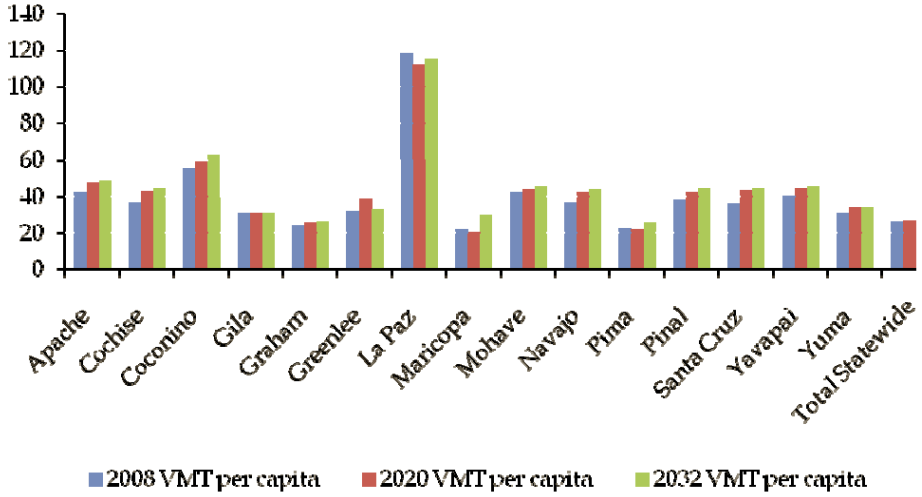
has been attacked as posing a potential diminution in property value compensable under the proposition. [15]

Prop 207 threatens the ability to alter any existing permitted development in unwanted or inefficient areas. Given the number of developments already permitted, Prop 207 may prove to be barrier to sustainable development.

Growing Automobile Dependence. The region's fragmented planning does little to reduce VMT growth, greenhouse gas (GHG) emissions, or the state's dependence on imported oil. In fact, it appears to increase these problems. The Natural Resources Defense Council ranked Arizona the seventh most vulnerable state to gas price changes.[16] It also ranked the state poorly (39th) for its lack of policy solutions to oil dependence; its transit spending was low and Arizona has no key transportation policies designed to reduce oil dependence.

According to the Arizona Investment Council (AIC), a full build-out of currently planned land use and transportation will more than double statewide VMT over the next 20 years.[17] According to the AIC, "the growth in VMT is a function of both population growth and increases in per-capita vehicle miles traveled." Dispersed land uses and expansion of freeway capacity leads to lengthening trips, according to the same study. Figure 3.6 shows the significant rise in trip lengths for Maricopa County in particular. Current planning only provides more capacity and does not effectively address demand management; it is unsustainable because much of the new VMT will be in highly congested conditions. (See Ch. 1. for a discussion about "induced demand.") It is like addressing a weight problem by loosening one's belt – it feels good until the belt is taught again, but now there is more weight. Other regions in the country questioned this process decades ago, and steered investments from freeways into public transit and effective growth management.

Figure 3.6: Daily Vehicle Miles Traveled per Capita for Arizona Counties



Source: Arizona Investment Council, p. 255.

While public-transit use in the main metropolitan areas of the state is projected to rise, the question remains: Is it enough? Table 3.2 shows these trends. The MAG region relies very little on public transit compared to its peer cities nationwide, and a doubling of its ridership

may not be enough. In the MAG region, 300,000 daily trips with a population of 6 million is very low. Automobile travel is still projected to rise even faster over the same period.

Table 3.2: Daily Transit Ridership Projections, 2008 to 2032

	2008	2020	2032	2008-2032 % Change
MAG	157953	242995	333952	111.4%
PAG	52909	71063	88018	66.4%
FMPO	428	498	561	31.1%
Total	211290	314556	422531	100.0%

Source: Arizona Investment Council, p. 262 (based on ADOT's *MoveAZ* Study).

Integrated land-use and transportation planning is the primary tool available to manage transportation demand and growth most effectively. In the words of planning scholar Jonathan Levine:

> The term "shared land-use authority" is used where municipalities are asked to conform to regional development needs. This essentially gives regional planning agencies the power to relax zoning restrictions in order for municipalities to meet regional development goals including density and other smart-growth elements. Here, regional needs trump individual municipalities' wants. This is the case of Portland, Oregon, where development rights were restricted outside of the urban growth boundary, but relaxed within it, allowing developers to build more higher-density and MUDs than previously allowed.[18]

Opportunities

High Growth Means High Opportunity. Metropolitan planning will have an important role to play in shaping and instituting new growth paradigms to meet the challenges outlined above. The Arizona Department of Economic Security estimates that almost 35% of the state's 2030 population has yet to arrive in the state; most of the projected growth will be in metropolitan areas (see Table 1.2 in Ch. 1). This means there are tremendous opportunities to redefine growth paradigms and change past growth patterns.

Climate Change and Transportation Innovations. Transportation accounted for 39% of all Arizona GHG emissions in 2000, well above the United States' 26% and the largest single emissions category. There is a growing statewide, national, and international movement to direct growth in more sustainable ways. The Arizona Climate Action Plan counts on transportation to provide a major share of emission reductions. The plan groups transportation and land use into one category of policy solutions and counts on them for about 20% of the necessary reductions. Recommended planning interventions include smart growth, improving non-automobile transportation options, transit-oriented design approaches, hydrogen fuel infrastructure, rebates for efficient vehicles, and signing on to the multistate CO_2 standards for new cars.

Beyond establishing the advisory group that produced the action plan, former Governor Napolitano also signed executive orders asking ADOT to inventory options for mass transit, including commuter and light rail,[19] 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."[20] The future of the Climate Action Plan is uncertain. These planning options are of key importance for metropolitan transportation planning in Arizona. Other metro areas, such as Atlanta, Denver, Portland, Seattle, and those in California, are moving forward to combine land-use and transportation planning to manage growth in a more sustainable way.

Smart Growth. The movement in urban planning for "smart growth" seeks to counter the scattered and uncoordinated development.[21] Smart growth attempts to exploit the underlying synergy between transportation and land use to create more efficient places, which in turn create benefits like stronger place-making, protection of open space, affordability, diversity of housing, and travel choices. Smart growth 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 across multiple sectors, both public and private. Overall, it attempts to internalize the externalized costs of uncoordinated growth. Smart growth places additional value on coordinated open spaces, walk-ability, connectivity, environmental and farmland preservation, and stakeholder involvement, compared to values emphasized in typical development processes. Smart growth promotes 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. It aims to make development decisions predictable, fair, and cost effective, and encourages community and stakeholder collaboration in development decision-making.

Smart growth is not just a dream of planners and activists. Indeed, it is a fairly mainstream view in many metropolitan areas in Arizona. For example, the recent "AZ One – a Reality Check for Central Arizona" regional visioning exercise involved 270 community members and produced the following key recommendations:[22]

- Preserve open space as a cornerstone of the region (100% - 30 of 30 groups).
- Support the current investment in infrastructure by encouraging growth along existing transportation corridors (90% - 27 of 30 groups).
- Connect existing and new employment, housing, and urban areas with multi-modal transportation options including freeways, light rail, commuter rail, and bus rapid transit (90% - 27 of 30 groups).
- Create new core urban centers and infill currently developed areas, allowing compact, higher-density development including mixed-use buildings (87% - 26 of 30 groups).
- Locate housing near jobs to create employment corridors (80% - 24 of 30 groups).
- Protect quality of life by emphasizing safe and livable neighborhoods, education, recreation, and arts (57% - 17 of 30 groups).
- Conserve natural resources; create sustainable communities (50% - 15 of 30 groups)
- Provide a diversity of housing options because affordability is important (43% - 13 of 30 groups).

Along similar lines, among the key Statewide Vision-21 task-force findings was the following: "There is a distinct gap in the coordination of land-use plans among state, local

and regional transportation plans."[23] This led to the task force's Major Recommendation Number Three: "Coordinate land-use planning and transportation planning."

Among the "Critical Needs Observations and Transportation Policy Implications" in the preliminary needs assessment of the ADOT Statewide Transportation Planning Framework was, among others: "Integrating land-use, economic development and transportation decision-making in a coherent manner to achieve Smart Growth, quality of life and economic sustainability."[24]

Legislation is beginning to catch up with public concern. Arizona enacted Growing Smarter in 1998 and Growing Smarter Plus in 2000. For an excellent discussion of the experience with these legislations, see Holway and Busby, Chapter 2: Smart Growth and Growing Smarter in Arizona in *Land Use: Challenges and Choices for the 21st Century*, 91st Arizona Town Hall. The Growing Smarter Oversight Council was created in 2001, followed by a "Growth Cabinet" in 2006. The suite of regulations contained in Growing Smarter/Plus legislation include:[25]

- Requires larger and fast-growing cities to obtain voter approval of their general plans at least once every 10 years, and to include a water-resources element in their plans.
- Requires mandatory rezoning conformance with General and Comprehensive Plans.
- Requires more effective public participation in the planning process.
- Requires cities and counties to exchange plans and coordinate with regional planning agencies, and encourages comments among entities prior to plan adoption, to promote regional coordination.
- Requires land-owner permission for plan designation or rezoning of private property to open space.
- Authorizes cities and counties to designate service-area limits beyond which services and infrastructure are not provided at public expense.
- Requires full disclosure to property buyers of the lack of services and facilities.
- Permits counties to impose development fees consistent with municipal fee statutes.
- Allows cities to create infill incentive districts and plans with expedited processes.

As summarized by Holway and Busby: "Assessments of Arizona's Growing Smarter legislation by expert practitioners reveal there is need for more regional cooperation, more tools to manage high rates of growth, and additional authority and resources for the management of state trust lands."[26] Nonetheless, the Smart Growth Scorecard is still being used and has ample funding for the near term.

Other policies are available to manage regional growth and travel demand, including congestion tolling, parking management, more significant developer impact fees, increasing the tax on gasoline and enabling its proceeds to be used for public transit, and regional growth boundaries, among others. All of these would reinforce the goals of smart growth while increasing revenues for future transportation investments.

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**MSA**	Metropolitan Statistical Area
COG	Council of Governments	**MUA**	Medium-size Urban Areas
CO2	Carbon Dioxide	**MUD**	Mixed-Use Development
CYMPO	Central Yavapai MPO	**PAG**	Pima Association of Governments
FMPO	Flagstaff MPO	**RTP**	Regional Transportation Plan
GHG	Greenhouse Gas	**TIP**	Transportation Investment Program
MAG	Maricopa Association of Governments	**VLUA**	Very Large Urban Areas
MPO	Metropolitan Planning Organization	**VMT**	Vehicle-Miles Traveled
O&M	Operations and Maintenance	**YMPO**	Yuma MPO

Aaron Golub is an assistant professor in the School of Planning and School of Sustainability at ASU. He received his PhD in Civil and Environmental Engineering from the University of California at Berkeley, a BS from Virginia Polytechnic Institute and State University, and an MS from MIT, both in Mechanical Engineering. His interests include sustainability and transportation planning, and his research focuses on the environmental and social-equity outcomes of planning processes, travel survey data analysis, transportation policy and finance analysis, public transportation planning, advanced bus systems, and vehicle technologies. He has consulted with on transportation projects with public agencies around the world, including the World Bank, United Nations, city governments, and sustainable-transportation advocacy organizations.

---

[1] Federal Highway Administration: www.fhwa.dot.gov/policyinformation/statistics/2007/ Highway Statistics, 2007.

[2] Collins, W. *The Emerging Metropolis: Phoenix, 1944-1973*. Arizona State Parks Board, 2005, pp. 109-117.

[3] Very large peer cities in the Mobility Report include: Los Angeles-Long Beach-Santa Ana, CA; San Francisco-Oakland, CA; Washington, DC-VA-MD; Atlanta, GA; Dallas-Fort Worth-Arlington, TX; Houston, TX; Detroit, MI; Miami, FL; Phoenix, AZ; Chicago, IL-IN; New York-Newark, NY-NJ-CT; Boston, MA-NH-RI; Seattle, WA; Philadelphia, PA-NJ-DE-MD.

[4] Schrank, D., and T. Lomax. *The 2007 Urban Mobility Report*. Texas Transportation Institute, 2007. mobility.tamu.edu/ums/. Accessed Mar. 6, 2009.

[5] Medium peer cities in the 2007 Mobility Report include: Austin, TX; Charlotte, NC-SC; Louisville, KY-IN; Tucson, AZ; Nashville-Davidson, TN; Oxnard-Ventura, CA; Jacksonville, FL; Raleigh-Durham, NC; Albuquerque, NM; Birmingham, AL; Bridgeport-Stamford, CT-NY; Salt Lake City, UT; Sarasota-Bradenton, FL; Omaha, NE-IA; Honolulu, HI; El Paso, TX-NM; Grand Rapids, MI; Allentown-Bethlehem, PA-NJ; Oklahoma City, OK; Fresno, CA; Richmond, VA; Hartford, CT; New Haven, CT; Tulsa, OK; Dayton, OH; Albany-Schenectady, NY; Toledo, OH-MI; Springfield, MA-CT; Akron, OH; Rochester, NY.

[6] Table 2.16. *Arizona's Rapid Growth and Development: Natural Resources and Infrastructure.* Arizona Town Hall, 2006.

[7] De la Cruz, E. R. Chapter 3: Land-Use Regulation. *In* Gober, P., et. al., *Land Use: Challenges and Choices for the 21st Century*, 91st Arizona Town Hall, October 28-31, 2007.

[8] The executive summary of the plan can be found at: www.mag.maricopa.gov/pdf/cms.resource/RTP_2007-Update_ExecSumm_Final34549.pdf

[9] www.flagstaff.az.gov/DocumentView.asp?DID=6403.

[10] www.azdot.gov/Statewide_Transportation_Investment_Strategy/Index.asp.

[11] *Building a Quality Arizona.* www.bqaz.gov/index.asp.

[12] Gober, et. al. *Land Use: Challenges and Choices for the 21st Century*, 91st Arizona Town Hall, October 28-31, 2007.

[13] See note 12, pp 12-13.

[14] See note 12, p.45

[15] See note 12, p.47

[16] Natural Resources Defense Council. *Addicted to Oil: Ranking States' Oil Vulnerability and Solutions for Change*, NRDC, 2007.

[17] Arizona Investment Council. *Infrastructure Needs And Funding Alternatives*

For Arizona: 2008-2032 Water, Energy, Communications And Transportation. 2008. Prepared By:
[18] Levine, 196.
[19] www.azclimatechange.gov/download/E0_2007_02.pdf.
[20] www.azclimatechange.gov/download/EO2007-05.pdf.
[21] Smart Growth Network. *This is Smart Growth.* www.smartgrowthonlineaudio.org/pdf/TISG_2006_8-5x14.pdf.
[22] Over 1,100 people were nominated as participants, of which 300 were selected and 270 participated. Participants included government and elected officials, tribal communities, large corporations, small businesses, nonprofits, neighborhood activists, interfaith groups, environmentalists, educators and more. They worked with a facilitator in 30 groups of 10 on maps representing 13,000 square miles of Maricopa and northern Pinal Counties.
[23] ADOT. *Vision21: The Transportation Vision 21 Task Force*, 2001.
[24] Arizona Statewide Transportation Planning Framework: Preliminary Critical Needs Definition. 2008
[25] AZ Department of Commerce. *Growing Smarter.* www.azcommerce.com/CommAsst/GrowSmart/Growing+Smarter+Legislation.htm.
[26] Holway, J., and K. K. Busby. Chapter 2: Smart Growth and Growing Smarter in Arizona *in* Gober, P., et. al. *Land Use: Challenges and Choices for the 21st Century*, 91st Arizona Town Hall, October 28-31, 2007.

Chapter 4

RURAL TRANSPORTATION

Ethan Rauch
AECOM Transportation

Jennifer Toth, P.E.
Arizona Department of Transportation, Multimodal Planning Division

John McNamara
AECOM Transportation

Key Points

- Rural transportation systems provide mobility for people and goods throughout Arizona, and play a vital role in the state's economy.
- "Building a Quality Arizona" (BQAZ) is a statewide long-range planning effort that focuses on rural Arizona through four regional framework studies that cover the 13 predominantly rural counties.
- BQAZ is an innovative process in many ways, such as its intense outreach to tribes, economic-development interests, neighboring states, and environmental groups; its inclusion of major facilities that do not belong to the state system; its multimodal and Smart Growth emphases; its distant (year 2050) planning horizon; and its sponsorship of Arizona's first statewide travel-demand model.
- In addition to maintaining and improving hundreds of miles of state highways throughout Arizona, ADOT supports rural transportation through programs like Rural Transit Assistance and Planning Assistance for Rural Areas.
- The principal challenge that transportation systems face in rural Arizona, as in the rest of the state, is to develop sources of funding that can accommodate rising travel demand due to rapid demographic and economic growth.
- The recently completed *Statewide Intrastate Mobility Reconnaissance Study* enumerates opportunities for improving the state's transportation systems. The current framework planning process will identify ways to exploit these opportunities in rural Arizona.
- A recent assessment of critical transportation needs identified billions of dollars in specific short-term improvement needs for highways, bridges, and public transportation in the rural counties.

Current Conditions

Rural Roadway Systems. Public roads and streets in rural areas account for 67% of roadway miles in Arizona. Of the approximately 37,000 rural-roadway miles, 16% (5,819 miles) is in the state highway system, 32% is under federal jurisdiction (e.g., U.S. Forest Service and Bureau of Indian Affairs routes), and the remaining 52% belongs to counties and

municipalities.[1] The rural state highway system, which includes most of the major routes connecting cities and counties, is categorized in five functional classifications: Principal Arterial Interstate, Principal Arterial Other, Minor Arterial, Major Collector, and Minor Collector.

Since only 12–25% of the state's population is rural (depending on how rural is defined[2]), it is perhaps surprising that rural areas account for 36% of statewide vehicle miles traveled (VMT).[3] Part of the explanation may be that rural trips tend to be longer than urban trips. In addition, some rural roads are heavily used by urban residents and by through traffic.

The heaviest traffic volumes in rural portions of Arizona generally occur on the state highway system. Data from the Highway Performance Monitoring System, obtained for all counties except Maricopa and Pima, shows annual average daily traffic (AADT) in 2006 ranging from 100 or so vehicles per day on the most lightly traveled routes to more than 40,000 on I-10 between Phoenix and Tucson. State highways in Arizona run the gamut from two-lane undivided highways to multilane Interstate highways with full-access control.

State highways are important carriers of freight as well as people. Trucks carry an estimated 76% (by weight) and 86% (by value) of freight flows in Arizona.[4] The *Arizona Multimodal Freight Analysis Study* indicates that several rural segments of the Interstate Highway system carry more than 10,000 commercial trucks per day. Commercial trucks as a proportion of daily traffic volume range as high as 51% on the Interstate system, and in the 21–35% range on State Route 85, US 93, and several other non-Interstate highways.[5]

Rural Public Transit and Passenger Rail. Local and regional transit systems deliver approximately 3.1 million miles of service per year to more than 868,000 riders in communities outside the state's five metropolitan areas: greater Phoenix, Tucson, Yuma, Flagstaff and Prescott. Eighteen such federally funded systems currently operate in 10 counties. Many communities in rural Arizona also have specialized services for the elderly and persons with disabilities. Yet rural areas are often difficult for transit to serve in a cost-effective manner. The 2007 *Arizona Rural Transit Needs Study* estimates that only 18% of estimated demand for rural transit service is currently being met, and that this will fall to 13% by 2016 if no additional services are introduced—even though the rural proportion of the state's population is declining.[6]

Greyhound Lines provides scheduled intercity bus service primarily along the Interstate highway corridors. Smaller carriers and airport shuttle services serve several additional destinations. Amtrak operates two trains across Arizona: the Sunset Limited along the Union Pacific and the Southwest Chief on the Burlington Northern Santa Fe (BNSF). The Grand Canyon Railway connects Williams with Grand Canyon National Park.

Rail Freight. Two of the nation's largest railroads provide freight service to and through the state (see Figure 4.1). The Union Pacific Railroad is engaged in a project to double-track its entire Sunset Corridor connecting the Los Angeles area with Texas. This corridor crosses the state through Yuma and Tucson, with branches from Picacho to Phoenix and from Tucson to Nogales. The double-track BNSF Railroad mainline crosses northern Arizona through

Kingman, Flagstaff, and Winslow. Its most important Arizona branch connects Phoenix with the mainline. Eight active short lines transport various commodities.

Non-Motorized Transportation. According to the *Statewide Bicycle & Pedestrian Plan,*[7] 59% of the state highway system (rural and urban) is rated "More Suitable" for bicycles, 34% is rated "Less Suitable," 4% has a prohibition against bicycle use, and 3% lacks data.

Existing State Plans and Programs

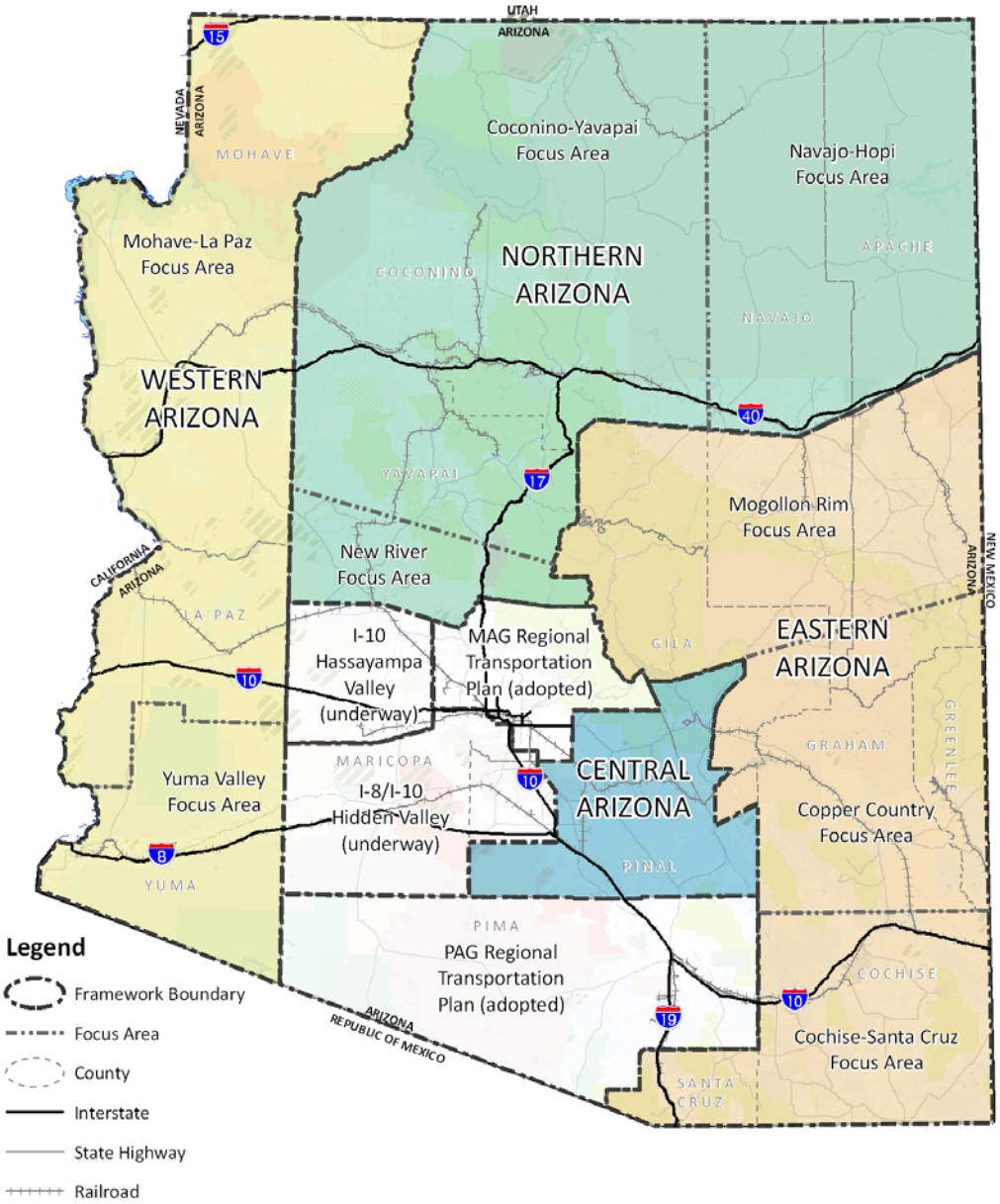
Building a Quality Arizona: Framework Planning and Visioning. The Arizona Department of Transportation (ADOT), along with regional Councils of Governments (COGs) and Metropolitan Planning Organizations (MPOs) across Arizona have embarked on a long-term transportation-visioning process known as Building a Quality Arizona, or BQAZ. The process began with two studies led by the Maricopa Association of Governments (MAG): the *Interstate 10 Hassayampa Valley Transportation Framework Study*[8] in a portion of Maricopa County, and the *Interstate 8 and Interstate 10 Hidden Valley Transportation Framework Study*[8] covering parts of Maricopa and Pinal counties. It continued with a statewide scoping effort, known as the *Statewide Intrastate Mobility Reconnaissance Study,*[8] sponsored jointly by all of the COGs and MPOs. This study recommended an ambitious *Statewide Framework* planning process, which is now being conducted under ADOT leadership.

The *Statewide Framework* transportation-planning studies (www.bqaz.gov) began in the fall of 2007 and are scheduled for completion by late 2009. ADOT is working with a range of stakeholders, including the COGs and MPOs, tribal communities, local governments, federal and state agencies, environmental groups, and business interests. To make the effort manageable, ADOT divided the state into six regions (Figure 4.1). ADOT will develop a *Statewide Planning Framework* based on the results of the regional studies and information from MAG and the Pima Association of Governments (PAG).

While specific planning methods differ, all of the MAG and ADOT framework studies share several characteristics:

- They are truly long-range visioning efforts, intended to identify corridors in which improvements will be needed to accommodate future growth.
- The planning horizons are 2030 and 2050 for the *Statewide Frameworks*, and an unspecified buildout year for the two MAG studies.
- The studies emphasize establishing the general location and capacity of major facilities, with details to be developed in subsequent planning efforts.
- The studies are multimodal, incorporating not just roadways but also public transit, rail, and to some extent, non-motorized transportation.
- Both the MAG and ADOT studies encompass major transportation facilities owned by cities, towns, and counties, in addition to state highways.
- Each study involves travel-demand modeling using the latest available land-use and socioeconomic data. For the *Statewide Frameworks*, ADOT developed its first statewide transportation model. In Arizona as in many other states, the lack of a

Figure 4.1: Regional Framework Study Area Location



Source: Arizona Department of Transportation.

statewide travel-demand model has made long-range transportation planning difficult and uncertain. Until now, technically sound tools for traffic forecasting have been available only in the metropolitan Phoenix and Tucson areas (MAG and PAG regions). The new model is expected to help ADOT develop the next long-range state transportation plans once the frameworks have been completed.

- Each study involves development and evaluation of alternatives (or "scenarios"), with heavy reliance on input from stakeholders and the community.
- All of the studies pay close attention to environmental stewardship. The data-collection phase of each study included an environmental scan to map natural and man-made features, show areas suitable for future development, and help identify fatal flaws.
- None of the studies are financially constrained, but all include an assessment of potential revenue sources to fund future improvements.

Long-Range Transportation Plan. ADOT will begin preparing the legislatively mandated Long-Range Transportation Plan (LRTP) in early 2009, which will use the *Statewide Frameworks* as its foundation. The Long-Range Transportation Plan will:

- Use the 40+ year vision from the Statewide Frameworks to establish the state's transportation future
- Use the 20-year implementation program as the basis for the development of the 20-year LRTP cost-constrained plan
- Integrate the five-year programming process

Rural Transit Assistance Programs. The Federal Transit Administration (FTA) annually provides funding to ADOT to support rural public-transit systems that serve communities with a population under 50,000. This program, known as Section 5311 after its authorizing legislation, encompasses both capital and operating assistance. 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.[9]

Arizona Rural Transit Needs Study. The *Rural Transit Needs Study*, completed in 2007, identifies rural public-transportation needs, and serves as an analytical foundation for establishing a long-term strategic direction for rural transit-service provision. The study projected that transit demand in rural Arizona will grow from 7.8 million passenger trips in 2007 to 10.5 million in 2016.[9]

Planning Assistance for Rural Areas (PARA). PARA is a new 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.[9]

Challenges

Rural Arizona, along with the entire state, faces critical transportation funding challenges. By 2050, nearly 7 million new residents, more than double the current population, may need to be accommodated by the state's transportation system. But the major existing sources of federal and state funding are declining in real value.[10]

Rural transportation funding is collected and distributed at the federal, state, and local levels. The federal Highway Trust Fund, which derives primarily from federal taxes on motor fuels, is an important resource for roadways and transit. Although Arizona received approximately $602 million in federal allocations last year, the Trust Fund almost ran out of money, because an unanticipated decline in vehicle miles traveled and an increase in fuel efficiency of vehicles reduced fuel-tax revenues. It recently received an emergency infusion of general funds from Congress to enable urgent construction projects to proceed. Revamping federal transportation funding will be up to the new Congress and administration.

The primary source of state transportation funding is the Highway User Revenue Fund (HURF), which is constitutionally restricted to street and highway purposes. (The state provides only minor funding for public transit.) HURF revenue derives mainly from motor-fuel taxes and a portion of the vehicle license tax. It is allocated by statutory formula among the state, cities, and counties, including jurisdictions in rural Arizona. However, HURF receipts are shrinking in real terms because the 18-cents-per-gallon gasoline tax has not changed since 1991. If adjusted for inflation, the rate would have risen to 28 cents per gallon today. The effect of inflation will be compounded by the recent reduction in VMT, expected improvements in vehicular fuel efficiency, and the costs of construction and materials, which had been rising faster than inflation in the years leading up to the current recession. In this light, it appears that raising the gas tax may be an important component of future financing.

Local governments may use a variety of funding sources for transportation, but most are hard pressed to meet their basic needs, such as public safety and other vital services. Recognizing the need for capital improvements, some rural counties in Arizona (as well as metropolitan counties) have enacted a sales tax (typically 0.5%) and development impact fees to pay for transportation improvements. A sales tax, however, is a regressive tax that falls disproportionately on the low and fixed-income population. Even with local communities supporting transportation funding, overall needs are not being met.

In the future, no single source of revenue will suffice to meet rural Arizona's multimodal investment needs. As stated in the *Statewide Intrastate Mobility Reconnaissance Study*, a transportation funding program to serve a growing economy statewide will need to be:

- Predictable, to facilitate a continuous transportation planning process
- Reliable, so that revenue will keep pace with increasing costs and demands, and minimize the need for executive, legislative, or voter-approved program changes
- Affordable, not imposing an undue burden on Arizonans, yet remaining proportional to the state's gross domestic product
- Multimodal, addressing all modes of passenger and freight transportation
- Multi-source, broadening and strengthening the base for Arizona transportation funding, and providing opportunities for private investment in transportation projects

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 or socioeconomically. The funding program also should send beneficial signals to transportation users in terms of

incentives and disincentives. While it may not be possible for any single funding program to achieve all of these goals, they are desirable to keep in mind.

Opportunities

Project/Program Level: Critical Needs and Representative Projects. In the spring of 2008, ADOT consulted the COGs, MPOs, and tribal communities, as well as its own district engineers, to identify critical transportation needs in Arizona.[11] This process identified approximately $162 billion in critical projects and programs statewide. The timeframe to address the critical needs extends to the year 2030. ADOT helped the regional planners and district engineers list representative projects to illustrate the critical transportation needs of the region. Table 4.1 summarizes these projects for the four regions covered by the *Statewide Frameworks*.

Table 4.1: Representative Projects and Programs

Frame-work Region	High-Capacity Roadways (Interstate highways, state highways and other freeways)	Public Transit/Rail	Principal Arterials
Central	• North-South Freeway • US 60 widening to 4 lanes • SR 77 widening and passing lanes • SR 79 widening	• Phoenix-Tucson intercity rail • Transit connectors	• Pinal County Regional Significant Routes
Eastern	• I-10 widening to 6 lanes • SR 90 widening to 4 lanes • US 191, US 70, and SR 260 widening	• Transit connector expansion • Rural bus service in several counties • Bisbee bus expansion	• Numerous road and bridge construction and reconstruction projects • Several roadway extensions • Pave or repave roads • Border improvements
Northern	• I-17 widening • I-40 widening • US 89 widening • US 160, SR 77, and SR 64 widening • US 191 and SR 264, drainage and passing improvements	• State match for Section 5310 • Vanpool expansion • Northern Arizona rural/urban connector	• Road or bridge reconstruction in several locations • Roadway extensions • Alternative routes

Source: Arizona Department of Transportation, "Preliminary Critical Needs Definition," updated April 17, 2008

Policy Level. The major findings and associated action items from the *Statewide Intrastate Mobility Reconnaissance Study*[12] are:

I. *Arizona is one of the fastest growing states in the nation and has a unique opportunity, through collaborative planning, to shape growth and transportation for future generations.*

- Establish a platform for statewide-framework and smart-growth planning that includes all levels of stakeholders and governments.
- Continue to invest in statewide data tools.
- Develop a planning-framework coalition with all neighboring states (including Sonora and Baja California) for a coordinated transportation system.
- Improve border connections with Mexico to facilitate trade (see Ch. 5).
- Create planning initiatives that develop long-term (50 years) transportation plans.

II. *Increased investment in transportation infrastructure will be required for Arizona to meet growing transportation demand and be competitive with the national and global economies.*

- Identify new transportation corridors to connect existing and emerging activity centers, and to provide alternative routes where few exist.
- Continue to invest in existing transportation corridors.
- Establish a network of primary and secondary freight corridors (see Ch. 13).

III. *Arizona's climate and relatively young infrastructure are assets to our quality of life; new transportation facilities will need a commensurate growth in maintenance and operation expenditures.*

- Increase capacity and efficiency through technological advances.
- Establish a program so that future facilities have a dedicated funding stream for operations and maintenance.
- Continue to build on and invest in new programs that improve the ability to respond to incidents that impede travel operations.

IV. *The Arizona economy is growing and changing to meet the challenges of global competition, sustainability, and economic well-being. Strategic transportation investments will be needed to ensure adequate mobility and economic prosperity.*

- Develop a permanent transportation funding program that meets the state's needs.
- When Arizona identifies new transportation corridors, define them as quickly as possible to permit advance right-of-way preservation.

V. *Arizona has the benefit of considerable . . . land available for development, a large portion of which is controlled by Arizona State Lands. A tremendous opportunity exists for the citizens of our state to assume a lead role . . . to effectively plan land use and transportation to help accommodate Arizona's share of . . . new citizens in the U.S.*

- Recognize that connectivity is essential for maintaining Arizona's economy..
- Expand Growing Smarter initiatives to weigh land-use decisions and their transportation impacts.
- Work to reform the land-use decision-making process for Arizona State Lands by improving the way that transportation facilities are developed on these lands.
- Expand the ability to incorporate, as early as possible, the decisions made by federal and state resource agencies into the transportation planning process.

List of Abbreviations Used

AADT	Annual average daily traffic	**LRTP**	Long-range Transportation Plan
ADOT	Arizona Department of Transportation	**MAG**	Maricopa Association of Governments
BNSF	Burlington Northern Santa Fe	**MPO**	Metropolitan Planning Organization
BQAZ	Building A Quality Arizona	**PAG**	Pima Association of Governments
COG	Council of Government	**PARA**	Planning Assistance for Rural Areas
DEs	District Engineers	**SR**	State Route
FTA	Federal Transit Administration	**VMT**	Vehicle miles traveled
HURF	Highway User Revenue Fund		

Ethan Rauch is a senior planner and project manager at AECOM Transportation in Phoenix. He has a BA from Brown University and an MS in transportation from Northwestern University. He is a certified Professional Transportation Planner and a member of the American Institute of Certified Planners. Mr. Rauch has a wide range of experience in multimodal corridor studies, regional studies, small area studies, framework plans, transit studies and other aspects of transportation planning. He is the author of "Context-Sensitive Solution for Arizona State Route 179: Needs-Based Implementation Plan," which appeared in *Transportation Research Record* No. 1904.

Jennifer Toth, P.E. is Director of Systems Planning with the Arizona Department of Transportation, Multimodal Planning Division. She has a BS in Civil Engineering from the University of Houston and an MS from the University of New Mexico in Construction Management. Ms. Toth has a history of advancing projects through sound technical analysis, interagency coordination, public involvement and consensus building. She is recognized nationally for the context sensitive efforts on the SR 179 project in Sedona.

John McNamara is a vice president with AECOM Transportation in Phoenix. He has a Bachelor of Architecture degree from the University of Illinois and completed graduate studies in urban design at the University of Wisconsin. He has more than 35 years of professional planning experience and has more than 18 awards, including most recently the Arizona Planning Association Historic Planning Pioneer award. He is a member of the American Institute of Architects and a Fellow of the American Institute of Certified Planners.

---

[1] ADOT, *Arizona Transportation Fact Book 2002*. tpd.azdot.gov/planning/2002factbook.pdf. Accessed Mar. 5, 2009.
[2] Cambridge Systematics and TranSystems Corporation. *Arizona Rural Transit Needs Study Final Report*, prepared for ADOT in November 2007. The *Rural Transit Needs Study* defines rural Arizona as the entire state outside the five Census-designated urban areas of metropolitan Phoenix, Tucson, Yuma, Flagstaff and Prescott. The current *Statistical Abstract of the United States*, using a different definition, shows only 12% of the state's population as rural in 2000.
[3] See note 1.
[4] Wilbur Smith Associates for ADOT, *Arizona Multimodal Freight Analysis Study*, technical memoranda.
[5] Regional Framework Studies, Working Paper #2, prepared by HDR Engineering, Kimley-Horn & Associates, Parsons Brinckerhoff, and URS Corporation for four regions of Arizona, available at www.bqaz.gov.

[6] *Arizona Rural Transit Needs Study Final Report*.
[7] Available at ADOT Multimodal Planning Division website, mpd.azdot.gov.
[8] Up-to-date information on all three studies is available at www.bqaz.gov.
[9] More information is available at mpd.azdot.gov.
[10] Information on transportation funding in Arizona was provided by Curtis Lueck of Curtis Lueck & Associates (CLA) in Tucson, Arizona. ADOT will issue a paper containing Dr. Lueck's findings and make it available at www.bqaz.gov.
[11] ADOT, "Preliminary Critical Needs Definition," updated April 17, 2008 and available at www.bqaz.gov.
[12] Items I through V are quoted directly from the *Statewide Intrastate Mobility Reconnaissance Study*, available at www.bqaz.gov.

Chapter 5

INTERNATIONAL TRADE AND TRANSPORTATION

Stephen Blank, Erik Lee, and D. Rick Van Schoik
Arizona State University, North American Center for Transborder Studies

Key Points

- Arizona plays an important role in NAFTA trade and transportation as an origin, a destination, a multi-modal land bridge, an inland port, and part of the CANAMEX trade corridor.
- Security operations at ports of entry hamper the flow of materials into and out of Arizona.
- A capacity crisis is emerging in the North American freight transportation system for handling imports and exports.
- Opportunities abound to improve transportation and trade across the border, but they depend on political will to be realized.

Current Conditions

NAFTA Background. The North American Free Trade Agreement (NAFTA) was signed by the United States, Canada, and Mexico in 1992. NAFTA is 1 of 11 free-trade agreements currently in effect between the U.S. and countries as diverse as Australia, Bahrain, and Chile. NAFTA facilitates free trade by removing many of the barriers and tariffs between sovereign nations. A free trade agreement such as NAFTA, however, does not go as far towards economic integration as a common market, which allows free movement of capital and labor across boundaries, or a true economic union such as the European Union, which employs a common currency as well as some common policies and centralized bureaucracy. Among trade experts, NAFTA is widely viewed as an innovative agreement that created important precedents for international trade negotiations and, in particular, for the General Agreement on Tariffs and Trade (GATT) Uruguay Round that followed its signing.

There is more to the "North American economic system," however, than free trade. Traditional trade—the exchange of finished goods among independent actors—does not define the relationship among the three North American nations. We don't trade with each other as much as we make things together. For example, there is no separate Canadian, Mexican, or even U.S. 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 supply chains, crossing borders, until the final assembly stage. Then the finished autos may move across borders again to be sold. The same is true in other industries.

Many of the most important issues that Arizonans will confront in the next decade can be viewed not only in the context of Phoenix, Tucson, or Arizona, but also in a comprehensive North American context:

- North America has one of the world's most integrated energy systems, which evolved over decades and gives the U.S. access to Canada's and Mexico's oil, gas, and electricity resources. Canada is our largest source of imported oil and Mexico is third. The North American system of gas pipelines and electricity transmission is seamless.
- Our regulatory systems are similar and typically facilitate easy access to one another's markets.
- Our capital markets are deeply integrated. Cross investment has increased dramatically. Foreign direct investment by NAFTA partners in the three countries doubled in the first 10 years. This was not just US investment--investment in the US by Canada and Mexico rose as well.[1]
- Environmental issues that loom large in our near-term future do not stop at the Rio Grande or at the 49th Parallel. Many of these issues are linked specifically to cross-border transportation, such as climate change, invasive species, endangered species and habitats, and air-shed pollution. Canadian, U.S., and Mexican environmental groups and government agencies have been working together for years on many bilateral and regional projects, facilitated by the Commission for Environmental Cooperation, created by NAFTA.
- Border security issues—such as illegal immigration, drugs, and terrorism—are also transportation issues. Few doubt that better cooperation among the three NAFTA partners would help ensure higher levels of security. Any consideration of closing or militarizing U.S. borders with Canada or Mexico should take into account the high competitive costs implied. The Arizona-Mexico border comprises 351 of the approximately 7,000 miles of often quite remote borders the United States shares with its two neighbors. Tightened border security is enormously difficult to achieve and is certainly not the only policy option available to maintain U.S. security.

Thus, transportation is of central importance to the North American economic system, and issues such as energy, manufacturing, jobs, and the environment can be viewed as telescoping local-to-continental systems.

Trade. The volume of goods moving across our borders increased dramatically in the 1980s and '90s, especially after NAFTA was signed. From 1993 to 2007, trade among the NAFTA nations more than tripled, from $297 billion to $930 billion (including shipments among establishments within the same company).[2] We export and import more goods to and from Canada than we do with any other country. Mexico was our second largest trading partner until 2005, when it was surpassed by China. Since 2005, China has become our second largest source of imports. But in 2007, the U.S. exported more than twice as much to Mexico (a country of approximately 106 million people) than to China (population 1.3 billion)! In addition, our relationship—or better yet, our partnership—with Canada is particularly remarkable, with $560 billion in trade in 2007 that supports millions of jobs in each country:[3]

> Canada's importance to the U.S. is not just a border-state phenomenon: Canada is the leading export market for 36 of the 50 U.S. States, and ranked in the top three for another 10 States. In fact, Canada is a larger market for U.S. goods than all 27 countries of the European Community combined, whose population is more than 15 times that of Canada.[4]

Arizona's exports in 2007 were valued at $19.2 billion, up 34% since 2000.[5] Mexico is Arizona's leading trade partner, as shown in Table 5.1. Trade for America estimates that Arizona's foreign trade is responsible for 553,000 jobs.[6]

Table 5.1: Value of Trade with Arizona's Leading Trade Partners, 2007

	Exports	Imports	Total Trade
Mexico	**$5.2 billion**	**$4.2 billion**	**$9.4 billion**
Asia	**$3.5 billion**	**$4.0 billion**	**$7.5 billion**
Canada	**$2.1 billion**	**$1.5 billion**	**$3.6 billion**

Source: North American Center for Transborder Studies.

Arizona's Border Ports. The ports of entry on Arizona's border with Mexico are shown in Figure 5.1a, along with the important highways and railroads that serve them. Only one of Arizona's border ports—Nogales—connects *directly* to an interstate highway or currently operational railroad.

Table 5.2 details the number of crossings and lanes of different types at each Arizona border port. As can be seen, capacity at Nogales Mariposa and Yuma is inadequate for the traffic volume passing through. In addition to the ports listed in the table, a new port of entry is under construction at San Luis, and a new cattle-crossing is planned for the Yuma area.

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

- An origin and destination
- A land bridge—the rail and road conduit from seaports and airports elsewhere into the interior of the United States.
- 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 (see Existing Plans and Programs).

Competitiveness and Transportation Infrastructure. Our transportation infrastructure, which enabled firms to develop complex cross-border supply chains in the 1980s and '90s, has now reached capacity. Even before 9/11, the physical infrastructure at critical Canadian and Mexican border crossings was nearly overwhelmed. As an example, in 2007, the California Department of Transportation estimated the U.S.-Mexican border transportation infrastructure deficit at between $860 million and $1.07 billion.[2] Delays at the ports of entry have increased at some crossings even after expediting pre-cleared and pre-screened crossers. Many industries and jobs in Arizona depend on unimpeded flows in and out of entry ports.

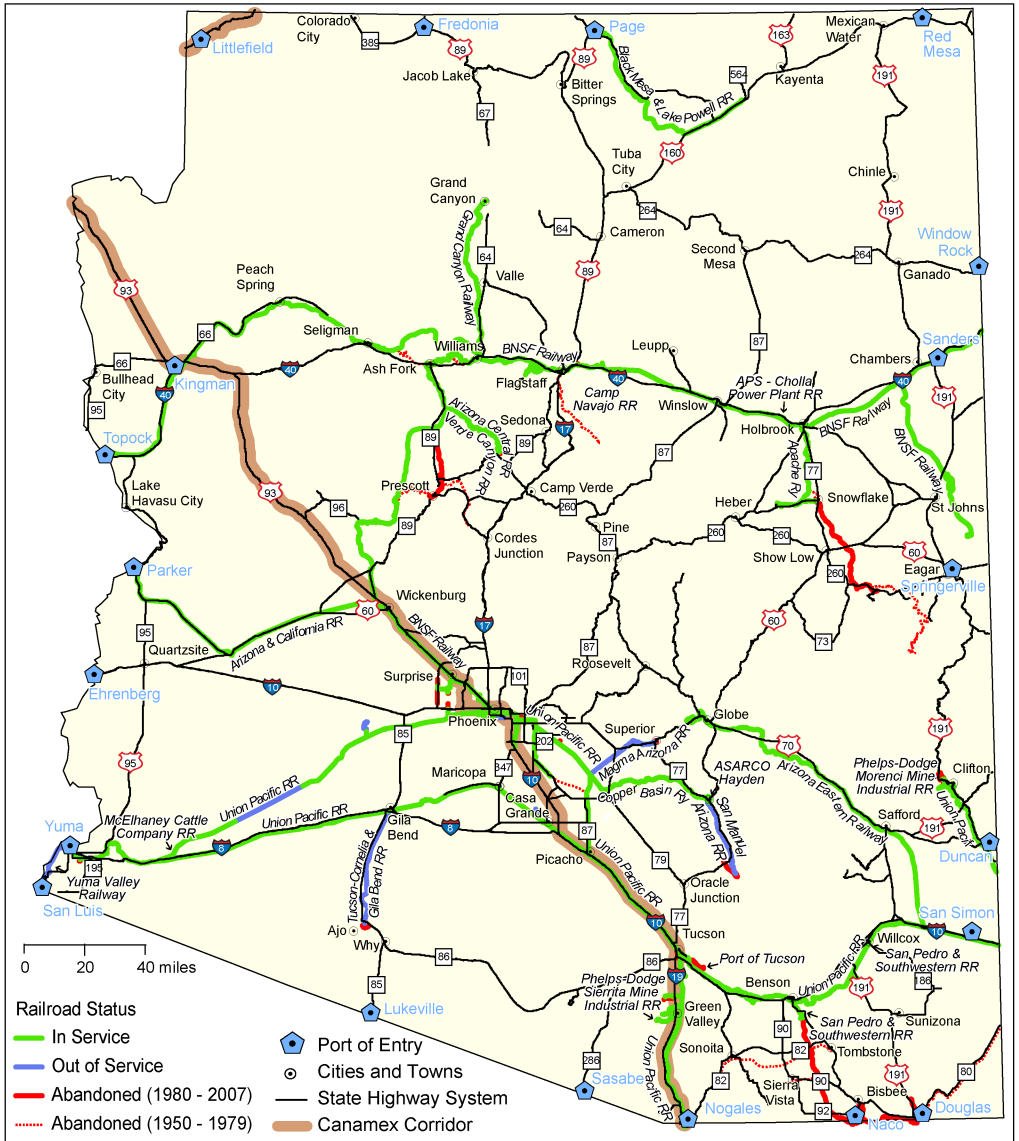


Figure 5.1a Arizona Border Ports and Related Networks

Source: Based on Maps prepared by ADOT 2007 Map Book (pp 41 and 49)

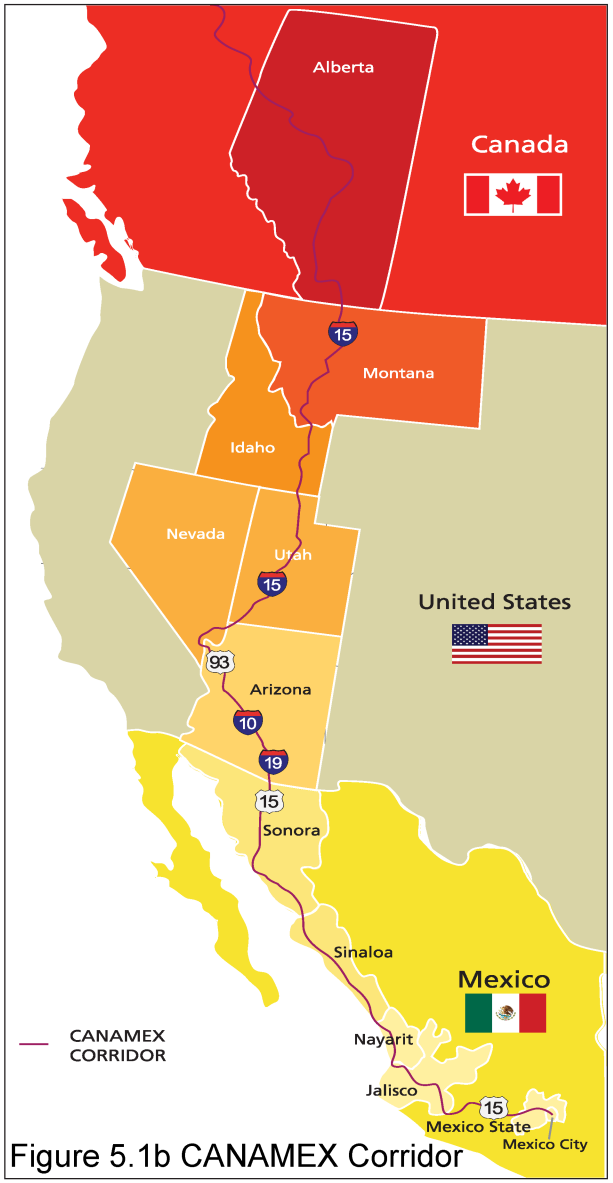


Figure 5.1b CANAMEX Corridor

Source: ASU North American Center for Transboarder Studies

Table 5.2: Northbound Crossings and Lanes at Ports Of Entry (2007)

PORT	TRUCKS, BUSES, COMMERCIAL LANES	PASSENGER VEHICLES/ PASSENGER LANES	PEDESTRIANS/ PEDESRTIAN LANES
Douglas	27,585 trucks 2593 buses 2 lanes	1,803,880 7 lanes	922,654 20 lanes
Lukeville	533 trucks 1805 buses 1 lane	451,055 3 lanes	87,412 5 lanes
Naco	4711 trucks 162 buses 1 lane	339,909 2 lanes	89,938 10 lanes
Nogales Deconcini	0 trucks 3083 buses 0 lanes	2.057,970 8 lanes	7,320,140 10 lanes
Nogales Mariposa	291,429 trucks 9169 buses 4 lanes	1,157,501 4 lanes	424,878 15 lanes
San Luis I	43,869 trucks 1 lane	2,484,563 6 lanes	2,969,816 6 lanes
Sasabe	309 trucks 1 lane	33,389 2 lanes	1093 1 lane

Source: U.S. Customs and Border Patrol.

Partly due to Mexico's failure to develop adequate infrastructure (communications, transportation, education), and partly to the new allure of Asia, many companies did not develop true "North American" strategies. Hopes that Mexico would become a major supplier for U.S. and Canadian firms—as in the auto industry—were disappointed. Since the beginning of this century, economic growth has slowed and North American integration has lost much of its luster. Reasons include the erosion of our freight-transportation system, the "thickening" of our internal borders (much, but not all, due to 9/11), and growing concerns about immigration and loss of sovereignty (see Challenges, below).

Existing Plans and Programs

Borders are artificialities of treaties and wars, originally intended to be frontiers and hinterlands. Instead, they are increasingly populated and developed zones rather than dividing lines. In addition, they are increasingly crossed by people, produce, products, resources, ideas, investment, pollution, and wildlife, by pathways regulated or not. Borders are the organizing mechanisms for trade and other flows between sovereign countries. Undoubtedly, borders confound optimal functioning in a number of areas, including productive trade and efficient transportation. The border ports are gateways, but they also hinder trade, tourism, and transportation because of the necessary infrastructure and security activities. Unfortunately, prosperity for the nations' interiors imposes a congestion cost at their 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.

Cabotage Rights. Cabotage rights allow a company from one country to trade in another country. While sovereign countries have the exclusive right to regulate trade and traffic within its territory, without cabotage rights foreign airlines would not be allowed to land at our airports and foreign ships would not be able to call at our ports. One of the most important provisions of NAFTA allowed a truck from one nation to travel to and return from anywhere in other NAFTA nations to deliver freight from its country of origin. However, various interests have used concerns about safety and environmental quality to continue to delay full implementation of this provision. But these concerns are not the only issue. Cabotage regulations prevent foreign trucks from carrying freight from one destination to another inside that country, thus making it difficult—often impossible—to organize a full backhaul. Given this situation, trucks now drop goods or trailers at the border. A second truck vehicle brings the load across the border where it is picked up by another truck and taken to its destination. Thus an entire "drayage" fleet and industry has been created to unload freight near the border, warehouse it if necessary, move it a few kilometers into the next country, and reload it.

Security. The post-9/11 security paradigm 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, a difficult political and economic transition in Mexico, and a deteriorating security situation in that country. The tension between trade facilitation and security confounds to such a degree that 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 that designs and builds federal public facilities. Nevertheless, no single agency is *formally* charged with primary responsibility for monitoring use, for identifying infrastructure problems, or for developing scenarios for entry-port usage requirements even in the near future.

CANAMEX. The 1995 National Highway Systems Designation Act defined CANAMEX as a "High Priority" trade corridor (Figure 5.1b). CANAMEX is 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."[7] The Canadian province of Alberta and the Mexican state of Sonora are also partners. The Corridor Plan calls for developing a continuous four-lane roadway, as well as communication ("smart corridor") and commerce elements. Arizona is the lead state: ADOT received $1 million of National Corridor Planning and Development funds from TEA-21 in 1999.

Challenges

Border Port Congestion. Following implementation in the mid-1990s of Operation "Gatekeeper" in San Diego and Operation "Hold the Line" in El Paso to deter illegal immigration, Arizona became a more important entry point for illegal immigration. Border wait-times after 9/11 added significant costs to trade, especially at the largest ports of entry, Nogales-Deconcini and Nogales-Mariposa. Quantifying the cost of these wait-times remains problematic; indeed, even the study of border wait-times is fraught with methodological and political difficulties. Arizona has worked with major stakeholders to upgrade its ports of entry with Mexico, though this effort has met its share of challenges. A planned $170-

million upgrade of the Nogales-Mariposa port of entry was not funded in the FY09 budget because the Department of Homeland Security chose to use those funds to help build a new headquarters for their department in Washington, D.C.

Upgrades of existing port-of-entry infrastructure will have to contend with a new seaport planned at Punta Colonet, located 150 miles south of the Tijuana-San Diego border in Baja California. A new rail line is proposed from Punta Colonet to the United States, perhaps through Yuma. This rail line has the potential to bring an enormous amount of Asian container traffic through Arizona. A recent working paper notes the possibility of 55 daily train crossings when the port is up and running at capacity.[8]

Broader North American Capacity Issues. During the 1980s and 1990s, transportation providers were able to meet the growing demands of users. Excess capacity existed in many systems, and new technology such as unit trains, double stacking of containers, and larger trucks were able to move more freight over the same highways and railroads. In addition, consolidation in the trucking and rail industries enabled suppliers to work more efficiently. Government policy focused on privatization and deregulation, although U.S. highway legislation also provided funds for many local transportation projects. Companies worked out individual strategies for building new continental systems and solved problems as they arose.

By the end of the 20th century, however, this situation had begun to change. Several factors strained the capacity of North America's freight-transportation system to service the economic system:

- The end of excess capacity
- The emergence of global-manufacturing value chains with vastly greater demand for freight-transportation capacity because of increasing imports from Asia
- The impact of post-9/11 measures on borders and ports
- The continued failure to coordinate regulations
- The accumulated effects of delayed maintenance

Many experts now spoke of an emerging crisis in North America's freight-transportation system. UPS CEO Mike Eskew observed: "What's shocking, quite frankly, is the inability of our transportation infrastructure to keep up with the normal day-to-day stresses imposed upon it . . . Our highways, waterways, railroads, and aviation network are simply not keeping up with ordinary demands."[9]

The transportation crisis threatens North America's integrated production system. A review of recent research on just-in-time (JIT) supply-chain philosophy and freight-transportation infrastructure conducted by the North American Transportation Competitiveness Research Council concluded: "The JIT-lean inventory advanced manufacturing system developed since the 1970s that enables North America to compete successfully with Asian and European manufacturers is now reaching its capacity limits. The supporting transportation infrastructure is now inadequate to handle the projected volume growth of North American supply chains' freight flows."[10]

"The result," observes Professor Mary Brooks, one of Canada's best known specialists on freight transportation, "has been to boost buffer stocks, and force just-in-time supply chain managers to re-examine their sourcing options; it is of concern to Canada that many U.S. companies will source domestically rather than within NAFTA due to border uncertainty."[11]

The three North American governments have responded to the growing crisis of capacity and congestion with recent transportation-infrastructure initiatives.[12] Several organizations have emerged to address the crisis—for example, the Coalition for America's Gateways and Trade Corridors, and the recent initiative by Mayor Mike Bloomberg and Governor Arnold Schwarzenegger to create Building America's Future, a non-partisan coalition for federal infrastructure investment.[13]

Current responses to the crisis suffer from three key failings:

- **Most initiatives are still national in scope and lack connectivity across borders.** National leaders remain reluctant to acknowledge the real nature of the North American economic system—that is, three independent nations sharing what is, in many sectors, a single, deeply integrated economic space. As a result, we lack a vision of what a North American freight-transportation system could and should look like within, say, the next two decades.
- **Responses tend to be driven by a single variable**—that is, by linear projections of volumes of goods to be moved. There is a general failure to recognize that multiple agents drive change and to respond accordingly.
- **Failure to suggest how coordination among the three nations** on freight-transportation infrastructure might be improved.

The complexity of the intertwined issues of transportation, infrastructure, trade, jobs, national security, immigration, and environmental protection—all of which span across three sovereign countries that are each, in their own right, federal systems consisting of 50 U.S. states, 13 Canadian provinces, and 31 Mexican states—is a major challenge in solving these problems.

Opportunities

Educational institutions share the responsibility for helping companies, policy makers, and the general public understand trade and its complexities. The North American Center for Transborder Studies at Arizona State University addresses this knowledge gap among universities, the private sector, and the public, with a special focus on trade and competitiveness. The Center recently prepared *A Report to President Obama on Building Sustainable Security and Competitiveness*, which suggested the following:[14]

1. Strengthening the **Mérida Initiative** in a way that maximizes bipartisan U.S. support and multi-partisan Mexican consensus and buy-in
2. Energizing the **North American Trilateral Leaders Summit** by expanding involvement by the three federal legislatures and other key stakeholders

3. Designating a **North America/borders authority** to coordinate sustainable security, preferably within the National Security Council, with a focus upon all critical border functions
4. Expanding **joint risk assessment and preparedness** for enhanced joint defense and better management of natural and human-generated catastrophes
5. Developing an effective **North American trade and transportation plan** that addresses congestion, bottlenecks, and infrastructure in all three countries
6. Creating a **joint, revolving fund for infrastructure investments** in North America, jumpstarting our collective economic engine for global competitiveness
7. Implementing a **North American greenhouse gas exchange strategy** to promote energy independence and climate security
8. Establishing **joint, practical assessment of progress** on key North American issues

If implemented, these national-level initiatives should have a net positive benefit for Arizona. The state would benefit tremendously from a more functional border that is well managed, and from border policies based on a thorough understanding of the risks inherent in cross-border trade.

The state of Arizona and local communities could consider some of the following steps:

1. Including investment in pilot projects as part of a "green" trade corridor
2. Expanding its investment in existing state "internationalist" organizations such as the Arizona Mexico Commission
3. Considering new ways to finance and operate its ports of entry, and specifically, conduct surveys on users' (travelers, tourists, students, shippers) willingness to pay to expedite crossing or to be assured of a set crossing time
4. More generally, bringing together key crossborder security, trade and sustainability components in ways that allow it to compete more effectively with crossborder trade flows in California and Texas

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**GATT**	General Agreement on Tariffs and Trade
CBP	Customs and Border Protection	**JIT**	Just-in-time
DHS	Department of Homeland Security	**NAFTA**	North American Free Trade Agreement

Stephen Blank is Co-Chair of the North American Transportation Competitiveness Research Council. He serves as Senior Research Fellow, North American Center for Transborder Studies at Arizona State University and Adjunct Research Scholar, Center for Energy, Marine Transport and Public Policy at Columbia University. He is currently the Ross Distinguished Visiting Professor of Canada-US Business and Economic Relations at Western Washington University. He received his B.A. from Dartmouth, M.A. from Cambridge and M.A. and Ph.D. from Harvard and has enjoyed a career in education and business for more than 40 years.

Rick Van Schoik is the Director of the North American Center for Transborder Studies at Arizona State University, which pursues complex, multidisciplinary, trinational research and policy work. He received a B.S. in oceanography and engineering from the U.S. Naval Academy, and was a Navy SEAL until he returned to

school for an M.S. in biology from San Diego State University. He conducted post-graduate studies in philanthropy at Harvard Graduate School of Education, and in Sustainable Development at Tufts, and attended the first Natural Resources Leadership Institute in North Carolina. He teaches about energy, environmental and water policy, science, law, economics, and engineering at ASU.

Erik Lee serves as Associate Director at the North American Center for Transborder Studies. From 2006-2007, Mr. Lee was program officer for the Merage Foundation for the American Dream based in Newport Beach, California. He was assistant director at the Center for U.S.-Mexican Studies at the University of California, San Diego from 2002-2006. Before that, Lee served as assistant managing director at the Southwest Consortium for Environmental Research and Policy at San Diego State University. He has consulted for philanthropic and educational organizations and has also served as a resource for a large number of local, national and international media outlets. Before completing his master's degree in Latin American Studies at UCSD in 2000, Mr. Lee worked as a university administrator and instructor in Hermosillo, Sonora for two and a half years. He received his bachelor's degree in English literature from the University of Arizona.

---

[1] *Office of the United States Trade Representative. NAFTA Facts.* www.ustr.gov/assets/Document_Library/Fact_Sheets/2008/asset_upload_file855_14540.pdf
[2] See note 1.
[3] The Embassy of the United State of America in Ottawa, *Canada. U.S.-Canada Relations: General Information.* ottawa.usembassy.gov/content/content.asp?section=can_usa&document=general.
[4] See note 3.
[5] U.S. Census Bureau. *2009 Statistical Abstract of the United States* (Table 1264). www.census.gov/compendia/statab/cats/foreign_commerce_aid/exports_and_imports.html.
[6] Trade for America. tradeforamerica.org/why/states/arizona.html.
[7] CANAMEX Corridor Coalition. *What is CANAMEX. www.canamex.org/background.asp.*
[8] Randolph, D. *Preparing for the Future Mexican Land Bridge to the United States,* NACTS/NATCRC Working Paper 6, March 2008. natcrc.org.
[9] "Transportation Infrastructure Failing the Nation, Says UPS CEO", *HOUSTON*, March 30, 2006 http://www.pressroom.ups.com/pressreleases/current/0,1088,4668,00.html
[10] Stanley, G. *Review of Recent Reports on North American Transportation Infrastructure, North American Transportation Competitiveness Research Council,* NACTS/NATCRC Working Paper 3, September 2007. nacts.asu.edu and natcrc.org.
[11] Brooks, M. *Mapping the New North American Reality: The Road Sector," Study Group on Mapping the New North American Reality.* www.irpp.org/miscpubs/archive/NA_integ/papers.htm
[12] Blank, S., G. Parsons, and J. Carlos Villa. *Freight Transportation Infrastructure Policies in Canada, Mexico & the US: An Overview and Analysis***,** NACTS/NATCRC Working Paper 5, March 2008. nacts.asu.edu and natcrc.org.
[13] There has been much ongoing work on border and regulatory issues, most importantly, the Border Transportation Working Groups. www.thetbwg.org/index_e.htm and www.borderplanning.fhwa.dot.gov/mexico.asp and the North American Competitiveness Council.
[14] North American Center for Transborder Studies, Arizona State University. *North America Next: A Report to President Obama on Building Sustainable Security and Competitiveness.* February 10, 2009. nacts.asu.edu/north-america-next.

Chapter 6

TRIBES AND TANSPORTATION IN ARIZONA

Esther Corbett
Inter Tribal Council of Arizona, Inc.

Norm DeWeaver
Independent Consultant

Patricia Mariella, Ph.D.
Arizona State University, American Indian Policy Institute

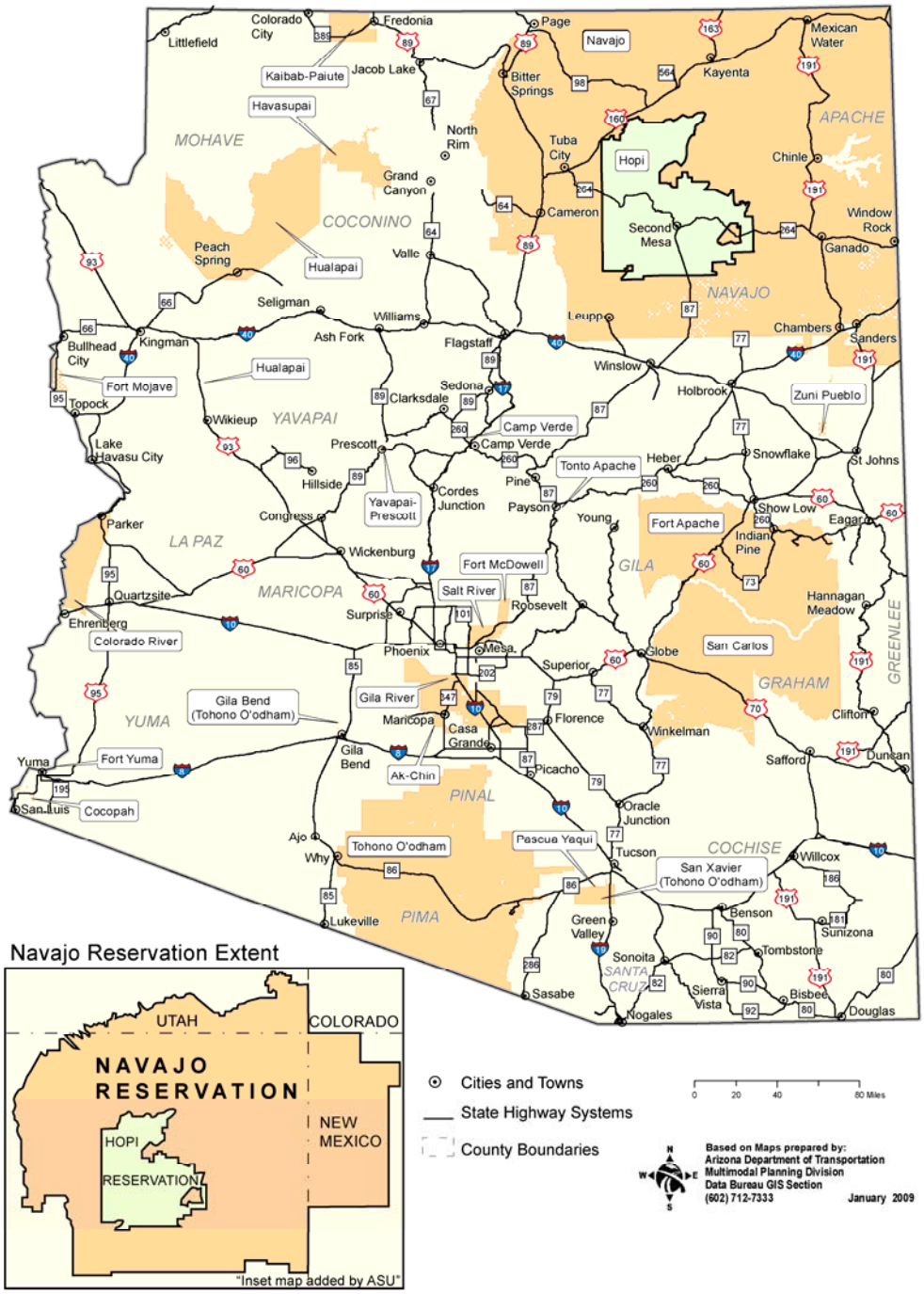
Key Points

- Nearly 20% of Arizona state highway miles cross Indian reservation land.
- There are roughly 15,000 miles of roads, most of which are unpaved, on Arizona reservations in the inventory for the federal Indian Reservation Roads program.
- The current annual level of federal funding available to Arizona tribes under the Indian Reservation Roads program represents less than 0.7% of the unmet need. State funding for that system is unavailable.
- In Arizona, the motor vehicle crash mortality rate for Indian people is more than triple the rate for the general population.
- Reservation residents must drive much farther to work, shopping, and services than residents in urban Arizona. Public transit services in such reservation communities are largely non-existent. Such factors are relevant to the evaluation of potential solutions to transportation infrastructure financing, such as increased fuel taxes and a Vehicle Miles Traveled taxation system.

Traveling Arizona highways is, for many, a trip through Indian Country. Indian tribes occupy 28% of the state's land area. Many of Arizona's major transportation corridors cross tribal lands. The State Highway system contains 1,324 miles of roads on tribal land, nearly 20% of the total mileage.[1] Every interstate highway passes through or near a reservation (Figure 6.1). Since the rights-of-way for these roads have been granted by tribal governments, the governments are key stakeholders in the transportation arena. 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.[2]

There are 22 federally recognized tribal governments within Arizona's boundaries. Their lands vary in area, population, accessibility, and cultural traditions. They include the Navajo Nation with a reservation the size of West Virginia, and the San Juan Southern Paiute Tribe with no trust-land base.

Figure 6.1: American Indian Reservation and Transportation District Boundaries



Some Arizona tribes are among the most isolated in the country. The Havasupai people occupy a side canyon of the Grand Canyon. There is no road access to their village. 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, and White Mountain reservations are many miles from a city of even moderate size. At the opposite extreme, several reservations share boundaries with urban areas in the East Valley and Tucson.

Current Conditions

Rights-of-Way. Under the U.S. Constitution, multiple treaties, federal law, and numerous Supreme Court decisions, Indian tribes have jurisdiction over what occurs within the boundaries of their reservations. Tribal land is held in trust by the U.S. government for the tribe involved.[3] As such, it is not subject to the condemnation procedures of state or local government that are sometimes used to acquire rights-of-way for transportation corridors. Although tribes have repeatedly given their consent to allow state roads to cross their land, making the development of major corridors such as I-10 possible, they expect benefits in return for allowing use of their limited land bases and for tolerating traffic impacts in their communities.

Authorizing rights-of-way for roads across tribal land can create significant economic-development opportunities, as well as environmental issues. 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. But the volume of traffic on interstates and major state roads that cross reservation land can cause serious problems. Periodically, traffic congestion and vehicle crashes on the through-roads spill traffic into residential areas, putting citizens at risk and forcing tribal governments to spend their limited resources to manage these incidents. Rights-of-way for limited-access highways can block movement from one village to another and to nearby agricultural areas. Air quality around major transportation arteries is degraded, affecting health and sometimes constraining land use.

The rural nature and relatively low population density of most reservation land encourages urban neighbors to assume that tribal land is "unused," and therefore a resource that should be available for transportation corridors. Some past state and regional transportation plans have assumed that tribal land was the least expensive and easiest to acquire for new or expanded freeways. After years of experience negotiating right-of-way issues, state and local transportation planners are now more careful to avoid designing routes that enter tribal lands. Recently, the Pinal County Manager said that the Hidden Valley Transportation Framework Study of future transportation corridors in Maricopa and Pinal counties was not considering any new routes that would cross the lands of the Ak-Chin Indian Community or the Gila River Indian Community.[4]

Indian Reservation Roads (IRR). The main source of information on the mileage, ownership, and condition of roads on Indian reservations is the national inventory of the Indian Reservation Roads (IRR) program, maintained by the Division of Transportation within the U.S. Bureau of Indian Affairs (BIA).[5] An IRR 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 Indian tribe involved.[6] The IRR inventory[7] for federal Fiscal Year (FY) 2008 includes over 15,000 miles of existing roads on the reservations of tribes whose main land bases are within Arizona borders.[8] BIA roads account for about 71% of the miles in this inventory. State roads constitute 14%, county roads 12%, and tribal and other roads 3%.

While nearly all of the state roads and most of the county roads are paved, over 74% of the BIA roads are not. About 66% of the total mileage consists of dirt roads; gravel roads account for another 4%,[9] and other categories account for the remainder.

Air Quality. Transportation corridors that increase traffic through reservation communities also increase air pollution from vehicle emissions. The National Air Toxics Assessment and the Joint Air Toxics Assessment Project, a multi-jurisdictional monitoring effort of the Salt River Pima-Maricopa and Gila River Indian Communities 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.

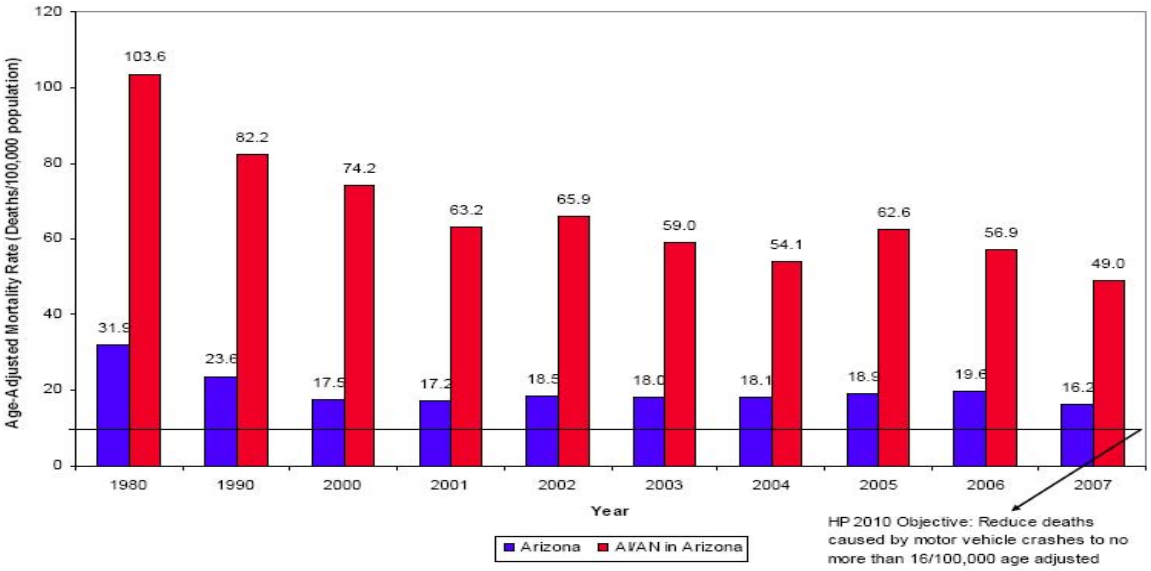
Emissions from vehicles traveling on roadways *near* tribal lands can also have adverse effects. Ozone is created by sunlight and heat acting on pollutants from vehicle emissions as they move through the airshed. Some of the highest readings in the Valley of the Sun are on or near the Salt River Pima-Maricopa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

The miles of unpaved roads in tribal communities also pose a health risk from particulates (dust). Children in tribal communities are especially vulnerable to respiratory health problems caused by particulate air pollution because they breathe more air for their body weight than adults, and they often wait daily for school buses on unpaved roads. School buses in tribal communities are often old, so problems caused by road dust are exacerbated by open windows on buses without air conditioning, and by high levels of diesel emissions.

Safety. Numerous studies on transportation safety in Indian Country have compiled alarming statistics on injuries and fatalities. Remoteness, lack of public transit, poor road conditions, and lack of roadside lighting all contribute to vehicle accidents.

- The Associate Administrator for Federal Lands in the U.S. Federal Highway Administration (FHWA) has noted that the annual fatality rate on reservation roads continues to be more than four times the national average.[10]
- The motor-vehicle-crash mortality rate for Indian people in Arizona, on and off reservation, is more than three times the rate for the general population of Arizona (Figure 6.2). Injuries from motor-vehicle crashes are among the top five causes of death for Indian people in Arizona.
- The motor-vehicle-related fatalities suffered by Indians in Arizona in 2003, on and off reservation, were roughly twice the number as those suffered by Indians in any other state. According to a BIA publication with state-by-state comparisons, the number of fatalities in Arizona represented about 22% of fatalities nationwide.[11]
- A study done for the National Highway Traffic Safety Administration found that from 1975 to 2002, the number of fatal crashes on reservation roads increased 52.5%. During the same period, the number of fatal crashes in the nation as a whole dropped by 2.2%.[12]
- An analysis by the *Arizona Daily Star* found that although Indian people make up only 6% of the state's population, they account for nearly one-quarter of the state's pedestrian fatalities.[13]

Figure 6.2: Motor Vehicle Collision Mortality Rates for American Indians/Alaska Natives in AZ 1980, 1990, 2000-2007



Source: Bureau of Public Health Statistics, Arizona Department of Health Services. Arizona Health Status and Vital Statistics Report, 2007.

Existing Plans and Programs

Road Funding. Funding for the IRR program is provided through the tribal provisions of the federal surface transportation act—currently the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Passed in August 2005, the Act authorizes $450 million in FY 2009 for the IRR program, to be divided among all tribes in the U.S. The money may be used for a variety of activities, including planning, transit facilities, maintenance, and road construction. IRR funding is, in reality, the only source of funding for BIA and tribal roads in Arizona.

Public Transit. Public transit is often missing in the small communities of rural Arizona, including tribal communities. A study conducted for the Arizona Department of Transportation (ADOT) found that 82% of the need for public transit in rural Arizona is unmet.[14] The study, which combined reservation needs with those of other rural areas, identified services to the elderly, disabled, and low-income populations as the most serious needs. Only three tribes receive federal Rural Public Transportation funding through ADOT to operate public transit systems: the Navajo Nation (Navajo Transit System), the Hopi Tribe (Hopi-Senom Transit), and the Salt River Pima-Maricopa Indian Community. Several tribes have received federal Tribal Transit Grant funding through the Federal Transit Administration to plan, establish, and operate transit systems: the Hualapai, Havasupai, Quechan, Cocopah, White Mountain Apache, San Carlos Apache, and the Yavapai-Apache Nation (at Camp Verde).

While public transit providing scheduled service over fixed routes is absent in most reservation communities, other mobility services exist. They are generally provided for a 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. Some tribes have purchased vans to serve the elderly and physically challenged, with funds from the federal Elderly and Persons with Disabilities transit program administered through ADOT.

Reservation school systems 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. For most reservation residents who do not own cars, family members and friends are the providers of last resort. Fragmentation of specialized services in education, health, and other programs can be a serious impediment to optimizing the limited transit resources available to tribal governments. 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. Recognizing this need, the Navajo Nation's Temporary Assistance for Needy Families (TANF) program tried to negotiate a contract with the Navajo Transit System to serve TANF clients. It failed, in large part because federal rules on cost allocation require a clear paper trail showing that federal funds for TANF are spent exclusively on that program's clients and purposes.

Safety. Tribal governments have responded to their serious transportation safety issues in many ways, including with safety audits, seatbelt education, and sobriety-checkpoint programs. The first ADOT-sponsored Road Safety Audit (RSA) was conducted on a road segment 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. Intergovernmental coordination among the Tohono O'odham Nation, the Pima Association of Governments (PAG, the regional transportation-planning agency), and ADOT was the key to planning improvements for a dangerous intersection identified in the RSA. PAG agreed to pay for developing a scope of work for the project, a process that is now underway. The tribe has assumed responsibility for some of the lower-cost improvements, such as supplying electricity for new street lights. The Navajo Nation was among the first tribes in the country to conduct a federally sponsored RSA, on the highway from I-40 at Lupton to Window Rock (the Navajo capital), and Fort Defiance. The audit identified a number of features needing improvement, such as signage, channelization, and pavement markings.[15] In 2004, the Centers for Disease Control and Prevention funded multi-year Prevention of Motor Vehicle Injuries grants to develop, implement, and evaluate tailored, tribal-community-based interventions, such as seatbelt education programs and sobriety checkpoints. Three of the four national pilot projects were in Arizona, with the Tohono O'odham Nation, and the San Carlos Apache and White Mountain Apache Tribes.

One impediment to safety improvements has been the fragmentation of responsibility among agencies. Several units inside USDOT 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. To increase attention to reservation transportation safety at the state level, the Governor's Traffic Safety Advisory Council has formed a subcommittee on tribal issues, led by the representative from Inter Tribal Council of Arizona.

Challenges

Although many aspects of tribal transportation are challenging, financing stands out above all. Despite a significant increase in funding from prior levels, the IRR program is grossly inadequate to meet tribal needs. The BIA estimates the unmet need in FY 2007 at over $10 billion for the tribes in Arizona, including all of the Navajo Reservation. In contrast, the actual funding allocated in FY 2008 was roughly $68.3 million. At this rate, it would take over 146 years just to meet the need as it existed in FY 2007,[16] let alone future needs that will continue to grow due to inflation and the additional mileage likely to be added to the system.

Tribes, as well as states, are concerned about reduced federal fuel-excise-tax collections that result in lower revenues for the federal Highway Trust Fund, the source of funds for the IRR program. This reduction of revenues is the result of a drop in vehicle-miles traveled and an increase in the fuel efficiency of vehicles that actually began before the current recession.[17] While these may be positive trends for national oil dependency, they threaten to produce a $4.3 billion shortfall in the Fund in FY 2009.[18] The impact could be devastating to tribal and state transportation programs alike.

The very-limited maintenance funding for reservation roads is an equally serious and closely related problem. For FY 2008, only $26 million was available to the U.S. Department of the Interior to maintain the over 108,000 miles in the IRR inventory.

As an example of road construction and maintenance needs, the Hualapai Tribe in northern Arizona cites the Diamond Creek Road that provides the only vehicle access to the Colorado River in the 200-plus miles between Lee's Ferry and Lake Mead.[19] The road, essential to tribal tourism, washes out an average of three times a year. Recent flooding also destroyed the trail system on the Havasupai Reservation, a system essential to the tourism industry that produces nearly all the tribe's non-governmental income.

Opportunities

Partnerships. Collaborative problem-solving efforts are underway to address challenges. “Partnership” is now the term used by all parties to describe the relationship between the tribes and ADOT. In contrast, just nine years ago an ADOT official devoted most of a report on state-tribal transportation coordination to discussing perceived obstacles such as tribal sovereignty issues, conflicts over Indian preference in employment (as authorized by federal law), and difficulties in negotiating rights-of-way.[20]

While some of these issues have yet to be resolved, relationships have improved. In 2006, FHWA presented a national award for transportation-planning excellence to ADOT for its Arizona Tribal Strategic Partnering Team. The Team consists of 23 members drawn from

tribes, federal agencies, and ADOT divisions. It brings together representatives from tribal, federal, state, and local governments and agencies to discuss state-tribal transportation issues and to develop inter-agency forums through which problems can be addressed.[21] The Inter Tribal Council of Arizona established the Transportation Working Group to facilitate information exchange among tribes and to advocate with the state and other agencies. Individual tribes also create partnerships. ADOT has formal partnership agreements with the Hopi Tribe and the Navajo Nation, and less formal relationships with a number of other tribes.

The major responsibility for state-highway-system planning in Arizona is shared by ADOT and the various regional planning organizations. The Salt River Pima-Maricopa Indian Community, the Fort McDowell Yavapai Nation and the Gila River Indian Community belong to the Maricopa Association of Governments, and the Salt River Pima-Maricopa Indian Community is a member of the organization's Transportation Committee. The Pascua Yaqui Tribe and Tohono O'odham Nation are members of the transportation committee of the PAG. The Cocopah Tribe is a member of the Yuma Metropolitan Planning Organization and the Hopi Tribe is a member of the Northern Arizona Council of Governments.

Financing for Transportation Improvements. Funding roadway improvements, public transit, safety programs, and other activities is a serious challenge. Tribal governments, like states, were pleased that highway construction funds were approved in the recently passed federal economic stimulus bill. The IRR program will receive an additional $310 million from that legislation.[22] Tribes are also hopeful that there will be improvements when Congress enacts the next iteration of the federal surface transportation statute. At the top of the agenda for Arizona tribes are continuing increases in construction money for the IRR program to compensate for rapidly rising construction costs and the huge backlog of unmet needs. Increased appropriations for the woefully inadequate routine-roads-maintenance line item in the U.S. Interior Department's budget is a close second. Greater support for data collection, management, and analysis is also essential to improve understanding of tribal needs and craft effective ways to meet those needs.

In 2007, the Hualapai Tribe proposed an innovative idea to the U.S. Senate Committee on Indian Affairs: the establishment and start-up funding of an IRR loan program comparable to the state infrastructure banks (SIBs).[23] Such an IRR SIB could make direct, low-interest loans to tribes for transportation infrastructure development, and guarantee loans to enhance the prospects for leveraging tribal resources.

Although tribes can borrow from the state's SIB, the low-interest Highway Expansion and Extension Loan Program, several major obstacles prevent effective access to this money. The barriers stem from program regulations that require tribal governments to:

- waive their sovereign immunity
- agree to resolve disputes in state courts
- create separate legal entities to receive the funding
- disclose their government assets

A separate, federal IRR infrastructure bank would bypass these issues.

Another barrier is a provision of the state constitution that has the effect of prohibiting direct tribal access to state transportation revenue in the Highway User Revenue Fund.[24] Levying tribal excise taxes on fuel sold on reservation land is a financing option available to a relatively few tribes with commercial gas stations on their land. Where this resource can be tapped, it can supplement the limited federal funding for transportation improvements. For example, the Navajo DOT recently took delivery of seven new state-of-the-art road graders purchased with tribal gas tax funds.[25]

The foregoing discussion relates to tribal-specific approaches to transportation financing. In addition, tribes and reservation residents have an important stake in what approaches are adopted for the state as a whole. Some of these potential solutions would seriously disadvantage Indian people, particularly in remote rural reservations. These include such ideas as increased fuel taxes, a VMT approach to transportation financing, congestion pricing and public private partnerships, all of which might be desirable in urban areas but would adversely impact the rural population who must drive considerably further to work, shopping, and services and where there is little private sector with which to create partnerships. (See Chapter 18 for a general discussion of transportation finance.)

As Arizona's population grows and new and expanded corridors are needed for roads and public transit, tribal engagement and partnership with state, local, and federal agencies on transportation issues will become even more important than it is now. Progress through partnership is possible as tribes and tribal communities work, along with the rest of Arizona, to meet transportation challenges in the decades to come.

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**PAG**	Pima Association of Governments
BIA	Bureau of Indian Affairs, U.S. Department of the Interior	**RSA**	Road Safety Audit
FHWA	Federal Highway Administration	**SIB**	State Infrastructure Bank
IRR	Indian Reservation Roads	**TANF**	Temporary Assistance for Needy Families

Esther Corbett is the Transportation Project Coordinator for Inter Tribal Council of Arizona, Inc. In this capacity she has worked since 1998 to increase the capacity of tribal governments to access transportation resources, develop transportation plans, and create and improve safety programs and transit services. Esther also leads the subcommittee on tribal issues of the Governor's Traffic Safety Advisory Council.

Norm DeWeaver, an independent consultant, has worked with tribal governments and Indian organizations in Arizona on many issues since 1972. He lives in Casa Grande.

Patricia Mariella is the Director of the American Indian Policy Institute, Arizona State University. The Institute collaborates with Indian tribes on issues that affect them and empowers tribes through the provision of information, expertise, and certifications.

---

[1] ADOT. Tribal Consultation Policy Annual Report September 2006-November 2007. December 5, 2007.
[2] As used in this paper, the following terms have the meanings described for them. The term "Indian Country" means federal reservation areas and other communities meeting the technical definition in U.S. law of Indian

Country. The term "tribe" means any Indian tribe, band or nation which is recognized as eligible for the special programs and services provided by the U.S. to Indians because of their status as Indians. The term "tribal government" means the governing body of an Indian tribe. The term "Indian reservation" means a geographic area established as such by treaty, statute or Executive Order of the U.S. government. The term "tribal lands" is used in this paper as synonymous with reservation(s). The term "Indians" or "Indian people" means persons who are members of an Indian tribe.

[3] 25 U.S.C. 2201.

[4] Levine, A. Road Strategy Spares Area's Tribal Lands. *Casa Grande Dispatch*, July 14, 2008.

[5] U.S. BIA, Division of Transportation. *Indian Reservation Roads Inventory*. www.doi.gov/bia/roadreservation.html. Accessed: October 9, 2008.

[6] Title 25 U.S. Code of Federal Regulations Section 170.5.

[7] The IRR inventory includes trails and proposed roads as well as existing roads intended for vehicle traffic. However, these uses do not figure significantly in the mileage summary data. The IRR program also includes bridges, which are reported and funded separately.

[8] This includes the entire Fort Mojave reservation, which extends into California and Nevada. It also includes all of the Navajo Reservation, which extends into New Mexico and Utah. It does not include the Fort Yuma Quechan Reservation, which has relatively little land in Arizona, nor the Zuni Reservation, whose major land area is in New Mexico. The San Juan Southern Paiute Tribe currently has no federal trust land.

[9] Data for the Arizona tribes other than Navajo were taken from Western Region, Division of Transportation, U.S. Bureau of Indian Affairs. *Indian Reservation Roads Program: Miles of Road by Organizational Responsibility and Surface Type*. Phoenix, AZ. November 6, 2008. The Navajo data is from Transportation Planning Program, Department of Transportation, Division of Community Development, Navajo Tribe. 2003 *Navajo Nation Long Range Comprehensive Transportation Plan*. October 2004.

[10] Statement of John R. Baxter, Associate Administrator for Federal Lands, Federal Highway Administration, U.S. Department of Transportation. *Testimony at a hearing of the Committee on Indian Affairs, U.S. Senate.* July 12, 2007.

[11] BIA Indian Highway Safety Program, U.S. Department of the Interior. *Traffic Fatality Crash Information 2003*. February, 2006.

[12] National Highway Traffic Safety Administration, U.S. Department of Transportation. *Fatal Motor Vehicle Crashes on Indian Reservations 1975 - 2002*. April, 2004.

[13] Tobin, M. Ariz. Indians a Fourth of Pedestrian Fatalities. *Arizona Daily Star*, December 18, 2005.

[14] Cambridge Systematics, Inc. *Final Report, Arizona Rural Transit Needs Study*. May 2008.

[15] Gibbs, M. et al., Opus Hamilton Consultants and Vanasse Hangen Brustlin Inc for the Office of Safety, Federal Highway Administration, U.S. Department of Transportation. *Tribal Road Safety Audits: Case Studies*. April 2008.

[16] U.S. Department of the Interior. Indian Reservation Roads Program. *RNDF Report, FY 2008 Relative Need Distribution Factors, FY 2007 Inventory.*

[17] Puentes, R. *The Road… Less Traveled: An Analysis of Vehicle Miles Traveled Trends in the United States.* The Brookings Institution, Washington D.C., 2008.

[18] American Road & Transportation Builders Association. *Recommendations for SAFETEA-LU Reauthorization. A New Vision & Mission for America's Federal Surface Transportation Program*. www.artba.org. Accessed November 5, 2008.

[19] Transportation Issues in Indian Country. *Testimony of Hualapai Tribe submitted at a hearing of the Committee on Indian Affairs, U.S. Senate*. July 12, 2007.

[20] Swan, J. *Native American Transportation Issues in Arizona*. Transportation Research Circular E-C039. Transportation Research Board of the National Academies, Washington, D.C. September 2002.

[21] ADOT. *Arizona Tribal Strategic Partnering Team*. ADOT Tribal Transportation Web site, www.aztribaltransportation.com/atspt/index.asp. Accessed November 3, 2008.

[22] National Congress of American Indians. *Economic Recovery & Reinvestment Act.* Updated 2/18/2009. www.indiancountryworks.org. Accessed February 23, 2009.

[23] See note 19.

[24] Arizona Constitution, Title IX, Section 14.

[25] Francis, K. New road graders will help reservation roads. *The Gallup Independent*, October 29, 2008.

Chapter 7

TRANSPORTATION ISSUES IN NATIONAL PARKS

Dave D. White, PhD and Jessica F. Aquino, MS
Arizona State University, School of Community Resources and Development

Key Points

- Automobile-based tourism in national parks has provided millions of Americans access to natural and cultural areas, but the National Park Service is struggling to deal with undesirable consequences of automobiles such as traffic congestion, crowding, and environmental impacts.
- Grand Canyon National Park demonstrates the potential of integrated transportation planning, alternative transportation systems, and coordination with gateway communities.
- National park visitors value their private vehicles for providing a sense of freedom and access, but also associate their cars with stress and conflict. They associate alternative transportation with an environmental ethic and lack of stress.
- Park transportation systems require financing for the full "life cycle" of planning, design, construction, operation, management, and maintenance.
- Park transportation systems are part of a broader context of visitor use and capacity planning; managing them using indicator and standards-based frameworks may improve their performance.
- Each park is unique and requires a transportation system that enhances its visitors' experiences and protects its resources.

In the United States, the private automobile is the primary way that nearly all people travel daily to work, shop, play, and obtain services such as medical care. Beyond its functional importance, the car is a powerful symbol of independence and social status in American society. Cars and roadways are also 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.[1] Public support for park preservation in the 19th and early 20th centuries was bolstered by transportation infrastructure that provided access to parks. Train and stagecoach travel—uncomfortable and expensive—dominated transportation in early American-national-park history. As auto tourism replaced stagecoach and train tourism, the emerging middle class explored park landscapes in their personal vehicles, experiencing parks in a more direct way than train travel had allowed.[2] Direct, popular access to national parks via automobiles presented new challenges. As early as 1920, National Park Service Director Stephen Mather struggled to balance improved road access for the public with preservation of the parks.[3]

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).[4] Public-land-management agencies

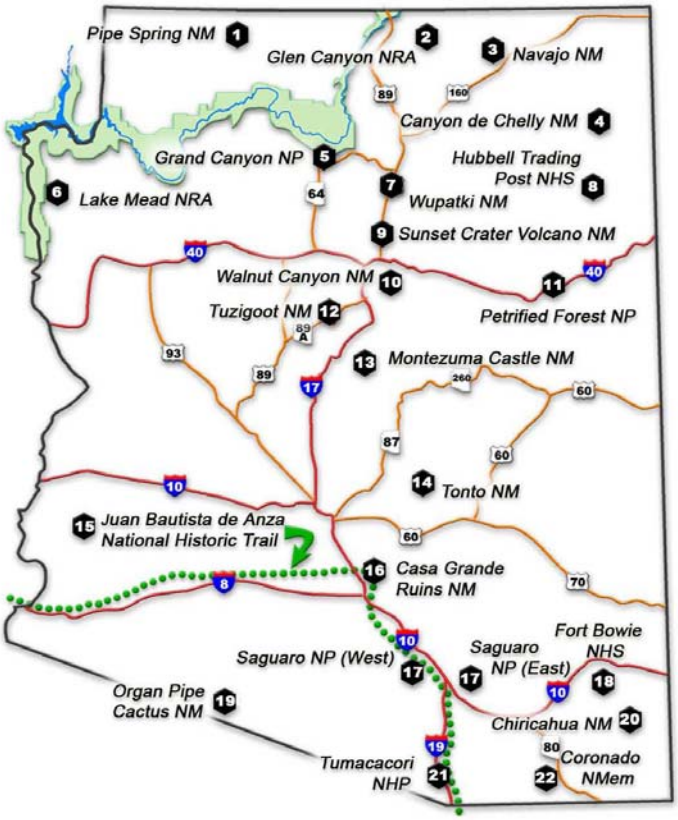
such as the NPS are increasingly concerned about the relationship between park transportation systems and quality of the natural environment, as well as about visitors' experiences.[5] Among the concerns are crowding, traffic congestion, parking shortages, increased air and noise pollution, and impacts on wildlife and roadside vegetation.

Addressing the transportation needs of parks and protected areas requires the coordinated efforts of public-land-management agencies, transportation agencies, local communities and businesses, non-governmental organizations, and academic researchers. This chapter provides an overview of current issues, future challenges, and opportunities related to transportation in Arizona's national parks, with a specific focus on the Grand Canyon.

Current Conditions

Transportation Issues in Arizona's National Parks and other Recreation Areas. 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 NPS units in Arizona—more than in any other state (Figure 7.1). These include 3 National Parks, 2 National Recreation Areas, 12 National Monuments, 2 National Historic Sites, 1 National Memorial, 1 National Historic Park, and 1 National Trail. Included among these jewels are

Figure 7.1: National Park Service Units in Arizona



Source: National Park Service.

Saguaro National Park, Petrified Forest National Park, and the crown jewel, Grand Canyon National Park (GRCA, the abbreviation used by the NPS).

We focus on GRCA to illustrate key transportation issues facing parks and recreation areas. Other areas and issues warrant careful attention but cannot be covered in depth here. For instance, how to manage 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[6]. Land managers are concerned about OHV impacts such as damage to vegetation, soil erosion, impacts to air quality, habitat fragmentation, lack of law enforcement, and vandalism. The U.S. Forest Service (USFS) is completing an extensive travel-management rulemaking process to designate OHV routes on its lands, and the Bureau of Land Management (BLM) faces significant challenges as it deals with OHV use. In the Sedona area, which attracts close to 3 million tourists annually,[7] the primary travel corridor and the developed tourism destinations parallel Oak Creek Canyon, providing recreation access but also putting pressure on sensitive riparian resources. In the Santa Catalina Mountains north of Tucson, the road into Sabino Canyon has been repeatedly washed out by flooding, and the scenic Mt. Lemon Highway suffers from stop-and-go traffic congestion and seemingly endless construction. These and other issues present both challenges and opportunities for park, recreation, and transportation planning and management in Arizona.

The Grand Canyon, designated a national park in 1919, has faced numerous transportation challenges and provides an instructive case study**.** GRCA has experienced traffic congestion and parking problems since automobiles became the primary way to access the park in the 1920s. By 1974, GRCA had introduced an optional, free shuttle-bus service to reduce the traffic congestion caused by nearly 3 million visitors entering the park annually.[8] By 1993, nearly 5 million visitors were entering the park, causing managers to reevaluate transportation to and along the South Rim of the Grand Canyon.[9]

In 1999, GRCA considered plans to combine the existing alternative-fuel buses with multi-use greenway trails and a light-rail system estimated to cost $150 million.[10] The proposed light rail would link parking lots outside the park's south entrance to transit stations at the Canyon View Information Plaza near Mather Point, and the Grand Canyon Village Transit Center. Day visitors would not be allowed to drive vehicles within the park and would be required to use the light rail, while overnight visitors would be allowed to park within the boundaries at either the lodges or the campgrounds, and then use the shuttle services to travel along the South Rim. A Record of Decision was created to prepare for the light-rail system to begin construction near the gateway community of Tusayan. It is important to note that inclusion of gateway communities is vital to transportation management practices within the NPS. For example, influences on travel to national parks can either positively or negatively impact the surrounding gateway communities that rely on tourism from national parks. Therefore, working cooperatively with local, state, and national organizations can help the National Park Service create a cohesive and efficient transportation system that addresses the park's needs and benefits the surrounding gateway communities.

For various reasons, including flat visitation levels between 1993 and 2000, rising estimated cost of the light-rail system, and political wrangling, Congress required the Secretary of the Interior to compare bus alternatives to the more expensive light rail before continuing with the project. After consideration of other options, the NPS decided to prepare a plan that was much less expensive than the light rail, and took into account the park's increased transportation needs and the needs of the outlying gateway communities. The plan included a voluntary shuttle-bus system for day visitors, a new parking facility at the Canyon View Information Plaza, a parking facility north of Tusayan, and more bus service between the two parking facilities. The increase in shuttle-bus services between these areas has proven to decreased traffic congestion in the South Rim of the canyon and has provided many visitors a convenient way of park outside GRCA to travel inside the park. GRCA has recently prepared a comprehensive visitor transportation plan, discussed below.

Existing Plans and Programs

GRCA South Rim Visitor Transportation Plan Environmental Assessment/Assessment of Effect. With funds from recreation-fee revenue, the park began transportation planning in accordance with the National Environmental Planning Act (NEPA). In February of 2008, the NPS and the Department of the Interior, in cooperation with the U.S. Department of Agriculture and the USFS, released the *South Rim Visitor Transportation Plan: Environmental Assessment/Assessment of Effect.* The report is a comprehensive study of the park's needs, including social and environmental impacts of traffic congestion within the park. The transportation plan establishes goals and objectives for transportation management until 2020. It also provides evidence that there is still a great need for management action to alleviate the environmental impacts of the high volume of visitors to the South Rim. For example, the NPS reported that in 2004, more than 4 million people visited the Grand Canyon, with more than 3 million entering through the South Entrance Station. Of those who visit the South Rim, approximately 75% traveled by private vehicle, 19% by tour bus, and only 6% by the Grand Canyon Railway.

Victoria Stenson, Landscape Architect and Project Manager at GRCA, says the park moved quickly to implement some parts of the plan to meet urgent needs. For example, GRCA visitors were experiencing long wait times to enter the park via the South Rim entrance. GRCA widened the road, installed a new kiosk, and added a traffic lane, mostly alleviating the problem. The park plans to establish transit service to the gateway community of Tusayan. GRCA ran a pilot transit program in 2008, conducting an onboard visitor survey to evaluate visitors' perspectives, and a series of focus groups to gauge stakeholder response. The results showed overwhelming positive response, and provided recommendations for improved facilities and tourist services in Tusayan. This example demonstrates the potential for successful comprehensive and integrated transportation planning.

Alternative Transportation Systems and Intelligent Transportation Systems. Alternative transportation systems (ATS) are an important trend in national park-transportation planning and management. Alternative transportation includes all modes of travel other than private vehicles: bicycles, busses, trains, trams, and walking. ATS integrates traditional modes (i.e., automobiles) and alternative modes (e.g., busses) to increase overall efficiency. To mitigate

social and environmental consequences of reliance on private automobiles as the primary means of visitor access, some parks, including GRCA, have implemented ATS in cooperation with the NPS Alternative Transportation Program. Other parks have adopted Intelligent Transportation Systems (ITS), which use technology to provide information to visitors, along with fleet management, automated vehicle location, and automated traffic management.[11] Many national park observers advocate replacing policies that accommodate or promote private-vehicle travel with policies that promote ATS and ITS. ATS and ITS are valuable, according to supporters, to protect natural resources and enhance visitors' experiences. Despite its potential advantages, however, alternative transportation remains controversial for some visitors and national park managers, especially if it is mandatory.[12]

Challenges and Opportunities

Enhancing Visitor Experience and Understanding Travel Behavior. As researchers, planners, and policy makers focus more on ATS and ITS, it is critical to understand how transportation systems affect park visitors' experience and behavior. For instance, recent research conducted in Yosemite National Park demonstrated that the national park transportation experience is multidimensional,[13] involving not only instrumental or functional elements, but also affective and experiential elements. The Yosemite research identified three dimensions of the transportation experience: freedom and access, environmental responsibility, and stress and conflict.

The Yosemite study also provides insight into how visitor experience differs when traveling by traditional or alternative transportation modes. Yosemite visitors more strongly associated freedom and access with private automobiles than with the park shuttle. Visitors valued their cars for many of the same utilitarian reasons that they value their cars when traveling around home and work: convenience, safety, ease of movement, and access. In addition to these instrumental factors, automobiles appeared to enhance subjective and affective experiences of freedom. However, visitors also agreed that traveling in the national park in their cars is associated with stress, parking difficulties, crowding, conflict, and delays. Visitors strongly associated the shuttle with affordability, connection with the natural environment, minimized environmental impact, and less congestion. Clearly, visitors see the connection between alternative transportation and stewardship of the park environment. It is likely that visitors consider tradeoffs among these dimensions when making travel-mode decisions in national parks.

It is also clear that national park visitors want choices. GRCA managers note that visitors want to choose whether to take alternative transportation or use their own vehicles. In park areas that are only accessible via transit, visitors want the service to use clean, low-emission technology, have frequent service, and be competitive with private vehicles in terms of convenience and access. This is consistent with findings from studies in other national parks, including Yosemite and Great Smoky Mountains National Park.[14]

Working With Gateway Communities. Yosemite has had a working history with its outlying gateway communities. For example, in 1992, Yosemite National Park formed the Yosemite Area Regional Transportation Strategy (YARTS) to explore alternative transportation that

would provide unlimited access to the park and reduce automobile congestion. The management members originally included the five counties that surround Yosemite in addition to: the NPS, the National Forest Service, the California Department of Transportation, the Federal Highway Administration, and the California Department of Tourism. The group's main objectives were to: increase transportation options for the public; reduce Yosemite's automobile dependency; help support local economies; and improve air quality within the park and its surrounding areas.[15] In 1999, two of the five surrounding counties, Madera and Tuolumne, resigned their positions on the YARTS management board. This display of protest mainly stemmed from fears that YARTS was the first step toward a ban on all private vehicles within the park.[16]

Visitation to Yosemite National Park is economically important to the surrounding gateway area's economy. The 4 million people traveling to Yosemite are estimated to pump $3 billion into the local economy, generating $300 million in retail, $2.7 billion in services,[17] and sustaining 7,625 jobs[18]. It is feared that restricting automobile access to Yosemite Valley would create negative economic impacts on the surrounding communities. It was decided that Yosemite should utilize voluntary shuttle service from the gateway communities. In May of 2000, YARTS began running regional transit buses. The YARTS buses serve three of the five outlying counties of Mariposa, Merced and Mono. Unfortunately, ridership on the YARTS buses has not been as successful as the free shuttle services within the park. More than 90% of visitors continue to arrive to the national park's Valley in private vehicles.[19]

Sustainable Financing and Integrated Planning for Park Transportation Systems. Financing and planning park transportation systems are a challenge in Arizona and around the country. At GRCA, ATS is currently financed by transportation fees from gate receipts. According to Jonathan Upchurch, who was for several years the National Park Foundation Transportation Scholar at GRCA, financing is a critical challenge for the NPS. Specifically, funds are needed to support a transportation system through its full "life cycle" of planning, design, construction, operation, management, and maintenance to address these current and future challenges.

Opportunities

Recent federal transportation bills provide evidence of commitment to solving transportation problems in national parks. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, the Transportation Equity Act for the 21st Century (TEA-21) of 1998, and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005 have encouraged a transportation planning framework within the NPS that integrates local, regional, and statewide transportation decision making.

TEA-21 required a comprehensive study of alternative-transportation needs in national parks and on other federal lands. The Federal Highway Administration and the Federal Transit Administration, in association with the NPS, BLM, and U.S. Fish and Wildlife Service, sponsored a study to examine the alternative-transportation needs within their sites.[20] To facilitate this process, the NPS initiated the Alternative Transportation Program (ATP) in 1998 to conduct research in the national parks. The study found that 118 of the 169 NPS

sites required some kind of alternative transportation system. In addition to conducting research, the ATP coordinates policies and projects that implement alternative transportation systems to and throughout national parks.[21]

The Department of the Interior signed a memorandum of understanding with the USDOT in 1997 to help develop a cooperative and integrated transportation-management system in the national parks. Several national parks were chosen for shuttle-bus demonstration projects, including Acadia, Grand Canyon, Golden Gate, and Yosemite. Different service strategies were considered for each park because each has complex transportation issues.

Transportation Systems in the Context of Visitor Use and User Capacity. National parks increasingly realize that to meet critical transportation needs, they must put transportation planning into the broader context of visitor use and user-capacity planning. User capacity refers to the types and levels of visitor use that can be accommodated while also sustaining resources and social conditions that complement the purpose of a park.[22] Addressing user capacity involves more than setting a maximum number of visitors. To determine user capacity, parks and protected areas are increasingly turning to indicator- and standards-based planning and management frameworks, such as visitor experience and resource protection. These frameworks require:

- Establishing desired conditions to provide a picture of the character and quality of the various settings in a park
- Choosing indicators—measurable variables used to track changes and assess progress relative to desired conditions
- Setting standards
- Determining the minimum acceptable conditions for each indicator
- Analyzing problems to identify and evaluate a range of management strategies

NPS planners and managers, along with university researchers and transportation consultants, have been developing indicators and standards to reflect the quality of visitors' transportation experiences in national parks.[23] These indicators can be integrated with other indicators of social and environmental conditions in a national park. Sample transportation-related indicators include travel time, visitors' perceptions of freedom and access, environmental responsibility, and stress and conflict. This approach proactively focuses on the *desired conditions* instead of reacting to changing conditions.

National parks and other protected areas provide individual, social, economic, and environmental benefits. Park transportation systems give visitors access to natural and cultural resources and support the economic vitality of local communities. Since the advent of automobile tourism, park transportation systems have primarily provided visitors access via private vehicles. In recent years, there has been a shift toward integrating transportation planning and management, and developing alternative and intelligent transportation systems. Grand Canyon National Park provides a case study that illustrates the opportunities and challenges of transportation in national parks. It is important to note, however, that there is a great diversity among NPS units. Therefore, each unit's transportation system requires

individual analysis to determine how it can support the desired social and ecological conditions for the park, enhancing visitor experience while protecting park resources.

List of Abbreviations Used

ATS	Alternative Transportation Systems	**OHV**	Off-highway Vehicle
BLM	Bureau of Land Management	**USDOT**	U.S. Department of Transportation
GRCA	Grand Canyon National Park	**USFS**	U.S. Forest Service
ITS	Intelligent Transportation Systems	**YARTS**	Yosemite Area Regional Transportation Strategy
NPS	National Park Service		

Dave D. White is Associate Professor in the School of Community Resources and Development at ASU. His research and teaching focus on human-environment interactions in national parks and other protected natural areas, and on science-policy interactions for environmental decision making. Dave is a science-policy research leader for the ASU Decision Center for a Desert City (DCDC), where he conducts research on DCDC as a "boundary organization" that links science and policy for water-management decision-making. Dave received his PhD from Virginia Tech.

Jessica F. Aquino is a Faculty Associate in the School of Community Resources and Development at Arizona State University. Her research interests are in tourism experience from the perspective of residents and tourists, and visitor experiences of museums, parks, and zoos. Jessica graduated from ASU with an undergraduate in Conservation Biology and a Masters in Recreation.

---

[1] Louter, D. *Windshield Wilderness: Cars, Roads, and Nature in Washington's National Parks*. University of Washington Press, Seattle, 2006.
Shaffer, M. S. *See America First: Tourism and National Identity, 1880-1940*. Smithsonian Institution Press, Washington, 2001.
[2] Barnett, G. Drive-by viewing - Visual consciousness and forest preservation in the automobile age. *Technology and Culture*, Vol. 45 No. 1, 2004, pp. 30-54.
[3] Havlick, D. G. *No Place Distant: Roads and Motorized Recreation on America's Public Lands*. Island Press, Washington, D.C., 2002.
[4] Dilsaver, L. M., and W. Wyckoff. Agency culture, cumulative causation and development in Glacier National Park, Montana. *Journal of Historical Geography*, Vol. 25, No. 1, 1999, pp. 75-92.
[5] White, D. D. An interpretive study of Yosemite National Park visitors' perspectives toward alternative transportation in Yosemite Valley. *Environmental Management*, Vol. 39, No. 1, 2007, pp. 50-62.
[6] White, D. D., and D. Myers. *Trails 2010: A Study of Arizona's Motorized and Non-Motorized Trail Users* Report for Arizona State Parks Board, Phoenix, AZ. Arizona State University, 2009.
[7] Pollack and Co. *Economic and Fiscal Impact of Annual Tourism in Sedona, Arizona*. www.visitsedona.com/files/misc/2006SedonaTourismImpact.pdf
[8] Turnbull, K. F. Transportation partnerships in the parks: Cooperative initiatives serve visitors, preserve the environment. *TR News*, July-August, , 2004, pp. 14-23.
[9] National Park Service. *South Rim Visitor Transportation Plan Environmental Assessment/Assessment of Effect*. National Park Service, U.S. Department of the Interior, December 2008. Available from http://www.nps.gov/grca/parkmgmt/trans.htm.
[10] Laube, M. M., and R. W. Stout. Grand Canyon National Park - Assessment of transportation alternatives. *Transit: Planning, Intermodal Facilities, Management, and Marketing*, Vol. 1735, 2000, pp. 59-69.
Shiftan, Y., D. Vary, and D. Geyer. Demand for park shuttle services - a stated-preference approach. *Journal of Transport Geography*, Vol. 14, No. 1, 2006, pp. 52-59.
[11] Daigle, J. J., and C. A. Zimmerman. The convergence of transportation, information technology, and visitor experience at Acadia National Park. *Journal of Travel Research*, Vol. 43, No. 2, 2004, pp. 151-160.
[12] Sims, C. B., D. G. Hodges, J. M. Fly, and B. Stephens. Modeling acceptance of a shuttle system in the Great Smoky Mountains National Park. *Journal of Park and Recreation Administration*, Vol. 23, No. 3, 2005, pp. 25-44.

[13] Youngs, Y. L., D. D. White, and J. A. Wodrich. Transportation systems as cultural landscapes in national parks: The case of Yosemite. *Society & Natural Resources*, Vol. 21, No. 9, 2008, pp. 797-811.
[14] See note 5.
[15] Dona, S. *Yosemite Access & Traffic Congestion*. Paper presented at the National parks: Transportation alternatives and advanced technology for the 21st century, Big Sky, MT, 1999.
[16] Nelson, B. W., and J. Tumlin. Yosemite Regional Transportation Strategy: Creating a public-private partnership. *Transportation Research Record*, Vol. 210, No. 1735, 2000, pp. 70-78.
[17] See note 15.
[18] Stynes, D. J., and Y. Sun. *Economic Impacts of National Park Visitor Spending on Gateway Communities: Systemwide Estimates for 2001*. National Park Service, 2003.
[19] NPS. *Yosemite National Park Visitor Study Summer 2005*. Moscow, Idaho, 2006.
[20] Turnbull, K. F. Transports to nature: Transportation strategies enhancing visitor experience of national parks. *TR News*, January-February, 2003, pp. 15-21.
[21] Daigle, J. J. Transportation research needs in national parks: A summary and exploration of future trends. *The George Wright Forum*, Vol. 25, No. 1, 2008, pp. 57-64. See note 12.
[22] Cahill, K. Making good decisions about visitor use and user capacity: A progress report from the field. In *George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites*, St. Paul, MN, 2007.
[23] White, D. D., J. F. Aquino, M. Budruk, and A. Golub. In review. Visitor experience and transportation systems in Yosemite National Park. *Journal of Travel Research*.

Chapter 8

HIGHWAY TRAVEL AND CONGESTION

Soyoung Ahn, Zuduo Zheng, and Sravani Vadlamani
Arizona State University, Civil, Environmental and Sustainable Engineering

Key Points

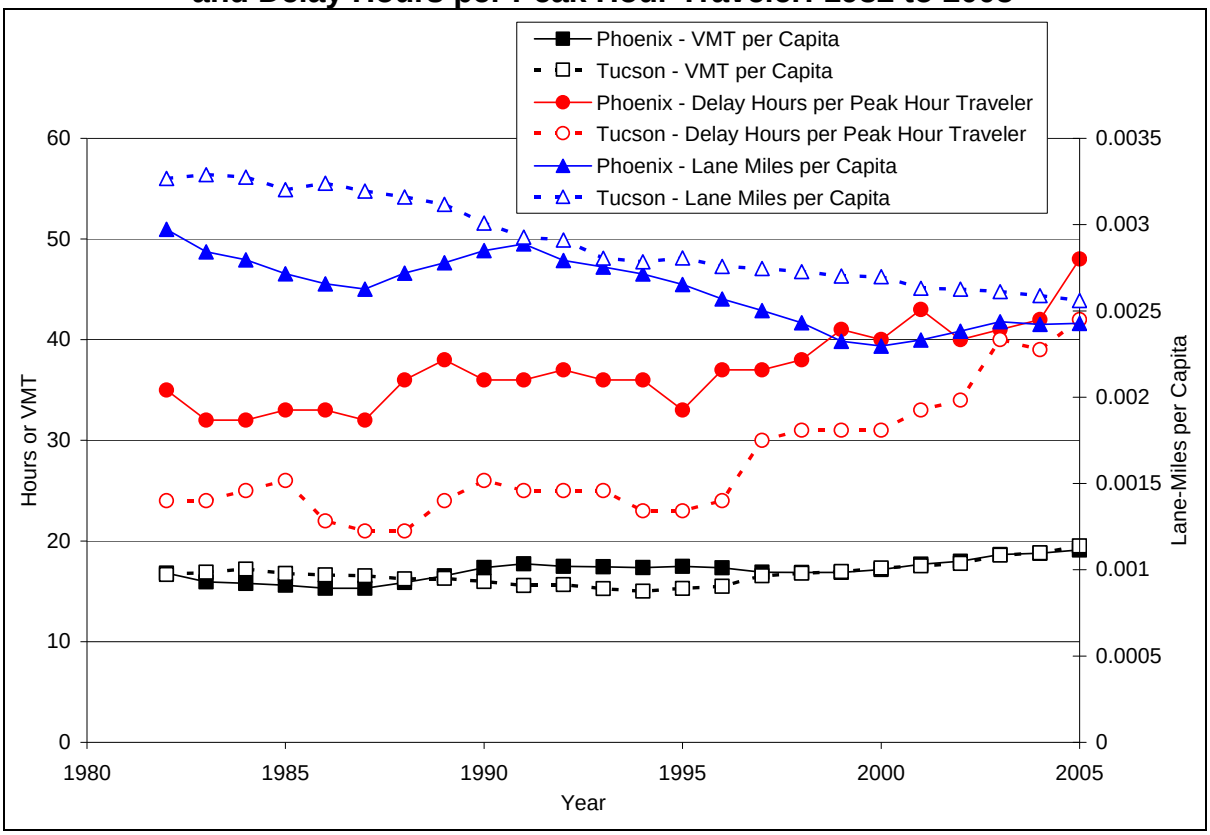
- In Phoenix and Tucson, vehicle miles of travel (VMT) have increased faster than lane miles, resulting in a steady increase in total travel delay.
- Recurrent bottlenecks and traffic incidents are major causes of congestion.
- Existing plans to cope with congestion include highway projects, freeway-management systems, incident-management systems, and advanced traveler-information systems based on rapid development of information and communication technologies.
- Challenges include promoting research to increase understanding of traffic congestion and travel behavior, and developing comprehensive strategies that tackle both supply and demand aspects of transportation while avoiding significant public opposition.
- A major initiative to relieve congestion was announced by the U.S. Department of Transportation (USDOT), which promotes solutions to balance supply and demand through various congestion-relief programs (e.g., congestion pricing), technological and operational improvements, public-private partnerships, and new strategic corridors for more efficient freight delivery.

Current Conditions

Traffic congestion is ubiquitous in modern urban society and has negative economic, environmental, and social impacts. According to the Urban Mobility Report released in 2007, Americans in 437 urban areas lost 4.2 billion hours and 2.9 billion gallons of fuel in 2005 just by sitting in traffic jams, resulting in $78 billion worth of delay and excess fuel costs.[1] With increasing population and projected growth in VMT, congestion-related problems will likely become more severe. In 2005, Phoenix was the 13th largest urban area in terms of population (3.3 million) and ranked 14th in terms of total annual delay, total excess fuel consumed, and total congestion cost.[2] Tucson ranked much lower (52nd) in terms of population in 2005. However, it ranked around 40th in terms of annual delay, excess fuel consumption, and congestion cost.[3] Not surprisingly, the Urban Mobility Report said that Tucson had “much higher congestion” in terms of total delay and delay per traveler, and “much faster growth” in terms of the delay per traveler as compared to other medium-sized urban areas (500,000-1 million in population). As in Phoenix, the increase in VMT was greater than the increase in lane miles.

Figure 8.1 shows VMT, lane-miles, and delay in Phoenix and Tucson on a per-capita basis. VMT per capita moved slowly but significantly upwards in Phoenix and Tucson through 2005, due to more automobile trips, longer trips, and less carpooling (see Fig. 1.4b in Ch. 1 for Arizona and U.S. trends through 2008). Meanwhile, per capita lane-miles decreased in both metro areas. Delay hours per peak-hour traveler (the net result of these two trends) rose 37% in Phoenix and 75% in Tucson from 1982 to 2005. Because the population of both regions has been increasing, the increase in VMT and delay-hours is even larger on an aggregate basis. Other aggregate congestion-related measures such as excess fuel consumption and congestion cost exhibit similar trends, especially since 1995.

Figure 8.1: Vehicle Miles Traveled and Lane-Miles per Capita, and Delay Hours per Peak Hour Traveler: 1982 to 2005



Source: Schrank, D. and T. Lomax. *2007 Urban Mobility Report*. Texas Transportation Institute, 2007.

Nevertheless, the Urban Mobility Report suggests that in comparison to the other largest 14 urban areas, Phoenix showed "lower congestion" in terms of delay per traveler, and "much lower congestion" in terms of total delay in 2005. Furthermore, the trends since1982 showed "much slower growth" in terms of both delay per traveler and total delay.

The Federal Highway Administration (FHWA) published a report in 2005 on traffic congestion and reliability.[4] The report breaks down the sources of total delay by cause. Bottlenecks are choke points on roadways where traffic exceeds roadway capacity. Queues develop at these bottlenecks and spread upstream against traffic flow, after which traffic conditions typically deteriorate. According to the FHWA report, 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 location, but some of the causes (e.g., bottlenecks and traffic incidents) are likely universal. Note that more than half of the congestion is non-recurrent in nature and thus, unpredictable.

Existing Plans and Programs

Supply-side measures to manage traffic congestion include expanding roadway capacity and improving roadway operation through applications of intelligent transportation systems (ITS), such as adaptive ramp-metering and traveler information. Measures to manage demand include policies that discourage use of single-occupant private automobiles during rush hours (e.g., congestion pricing and high-occupancy-vehicle [HOV] lanes), land-use planning for smart growth, and mass transit.

Highway Projects. According to its regional transportation plan, the Maricopa Association of Governments (MAG) will add 350 miles of new and improved freeways in the Phoenix metropolitan region in the next 20 years, to accommodate increasing travel demand.[5] Figure A-3.1 in Appendix 3 shows the current freeway network (in green) and planned construction (in red) over the next 20 years. The new freeways are designed to serve drivers on the western periphery of the metropolitan region, into which suburbs are expanding. Improved freeways will feature added lanes, HOV lanes, and new interchanges with arterial streets.

In a recent report to the State Transportation Board, ADOT recommended a transportation investment strategy with a budget of $42.6 billion.[6] Strategic highway projects were allocated 58% ($24.7 billion) of this budget. The recommended roadway investment in each county in Arizona is illustrated in Appendix 4. The plans for Maricopa, Pinal, and Yavapai Counties include potential public-private partnership (PPP) projects.

Freeway Management System. ADOT has implemented various intelligent transportation systems, which are made possible by rapid development in communication technologies.[7] A notable mitigation system is the freeway management system (FMS), designed to address the primary causes of congestion and to increase freeway efficiency. ADOT has implemented the FMS for nearly 100 miles of regional freeways, and plans to expand the system in the region. Objectives of the FMS are to mitigate congestion, enhance safety, and save fuel by deploying state-of-the-art technologies. The components of the FMS are:

- ***Traffic sensors*** such as inductive-loop detectors and passive-acoustic detectors are installed in each travel lane at one-third-mile spacing and provide vehicle-count, speed, and occupancy (a measure of traffic density) data. The data are used to detect incidents, measure freeway performance, provide traveler information, and enhance freeway operational capability.
- ***Communications systems*** connect central monitoring computers and field sensors, cameras, and variable message signs, enabling real-time data collection and traffic control.

- ***Closed-circuit television (CCTV) monitoring system*** cameras are installed on both sides of freeways at approximately one-mile intervals, and can tilt, pan, and zoom to provide continuous monitoring, including verification of traffic incidents.
- ***Variable-message sign*** **(VMS)** provide information to motorists. ADOT displays messages on VMSs to alert motorists to road construction, closures, traffic incidents, and real-time travel-time information (on certain corridors). The messages on the signs can be changed remotely. Signs are placed near freeway-to-freeway interchanges, about every two miles in urban areas, and at strategic locations with high accident rates, volume-to-capacity ratio, or diversion potential.
- ***Ramp metering*** systems regulate inflows from on-ramps to increase efficiency of the mainline freeway traffic and reduce overall delays. Early ramp-metering systems in the United States were pre-timed and designed to cope with typical traffic conditions derived from historical traffic information. Thanks to improved communication technology, this strategy is being replaced by an adaptive system that accounts for real-time traffic conditions measured by sensors on the freeways. The adaptive ramp-metering system is expected to perform better with daily fluctuations and non-recurrent freeway conditions.
- ***Traffic-interchange signals*** are placed at freeway interchanges with crossroads.
- ***The Traffic Operations Center (TOC)*** is a statewide facility designed to oversee the FMS and serve as the central control system. The TOC operates 24 hours a day, 365 days a year. Using central workstations and video displays, the operators monitor real-time traffic conditions and controls in the Phoenix metropolitan area.

Incident Management. Traffic incidents are a significant cause of traffic delays. It is imperative to detect, respond to any medical needs, and clear incidents as quickly as possible to minimize delays. One of the primary responsibilities of the ADOT TOC is to respond to traffic incidents on freeways and dispatch crews to manage and clear the incident sites.[8] Incidents are identified by the FMS or other reliable sources and confirmed by CCTV cameras. All incidents are logged automatically using the automated incident-logging system.

The Freeway Service Patrol (FSP)[9] is an incident-management program designed to assist motorists dealing with minor accidents or disabled vehicles. Its aim is to promptly clear minor incidents (or move them to the shoulder) to minimize their impact on traffic delay and safety. Service vehicles patrol highways and freeways in the Phoenix area to locate and help motorists with minor incidents. The program is coordinated by ADOT, MAG, the Arizona Department of Public Safety (DPS), and FHWA.

Advanced Traveler Information Systems. Freeway traffic conditions are unpredictable because of daily fluctuations and non-recurrent congestion due to incidents, bad weather, and road construction.[10] Although it is difficult to quantify the savings, there is consensus that real-time traffic information is valuable to motorists regardless of the actions motorists take as a result of the information provided. ADOT provides information via VMSs, Internet, and telephone about estimated travel time, traffic conditions (speed), incidents, and construction. Arizona is one of the first states to use a 511 telephone hotline to broadcast real-time traffic conditions. The system uses speech-recognition technology to interpret users' spoken

requests. The corresponding Internet site (az511.com) provides the same information as the telephone service, along with live-camera images. ADOT recently launched a program to provide real-time travel-time estimates through VMSs on several freeway corridors during morning and afternoon peak hours. Evaluation of this system is ongoing.

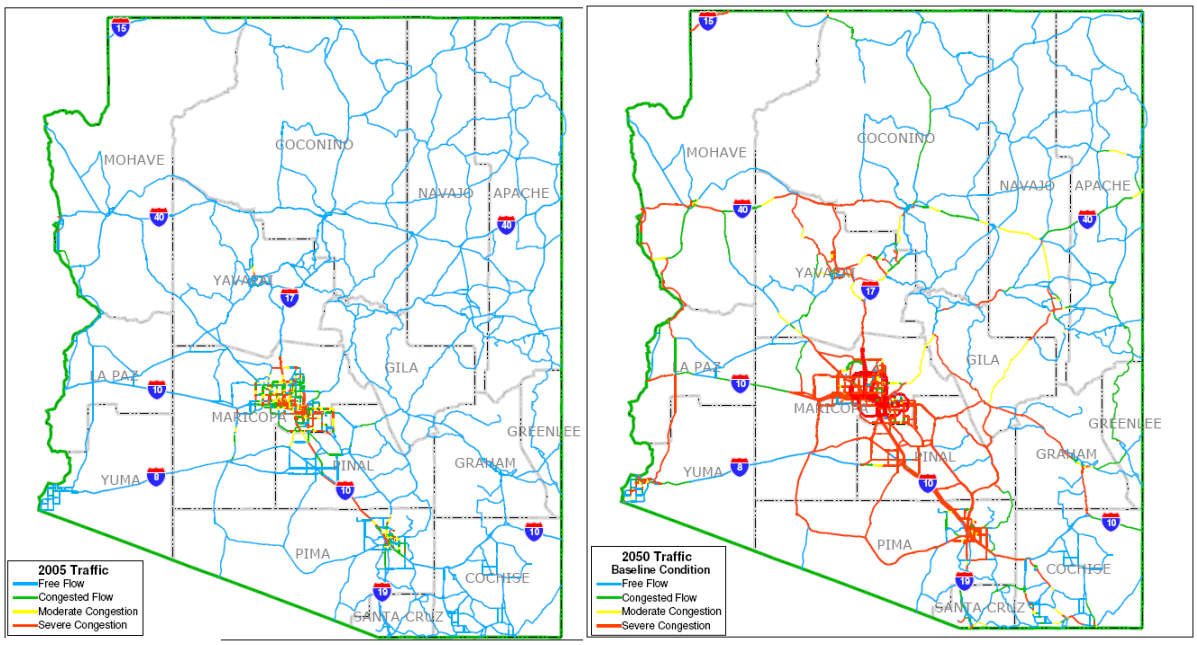
Challenges

For traffic-control strategies to be effective, they must be based on a comprehensive and accurate understanding of traffic behavior. Although we understand the basic mechanism of congestion, some aspects remain puzzling. The dynamics of traffic flow involve not only physical laws and characteristics, but also the psychological characteristics of individual drivers; thus, the dynamics are variable and random. It is important to continue to invest efforts in research on traffic dynamics and development of ways to deal with congestion.

As numerous reports and research suggest, congestion is a problem driven by supply and demand, as well as by other elements such as safety. Comprehensive strategies that tackle all major elements of congestion need to be developed to effectively manage congestion. Moreover, strategy implementation must be coordinated across different modes and agencies to maximize benefits. Arizona is certainly moving in this direction by fostering multi-modal planning and collaboration among agencies.

Managing congestion sometimes requires policies that the public views as draconian, or as imposing unfair charges for public facilities (like freeways) that have traditionally been free of charge. Public opposition is a significant challenge to some methods of congestion management. Even so, if nothing is done to manage demand, the future of the freeway system does not look bright. Figure 8.2 shows current congestion hot-spots alongside projected hot-spots in 2050 assuming that population growth and freeway expansion occur as

Figure 8.2: Current (2005) and Projected (2050) Traffic Conditions



Source: ADOT.

they are currently forecasted in 2008.[11] With no additional investments, technological advancements, multi-modal investments or land-use controls, it is evident that much of the system would not offer acceptable levels of service.

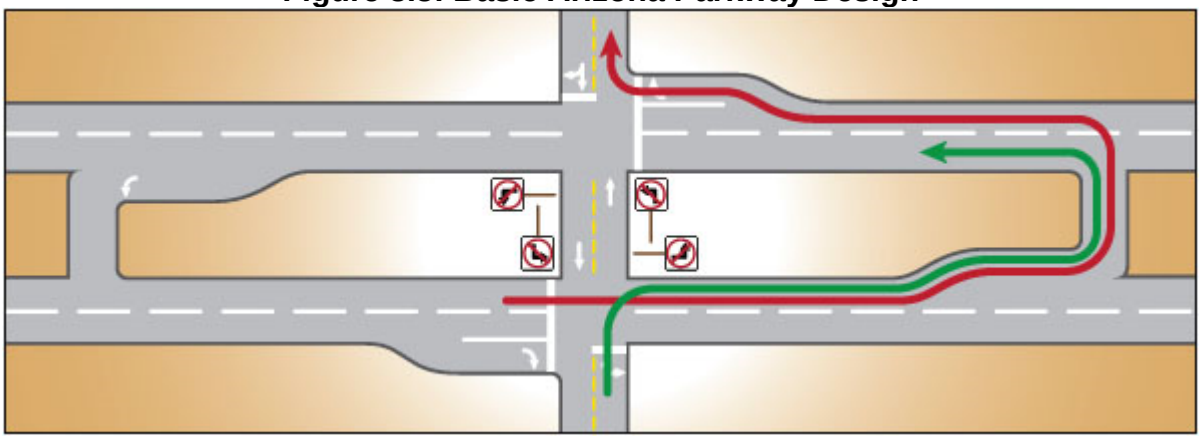
Opportunities

A process to address both supply and demand is articulated in the National Strategy to Reduce Congestion on America's Transportation Network (the Congestion Initiative), announced by the USDOT in May 2006.[12] It emphasizes mitigating congestion by managing both supply and demand:

- ***Congestion Relief Programs***. From an economic point of view, congestion results from an imbalance between supply and demand that arises when the true costs of using road facilities are different from the costs users pay. Costs paid by users do not include the marginal cost imposed on other users of the same facility, or the cost of externalities (e.g., pollution) imposed on non-users. Pricing strategies include tolls by time of day, express toll lanes (or HOT lanes), tolls based on congestion level, and area-wide charges. Congestion pricing has not been implemented in Arizona but is used elsewhere in the United States and in other countries. Although congestion pricing can generate direct revenue, it faces opposition. A recent attempt at instituting congestion pricing in New York City was met with support at the city level, but resistance at the state level, which eventually ended the proposition. Many people consider it double pricing since they already pay for vehicle registration, insurance, and fuel tax. Another criticism is that the system favors the rich, who can afford to pay the user fees. Nevertheless, because of successful implementation in foreign cities (e.g., Singapore, London) and increasing congestion levels, congestion pricing may well become an important strategy in the United States.
- ***Technological and Operational Improvements***. This supply-side component aims to improve management and operation of transportation facilities. It addresses both recurrent and non-recurrent congestion by providing accurate traveler information; improving traffic-incident management, mobility around work zones, and traffic-signal timing; and relieving traffic congestion at bottlenecks. Rapidly developing communication technologies contribute to these improvements.
- ***Public-Private Partnerships***. Under PPPs, private-sector entities are allowed to participate in financing and managing transportation projects. The USDOT fosters PPPs through innovative financing mechanisms and various initiatives to allow flexibility in project delivery.[13]
- ***Corridors of the Future***. In September 2007, USDOT announced six interstate routes to be multi-state corridors under an initiative to reduce congestion for freight delivery.[14] One of the main east-west routes, I-10, crosses Arizona. These projects are currently in the initial stages.
- ***Smart Growth***. New land-use initiatives in Arizona and around the country (see Ch. 3) offer opportunities to control congestion. These higher-density and mixed-use land-development paradigms can effectively bring populations closer to destinations, thereby reducing the frequency and length of automobile travel and improving the competitiveness of public transit and walking.

- ***Arizona Parkway***. New approaches to roadway design can improve efficiency and flow and increase capacity without needing to fully limit access such as with freeways. One example gaining stature in Arizona is known as the Arizona Parkway. By placing left turns away from the intersections, traffic flow at intersections is improved and the likelihood of collisions is lowered. Figure 8.3 shows a basic schematic of the design.[15]

Figure 8.3: Basic Arizona Parkway Design



Source: Building a Quality Arizona. www.bqaz.org/azparkway/index.asp

Technological enhancements can also provide great opportunities to improve transportation operations and manage demand and therefore congestion. The following technologies are state-of-the-practice and are applied in various aspects of transportation systems, especially congestion management.

- ***Global positioning system (GPS)*** is a global navigating satellite system that has been widely used in various transportation systems applications. GPS can trace vehicle location, time and velocity. Typical applications include vehicle tracking for commercial vehicles, vessels, transits, and maintenance vehicles for more efficient operations. GPS is also utilized for on-board navigation systems that provide route guidance to drivers, alert them of congestion or incidents ahead, and recommend alternative routes. GPS is also being used to collect traffic conditions (e.g., travel time) on freeways for various purposes including performance monitoring, congestion pricing and provision of travel information to users.
- ***Geographic information system (GIS)*** is another technology that has wide applications in transportation systems. GIS is "a collection of computer software, hardware, data, and personnel used to store, manipulate, analyze, and present geographically referenced information."[16] GIS is often integrated with GPS to provide users with traffic conditions, weather, road surface condition, construction and maintenance work, incidents, etc.
- ***Short-range wireless based communication technologies*** transfer information from vehicles to other vehicles or road side units. These technologies are used for purposes such as automatic vehicle identification, automatic sensing and classification of vehicles, which are often used in cordon pricing and mileage based pricing. Wireless LAN technologies are also used for information exchange. On

board units consist of data radios to exchange information and include dashboard display, GPS unit, antenna and mileage counters (for mileage based pricing as in Oregon) and zone differentiators (to differentiate vehicles based on geographic zones and time of day and week).

- ***Vision-based technology*** is used for vehicle detection, monitoring and enforcement. In many cities, vehicle detection using cameras and image processing techniques is replacing conventional detection systems (e.g., inductive loop detectors) for traffic signal operations. Cameras are also used in enforcement, such as tolls, red-light running, and speeding, in order to identify violators.
- ***Variable message signs*** provide travel information to the travelers en route. They use fiber optics and light emitting diodes (LEDs) to improve the readability of messages. They provide real time information on travel time, incidents, and work zones.[17]

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**ITS**	Intelligent Transportation Systems
CCTV	Closed Circuit Television	**MAG**	Maricopa Association of Governments
DPS	Department of Public Safety	**mpg**	Miles per gallon
FHWA	Federal Highway Administration	**PPP**	Public-Private Partnership
FMS	Freeway Management Systems	**TOC**	Traffic Operation Center
HOV	High Occupancy Vehicle	**USDOT**	U.S. Department of Transportation
HOT	High Occupancy Toll	**VMT**	Vehicle miles traveled

Soyoung Ahn is an Assistant Professor in Civil, Environmental, and Sustainable Engineering at ASU. She received her PhD (2005) from the University of California, Berkeley and was a Postdoctoral Research Associate in the Department of Civil and Environmental Engineering at Portland State University, Oregon. Her expertise is in traffic operations, ITS applications in transportation, congestion management, and traffic simulation. Her research has been published in international journals and presented at numerous academic institutions.

Zuduo Zheng and **Sravani Vadlamani** are graduate students in Civil, Environmental, and Sustainable Engineering at ASU.

---

[1] Schrank, D. and T. Lomax. *The 2007 Urban Mobility Report*. Texas Transportation Institute, 2007.
[2] See note 1.
[3] See note 1.
[4] Cambridge Systematics and Texas Transportation Institute. *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation*. FHWA, U.S. Department of Transportation, 2005.
[5] Maricopa Association of Governments. *Regional Transportation Plan: 2007 Update*. Maricopa Association of Governments, 2007.
[6] ADOT. *Statewide Transportation Investment Strategy*. azdot.gov/Statewide_Transportation_Investment_Strategy/PDF/Final_Report_061908.pdf. June 19, 2008. Accessed Dec 15, 2008.
[7] ADOT. *ADOT ITS*. az511.gov/Documents/adot_its.pdf. Accessed Dec 12, 2008.
[8] ADOT. *Incident Management*. az511.gov/Documents/incident_managment.pdf. Accessed Dec 12, 2008.
[9] Arizona Department of Public Safety. *Freeway Service*. www.azdps.gov/agency/highwaypatrol/freewayservice/default.asp. Accessed Dec 12, 2008.
[10] ADOT. *Motorist Information Systems*. az511.gov/Documents/motor_info_systems.pdf. Accessed Dec 12, 2008.
[11] ADOT. *Statewide Framework Study*, 2009. www.bqaz.org/.
[12] U.S. Department of Transportation. *National Strategy to Reduce Congestion on America's Transportation Network*. U.S. Department of Transportation, May 2006.

[13] U.S. Federal Highways Administration. *Public-Private Partnerships*. www.fhwa.dot.gov/PPP/. Accessed Mar. 4, 2009.
[14] U.S. Department of Transportation. *National Strategy to Reduce Congestion: Corridors of the Future.* www.corridors.dot.gov/index.htm. Accessed Dec 12, 2008.
[15] *Building a Quality Arizona*. 2009. www.bqaz.org/.
[16] Federal Highway Administration. *GIS in Transportation*. www.gis.fhwa.dot.gov/.
[17] California Center for Innovative Transportation. *ITS Decision: Services and Technologies*. www.calccit.org/itsdecision/serv_and_tech/Traveler_information/Enroute/vms_summary.html.

Chapter 9

PUBLIC TRANSIT

Mark Hickman
University of Arizona, Department of Civil Engineering and Engineering Mechanics

Key Points

- Arizona offers a variety of public transit services in both urbanized and rural areas.
- Phoenix and Tucson are planning and implementing new services, including rail, express bus, and bus rapid transit, to attract automobile users to public transit.
- Land-use planning is improving in ways that support transit ridership in the Phoenix and Tucson metropolitan areas.
- Finding reliable, consistent sources of operating funds remains a challenge for urban areas, particularly Tucson, and for smaller cities and rural areas. Additional sources of funding are needed, as is more consistent funding from existing sources.

Current Conditions

Public transit plays an important role in meeting the mobility and access needs of the general public, and helps meet urban and rural goals for economic development, land use, air quality, energy efficiency, and reducing greenhouse-gas emissions.[1] Energy constraints, rising prices, and global climate issues (see Ch. 1 and Ch. 2) will make public transit even more important in the future. Public transit is viewed as an important and desirable service worthy of public financial support in most of the United States (see Ch. 3 for the importance of public transit in Arizona's metropolitan areas). The need for public-transit funding is heightened by the many government policies—primarily federal, but also state and local—that subsidize and provide economic incentives for automobile use.[2,3]

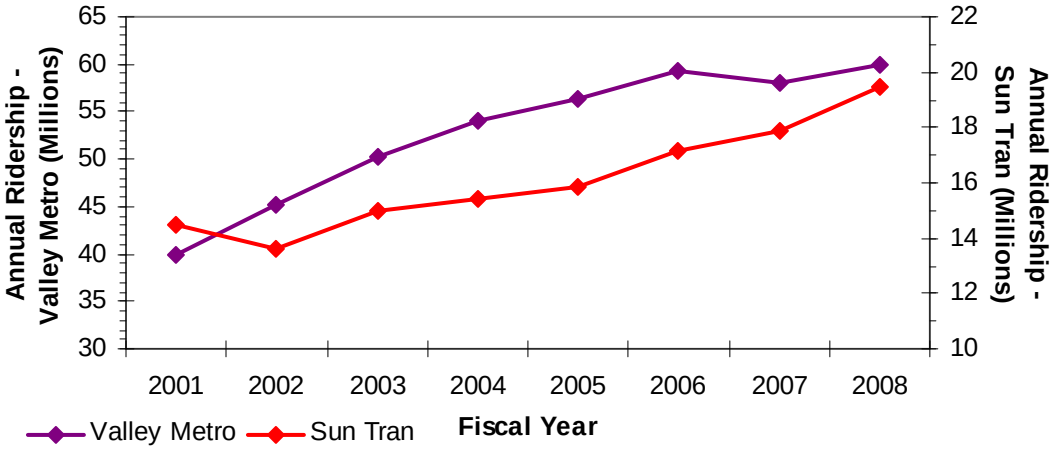
Service Types and Performance. Public transit service in Arizona is of two types: scheduled, fixed-route bus (and now light rail), and paratransit that is provided in response to specific requests for service. In this chapter, we define public transit as a mobility service provided to the general public that is owned and operated by the public sector, or under contract to the public sector. In general, the phrase "mass transit" is also used to describe public transit, but more commonly "mass transit" describes fixed-route bus and rail service.

Public transit in Arizona is local or regional, with minimal service between cities and towns. (For intercity issues, see Ch. 12.) In the Phoenix area, the Regional Public Transit Authority (RPTA), also known as Valley Metro, coordinates public transit service among several major cities and towns. In Tucson, the primary public transit service is offered by Sun Tran, organized by the City of Tucson. In other urbanized areas with more than 50,000 people (Avondale, Flagstaff, Prescott, and Yuma), and in non-urbanized parts of the state, the municipal government manages and operates the public transit service.

The number of transit riders in Arizona has grown considerably since 2000 because of population growth and demographics, rising gasoline prices, and expansion of transit services. Figure 9.1 shows the fixed-route ridership for the Phoenix and Tucson metropolitan areas since 2001. In Phoenix, only about 2% of the total commuting trips use mass transit; in Tucson, the percentage is only slightly higher at 2.5%. Both are considerably below the national average of 4.6%. Rural transit ridership (FY 2007) is estimated to be approximately 1.4 million rides per year, out of a total rural population of about 1.5 million persons, giving an average ridership of just under one trip per person per year in these rural areas.[4]

In Phoenix and Tucson, transit agencies have been successful at increasing ridership. But the largest groups of users are lower income, and often cannot travel by automobile. In Phoenix, most transit riders are lower income: in a 2006 survey, about 66% of passengers had household incomes under $30,000.[5] In Tucson, a 2004 survey found that over 65% of passengers had household incomes under $30,000.[6] About 53% of passengers in Phoenix and 46% of passengers in Tucson had no working vehicle in their household.[2,3] Taking into account riders who may have a car in the household but do not have daily access to it, the percentages rise to 78% of Phoenix passengers and 80% of Tucson passengers who do not have an automobile as an alternative to public transit.[2,3]

Figure 9.1: Annual Ridership for Valley Metro and Sun Tran



Sources: Annual reports for each transit agency

There are different ways to measure the performance of transit operators in the state. A common set of measures includes operating cost per mile traveled in revenue service (so-called "revenue miles"), and operating cost per passenger carried, both of which measure the cost-effectiveness of service. Recent (2007) data from Valley Metro and Sun Tran is shown in Table 9.1.[7] While these costs may seem high, they are typical of public transit agencies in the United States.

Table 9.1: Selected Transit Performance Measures, 2007

Performance Measure	Valley Metro	Sun Tran
Operating cost per revenue mile, Fixed-route bus service	$6.51	$6.12
Operating cost per passenger, Fixed-route bus service	$2.37	$2.43
Operating cost per passenger, Paratransit	$35.33	$29.36

Source: National Transit Database (2007).

Funding. Virtually all public transit services in the United States depend on public subsidies. Fares cover only a small fraction of the total cost of service; remaining costs are covered by various public sources. Fares cover approximately 28% of the total operating cost (excluding capital costs) for Valley Metro and 18% for Sun Tran.

Funding for public transit service is usually broken into separate categories for operating and capital expenses. In Arizona, funding comes from several sources; some specifically fund either operating or capital expenses, while others are flexible about how the funding can be used. Funding sources include the U.S. Department of Transportation (USDOT), the Federal Transit Administration (FTA, within USDOT), various state funds, and local taxes and general revenues.

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). The amount of funding is determined through a federal formula allocation. If the urban area has a population over 200,000, the FTA provides funding only for capital expenses, at a ratio of up to 80% federal share to 20% local or state match. Thus, the Phoenix and Tucson metropolitan areas are ineligible for federal funds for operations. Valley Metro received approximately $43.1 million in capital funding from Section 5307 funds in FY 2008, and Sun Tran received about $10.6 million. The FTA funds both operations (up to 50% federal share) and capital expenses (80% federal share) for urban areas with populations between 50,000 and 200,000; this amounted to about $3.4 million split between Avondale, Flagstaff, Prescott, and Yuma in FY 2008.

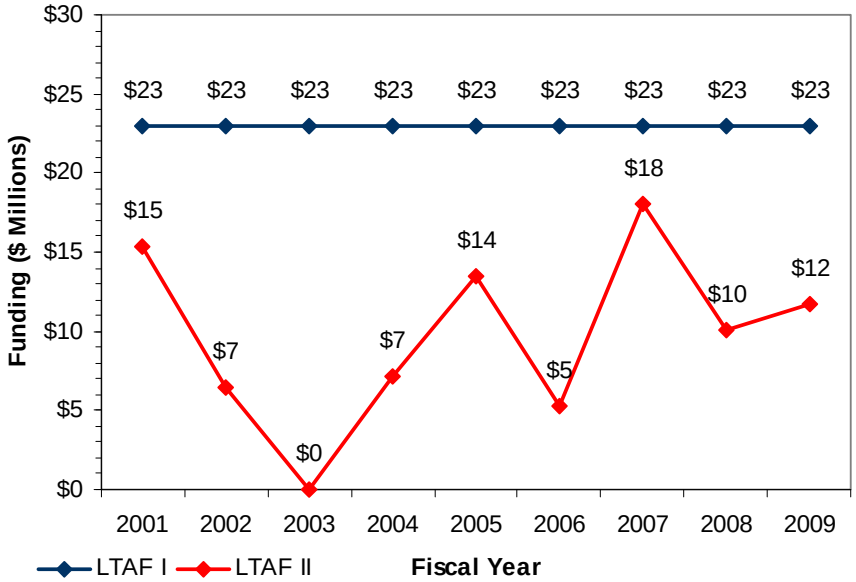
The FTA provides Section 5311 funds directly to the state for distribution (as a pass-through) to areas with fewer than 50,000 people, to cover capital (80% federal share) and operating expenses (up to 50% federal share) of public transit. Arizona received $8.9 million in Section 5311 fund for FY 2008. Paratransit services are also funded by the FTA with Section 5310 funds for the elderly and disabled, which can be used to cover capital expenses for vehicles and facilities. FY 2008 funding for Arizona from the FTA 5310 program was $2.3 million.

The FTA also has discretionary grants for large capital projects. Valley Metro recently began service on its initial phase of light rail; the total capital expenses of $1.4 billion were covered by 46% federal funds and 54% local and state matching funds. Federal dollars included $587 million from a "New Starts" grant, and $59 million from another USDOT program, Congestion Mitigation and Air Quality. Valley Metro used the Phoenix regional, half-cent sales tax for transportation to provide the local match for light rail. The City of Tucson is currently developing a modern streetcar system. The system will presumably be funded at the 50% level by the FTA (up to $75 million), with the local match provided by the half-cent sales tax for the Regional Transportation Authority in Pima County.

The primary source of public transit funding from the State of Arizona is the Local Transportation Assistance Fund (LTAF). There are 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. LTAF I, capped at

$23 million per year, is managed by the Arizona State Treasurer's Office and distributed to municipalities for transportation services based on population. LTAF II is managed by the Arizona Department of Transportation (ADOT) and distributed to Valley Metro, MPOs, and other municipalities according to a formula. The amount of funding distributed under LTAF II has varied considerably over the years, with rescissions by the Arizona State Legislature during budget negotiations. Total distributions for LTAF I and II since FY 2001 are shown in Figure 9.2.

Figure 9.2: State Funding through LTAF Distributions



Source: Annual reports, Arizona Department of Transportation

Public transit funding sources also vary at the local level. In metropolitan Phoenix, many local expenses for Valley Metro are covered by the Public Transportation Fund (PTF), an account within the half-cent sales tax (most recently, Proposition 400) approved by voters. This coverage amounted to approximately $129 million in FY 20008. Additional expenses are covered by general revenues and LTAF II funds from municipalities in the region. For Sun Tran, most of the operating and capital expenses are covered by City of Tucson general revenues. These provided $33.8 million for fixed-route operations, and $13.1 million paratransit services (Van Tran) in FY 2008. In 2006, a Regional Transportation Authority (RTA) was established for the Tucson metropolitan region. It is funded by a half-cent sales tax and supports a number of new services. In other municipalities, public transit service depends on federal and state funding, with supplements from a combination of general revenues and other taxes (e.g., sales or excise taxes).

Existing Plans and Programs

A number of major initiatives that have been made possible through the 20-year extension of the half-cent sales tax (through the PTF) in the Phoenix metropolitan area, including:

- Inauguration of the 20-mile light-rail service in December 2008
- Continued planning of light rail line extensions, including up to six that may be in place by 2025[8]
- Continued development of Bus Rapid Transit (BRT) on both freeways and arterials
- Service expansion for paratransit services
- New fixed-route bus services, route extensions, and extended service hours on existing bus routes
- Considerable expansion of dial-a-ride (paratransit) service

For the Tucson metropolitan region, RTA funding makes the following expansions of transit service possible:

- Development of a "modern streetcar" system (like light rail but with slightly smaller and lighter cars), pending approval of the 2008 Final Environmental Assessment
- Expanded routes, extended service hours on evenings and weekends, new express-bus services and neighborhood-circulator service, and new park-and-ride centers
- Expanded Van Tran paratransit service to meet anticipated growth in demand

Major state initiatives led by ADOT include:

- *Arizona Rides*, a program to coordinate public transit service with other human-services transportation across the state
- *Regional Transit Connector Service*, a pilot program to initiate inter-city service from rural communities to urban areas

Challenges

Major Urban Areas. Phoenix and Tucson appear to be making steady progress with transit. Both cities have been successful in initiating major capital projects (light rail and modern streetcar), and in procuring federal funding. Phoenix has already established light-rail service and is planning its expansion. Both metropolitan areas recently passed sales-tax measures to support continuing operations and service expansion.

Yet both cities struggle to attract automobile travelers to public transit. New options like the light rail in Phoenix, a modern-streetcar system in Tucson, express-bus services, and BRT (a bus service that includes limited stops, dedicated right-of-way, signal priority, and advanced fare media) make transit more attractive. But because these are either recent or pending improvements, there is still uncertainty about how effective they will be. Some newer express bus services in Phoenix have been successful in attracting new riders.

A second challenge is planning land use to support transit ridership. Generally, high population density and mixed land uses make trips shorter and thus increase use of public transit, bicycling, and walking, which presents a challenge for Phoenix and Tucson. Phoenix has developed an "Interim Transit-Oriented Zoning Overlay District" as part of its zoning code. Tucson lacks similar transit-oriented zoning, but does have standards for pedestrian-

and transit-friendly development, particularly for downtown infill projects. Both regions have limited experience with these kinds of land-use regulations.

Another major challenge is finding stable and growing sources of operating funds. Both Phoenix and Tucson have cut services in FY 2009 because of insufficient funding. Valley Metro's service cuts are largely due to a drop in sales-tax revenue to the PTF. In Tucson, service cuts are due to a decrease in the city's general revenue funds (primarily those from property taxes).

Federal law prevents both cities from receiving operating assistance through FTA Section 5307 formula funding. Therefore, these two urban areas must rely much more on the fare box, and on state and local funding sources. The PTF in Phoenix is a good model for public funding, with a fairly stable income from sales taxes. In difficult economic times such as the current recession, however, such funding may decrease, necessitating service cuts. Futhermore, sales taxes are not directly tied to transportation activities and can be regressive, burdening lower-income households much more than those with higher incomes (see Ch. 18). Tucson has no dedicated local funding for transit service. Since 2006, service expansion has been paid for by the RTA's regional sales tax, but existing service has not. Sales-tax revenues have decreased in the economic downturn, and are indirect and regressive. Even with stimulus monies coming to Arizona for public transit, this operating shortfall could lead to a sad irony: stimulus monies are to be used strictly for capital expenses, which generally include system expansion and vehicle purchases. New construction could begin while services are being cut due to operating fund shortfalls.

Services for the Elderly and Disabled. Paratransit services for the elderly and disabled face challenges across the state (see Ch. 15). Service is costly, averaging over $30 per trip. FTA Section 5310 funds have been a steady, though inadequate, source of support for these services. LTAF and municipality general revenues can complement the federal funds, but as Arizona's population ages, demand for these services will increase and other sources of funding may be required. In particular, social-services funding may become available for paratransit service. Greater oversight by public officials, in the form of performance monitoring and management, may be necessary. Establishing quantitative measures of performance success might make decisions more effective, objective, and transparent.

Rural Transit Needs. A recent report commissioned by ADOT[9] analyzed the public transit needs in rural parts of the state. In 2007, about 1.4 million transit trips were taken in rural Arizona. The study also estimated that the total *demand* for service in rural Arizona is over 7.8 million trips per year, meaning that only about 18% of the total demand is being met. Rural transit service costs about $12.1 million annually for operation and $19.9 million for capital investments (vehicles and facilities). These expenses are covered primarily by Section 5311 funds ($8.9 million in FY 2008) and LTAF funding. Rural transit service is clearly expensive, averaging over $8.50 per trip in operating costs. But with population growth and demographic shifts in rural parts of the state, demand could grow significantly, requiring new sources of funding. Rural transit areas require more cost-effective and innovative service concepts to meet travel demands.

Reliability of Financing. All of the above challenges imply a need for increased funding. Historically, LTAF II has been an unstable, unpredictable funding source, creating significant problems for transit agencies, particularly those outside the Phoenix and Tucson metropolitan areas. A recent nationwide analysis of federal and state funding for public transit shows that funding in Arizona is highly volatile.[10] Arizona ranked fifth highest among 50 states in terms of *variability* of state funding, and second highest among states in variability of federal funding from year to year. Local sources of funding can also be volatile.

Opportunities

Service Development. 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:

- Expand services, particularly by procuring federal funds for urban-rail projects, for commuter-rail studies, and for BRT implementation. These services provide both the challenge and the opportunity to attract new riders away from automobile use.
- Encourage innovative services, such as flexible routing, route deviation, integrated paratransit and fixed-route services, and freeway and arterial BRT services.
- Implement land-use and development policies, such as transit-oriented development zoning, that support increased use public transit and of alternative transportation modes.
- Coordinate transit service with human-services transportation, by monitoring the *Arizona Rides* program and encouraging more communication and coordination among transit providers and human-services organizations.

Funding. A recent report completed for the Arizona Transportation Research Center[11] suggests adding dedicated funding for public transit, perhaps through: (1) development-impact fees; (2) rental-car taxes; (3) vehicle-registration fees; (4) increased fuel taxes; and, (5) increased sales taxes. Each of these sources has advantages and disadvantages in terms of the amount of funding available, stability of funding over time, directness of the connection between the source of funds and public transit, and different impacts on different income groups and geographic areas (urban vs. rural). Nonetheless, these kinds of funding are common for public transit. Opportunities exist to improve the financial situation of public transit in Arizona:

- Make sure that Arizona transit agencies apply for federal funds, and ensure that funds allocated to Arizona are distributed in full to agencies and municipalities.
- Support initiatives to increase local, regional, and statewide funding for public transit.
- Continue to allow state and local transit funding to be used for any combination of operating, capital, and planning expenses.
- Consider allowing statewide Highway User Revenue Fund (HURF) monies (from gasoline taxes) to be used for public transit purposes (currently restricted by state legislation). Nineteen of the five states currently allow this.
- Consider performance measures and related criteria to improve management (and perhaps funding-allocation decisions) of rural and paratransit services.

List of Abbreviations Used

BRT	Bus Rapid Transit	**PTF**	Public Transportation Fund (Phoenix)
FTA	Federal Transit Administration	**RPTA**	Regional Public Transit Authority (metro Phoenix)
HURF	Highway Users Revenue Fund	**RTA**	Regional Transportation Authority (metro Tucson)
LTAF	Local Transportation Assistance Fund	**USDOT**	U.S. Department of Transportation
MPO	Metropolitan Planning Organization		

Mark Hickman is an associate professor in transportation engineering in the Department of Civil Engineering and Engineering Mechanics at the University of Arizona. Dr. Hickman has taught courses and conducted research on public transit planning and operations, transportation planning, and traffic engineering. He also conducts research on the application of remote sensing technology in transportation.

---

[1] American Public Transportation Association. *2008 Public Transportation Fact Book*. www.apta.com/research/stats/.
[2] Beimborn, E., and R. Puentes. *Highways and Transit: Leveling the Playing Field in Federal Transportation Policy.* Brookings Institution, Washington, D.C., 2003.
[3] Charles River Associates. *Building Transit Ridership: An Exploration of Transit's Market Share and the Public Policies that Influence It.* Transportation Research Board: Transit Cooperative Research Program, Report 27, 1997.
[4] Cambridge Systematics, Inc. and TranSystems Corporation. *Arizona Rural Transit Needs Study*. Final Report, May 2008.
[5] WestGroup Research Answers. *Rider Satisfaction Survey: Total Market 2006*. Prepared for Valley Metro, Fall 2006.
[6] S.R. Beard & Associates, Inc., Hexagon Transportation Consultants, Inc., and Texas Transportation Institute *Tucson Transit On Board Origin And Destination Survey, Conducted October 2004*. Final Report, May 2005.
[7] National Transit Database Agency Profiles. *FY 2007.* www.ntdprogram.gov/ntdprogram/archives.htm Accessed Jan. 2, 2009.
[8] *Valley Metro, Metro Light Rail Future Extensions*. www.valleymetro.org/metro_light_rail/future_extensions/. Accessed Jan. 2, 2009.
[9] See note 4.
[10] ICF International. *Comparative Review and Analysis of State Transit Funding Programs.* National Cooperative Highway Research Program (NCHRP) Report 569, Transportation Research Board, 2006.
[11] Ernzen, K., and J. Ernzen. *Developing a Stabilized Public Transportation Revenue Source*. ADOT, Arizona Transportation Research Center Report No. 620, January 2007.

Chapter 10

NON-MOTORIZED TRANSPORTATION

Ram M. Pendyala, Karthik Konduri, and Joseph Plotz
Arizona State University
Department of Civil, Environmental, and Sustainable Engineering

Key Points

- Nationally, bicycling and walking make up a very small share of total travel, on the order of a few percent each.
- Major cities in Arizona are among the top 50 for walking and cycling in the nation.
- Safety is a key issue in improving conditions for cyclists in Arizona—among the 50 states, it ranks fifth most dangerous for pedestrians, and eighth most dangerous for cyclists.
- Many jurisdictions in Arizona have created bicycle and pedestrian plans that help to guide investments.
- Land-use and roadway planning, which remain highly automobile-centric, present barriers to improvements to non-motorized travel.
- Non-motorized transportation modes (NMT) remains a low priority in transportation financing and NMT plans are slow to be implemented.

Current Conditions

Non-motorized transportation modes (NMT) such as bicycling and walking 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 societies. NMT is considered "sustainable" because it consumes relatively little fossil fuels, emits relatively few greenhouse gases (GHG), promotes healthy and active living, and fosters a sense of connectivity and community. There is great interest in the United States in promoting bicycle- and walking-friendly communities, a.k.a., 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.

National Trends. The 2005 American Community Survey (ACS) conducted by the U.S. Census Bureau provides information about the transportation mode used between home and work for the more than 133 million U.S. workers (Table 10.1).[1] Walking accounts for about 2.5% of the mode share and bicycling for just under 0.5%. Males and females choose walking about equally, but three times more males bicycle to work. Using transit and working at home both have greater mode share than the two non-motorized modes combined. Also, the number of "hybrid" electric-powered bikes is growing, though they will not be treated specifically in this chapter.

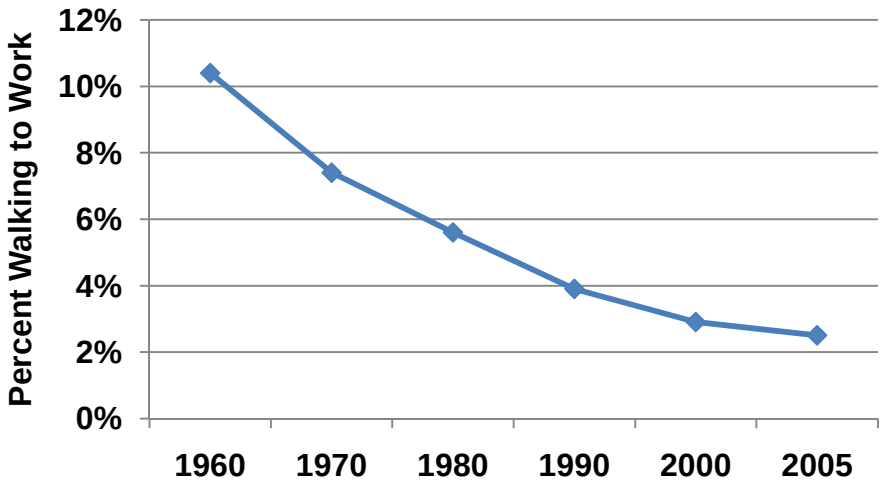
Table 10.1: Mode Share for the Journey to Work in the United States (2005)

Mode Type	All Workers	Male	Female
Number of Workers	133,091,043	72,059,758	61,031,285
Drive Alone	77.0%	76.7%	77.3%
Carpool	10.7%	11.1%	10.1%
Transit	4.7%	4.2%	5.1%
Bicycle	0.4%	0.6%	0.2%
Walk	2.5%	2.5%	2.4%
Work at Home	3.6%	3.3%	3.9%

Source: U.S. Census Bureau (2005).

In the United States, the percentage of people who walk to work has declined steadily over the past 50 years. In 1960, more than 10% of workers walked to work. By 1990, this percentage had dropped to just under 4%, and to 2.5% in 2005.

Figure 10.1: Trend in Share of Workers Walking to Work



Source: U.S. Census Bureau, 2007

Walking to work has declined for several reasons. The most notable reason is probably the dominance of low-density, automobile-oriented development patterns (i.e., sprawl) in virtually all U.S. cities over the past 50 years. Zoning regulations, excellent highway access, increasing 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. Combined with increasingly complex travel patterns that include taking children to and from school and other activities and running errands on the way to and from work, the decline of walking as a means of transportation is not surprising. Even among children, the walk mode share has fallen considerably over the past few decades; with greater separation between home and school, and concerns about safety and security, children are increasingly being chauffeured to and from school and other activities.[2]

Non-Motorized Travel Characteristics: A Focus on Arizona. Comparing journey-to-work mode choice across U.S. cities sheds additional light on NMT usage. Table 10.2 shows the

percentage of people walking or bicycling to work in the 12 cities with highest use of NMT. It also includes the position and ranking of Arizona's three most populous cities.

Tucson ranks fourth among all cities in percent of workers bicycling to work. Mesa and Phoenix rank 16th and 22nd, respectively, but less than 1% of all workers bicycle to work. Arizona cities do not fare nearly as well on walking. Tucson is ranked 18th, while Mesa and Phoenix are ranked 25th and 42nd, respectively. Nevertheless, the inclusion of these three cities in the top 50 with respect to bicycling and walking to work is quite encouraging, and bodes well for the future of NMT mode use in the state.

Table 10.2: Percent of Workers Bicycling and Walking to Work (2005)

City	Workers	% Bike	City	Workers	% Walk
1. Portland, OR	257,510	3.5	1. Boston, MA	253,201	12.5
2. Minneapolis, MN	189,294	2.4	2. Washington, DC	249,865	10.0
3. Seattle, WA	301,704	2.3	3. San Francisco, CA	381,922	9.6
4. Tucson, AZ	**233,526**	2.2	4. New York, NY	3,429,194	9.4
5. San Francisco, CA	381,922	1.8	5. Philadelphia, PA	537,233	8.1
6. Sacramento, CA	188,563	1.7	6. Honolulu, HI	173,656	6.9
7. Washington, DC	249,865	1.5	7. Seattle, WA	301,704	6.9
8. Oakland, CA	164,169	1.4	8. Minneapolis, MN	189,294	5.8
9. Honolulu, HI	173,656	1.4	9. Chicago, IL	1,162,550	5.5
10. Denver, CO	270,025	1.4	10. Baltimore, MD	254,908	5.4
11. Austin, TX	354,416	1.3	11. Denver, CO	270,025	4.8
12. New Orleans, LA	177,351	1.0	12. Portland, OR	257,510	4.3
16. Mesa, AZ	**196,731**	**0.8**	**18. Tucson, AZ**	**233,526**	**3.1**
22. Phoenix, AZ	**662,242**	**0.6**	**25. Mesa, AZ**	**196,731**	**2.1**
			42. Phoenix, AZ	**662,242**	**1.6**

Source: U.S. Bureau of the Census (2005).

According to the 2001 National Household Travel Survey (NHTS) conducted by the U.S. Department of Transportation (USDOT), 8.3% of all non-work-related trips are on foot and 0.6% are by bicycle in the Phoenix-Mesa Metropolitan Statistical Area (MSA).[3] The survey subsample of people aged 16 years and over in the Phoenix-Mesa area indicated that walking and bicycling were predominantly for social and recreational purposes. Among all bicycle trips reported by survey participants, about 70% were home-based, social-recreation trips, with the remainder reported as "home-based other" trips (those that either begin or end at home.). One-quarter of the walking trips were not home-based trips (neither end of the trip was the home location), and about 15% were home-based shopping trips. Nearly one-quarter of all home-based, social-recreational trips were reported as using NMT, with walking accounting for about 22% of these trips and bicycling for the remaining 3%.

Clearly, NMT constitutes a small portion of overall trip making. It comprises only about 8.5% of all travel undertaken by those aged 16 years and over in the Phoenix-Mesa MSA. In fact, 80% of the NHTS respondents in this area reported that they did not make even a single trip by NMT on the day for which they reported all of their trip-making. Since NMT provides a limited range of mobility compared to motorized transportation modes, it is no surprise that NMT modes account for a small fraction of total travel, particularly in locations characterized by dispersed-land-use development patterns. Due to the slow nature of NMT, their average trip durations are a few minutes longer than those of the auto mode. While the

average trip duration for the auto mode is about 18 minutes, the corresponding values for walk and bicycle trips are 20 and 22 minutes, respectively. This is an important consideration when planning NMT transportation facilities: people using NMT modes travel shorter distances, but are exposed to weather, traffic, and the environment for about the same amount of time as an average automobile trip lasts.

Pedestrian and Bicycle Safety. Safety and security are two major issues associated with NMT. Safety is related to the traffic conflicts and crash occurrences associated with a mode of transportation. 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. Travelers tend to avoid using modes of transportation in which they are more vulnerable to criminal acts. 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. The National Highway Traffic Safety Administration (NHTSA) has published several reports on pedestrian and bicycle safety.[4] It reports that 4,654 pedestrians were killed in traffic accidents in the United States in 2007—a decrease of 13% in pedestrian fatalities compared to 1997. Another 70,000 pedestrians were injured in traffic accidents. NHTSA reports that in 2007:

- About 70% of the pedestrians killed were males; the fatality rate per 100,000 people was 2.19 for males, more than double that of females (0.91 per 100,000).
- Persons aged 70 years and over accounted for 16% of pedestrian fatalities and an estimated 6% of all pedestrians injured in 2007. The fatality rate for this age group was 2.66 per 100,000, higher than of any other age group.
- About 20% of all children between the ages of 5 and 9 years who were killed in traffic crashes were pedestrians.
- Alcohol is involved in 39% of pedestrian fatalities; for drivers or passengers in vehicles, it is 19%.

The NHTSA has conducted a comprehensive analysis of the factors associated with pedestrian crashes and fatalities. The findings of the 2007 national pedestrian safety analysis found that, of all pedestrian fatalities:

- 73% occurred in urban areas.
- 77% occurred at non-intersection locations.
- 90% of pedestrian fatalities occurred under normal weather conditions.
- 67% occurred between 6:00 p.m. and 6:00 a.m.
- 18% involved hit-and-run crashes.
- 44% occurred on roadways without crosswalks.
- Nearly 50% occurred on Friday, Saturday, and Sunday combined.

The NHTSA also provides bicycle-safety statistics.[5] In 2007, NHTSA reports that 698 cyclists were killed and 44,000 were injured in traffic crashes, accounting for 2% of all traffic fatalities and 2% of all people injured in traffic crashes. The number of bicycle fatalities in 2007 is 14% lower than that in 1997, when 814 cyclists died in traffic crashes.

The cyclist fatality rate per million people in 2007 was 2.31, compared to 3.04 in 1997. Cyclists accounted for 13% of all non-vehicle-occupant traffic fatalities in 2007. Those under 16 years of age accounted for 15% of all cyclists killed and 29% of those injured in traffic crashes in 2007. Most cyclists killed or injured in 2007 were males; they account for 88% of cyclist fatalities and 83% of cyclist injuries.

Arizona ranks high in pedestrian and bicycle fatalities compare to other states. In 2007, 154 pedestrians died in the state, a fatality rate of 2.43 per 100,000 people (down from 3.00 in 2001, when 159 pedestrians died). In 2001, the state had the second highest pedestrian fatality rate; the rate improved slightly to fifth in 2007. The pedal cyclist fatality rate is 3.31 per million people in Arizona, the eighth highest in the nation. In 2007, 21 cyclists died in the state, or 2% of all cyclists who died on the nation's roadways.

Existing Plans and Programs

There is considerable interest in pedestrian and bicycle transportation planning in the United States. Many magazines, organizations, and websites rank cities on walkability, pedestrian-friendliness, and bicycle-friendliness. These rankings vary depending on the factors considered in the ranking process, and it is noteworthy that several Arizona cities have appeared in various rankings. In 2007, *Prevention Magazine* published a list of best walking cities based on such factors as percent of population that walks for exercise, use of mass transit, parks per square mile, points-of-interest per square mile, average winter and summer temperatures, and percentage of athletic-shoe buyers.[6] Chandler ranked ninth in the nation. The rating system was revised in 2008 to include more factors and criteria. In the new system, Tempe was Arizona's highest-ranked city at 67th, followed by Yuma at 84th, Scottsdale at 90th, Glendale at 191st, Mesa at 201st, Tucson at 263rd, Chandler at 286th, Phoenix at 343rd, and Gilbert at 419th. It is encouraging to note that no Arizona city ranks among the 10 worst cities for walking in the nation.

Similar rankings have been developed for bicycling. In 2006, *Bicycling Magazine* listed the best bicycling cities in different size categories.[7] The best city overall was Portland, Oregon. Phoenix earned an honorable mention among cities with a population of 1 million or more, and Tucson was ranked second among cities with populations of 200,000-500,000, behind Madison, Wisconsin. Tucson ranked fifth in a ranking developed by the League of American Bicyclists' Bicycle Friendly Community Campaign. In noting Tucson's bicycle friendliness, the report says that "making it easier and safer for residents to bike, the city requires all new roadway projects to include bicycle facilities; in the last two years, the city has added about 30 miles of bike lanes."[8] The campaign also awarded ratings to different cities based on their bicycle friendliness. Tucson received a gold rating, and Tempe and Scottsdale silver ratings. Overall, the League ranked Arizona third among states for bicycle-friendliness. Again, it is encouraging to note that no Arizona city appears among the nation's worst; that distinction goes to Dallas, Memphis, and Miami, according to *Bicycling Magazine*.

A common feature of many highly rated cities 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 important to consider the connectivity, integrity, and accessibility of bicycle and pedestrian transportation networks. Several states, cities, and counties have developed comprehensive, long-range plans for developing bicycle and pedestrian transportation networks. The USDOT has played a key role in moving these plans forward, publishing a National Bicycling and Walking Study in 1994 that established two important goals: doubling the modal shares for bicycling and walking, and reducing the number of fatalities and crashes involving bicyclists and pedestrians by 10%.[9] Every state department of transportation has a Bicycle and Pedestrian Coordinator to promote and facilitate investment in and enhancement of NMT. The Bicycle and Pedestrian Program of the Federal Highway Administration (FHWA) oversees all state-level bicycle and pedestrian initiatives.

In Arizona, ADOT has developed a long-term plan for a system of shared roadways, and bicycle and pedestrian facilities: the Statewide Bicycle and Pedestrian Plan. The first phase of the plan, implemented in 2003, reviewed existing infrastructure, developed a statewide bicycle network, and made recommendations for accommodating bicyclists and pedestrians. Existing programs, such as the City of Prescott Safe Routes to Schools Program and the City of Mesa Bicycle Rodeo, were identified and reviewed to develop recommendations for improving biking and walking infrastructure.[10] In the second phase, key recommendations from the first phase were implemented, and informational guides and educational materials were prepared and disseminated.[11] Now in its third phase, the planning process has developed several proposals to enhance community 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.[12]

The Maricopa Association of Governments (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 adopted a plan for a bikeway system in 1987. The plan called for the development of nearly 600 miles of bikeways in the city, which then had only 75 miles. Over the next several years, the City constructed nearly 360 miles of the planned bikeways and has since spent about $500,000 annually to construct new bicycle facilities. There are currently more than 500 miles of bikeways. In 1994, the City required that all new development projects provide bicycle lanes adjacent to their properties.[13] The City of Tempe has an extensive bikeway system of more than 165 miles. The city also plans to promote and encourage NMT by lowering speed limits on arterial streets, building freeway-crossing facilities, and constructing a multi-use path along a city canal in the next five years.[14] The Pima County region, which includes Tucson, also has a widespread bicycle network with nearly 600 miles of bicycle lanes, routes, and shared-use paths and trails.[15]

ADOT is currently working with the FHWA on a Pedestrian Safety Action Plan. Under the Plan, four cities, including Phoenix, with high pedestrian fatalities are implementing safety measures to improve pedestrian safety. The initiative aims to reduce pedestrian-related fatalities and injuries by 10% (from the 2008 level) within three years. The goal of the

Arizona Strategic Highway Safety Plan, developed by the Arizona Governor's Traffic Safety Advisory Council, is to reduce the number of fatalities by 12% from that of 2007.[16]

Challenges

NMT has an important role to play in meeting mobility and accessibility needs of citizens in our communities. In Arizona, NMT will likely continue to play a smaller role in meeting those needs than do motorized modes of transportation. The challenges facing NMT are:

- *Land-Use Development Patterns*: Despite attempts in recent years to reverse sprawling development patterns, they remain the dominant land-use pattern in the state. The viability of walking and bicycling as means of transportation is strongly linked to the pattern of land use. When land-use patterns are concentrated and characterized by mixed uses—where jobs, shops, and housing are mixed together in close proximity to open green spaces—walking and bicycling can thrive. In the absence of such land-use patterns, people are unlikely to choose walking and cycling as modes of transportation.
- *Climate*: The Arizona climate is both a blessing and a curse for NMT. Most of Arizona does not experience extremely cold or snowy weather. On the other hand, temperatures during the warm months discourage bicycling and walking. Similarly, during the winter months, the cold can discourage some from braving the elements. There are only about six months, during spring and fall, when the weather is conducive to walking and bicycling. This limits the potential for walking and bicycling to become significant modes of transportation.
- *Traveler Incentives and Disincentives*: Use of NMT is closely tied to its cost and convenience, particularly in relation to other modes of transportation. For example, the provision of facilities such as secure bicycle parking areas, showers and lockers, and amenities like those at some of the new transit centers along the Valley Metro light-rail line, can encourage the use of NMT. Schemes that increase the cost of automobile use, such as parking pricing and tolls, can discourage automobile use and promote use of alternative transportation modes, particularly for short trips for which bicycling and walking may be viable. In the absence of these provisions, the state is likely to make little progress in increasing the use of NMT.
- *Regulatory Framework and Policy Structure*: Land-use, parking, and transportation policies are important in shaping transport-mode usage patterns. 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. Flexible regulatory frameworks that allow firms to provide bicycle parking instead of automobile parking, for example, would enhance bicycle use and discourage automobile travel.
- *Design of the Transportation Network*: Arizona's transportation network is highly automobile-oriented. Metropolitan areas have wide freeways, multi-lane arterials, and high-speed highway corridors. Although progress has been made to expand pedestrian and bicycle transportation facilities, the transportation network remains unfriendly to NMT users. Safety, prevention of traffic conflicts, well-engineered

bicycle and pedestrian transportation facilities, and crash-avoidance measures must become important considerations for transportation engineers and planners.

- *Financing*: NMT still represents a small fraction of total transportation spending in the country and the state. Nationally, only about 1.5% of federal transportation dollars go to fund bike paths and walking trails, despite the fact that 10% of all trips to work, school, and the store occur are made by bike or on foot, and bicyclists and pedestrians account for about 12% of annual traffic fatalities.[17] In Maricopa County, Proposition 400 authorizes a 20-year continuation of the half-cent sales tax for transportation projects in Maricopa County. The proportion of Proposition 400 monies allocated to bicycle and pedestrian transportation modes is too small to track.[18] In the recent TIME (Transportation and Infrastructure Moving Arizona's Economy) initiative that never made it to the voters, bicycle and pedestrian transportation investments were listed as one of a dozen potential uses vying for just 4% of the funds to be collected under the initiative.[19]

Opportunities

Challenges may limit the potential of NMT in the state, but the role played by these modes in meeting mobility and accessibility needs can be expanded by taking advantage of key opportunities, particularly among certain market segments and in denser areas of the state.

Over the past few years, the state has enhanced the bicycle and pedestrian transportation network in urban areas. By improving facilities and providing choices to transportation-system users, it is possible to influence mode choices and increase NMT mode use. The USDOT has implemented a Non-motorized Transportation Pilot Program authorized by Section 1807 of the SAFETEA-LU legislation. $25 million was provided to each of four communities: Columbia, MO; Marin County, CA; Minneapolis Area, MN; and Sheboygan County, WI. The program studies and demonstrates how investing in bicycle and pedestrian transportation networks, even in locations with harsh weather and sprawl development, can significantly increase NMT use. Preliminary reports indicate that bicycle and pedestrian network improvements directly yield decreases in automobile use and automobile travel.

Arizona can take advantage of federal investments in NMT. In 2008, the FHWA supported nearly 1,817 new NMT projects, disbursing nearly $540 million from the Federal-Aid Highway Program Funding. Bicycle and pedestrian projects are eligible for virtually all major Federal-Aid highway, transit, and safety programs, as long as the projects are primarily for transportation. These programs include 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, and the Safe Routes to School Program.[20]

Arizona's metro areas are hospitable to bicycle and pedestrian modes of travel. The terrain, particularly in the Valley, is relatively flat. Weather is regarded by many as desirable and pleasant, with mild temperatures and low humidity during the non-summer months. The new light-rail line, with planned expansions into new areas of the Valley, offers an opportunity to

influence land-use patterns, promote walking and bicycling in high-density developments along the line, and encourage pedestrian and bicycle access to light rail.

The macroeconomic picture also presents opportunities. When fuel prices spiked to over $4 per gallon last summer, many travelers to cut back on driving and considered alternative modes of transportation. Although fuel prices fell back to historic lows at the end of 2008, both the low prices and decreased travel demand are likely linked to the overall economic downturn. Fuel prices and travel demand will probably increase again (see Ch. 2) as the economy improves. If a strong network of pedestrian and bicycle transportation facilities is established, along with high-density mixed-use development patterns, then Arizona can expect to see increased use of NMT. People will seek alternatives to automobile travel if fuel prices rise, and NMT may prove to be viable, particularly for short trips.

List of Abbreviations Used

ACS	American Community Survey	**NHTSA**	National Highway Traffic Safety Administration
ADOT	Arizona Department of Transportation	**NMT**	Non-motorized modes of transportation
APMA	American Podiatric Medical Association	**POD**	Pedestrian Oriented Development
FHWA	Federal Highway Administration	**SAFETEA-LU**	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
GHG	Greenhouse Gases	**TOD**	Transit Oriented Development
MAG	Maricopa Association of Governments	**TRB**	Transportation Research Board
MSA	Metropolitan Statistical Area	**USDOT**	United States Department of Transportation
NCHRP	National Cooperative Highway Research Program	**VMT**	Vehicle miles traveled
NHTS	National Household Travel Survey		

Ram M. Pendyala is a Professor of Transportation Systems in the Department of Civil, Environmental, and Sustainable Engineering at ASU in Tempe. He studies travel-behavior characteristics, sustainability of transportation systems, and forecasts and models travel demand. He has done extensive research on multimodal transportation planning, and regularly advises local and national agencies on transportation policies and trends. He served as the Chair of the Transportation Research Board Committee on Traveler Behavior and Values from 2003 to 2009, and is currently the Vice-Chair and Chair-Elect of the International Association for Travel Behaviour Research. His PhD is from the University of California at Davis.

Karthik Konduri is a doctoral student in the Department of Civil, Environmental and Sustainable Engineering at ASU in Tempe. His research focuses on activity-based-travel-demand modeling, travel-behavior analysis, and transportation safety.

Joseph Plotz is a research assistant in the Department of Civil, Environmental and Sustainable Engineering at ASU in Tempe. His research includes light-rail impacts on urban areas, non-motorized transportation modes, GIS mapping, and analysis of travel-behavior characteristics.

[1] American Community Survey. *Most of Us Still Drive to Work – Alone Public Transportation Commuters Concentrated in a Handful of Large Cities*. U.S. Census Bureau, U.S. Department of Commerce, 2007. www.census.gov/Press-Release/www/releases/archives/american_community_survey_acs/010230.html.
[2] McDonald, N. C. Children's Mode Choice for the School Trip: The Role of Distance and School Location in Walking to School. *Transportation*, Vol. 35, No. 1, 2008, pp. 23-35.
[3] National Household Travel Survey. *2001 Survey.* U.S. Department of Transportation, Federal Highway Administration. nhts.ornl.gov/index.shtml. Accessed Jan. 7, 2009.
[4] National Center for Statistics and Analysis. *Traffic Safety Facts: Pedestrians*. National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation, 2007. www.walkinginfo.org/facts/docs/PedTSF_2007.pdf.
[5] National Center for Statistics and Analysis. *Traffic Safety Facts: Bicyclists and Other Cyclists.* National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation, 2007. www.bicyclinginfo.org/facts/docs/BikeTSF_2007.pdf.
[6] America's Best Walking Cities. Best (And Worst) Walking Cities in America Ranked by Prevention & APMA. American Podiatric Medical Association, *Prevention Magazine*, www.apma.org/s_apma/bin.asp?CID=382&DID=22708&DOC=FILE.PDF. Accessed Jan. 7, 2009.
[7] Business Wire. Portland, Oregon Once Again Tops Bicycling's Rankings of America's Best Cycling Cities; Portland Maintains Top Overall Spot from Previous Bicycling Rankings. *Bicycling Magazine*, www.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20060126005585&newsLang=en. Accessed Jan. 7, 2009.
[8] League of American Bicyclists. *Bicycle Friendly Community Campaign*. www.bikeleague.org/programs/bicyclefriendlyamerica/communities/. Accessed Mar. 3, 2009.
[9] Federal Highway Administration. *The National Bicycling and Walking Study, Transportation Choices for a Changing America*. U.S. Department of Transportation, Washington, D.C., 1994. drusilla.hsrc.unc.edu/cms/downloads/NatlBicycleWalk94.pdf.
[10] Kimley-Horn and Associates, Inc. *Arizona Statewide Bicycle & Pedestrian Plan*. Prepared for the Arizona Department of Transportation, Arizona, August 2003. www.azbikeped.org/appendix%20c/00%20ADOT%20BikePed%20Plan.pdf.
[11] Kimley-Horn and Associates, Inc. *Arizona Statewide Bicycle & Pedestrian Plan Phase II Plan*. Prepared for the Arizona Department of Transportation, Arizona, December 2004. www.azbikeped.org/images/ADOT%20BP%20PII%20final%20report.pdf.
[12] Kimley-Horn and Associates, Inc. *Arizona Statewide Bicycle & Pedestrian Program: Summary of Phase III Activities*. Prepared for the Arizona Department of Transportation, Arizona, January 2007. www.azbikeped.org/images/ADOT%20BP%20PII%20final%20report.pdf.
[13] de Cerreno, A. L. C., and M. L. H. Nguyen-Novotny. *Pedestrian and Bicyclist Standards and Innovations in Large Central Cities.* Rudin Center for Transportation Policy and Management, New York University, Wagner, January, 2006. wagner.nyu.edu/rudincenter/files/bikeped.pdf.
[14] Tempe in Motion (TIM). *Current Bicycle Projects*. City of Tempe, Arizona. www.tempe.gov/Tim/Bike/BicycleProjects.htm. Accessed Jan. 15, 2009.
[15] Transportation Planning. *Bicycles/Pedestrians*. Pima Association of Governments, Arizona. www.pagnet.org/Programs/TransportationPlanning/BikePedestrians/tabid/486/Default.aspx. Accessed Jan. 15, 2009.
[16] Kimley-Horn and Associates, Inc. *Goals and Emphasis Areas to Improve Pedestrian Safety in Arizona.* Prepared for Arizona Department of Transportation, Arizona, Working Paper No. 2, August 19, 2008. mpd.azdot.gov/planning/Files/PedSafety/2008.08.19_PSAP_WP2_FIN01.pdf.
[17] Mieszkowski, K. *The Bicycle Thief.* Salon Media Group, San Francisco, CA. www.salon.com/news/feature/2007/09/14/bike_paths/.
[18] Maricopa Association of Governments. *2005 Annual Report on the Status of the Implementation of Proposition 400.* Section 6.1.6, p 27. www.mag.maricopa.gov/pdf/cms.resource/ANNUALREPORT89292.pdf.
[19] Transportation and Infrastructure Moving Arizona's Economy ("TIME") Act. www.azsos.gov/election/2008/general/ballotmeasuretext/I-23-2008.pdf.
[20]Berkovitz, A. *Federal Funding for Pedestrian Projects.* FHWA Resource Center – San Francisco, CA. www.walkinginfo.org/training/pdps/ppt/Berkovitznotes.ppt.

Chapter 11

AIR TRANSPORTATION

Laurence E. Gesell, Ph.D.
Arizona State University Polytechnic Campus, School of Applied Arts and Sciences
Department of Social and Behavioral Sciences

Key Points

- In 2007, over 47 million passengers were enplaned in Arizona, 100 to 1,000 times more than used Greyhound buses or Amtrak trains for long-distance transportation.
- Phoenix and Tucson account for 96% of the enplanements.
- The federal Essential Air Services program subsidizes service to a few smaller communities.
- Nationally, airlines face uncertainties about fuel cost and availability, and passengers can expect to pay higher airfares and fly in more crowded airplanes.
- Airports are experiencing decreased revenues and deferring capital improvements, while simultaneously Arizona's only large hub airport is nearing gridlock.

Current Conditions

This short chapter presents a global overview of air transportation, specifically of the scheduled airline industry, and of its impact on the State of Arizona. It does not focus on general aviation, air commerce, military air bases, or road and rail transportation in and around airports, which are beyond its scope.[1] Information regarding aviation in Arizona more generally will be forthcoming from a State Airport System Plan (SASP) study currently under development.

Air Traffic. U.S. airline-passenger traffic has grown steadily from 275 million enplaned passengers in 1978 to 765 million in 2007, and is forecast to reach 1.29 billion passengers by 2025. Between 2002 and 2007, traffic grew 21% at Phoenix Sky Harbor and 16% at Tucson International Airport, Arizona's two principal air terminals.[2] In 2007 there were 47,589,285 passengers enplaned in the state, or 6% of all U.S. enplanements. Comparatively, there were 80,370 passengers on Amtrak and an estimated 400,000 riders on Greyhound that same year.[3]

Transport of air cargo has grown robustly as well. Although 2005-2007 represents the weakest growth period since the early 1990s, world air-cargo traffic nevertheless grew 1.7% in 2005, 3.2% in 2006, and 5.1% in 2007.[4] Since 2007, however, high fuel prices and financial turmoil have made airfreight expensive, resulting in reduced demand. In 2007, and at a time when demand rose nationwide, in Arizona air-cargo landing weight decreased 2.1% and 3.8% in Phoenix and Tucson, respectively.[5]

Airport Infrastructure. Airports are generally divided into air carrier versus general aviation. The Federal Aviation Administration (FAA) categorizes air-carrier airports

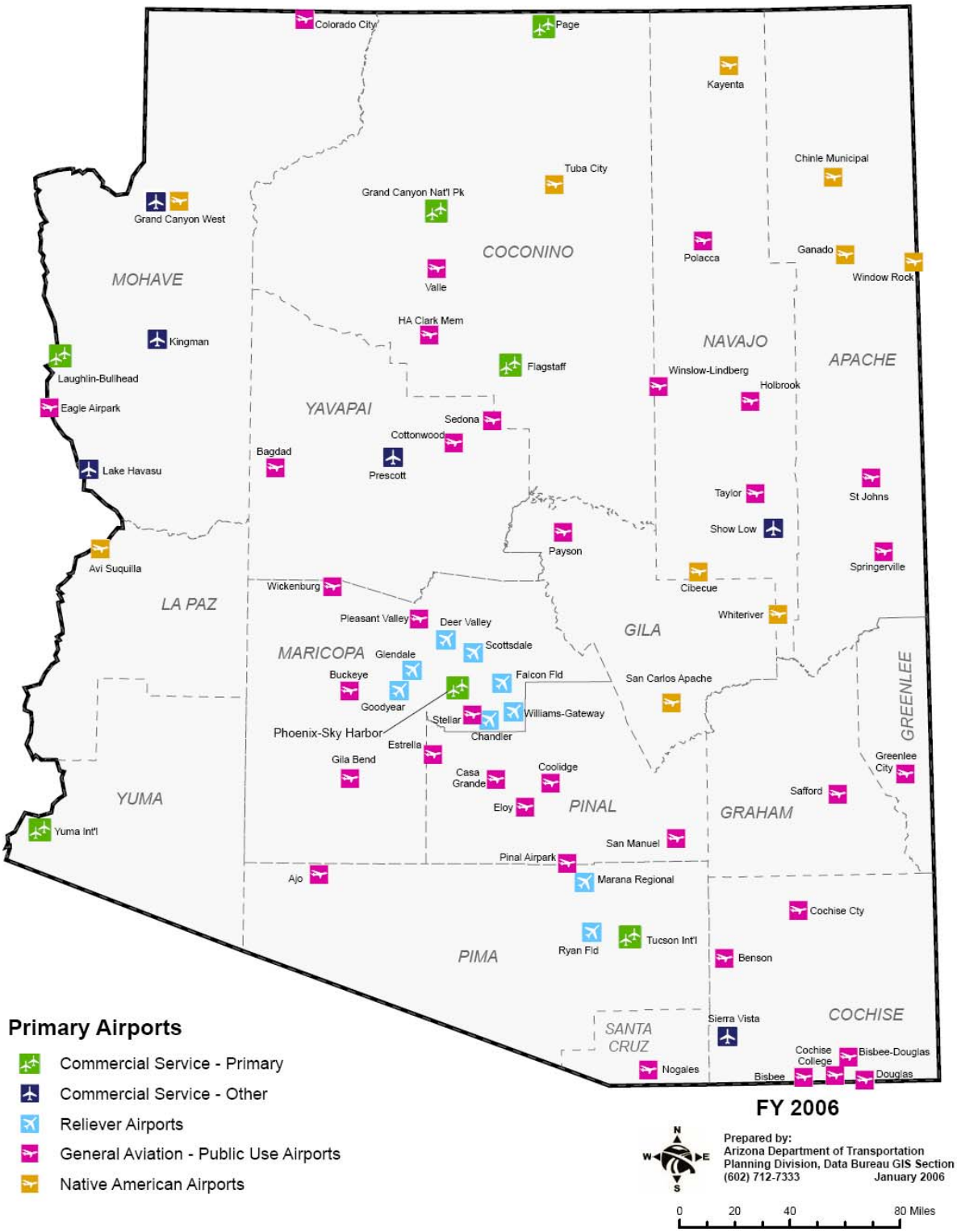
fundamentally by the passengers served and by the population densities where the airports are located. Air-carrier or commercial-service airports are either primary (having more than 10,000 boardings each year) or non-primary (at least 2,500 and no more than 10,000 enplanements per year). The air-carrier airport categories determined by population densities are known as the Hub System. The hubs fall into four classes plus two subclasses as determined by each community's percentage of the total annual air carrier-enplaned passengers in the United States: large (1% or more), medium (at least 0.25% but less than 1%), small (at least 0.05% but less than 0.25%), primary non-hub (more than 10,000 enplanements but less than 0.05%), and non-primary non-hub (at least 2,500 and no more than 10,000 enplanements).[6] In Arizona, "primary" refers to general aviation as well as air-carrier airports that are included in the State Airport System. Figure 11.1 shows ADOT's most recent map of the primary-airport system (designations are subject to frequent change). Arizona has seven primary commercial airports. There is one large-hub airport (Phoenix Sky Harbor), one medium-hub airport (Tucson), and five non-hub airports (Flagstaff Pulliam, Grand Canyon (Tusayan), Laughlin-Bullhead, Page, and Yuma).

In addition, there are six non-primary commercial-service airports: Grand Canyon West (Peach Springs), Lake Havasu, Kingman, Prescott, Show Low, and Sierra Vista. The large- and medium-hub airports account for 96% of all enplanements in Arizona, with 87% at Sky Harbor alone and 9% at Tucson. About 3% is comprised of "leisure" or time-insensitive travel, primarily tourist flights from the Grand Canyon airports. The remaining 1% consists of intrastate and interstate airline connectivity to and from smaller Arizona airports.

In 2007, Yuma enplaned 77,000 passengers and Flagstaff 44,000 (compared with 20.8 million for Phoenix and 2.2 million for Tucson). Yuma is currently served by United Express with service to Los Angeles (LAX), and US Airways with service to Phoenix. Flagstaff is served by US Air to Phoenix and by Horizon to Prescott and LAX. Air service to smaller Arizona cities is subsidized by the federal Essential Air Service program (see Existing Plans and Programs). The Page and Show Low airports have flights to Phoenix, but also to Denver, CO and Farmington, NM. Prescott likewise connects by air to Phoenix but also to Ontario, California. Great Lakes Airlines was recently awarded a contract to serve Kingman, which at a minimum will have flights to/from Las Vegas.

Phoenix-Mesa Gateway Airport had 1,655 passenger enplanements in 2005 and 3,790 in 2006 (all unscheduled). The airport was designated by the FAA as a general-aviation reliever airport, which means that it may be used to relieve congestion at Phoenix Sky Harbor. However, Allegiant Air began offering scheduled commercial jet service in October 2007. By July 2008 there were about 9,500 enplanements. Grand Canyon Airport was one of the airports originally listed as eligible for Essential Air Service (EAS) designation. It now offers only sightseeing flights over the Grand Canyon, and there are no commercial airlines that fly directly to/from the airport. Laughlin-Bullhead City is another airport that had been served by a variety of airlines whose service was accompanied by hotel packages and round-trip tickets, but which currently does not have an airline. Similarly, Sierra Vista once had air service as well, but it no longer does. Although Scottsdale is predominantly an airpark, it too sought designation as an air-carrier airport, but currently has no scheduled airline service.

Figure 11.1: State of Arizona Primary Airport System



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 11.1), as well as secondary general aviation airports (not shown).[7] General aviation covers all types of civil flying other than the scheduled air carriers. While commercial air service is limited to a handful of larger communities in the state, general aviation provides access by air to nearly 100 communities statewide. 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, and especially emergency "medevac" flights. While data are scarce, it is estimated that about 2 in 10 passengers travel by general aviation.

Economic Impact. In Arizona, where the majority of visitors arrive by air, fewer flights and higher fares mean fewer customers for hotels, restaurants, auto-rental agencies, restaurants, golf courses, and so on. At risk is a substantial cut in the $19 billion in annual visitor spending.[8] The 2008 economic-impact report for the Phoenix Airport System indicates the system is a major component of the State's economy, creating jobs, income, and revenues both on and off the airport. The Phoenix Airport System created a total economic impact (including multiplier effects) of $33 billion in 2007.[9] Comparatively, the economic benefits of the Kingman Airport were estimated at $33 million in 2004.[10] For Prescott, the economic impact was over $68 million in 2006.[11] Demand constrained by lack of airport-system capacity will lead to lost revenue for the State and hence lower economic impact.

Airport Congestion. While the basic infrastructure, runway capacity, and the level of service at most of the state's airports are generally good,[12] paradoxically, Arizona's only large-hub airport has capacity constraints that need to be addressed sooner rather than later. Phoenix is one of 15 metropolitan areas that could become "capacity locked" by 2025.[13] A third runway was built in 2000, and Sky Harbor acquired an interest in Phoenix-Mesa Gateway Airport in hopes of adding more capacity. Unfortunately, the third Sky Harbor runway has limited utility in 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.

Existing Plans and Programs

With the exceptions of deciding where an airport will be located, and its ownership, operation, and maintenance, which remain local responsibilities, the Airline Deregulation Act of 1978 placed primary regulatory responsibility for the nation's air transportation system with the federal government, the planning results of which are published periodically by the FAA in the National Plan of Integrated Airport Systems (NPIAS). The people of Arizona have limited opportunity to participate other than through efforts directed at the state's airports. In this regard, the Governor's Advisory Council on Aviation (ACA) recommended legislation in 2007 to protect land use, increase capacity, and address funding needs of the state's airports.[14] In 2008, of the 19,815 total airports in the United States, only 5,190 were open to the public, and of the latter, only 3,411 were included in the NPIAS.[15] Of the 94

airports in Arizona, only 59 are included in the Primary State Airport System. Contributing to the NPIAS are local and state airport-system plans. On February 8, 2008, the ADOT Aeronautics Division initiated a comprehensive revision of the State Airport System Plan (SASP).[16] The updated SASP is highly anticipated since the last one was completed more than 10 years ago. ADOT Aeronautics also develops a Five-Year Airport Capital Improvement Program (ACIP) to parallel the FAA's Airport Capital Improvement Program.

In addition to the federal initiative, passage of the Vision 100–Century of Aviation Reauthorization Act in 2003 led to formation of the Interagency Joint Planning and Development Office (JPDO), which is charged with developing the vision for the 2025 Next Generation Air Transportation System (NGATS) and defining the research necessary for achievement. The NGATS vision calls for a system-wide transformation leading to a new set of capabilities that will allow the system to respond to future needs in air transportation.[17]

Essential Air Service. The Airline Deregulation Act, passed in 1978, gave airlines nearly complete freedom to determine the markets they would serve and the fares they would charge. The Civil Aeronautics Board (CAB) established the EAS program "to guarantee that small communities that were served by certificated air carriers before deregulation maintain a minimal level of scheduled air service."[18] Since sunset of the CAB in 1985, the EAS Program has been managed by the USDOT. Kingman, Page, Prescott, and Show Low receive EAS subsidies. Currently, all of the EAS contracts in Arizona are awarded to Great Lakes Airlines, which provides two levels of service in either 19-seat or 32-seat twin-turboprop aircraft. Combined, the airline receives a total subsidy of $3,924,227 for serving EAS airports in Arizona.[19]

Challenges

While capacity constraints at Sky Harbor and the tenuous nature of subsidized air service to smaller communities pose challenges to Arizona's air transportation system, the condition of the national airline industry may constitute the most serious challenge of all. Passengers should expect fewer, more crowded, and more expensive flights to, from, and within Arizona. As a state that relies heavily on tourism, is a long distance away from Northeast and Midwest urban centers, and is home to many remote communities, the national trends reviewed below have serious implications for Arizona.

Airlines in Distress. Discounting periodic downturns, on average, air traffic has steadily expanded over the past three decades. It is thus a paradox that the airlines persistently find themselves in poor financial condition. There was a ray of hope in 2007, when the world's airlines posted a $5.6 billion profit. But due in large part to record-high fuel costs, the airlines lost money in 2008 and, anticipating a loss in 2009, they began scaling down capacity[20] by aggressively cutting costs and de-bundling services to create new revenues.[21] These moves, coupled with declining fuel costs, may actually result in a modest profit for U.S. airlines in 2009, but unfortunately the underlying reason for the precipitous drop in oil prices—falling demand due to the recession—is more insidious and possibly more threatening.[22] It is feared that any cost cuts are destined to be overshadowed by steadily worsened demand, and these conditions will have a direct impact on passenger access to air transportation in Arizona as elsewhere.[23]

Fewer Flights. Even when traffic demand was higher, the industry was not keeping up with increasing operating costs and fluctuating oil prices.[24] Faced with the prospect of high prices for fuel, most U.S. airlines began scaling down capacity by eliminating their least profitable routes. Legacy carriers started reducing long flights to save fuel costs, eliminating direct flights and maximizing efficiencies by connecting flights through their hub-and-spoke systems, and de-peaking their hub airports.[25] Particularly hard hit by the high cost of fuels have been the Low-Cost Carriers (LCCs) and Regionals.[26] Their strategy for survival has been to reduce flight frequencies and load more passengers on fewer aircraft. Network carriers had already reduced their domestic capacity by 25% between 2000 and 2007.[27] Domestic capacity could see additional cuts of 10% to 20% depending on the direction of fuel prices.[28] Airlines are also looking to capital markets for asset sales (including sale of their excess aircraft) to strengthen their cash positions.

It might be noted that in Arizona, access to other modes of transportation may be restricted as well. Amtrak, for example, has two main east-west lines crossing Arizona, the Southwest Chief and the Sunset Limited. Access to the Sunset Limited from the Tucson metropolitan area is generally available, but access from the Phoenix valley to either the Limited or the Chief is via bus connections. Greyhound, like the airlines, has been transforming its bus network to become a smaller, simpler network of routes.[29] Even transportation by private automobile is down, with Americans driving 100 billion fewer miles in 2008 than in 2007.[30]

Oil Prices. Having already reduced labor, significantly cut costs, and adjusted capacity, the airlines may improve their positions only if oil prices stay below $70-80 a barrel.[31] Fortunately, by fall 2008, oil prices fell 56% lower than the record $147.27 per barrel set the previous summer.[32] But even if oil prices remain relatively low, the airlines are not likely to increase capacity in attempt to service more demand. Since fuel costs have a greater impact upon LCCs, some airlines collapsed when the price of oil skyrocketed. Frontier filed for Chapter 11 bankruptcy protection, and Southwest postponed plans for expansion.[33] As the network carriers contract, the LCCs are not in position to backfill the service void by increasing capacity in the marketplace. High fuel costs have an even greater impact on small regional carriers like Great Lakes Airlines, which currently services rural communities including Kingman, Page, Prescott, and Show Low.

There is fear that oil price relief may be only temporary, and the price will go back up as the economy recovers.[34] Refining capacity is limited, and the price of extracting crude oil is inching toward $100 per barrel—much higher than the $70-80 quoted above.[35] A worse, yet entirely possible, scenario would envision a sudden disruption of oil supplies, whereupon the price of fuel would skyrocket. As a result, the airlines are bracing for higher fuel prices in the long run.[36]

Arizona is one of the most aggressive states when it comes to the use of alternative fuels, and both Phoenix Sky Harbor and Tucson International Airports have made great strides in converting their *ground* fleets to alternative fuels, including compressed natural gas, bio-diesel, and hybrid electric/gasoline. However, airlines are faced with a major challenge. In the *sky* there are no solutions for an interim (hybrid) bridge between fossil fuels and the

development of a hydrogen economy, other than with biofuels, which can be even more expensive than fossil jet fuels and become competitive only when gasoline prices are high.[37]

Crowded Aircraft. Forecasting of the airline industry has never been more difficult than it is right now,[38] but trends suggest that with reduced capacity, passengers will have more limited access to air travel. Airline-passenger load factors for the last year (1978) before full deregulation averaged 61%, and remained so through 1988.[39] For a long time it was commonly accepted that 61-62% was the practical limit above which consumers would begin to suffer adverse affects through overbooking, lost luggage, delays, and so forth. Irrespective of the downside effects, average load factors have since crept up. In 1994, the average was 64.3%, which eclipsed the previous high of 62.6% set in 1992.[40] With an annual load factor of 66.5%, Southwest Airlines had the highest average domestic load factor for a U.S. carrier in 1996. Load factors peaked between 70% and 80%, but then fell abruptly following the 9/11 terrorist attacks.[41] By 2007, domestic scheduled airlines collectively had an average load factor of 79.9%.[42] Load factors approximating 80% or more portend a future of crowded (even overly crowded) airplanes. Seemingly, the only thing that might bring the load factors down is a serious drop in demand, which, short of raising the airfares, could put the airlines back in the red.

Load factors for alternative modes of travel are increasing as well. A smaller route system at Greyhound should translate into higher load factors. Amtrak's average load factor has been less than optimal, but rose from a low of 48% in 2007 to a high of 53% in 2008.[43] Load factor on the Sunset Limited was only 44% in 2007, but on the Southwest Chief it was 63%, which was near its practical capacity and is increasingly limiting access to interstate rail service for many Arizonans. A long-distance train is considered "sold out" at a load factor of 65%, due to on/offs and seat/berth turnover. [44]

High Airfares. With load factors averaging 80%, pressures for higher fares will mount, and difficulties for travelers will escalate.[45] Airfares for flights from Phoenix in 2008, for example, were 28% higher than the year before.[46] In a deep recession, which appears likely at least through 2009, those potential passengers at the lower end of the economic spectrum will be the least likely to travel. Unsurprisingly, the airlines know this. United Airlines, for example, is steering from "unprofitable leisure flying towards markets of greater importance,"[47] meaning markets with customers who can and will pay for higher, more profitable fares. In effect, network carriers are "bolstering their premium-class product."[48] Even if oil prices come down, an economy in recession and lack of consumer confidence may preclude air travel for those who can least afford it, and the airlines may again become an elite mode of transportation—in total contradiction to airline deregulatory policy.

By the mid-1980s, the airline industry had become more concentrated than before deregulation, with the top four airlines controlling nearly 57% of the domestic enplanements in 1987.[49] The top four airlines still capture about 51% of the market.[50] A highly concentrated market would suggest oligopoly, one of the economic theories of which is that companies tend not to engage in price competition and prices only go up. But this depends on whether firms behave rationally. Airlines have typically but non-rationally flooded the market with excess capacity. Today's market may be different. With the onset of a serious

recession and airlines collectively targeting higher-fare customers, fares can only be expected to go higher. Recent flight cutbacks were, in fact, designed to reduce costs and force fares higher. It is nevertheless still possible for fares to go down if demand drops so precipitously that carriers find themselves once again with excess capacity; in that case, any fare at all is better than flying with empty seats. In early 2009, a wave of fare sales did indeed spread across the industry. Even so, on average, base airfares are higher today and most of the sales come with restrictions.[51]

Implications for Arizona. As the airlines go, so go the Arizona airports they serve, which now have less traffic and associated revenues, in turn resulting in layoffs, wage freezes, and curtailment of construction projects.[52] For example, Phoenix Sky Harbor reported traffic down 8.8% and it is deferring certain capital improvements, keeping in place hiring freezes for non-essential workers and cutting its operating budget by $8 million.[53] Southwest announced it would be eliminating 57 flights from Tucson and replacing them with 40 that it sees as more profitable.[54] Yuma was projected to enplane over 91,000 passengers in 2008, up 26% from the year before, but may well see a decline in 2009. Douglas Parker, CEO of US Airways, indicates the flight reductions are likely permanent.

Opportunities

The Airline Deregulation Act of 1978 greatly restricted state involvement in the air transport system, other than responsibility for the terminal ends, the airports. In this regard, the lack of capacity at Phoenix Sky Harbor is critical and the pending shortfall is something the State can and should address. For example, the State might revisit the study for a new airport located between Phoenix and Tucson. Another alternative might be high-speed-rail connectivity between Phoenix and Tucson that would not only facilitate travel between the two major Arizona cities, but might also take advantage of already-existing excess capacity at Tucson International, and thereby make Tucson a more viable destination by air, with ground connection to Phoenix and elsewhere in the State.

The alternative-fuel dilemma in the skies should cause the state to pause and consider alternatives. On the ground, states have considerably more power to influence alternative and/or inter-modal forms of transportation. Perhaps now is the time for Arizona to be looking seriously at high-speed-rail connectivity not only between Phoenix and Tucson, but to southern California as well—to link up with the high-speed rail line under development along the Pacific Coast—and perhaps plan on traveling by air less, only as necessary, and restricted to long-haul routes where air transport is the most efficient.[55]

List of Abbreviations Used

ACA	Governor's Advisory Council on Aviation	**LCCs**	Low-cost carriers
ACIP	Airport Capital Improvement Program	**JPDO**	Interagency Joint Planning and Development Office
ADOT	Arizona Department of Transportation	**NGATS**	Next Generation Air Transportation System
EAS	Essential Air Service	**NPIAS**	National Plan of Integrated Airport Systems
FAA	Federal Aviation Administration	**SASP**	State Airports System Plan

Laurence Gesell has been on the faculty at ASU since 1984. He is located in the Department of Social and Behavioral Sciences and teaches a variety of courses in Science, Technology, and Society. He has authored more than 20 books, numerous professional papers, journal articles, and final consultant reports. Prior to ASU, Dr. Gesell was the Airports Manager for the County of San Luis Obispo, California (1979-1984), and is an Accredited Airport Executive (AAE). From 1973 to 1979, he was an airport planning project manager with Howard, Needles, Tammen and Bergendoff, a leading design firm of architects, engineers, and planners. Dr. Gesell is a commercially rated pilot, retired Lieutenant Colonel, Master Army Aviator, and veteran of the Vietnam conflict where he was awarded the Distinguished Flying Cross and 39 awards of the Air Medal. He was inducted into the Arizona Aviation Hall of Fame in 2008.

---

[1] "Air transportation" is the interstate, overseas, or foreign transportation of passengers or property by aircraft as a common carrier for compensation, or transportation of mail by aircraft. "Common carrier" refers to a carrier required by law to convey passengers or freight without refusal and which holds itself out to the public as engaged in the business of transportation of persons or property from place to place for compensation, and who offers services to the public generally. "General aviation," on the other hand, consists of aviation other than military and commercial common carriage and includes business flying, instructional flying, personal flying, and commercial flying. "Commercial operator" means a person other than an air carrier, who conducts operations in air commerce carrying persons or property for compensation or hire. "Air commerce" means the interstate, overseas, or foreign carriage by aircraft of persons or property for compensation or hire, or the carriage of mail by aircraft, or the operation or navigation of aircraft in the conduct or furtherance of a business or vocation (i.e., not as a common carrier). *See* Gesell, L. E. *Air Transportation: Foundations for the 21st Century, 2nd ed.* Chapter 18. Coast Aire Publications, L.L. 2005.
[2] Executive Summary of the Governor's Advisory Council on Aviation Final Report, Jan. 31, 2007.
[3] *See* Transportation Statistics Annual Report 2007. DOT Bureau of Transportation Statistics; *see also* National Plan of Integrated Airport Systems 2009-2009. FAA Report to Congress; *see also* Amtrak. Amtrak Fact Sheet, Fiscal Year 2007 State of Arizona, Jan. 2008; *see also* Greyhound Lines. *Greyhound Facts and Figures*, www.greyhound.com. Accessed Jan. 6, 2009.
[4] Boeing. *World Air Cargo Forecast*. www.boeing.com. Accessed Jan 8, 2009.
[5] Final CY07 (FY09) Cargo Landing Weight. DOT Bureau of Transportation Statistics, Sep. 26, 2008.
[6] *See* Gesell, L. E., and R. R. Sobotta. *The Administration of Public Airports, 5th ed.* Chapter 4. 2007.
[7] Secondary Airport System. ADOT Aeronautics Division. 2006. *www.dot.state.az.us/aviation/airports/PDF/SecondaryAirportSystem2006.pdf.*
[8] Gilbertson, D. *Airline Woes Pinch Arizona Tourism*, AZCentral.com. Accessed Sep. 21, 2008.
[9] W.P. Carey School of Business, Arizona State University. *Economic Impact of the Phoenix Airport System Update: 2007.* Mar. 2008.
[10] Executive Summary. *Economic Benefit Analysis, Kingman Airport.* 2004.
[11] William V. Cheek & Associates. *Prescott Airport Economic Impact Study*. May 3, 2006.
[12] ADOT Aeronautics Division, *State Aviation Needs Study (SANS) 2000.* www.dot.state.az.us/aviation/library/pdf/StateAviationNeedsStudy-2000,ExecutiveSummaryBrochure.pdf.
[13] *See* National Plan of Integrated Airport Systems 2009-2013. FAA Report to Congress, Sep. 30, 2008.
[14] In 2006, there were 67 airports in the State of Arizona Primary Airport System; Arizona Department of Transportation Planning Division, Data Bureau GIS Section, Jan. 2006.
[15] *See* note 13 above.
[16] The Arizona Department of Transportation (ADOT) Aeronautics Division initiated a comprehensive State Airports System Plan (SASP) on February 8, 2008. Wilbur Smith Associates, Inc. is conducting the study.
[17] *See* Next Generation Air Transportation System (NGATS) Air Traffic Management (ATM)-Airspace Project. National Aeronautics and Space Administration, Jun. 1, 2006.
[18] U.S. Department of Transportation, Office of Aviation Analysis. *Essential Air Service Program*. ostpxweb.dot.gov/aviation/x-50%20Role_files/essentialairservice.htm. Accessed Feb. 20, 2009.
[19] Subsidized Essential Air Service (EAS) Outside of Alaska. Domestic Analysis Division, Nov. 1, 2008.
[20] "Capacity," meaning aircraft in their fleets and seats available for sale.
[21] "De-bundling" refers to charging extra for meals, snacks, beverages, pillows, blankets, or in the case of Southwest Airlines, for the privilege of going to the front of the line for seating.
[22] Editorial. Market Focus. *Av. Wk. & Space Tech.*, Jan. 5, 2009.

[23] *See* Schofield, A. Airline Angst. *Av. Wk. & Space Tech*., Sep. 8, 2008; *see also* Wall, R. Survival Strategies, *Av. Wk. & Space Tech.*, Sep. 8, 2008.
[24] *See* Schofield, A. note 23 above.
[25] Ott, J. Bracing for the Worst. *Av. Wk. & Space Tech.*, Jun. 9, 2008, p. 27; *see also* Editorial. Profits are Nice, But the Airline Glass is Only Half Full. *Av. Wk. & Space Tech.*, Jan. 22, 2007, p. 58; *see also* Michaels, D. Airlines Cut Long Flights to Save Fuel Costs. *Wall St. J.*, Jul. 8, 2008, Travel section.
[26] The one exception has been Southwest, who fortunately had hedged against rising fuel costs.
[27] Compart, C. New Directions. *Av. Wk. & Space Tech.*, Sep. 22, 2008, p. 74.
[28] Schofield, A. Capacity Carnage. *Av. Wk. & Space Tech.*, May 26, 2008, p. 58.
[29] Greyhound Lines, *About Greyhound*, www.greyhound.com. Accessed Jan. 6, 2009.
[30] Decline in American Driving Reaches Year-Mark. Department of Transportation Press Release, Dec. 12, 2008.
[31] *See* Anselmo, J. C., M. Unnikrishnan, and R.Wall. Wild Card. *Av. Wk. & Space Tech.*, Nov. 10, 2008, p. 40; *see also* Ott, J. note 25 above.
[32] Lammers, D. Oil Prices Swing Wildly as Dow Rally Fails. *Associated Press*, Nov. 10, 2008; *see also* Anselmo et al. note 31 above.
[33] See note 27 above.
[34] Williams, M. Oil Prices Follow Wall Street on Wild Ride. *Associated Press*, Nov. 13, 2008.
[35] Editorial. Reality Check on Oil Prices. *Av. Wk. & Space Tech.*, Aug. 11, 2008, p. 70.
[36] See Anselmo et al. note 31 above.
[37] *See* Warwick, G. Biofuel Boost. *Av. Wk. & Space Tech.*, Nov. 24, 2008, p. 38.
[38] *See* Schofield, A. note 23 above.
[39] "Load factor" (for passenger service) means the percent that revenue passenger-miles are of available seat-miles in revenue passenger services, representing the proportion of aircraft seating capacity that is actually sold and utilized. It is determined by dividing revenue passenger miles by available seat miles. For example, an aircraft with 100 available seats, but with only 80 passengers on board, would have a load factor of 80%.
[40] Bowles, R. *Executive Summary*. 20th Annual FAA Commercial Aviation Forecast Conference Proceedings, 1975.
[41] Corrections & Amplifications. Airlines' Load Factors. *Wall St. J.*, Fri., Apr. 19, 2002.
[42] December 2007 Airline Traffic Data: Airlines Carry Record 769 Million Passengers in 2007. Department of Transportation, Bureau of Transportation Statistics, Thurs., Mar. 13, 2008. For example, United Airlines reported a passenger load factor of 81.3% when Southwest Airlines had a load factor of only 70.4%; *see* Southwest Airlines Fills 70% of Seats in October. *Dallas Morning News*, Nov. 11, 2008; *see also* United Airlines Load Factor Slightly Up in October. *Datamonitor*, Tues., Nov. 4, 2008.
[43] DOT, Bureau of Transportation Statistics, *Rail Capacity Utilization: Rail Passenger Load Factor*, www.bts.gov. Accessed Jan. 6, 2009.
[44] United Rail Passenger Alliance. *This Week at Amtrak 2007-01-12*, www.unitedrail.org. Accessed Dec.6, 2009.
[45] *See* Ott, J. note 25 above.
[46] *See* note 8 above.
[47] John Tague, as quoted in Schofield, A., R. Wall, and J. Flottau. Busting Borders. *Av. Wk. & Space Tech.*, Jun. 9, 2008, p. 28; *see also* Ott, J. note 25 above.
[48] Wall, R. Murky Outlook. *Av. Wk. & Space Tech.*. Feb. 11, 2008, p. 39.
[49] Texas Air (including Continental and Eastern), United, Delta, and American; *see* Gesell, L. E. *Airline Re-Regulation*. Coast Aire Publications. 1990, pp. 40-41.
[50] Delta (including Northwest), Southwest, American, and United); Analysis of Department of Transportation, Bureau of Statistics data for the *Top 10 U.S. Airlines, ranked by January-August 2008 System Enplanements*, www.bts.gov. Accessed Nov. 20, 2008.
[51] Weber, H. R. New Year Brings Fleet of Air Fare Sales. *Associated Press*, Jan. 6, 2009.
[52] Sunnucks, I. Traffic Down at Sky Harbor, Other Major U.S. Airports. *Phoenix Bus. J.*, Sep. 15, 2008.
[53] *Ibid*.
[54] Hatfield, D. *Tucson Airport Passenger Numbers Fall at End of 2007.* AzBiz.com. Accessed Jan. 25, 2008.
[55] Phillips, M. Fed Up With Flying? Here Are Some Solutions. *Wall St. J.*, Sep. 29, 2008.

Chapter 12

LONG-DISTANCE PASSENGER RAIL

Matthew Croucher, Tim James, and Eva Madly
Arizona State University, W.P. Carey School of Business

Key Points

- Ridership on existing long-distance passenger railroad routes in Arizona is low, at just 88,305 users in 2008.
- Support for establishing a high-speed intercity service between Phoenix and Tucson has grown recently. The Arizona Department of Transportation (ADOT) released a report on the feasibility of such a service in 1998, and is updating the report.
- A passenger railroad service between Phoenix and Tucson faces major financial challenges. Construction costs are estimated at $800 million, and large annual subsidies will be needed to keep the railroad operating.

Current Conditions

Existing Long-Distance Passenger Rail in Arizona. Of the state's 2,654 miles of track, most are used for freight, with only a small percentage used for passenger traffic. Arizona's intercity scheduled passenger rail service is operated by the National Railroad Passenger Corporation (Amtrak), which began service in Arizona in 1971.[1] Amtrak operates three intercity rail services in Arizona,[2] paying track owners (including freight operators Union Pacific and Burlington Northern Santa Fe [BNSF]) for use of the track. The services are:

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

Amtrak ridership on these routes has increased slightly during recent years[3] but still remains low, as Table 12.1 illustrates.

Aspirations for High-Speed Intercity Passenger Rail in Arizona. Former governor Janet Napolitano made it clear that a high-speed passenger rail service between Tucson and Phoenix is a priority, although the feasibility of establishing such a service has stimulated considerable debate.

Table 12.1: Annual Amtrak Station Ridership in Arizona, Fiscal Year 2008

City	Ridership
Benson	1,064
Flagstaff	39,723
Kingman	10,322
Maricopa	6,393
Tucson	14,780
Winslow	4,767
Williams Junction	8,199
Yuma	3,057
Total, Arizona	**88,305**

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

Amtrak has no public plans to alter its existing pattern of long-distance passenger routes. However, ADOT is a member of the States for Passenger Rail Coalition, whose mission is to promote the development, implementation, and expansion of intercity passenger rail services and to advocate for federal funding.[4]

Alternative Transportation between Phoenix and Tucson.
Passenger trips between Phoenix and Tucson by automobile, bus, and air provide a starting point for evaluating the size of the potential passenger-rail market.

ADOT traffic count data indicate that traffic on I-10 between Phoenix and Tucson in 2008 averaged 45,000 vehicles per day, or 16,425,000 per year.[5] Intercity bus operators between Phoenix and Tucson include Greyhound and Arizona Shuttle Services. Greyhound operates 16 one-way trips per day (8 each from Phoenix and Tucson), charging $21 for a nonrefundable adult fare. Arizona Shuttle primarily serves airline passengers and operates 36 one-way trips per day (18 each from Phoenix and Tucson). The standard one-way ticket price is $33, with additional fees for same-day service or home pickup. Arizona Shuttle Service transports over 100,000 passengers per year.[6]

Mesa Airlines flies between Phoenix and Tucson. Fares range from $304 for a roundtrip purchased a month in advance, to $1,304 for a next-day roundtrip.[7] Information on how many air passengers between Phoenix or Tucson are traveling only between those two cities and how many are just changing planes were not available, but a study by the Tucson Airport Authority estimates that between 250,000 and 500,000 Tucson-related enplanements (out of 4.43 million[8]) leave for Phoenix to begin their air travel there.[9]

Commuters between Phoenix and Tucson are a primary target group of the proposed intercity rail services; Table 12.2 provides commuter statistics for 2000.

Table 12.2: County-to-County Worker Flows

Residence County	Workplace County	Daily Commuters
Pinal	Maricopa	19,918
Maricopa	Pinal	7,751
Pinal	Pima	2,601
Pima	Pinal	1,974
Pima	Maricopa	1,838
Maricopa	Pima	1,214
Total		**35,296**

Source: ADOT Phase I (2007) report based on year 2000 Census Transportation Planning Package

Existing Plans and Programs

Plans for Intercity Passenger Rail Service between Phoenix and Tucson. ADOT completed a High-Speed Rail Feasibility Study in 1998 that examined transportation alternatives between Phoenix and Tucson.[10] The study is being updated; at present it consists of draft Phase I[11] and Phase II[12] reports. The 1998 study evaluated six alternatives for the Phoenix-Tucson transportation corridor:

- No-build
- Highway widening
- Conventional rail with *minor* upgrade
- Conventional rail with *major* upgrade
- High-speed electric rail
- High-speed magnetic-levitation rail

The study concluded that in the long term, a partially elevated, high-speed electric railway with exclusive right-of-way should be implemented, utilizing the existing Union Pacific (UP) Railroad alignment, but that the initial phase of the project should be minor upgrades to the existing railroad, with use of conventional diesel-electric locomotives. Future upgrades would be phased in as ridership increased and funds become available.

The more recent Phase I (2007) and Phase II (2008) reports conclude that conventional rail with *minor* upgrades is the most feasible alternative to pursue because it is the least costly and would take the shortest time to place in operation. "Conventional rail with minor upgrades" means making minor improvements to existing freight track and right-of-way and using conventional diesel-electric rolling stock, similar to existing Amtrak trains. The targeted maximum speed was raised from 80 mph to 110 mph to make the train ride more competitive with the automobile in terms of journey time. At an *average* speed of 62 mph, the average journey by train would be two hours long. Average journey time by automobile would be 103 minutes at an *average* speed of 65 mph (also taking into account the door-to-door convenience of cars).

There are eight potential stations along the 121 miles between downtown Phoenix and downtown Tucson: Central Avenue (Downtown Phoenix), Sky Harbor Airport, Tempe, Mesa/Gilbert, Coolidge, Orange Grove (North Tucson), and Tucson (Figure 12.1). Three alternatives for establishing a passenger railroad between Phoenix and Tucson are outlined in Table 12.3.[13] All assume that the proposed line utilizes the existing UP alignment.

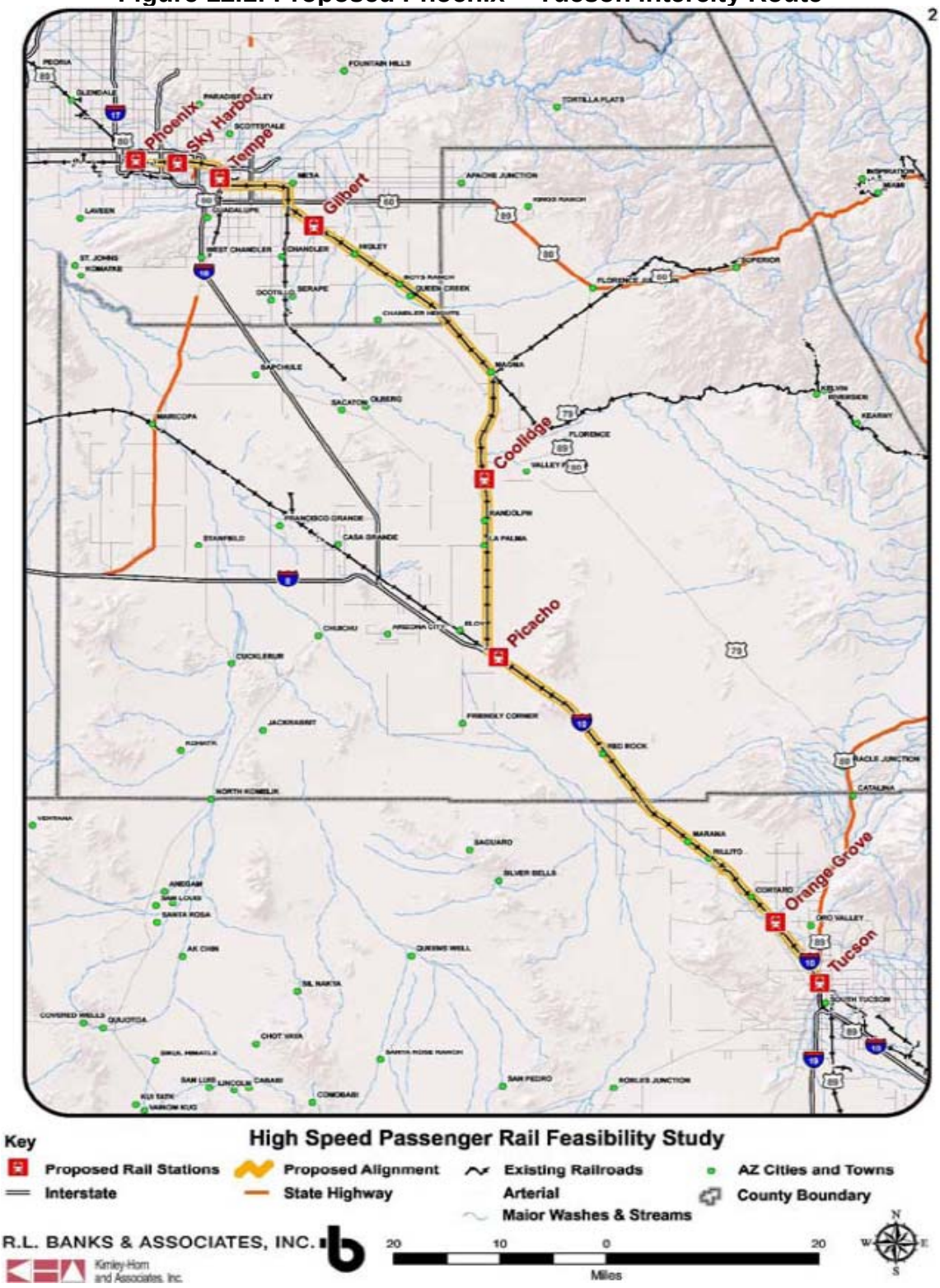
Table 12.3: Characteristics of Railroad Development Alternatives in Arizona[14]

	Conventional rail with minor upgrade	**Conventional rail with major upgrade**	**High-speed, partially elevated electric rail**
Type of Rail Tracks	Use of existing train tracks	Use of existing train tracks	Exclusive track
Top Speed	110 mph	125 mph	175 mph
Average Speed	62 mph	88 mph	125 mph
One-way Trip Time	117 minutes	82 minutes	61 minutes
Construction Costs	$800 million	$1.57 billion	$5.2 billion
Number of one-way trains/day	7	18	18
Seats per Train	520	500	480
Operating and Maintenance Costs (Annual)	$34.1 million	$130.8 million	$190.4 million
One-Way Fare	$20.00	$44.00	$51.00
Annual Users	1,002,000	1,332,000	1,409,000
Annual Fare Revenue	$16.0 million	$46.9 million	$57.5 million
Farebox Recovery*	50%	36%	30%
Annual Subsidy Needed	$18.1 million	$83.9 million	$132.9 million
Time Saved Compared to Automobile**	-14 minutes	21 minutes	42 minutes
I-10 Vehicle Miles of Travel Savings (Annual)	98,550,000	193,450,000	219,000,000
Population at End-points[15] (Metro Areas)	Phoenix: 4,179,424 Tucson: 967,089		
Population Along the Route	47,704		
Total Population	5,194,220		
Employment at End-points[16] (Metro Areas)	Phoenix: 1,891,210 Tucson: 379,560		

Source: ADOT: 1998 report, 2007 Phase I report, 2008 Phase II report, and authors' calculations.

Comparison to Similar Intercity Rail Routes. To provide a basis for analysis and evaluation, we selected five existing Amtrak routes in other states that are comparable to the proposed Phoenix-Tucson line, based on similarity of criteria such as length, population served, and number of stations. Table 12.4 summarizes characteristics of these routes. Corridors that are not comparable to Phoenix-Tucson, such as Boston-New York-Washington, are not included in Table 12.4.

Figure 12.1: Proposed Phoenix -- Tucson Intercity Route



Source: R.L. Banks & Associates, Inc. High Speed Passenger Rail Feasibility Study prepared for ADOT, Phase II Report, August 2008.

Table 12.4: Characteristics of Comparable Railroad Routes[17]

	Los Angeles- Sa Diego, CA[18]	Portland-Eugene, OR[19]	Seattle, WA-Portland, OR[20]	Boston, MA-Portland, ME[21]	Birmingham, AL- Atlanta, GA
Route name*	Pacific Surfline	Coast Starlight and Cascades	Cascades	Downeaster	Crescent
Length (miles)	129: LA-SD, 351: entire Surfliner route	124	186	114	147
Shared/Exclusive Tracks	shared	shared	shared	shared	shared
Top Speed (mph)	90	79	79	79	79
Ave. Speed (mph)	47	45	53	46	42
Construction Costs	$1.1 billion since 1976 for entire Surfliner route			$82 million	
Number of One-way Trains/Day	11	3	10	10	2
Seats per Train	425	244	244	230	
Operating and Maintenance Costs (Annual)	57.2 million (for the entire Surfliner route)			$13.5 million	
One-Way Fare	$29	$22	$28	$14	$31
Annual Users**	2,655,490 (FY2005-6, entire route)	130,000 (2006)	600,000	441,769	
Annual Revenue	$32.5 million		$16.8 million	$6.0 million	
Farebox Recovery	57% (FY2005-6)			41% (2006)	
# of Stations	10	5	8	10	3
Transit Systems Available at Endpoints	Los Angeles: Metro rail subway/light rail and buses	Portland, OR: Tri-Met light rail, bus and streetcar system	Seattle: buses	Boston: subway, buses	Birmingham: buses, DART trolleys
	San Diego: Trolley (light rail), commuter rail and buses	Eugene: Lane Transit District buses	Portland, OR: Tri-Met light rail, bus and streetcar system	Portland, ME: city buses	Atlanta: MARTA rail system, buses
Time Saved Comp. to Automobile[22]	-23 minutes	-45 minutes	-10 minutes	-30 minutes	-70 minutes
Population at Endpoints[23] (Metro Areas)	Los Angeles: 12,875,587	Portland, OR: 2,175,113	Seattle: 3,309,347	Boston: 4,482,857	Birmingham: 1,108,210
	San Diego: 2,974,859	Eugene: 343,591	Portland, OR: 2,175,113	Portland, ME: 513,102	Atlanta: 5,278,904
Employment at Endpoints[24] (Metro Areas)	Los Angeles: 5,682,670	Portland, OR: 1,021,030	Seattle: 1,682,770	Boston: 2,468,720	Birmingham: 515,200
	San Diego: 1,319,170	Eugene: 149,850	Portland, OR: 1,021,030	Portland, ME: 196,810	Atlanta: 2,394,190

Sources: Amtrak, California Department of Transportation, Oregon Department of Transportation, U.S. Bureau of Census, Bureau of Labor Statistics and Mapquest.com

The population on the proposed Phoenix-Tucson route is comparable to that of the Seattle-Portland (Oregon), Boston- Portland (Maine), and Birmingham-Atlanta routes. Despite the similar population size served, annual ridership on the Phoenix-Tucson route is projected to be about 1 million riders per year, much higher than the average ridership of 391,000 passengers per year on the comparable routes.

The five comparable corridors have average speeds between 42 and 53 miles per hour, compared with 62 mph for the Phoenix-Tucson line. The average number of stations of the five comparison routes is 7.2, very close to the 8 proposed stops for the Phoenix-Tucson route. The average fare of the five existing routes, at $25, is slightly higher than the suggested fares of $20–$22 for the Phoenix-Tucson route. The average number of one-way trains per day, 7.2, is nearly the same as the proposed 7 trains per day between Phoenix and Tucson. The time lost compared to driving an automobile on the Phoenix-Tucson route is also comparable to or better than that of the existing routes.

Recent Developments. In late 2008 the Federal Railroad Administration awarded ADOT a $1 million grant to conduct an environmental study of high-speed intercity rail services between Phoenix and Tucson. The grant was awarded under the Fiscal Year 2008 Capital Assistance to States- Intercity Passenger Rail Service Program. However, matching funds of $1 million need to be secured from state, local, and private sources before the environmental study can be initiated. There are no committed funds at this time but state officials plan to confer with regional planning officials to discuss possible funding alternatives.

Challenges

Capital Costs. Capital costs for even the least expensive option (conventional with minor upgrades) are estimated by the ADOT Phase II report to be $800 million, of which $45.5 million (5.7%) is for rolling stock and the remaining $754.6 million for other capital costs. These include estimated construction costs of $520.3 million (20% for tracks, 26% for structures, 28% for signal work, 4% for stations, 5% for earthwork, and 17% for other costs). Engineering/Mobilization/Demobilization/Construction Management (EMDCM) costs represent an additional 15% of the construction costs, while contingencies represent 30% of the subtotal for both construction and EMDCM. Real-estate costs are not included in the $800 million estimate. Federal, state, local, and private sources of revenue would probably be needed for such a major project. A 2008 proposition for a sales-tax increase to pay for roads and rail in Arizona (Proposition 203, the TIME Initiative) failed to get the necessary signatures to go on the ballot.

ADOT's 1998 and Phase I reports discuss project financing in terms of federal, state, local and private funding. If federal funding is pursued, new environmental studies will be required even if all new construction is within existing railroad right-of-way, since there will be new environmental impacts associated with high-speed rail. Because a large-scale environmental study usually takes a long time, it would be advisable to proceed without federal funding if possible, in order to implement new passenger rail service by 2012. Federal funding possibilities include: Earmark, Congestion Mitigation and Air Quality, Surface Transportation Program (STP), Section 130 (grade-crossing safety) program, high-

speed rail corridor development program, rail line relocation project grants, State Infrastructure Bank, and Transportation Infrastructure Finance and Innovation Act funds.

If no federal funding is involved, then, at a minimum, the State of Arizona environmental process must be observed. Recently, at the state and local level, dedicated funding sources have been provided for the light rail in Phoenix and a modern-streetcar service planned for downtown Tucson. Several initiatives have been passed for funding rail projects since 1998, and the likelihood of voters supporting rail services is greater than before.

The likelihood of obtaining private funding for passenger rail is small, as passenger rail systems worldwide are government-subsidized. Passenger-rail-station development could attract some private investment.

Continuing Funding. Attention must be paid to the large, ongoing subsidies needed to keep passenger rail routes operating. The farebox recovery ratio—the percentage of annual operating and maintenance (O&M) costs covered by fare revenue—ranges from a low of 41% for the Downeaster route to a high of 57% for the densely populated Pacific Surfliner route. For the proposed Phoenix-Tucson route, this ratio is estimated to be 50% for the conventional rail with *minor* upgrade alternative, and as low as 30% for the high-speed electric rail alternative.[25] This means that large subsidies from federal, state, or local sources will be required to keep the passenger railroad operating. It should also be noted that the farebox recovery ratio does not take into account capital outlays.

Estimated Subsidy. A financial analysis performed by the authors indicates that a very high subsidy would be required for the proposed Phoenix-Tucson route during early years of its operation, but the subsidy would decline steadily to 21% of its original amount by the 30th year. Assuming that the capital costs of the conventional rail with *minor* upgrades (estimated to be around $800 million) are financed at an interest rate of 6% and repaid over 30 years, the proposed railroad will still need a large subsidy per passenger even 10 or 20 years after its opening, with ridership is assumed to have grown by 25-50% (Table 12.5).

Table 12.5: Financial Analysis of the Phoenix-Tucson Route[26]

Year	Ridership	Avg. Cost per Rider	Avg. Fare	Subsidy per User
2012	1,002,000	$115.04	$16	$99.04
2020	1,229,000	$83.36	$16	$67.36
2030	1,502,000	$57.54	$16	$41.54
2041	1,872,836	$36.74	$16	$20.74

Sources: ADOT Phase I report (2007), Phase II report (2008), and authors' calculations

.

The high subsidies necessary to keep intercity passenger rail operating are noted in an Amtrak report to the U.S. Congress.[27] The *financial* losses per rider for some of the routes examined are $18 for the Pacific Surfliner, $13 for the Cascades, $109 for the Coast Starlight, and $155 for the Crescent routes. The amount of likely ongoing *financial* subsidy required to operate a passenger railway means that costs and benefits must be thoroughly investigated to ensure good value for public money before any shovel hits the dirt. The financial costs and benefits of such a project do not paint a complete picture of the full *economic* costs and benefits, which include the value of people's time, health, and safety, as

well as environmental impacts and other externalities. Some of these nonfinancial factors are discussed briefly, below in *Opportunities*.

Further Challenges. Further challenges associated with the proposed Phoenix-Tucson intercity route include:

- **Travel Time:** Passenger rail service must be fast enough to compete with the automobile; otherwise it will prove unpopular for a relatively short journey. Currently, travel time in an automobile between Phoenix and Tucson is approximately 1 hour and 43 minutes and averages 65 mph.
- **Track Congestion:** Passenger rail would interact with an expanding freight system. This may prove challenging in an environment where freight and passenger trains compete for use of a limited number of rail lines and freight owns the infrastructure.
- **Infrastructure:** Existing train stations must comply with regulations or new ones must be built. Plans call for at least eight stations between downtown Phoenix and downtown Tucson. In addition, appropriate feeder networks need to be planned and implemented to serve passengers at rail stations. Intermodal integration may include parking, light rail and commuter rail, local buses, rental-car services, taxi services, and bicycle facilities.
- **Safety:** Safety at grade crossings needs to be improved, given the additional number of trains and their higher speeds. The ADOT Phase II report (2008) makes recommendations about this issue.
- **Environment:** Environmental impacts need to be carefully estimated, and a National Environmental Policy Act analysis must be performed if new transportation services between Phoenix and Tucson are to be established. According to the ADOT Phase II report, anticipated environmental effects appear to be minimal. In fact, there could be substantial environmental benefits in the long run from reduced local air pollution and climate change.

Opportunities

Opportunities associated with the proposed Phoenix-Tucson railroad include:

- **Population Growth:** According to projections issued by the Arizona Department of Economic Security, Arizona's population will reach 10 million by 2028. A large portion of this population increase will occur in Maricopa and Pinal Counties, where the rail service is expected to run. The communities would benefit from a fast passenger rail service connecting them with downtown Phoenix and Tucson.
- **Productivity:** Though difficult to quantify, societal benefits result from people using inter-city passenger rail services instead of driving. For example, passengers can work on their laptops, read, or simply rest during the train ride.
- **Employment:** Currently, 85% of Arizona's employment opportunities are in Phoenix and Tucson. This is expected to continue, because a large portion of the population growth in the state will occur in these two metropolitan areas.

Convenient travel between the two cities is essential for economic and population growth and development.

- **Cultural and Economic Centers:** The two metropolitan areas house nearly all of the State's major governmental, educational, cultural, medical, recreational, and financial institutions.
- **Tourism:** Seventy-five percent of tourism expenditures in Arizona are in Maricopa and Pinal counties. Passenger rail service between Phoenix and Tucson will increase access to these areas for tourists.
- **Air Travel Substitute:** Air passengers between Phoenix and Tucson will switch to rail if it is at the right price and speed (see Ch. 11). Current travel by airplane between Phoenix and Tucson is expensive and time consuming when bag check, security, and baggage claim are factored in.
- **I-10 Congestion:** Passenger rail would reduce traffic on I-10 between Phoenix and Tucson and make widening the freeway less imperative. It will thus avoid problems with bridges and environmental impacts. Average traffic delays on I-10 per vehicle trip were approximately 2 minutes in the Phoenix area and 37 seconds in the Tucson area in 2002; however, these delays are estimated to increase to more than 9 minutes in the Phoenix area and more than 3 minutes in the Tucson area by 2025.[28] According to ADOT's Phase II report, the cost estimate for widening I-10 to 10 lanes between Phoenix and Tucson is $2.6 billion (in 2008 dollars; this includes the cost of construction, right-of-way, design, environmental, and utility costs).
- **Environment:** Moving automobile drivers and air passengers to trains is environmentally friendly. Assuming average values for passengers per train, car, and airplane, switching from road or air to rail will decrease CO_2 output by thousands of tons each year. If and when a carbon cap-and-trade system is implemented in the United States, the cost of air and automobile travel would increase more than rail costs would, with the result that ridership on rail would increase and/or rail fares could be raised. Either result would have the effect of reducing the financial subsidy required.

This chapter explored the various options for rail connections between Tucson and Phoenix, there are other possible surface transportation solutions for this long-distance corridor. Before major transport investments can receive federal funding, they must undergo a thorough comparison of different possible solutions. While a thorough comparison of alternatives is beyond the scope of this chapter, we would be remiss not to mention the bus alternative. Long-distance coaches enjoy high and growing ridership between many major cities in the United States, use existing roads and HOV lanes, and require little to no subsidies for capital or operating costs. The rail and bus alternatives differ on many other criteria, including geographic coverage, permanence, comfort, appeal, speed, capacity, connectivity with other modes including light rail and Amtrak, energy use, ability to attract "transit-oriented development," and a variety of other dimensions to keep in mind as you consider the potential for long-distance rail in Arizona.

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**mph**	Miles per hour
BNSF	Burlington Northern Santa Fe	**O&M**	Operating and Maintenance
EMDCM	Engineering/Mobilization/Demobilization /Construction Management	**UP**	Union Pacific
FY	Fiscal Year		

Matthew Croucher is a Research Economist at the L. William Seidman Research Institute at ASU's W. P. Carey School of Business and a faculty member in the Department of Economics. His BA is from Sheffield University in the UK and his MS and PhD are from ASU. At the Seidman Research Institute, Dr. Croucher has been involved in several projects, including *Infrastructure Needs and Funding Alternatives for Arizona: 2008-2032* for the Arizona Investment Council, an optimal inventory model for SkyMall Inc, Arizona 2030, and the PEW Research Center on the States.

Timothy James is Director of Research and Consulting at the Seidman Research Institute and Professor in the Department of Economics. Dr James has a BA and an MA from the University of Warwick, and a PhD from the University of Southampton in the UK. Dr. James has extensive experience in research and consulting for both the public and private sectors. Clients he has advised on transportation issues include the Prime Minister of the UK, the state of New Jersey, the Texas Department of Transportation, Goldman Sachs, Morgan Stanley, UBS, and the BBC, and, more recently, the Arizona Investment Council and the Pew Center on the States.

Eva Madly is a Research Economist at the Seidman Institute. She received an MA in Economics from Western Michigan University. Ms. Madly worked as a Research Analyst at the W.E. Upjohn Institute in Kalamazoo, Michigan, and has participated in research projects about the labor market, simulating the impacts of certain policies, evaluating the effectiveness of employment services, and examining the adequacy of workers' compensation benefits.

---

[1] In addition there are also two tourist railroads -- the Grand Canyon Railway and the Verde Canyon Railroad – which we do not discuss here.
[2] R.L. Banks and Associates, Inc. *State of Arizona Railroad Inventory and Assessment-2007.* tpd.az.gov/transit/PDF/FINAL_2007_AZ_RR_Inv_Assess.pdf. Accessed Dec. 2, 2008.
[3] Amtrak News Release. *Annual Amtrak Ridership Sets All- Time Record; Fifth Straight Year of Increases, October 2008.* www.amtrak.com/servlet/ContentServer?pagename=Amtrak/am2Copy/News_Release_Page&c=am2Copy&cid=1178294234716&ssid=180. Accessed Nov. 4, 2008.
[4] www.s4prc.org/info/. Accessed Dec. 4, 2008
[5] Cambridge Systematcs, Inc. *Pinal County Small Area Transportation Study.* Prepared for Arizona Department of Transportation, 2008.
[6] www.arizonashuttle.com. Accessed January 20, 2009.
[7] www.orbitz.com. Accessed January 23, 2009
[8] Tucson International Airport. www.tucsonairport.org/html/tia_tiafacts.html. Passenger statistics are for 2007. Accessed Jan 13, 2009.
[9] Wilbur Smith Associates, Inc. *Pima Association of Governments Regional Aviation System Plan, June 2002.* www.azdot.gov/aviation/library/pdf/PAG_RASP_05.pdf. Accessed Jan 21, 2009.
[10] Kimley- Horn and Associates, Inc. *Arizona High Speed Rail Feasibility Study. Final Report, April 1998.* mpd.azdot.gov/transit/PDF/AZ_High_Speed_Rail_Feasibility_Study_0498.pdf. Accessed Dec. 3, 2008.
[11] R.L. Banks & Associates, Inc. *High Speed Passenger Rail Feasibility Study*. Prepared for Arizona Department of Transportation, Phase I Report, March 2007.
[12] R.L. Banks & Associates, Inc. *High Speed Passenger Rail Feasibility Study.* Prepared for Arizona Department of Transportation, Phase II Report, August 2008.
[13] We did not include the magnetic levitation alternative which is significantly more expensive.
[14] In Table 12.3, amounts are in 2007 dollars. All other data are for 2007 unless noted otherwise. *Farebox revenue measures the extent to which revenues generated from fare collection cover O&M costs. A survey of

U.S passenger rail operations revealed that annual fare revenues equal 60-80% of annual O&M costs. The revenue shortfall needs to be provided from Federal, State and/or local tax sources. **Travel time by automobile between the two cities is assumed to take 103 minutes at an average speed of 65 mph. Rail travel times do not include access and egress travel times or wait times at origin. Automobile travel times do not include access times to the freeway.

[15] U.S. Bureau of Census estimates as of July 1 2007

[16] Bureau of Labor Statistics, May 2007 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates

[17] In Table 12.4, amounts are in 2007 dollars. All other data are for 2007 unless noted otherwise. Data were not available for some characteristics of certain routes. *The intercity routes examined represent segments of generally longer routes. **Passenger counts refer to trips with origin and destination on the analyzed segments, except for the Surfliner route where passenger counts were available only for the entire route which runs between San Diego –Los Angeles- San Luis Obispo.

[18] California Department of Transportation. *California State Rail Plan: 2007-08 to 2017-18*. 149.136.20.80/rail/dor/assets/File/Report_Files/csrp2007FINAL_V3.pdf. Accessed Dec. 11, 2008.

[19] The Oregon Department of Transportation. *2001 Oregon Rail Plan.* November 2001. www.oregon.gov/ODOT/RAIL/docs/Publications/railplan01.pdf. Accessed Dec 10, 2008.
The Oregon Department of Transportation. *Passenger Rail Program: Amtrak Ridership.* www.oregon.gov/ODOT/RAIL/Passenger_Rail.shtml. Accessed Dec. 10, 2008.

[20] *Amtrak Cascades Quick Facts*. www. amtrakcascades.com. Accessed Dec. 12, 2008.

[21] Farebox Recovery and construction costs:
Agenda: Connecticut Public Transportation Commission Meeting, September 7, 2006. www.ct.gov/dot/lib/dot/documents/dcptc/minutes/806m.pdf . Accessed Dec 16, 2008
O&M costs: *The Christian Science Monitor.* Amtrak Downeaster: Successful Train Faces Uncertain Future. December 24, 2007. www.thetransitcoalition.us/NewsPDF/csm20071224a.pdf. Accessed Dec. 12, 2008.

[22] Compared to trip times for automobiles using mapquest.com

[23] U.S. Bureau of Census estimates as of July 1 2007

[24] Bureau of Labor Statistics, *May 2007 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates*

[25] Authors' calculations using annual fare revenue numbers from the ADOT Phase I report and then dividing O&M costs by the fare revenue to obtain the farebox recovery ratio.

[26] In Table 12.5, O&M costs are assumed to stay constant. Ridership numbers are based on the estimates provided by the ADOT Phase I report until 2030 and assume a growth rate of 2.03% afterwards. All amounts are in 2007 dollars. The $16 average fare is based on the ADOT Phase I report, which assumes that discounts of 50% will be applied for children, the elderly or disabled riders and pre-trip discounts of 25% will be available for commuters who purchase multi-tickets, resulting in an average fare paid across all riders of $16, which represents 80% of the adult full fare.

[27] Amtrak Reform Council. *An Action Plan for the Restructuring and Rationalization of the National Intercity Rail Passenger System*: A Report to the Congress. February 2002.

[28] Cambridge Systematics, Inc. *MoveAZ Plan*. Prepared for Arizona Department of Transportation, September 2004.

Chapter 13

FREIGHT AND LOGISTICS

Arnold Maltz
Arizona State University, W.P. Carey School of Business,
Supply Chain Management

Key Points

- No single entity is responsible for planning freight transportation in Arizona.
- Arizona freight transportation is primarily provided by trucks, which can comprise nearly half the traffic on rural interstate highways.
- Much of Arizona's freight traffic is through traffic between California and states farther east, suggesting potential for diversion to rail as the infrastructure improves.
- Arizona could be a "test bed" for new technology because it is home to two very large trucking companies, and both western railroads have extensive Arizona operations.

Like many states, Arizona does not have a specific state agency responsible for planning and monitoring freight transportation. However, the Arizona Department of Transportation (ADOT) has commissioned studies on various issues connected with freight transportation. In particular, the Arizona Multimodal Freight Analysis, conducted by Wilbur Smith and Associates, was completed in October 2008. Much of the information in this chapter is based on the findings of this extremely comprehensive and timely study.

Current Conditions

Freight transportation and warehousing is estimated to account for over 237,000 jobs and $5.7 billion of Arizona's economic activity.[1] Arizona is a net importer of goods, so efficient freight transportation is clearly an important factor in quality of life for Arizona citizens.

Transportation of Freight – Truck vs. Rail. As is typical in the United States, trucks carry most of the freight traveling in Arizona. Table 13.1 shows that trucks handle roughly 76% of all weight and 85% of the value of merchandise moving in Arizona.

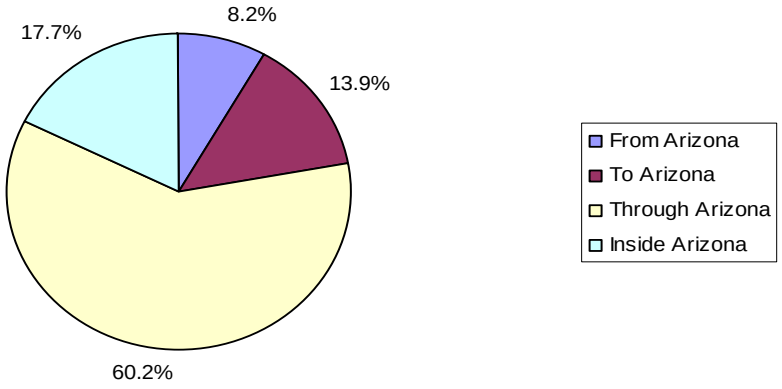
Arizona - A "Pass Through" State for Freight. Although Arizona originates and receives merchandise and materials consumed by its population, most of the freight moving in Arizona is from outside the state and is destined for use in another state (Figure 13.1).

Table 13.1: Freight Carried by Mode of Transportation (2005)

Mode Type	Weight (000 tons)	Value (000 $)	Weight %	Value %
Truck	421,525	$1,998,091	75.7%	85.5%
Rail	134,527	$ 334,756	24.2%	14.3%
Air	505	$ 5,208	0.1%	0.2%
Total	556,557	$2,338,055	100%	100%

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

Figure 13.1: Inbound, Outbound, Internal and Through Freight (based on weight)



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

Four Major Routes. Most of the freight traveling in Arizona travels on I-10 or I-40 if going by truck, or on the Burlington Northern and Santa Fe (BNSF) northern route or the Union Pacific (UP) Sunset Route if moving by railroad (see Fig. 5.1 in Ch. 5). The concentration of freight on these few routes adds to congestion problems for Arizona, especially in the crowded metropolitan areas of Phoenix and Tucson.

Both I-10 and I-40 typically handle over 10,000 trucks per day, and in the less populated regions of Arizona heavy trucks make up 40-50% of the vehicles on those routes.[2] I-17 also has significant truck traffic since it serves as a connection between these routes. Furthermore, two interchanges, the "Stack" (I-10, 51, and 202) and the "Mini Stack" (I-10 and I-17), have been identified as among the most congested interchanges in the United States. On I-40, congestion is highest around Flagstaff where I-17 and I-40 cross.[3]

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 United States. The BNSF route through Kingman, Flagstaff, and Winslow handles 120 trains per day, each averaging 200 or more containers (1 container is equivalent to 1 truckload).[4] The UP route through Tucson currently sees 70 trains per day. Union Pacific is upgrading its Arizona route by adding a second parallel track from Los Angeles to El Paso, which should be complete by 2011.[5] BNSF is developing intermodal yards in Phoenix and supporting the development of an industrial park near Kingman.[6]

The population centers of Phoenix and Tucson have the only major air-freight operations in the state, and in fact Phoenix Sky Harbor handles more than 80% of the air freight in Arizona.[7] There are other possibilities in Yuma, Mesa Gateway, etc. but these airports are not utilized for freight to any significant extent. Like intermodal rail, air freight potential is limited by the distance to much bigger markets such as southern and northern California. In fact, a significant amount of freight tendered to air-freight companies for California and other "close" markets actually travels by truck.

Existing Plans and Programs

Authority for Planning and Enforcement. No particular agency has responsibility or authority for freight transportation and logistics in Arizona. However, the Planning Division of ADOT has initiated studies and reports pertaining to freight issues, including the recent *Arizona Multimodal Freight Analysis*. Both the Maricopa Association of Governments (MAG) and the Pima Association of Governments (PAG) have conducted planning studies relative to freight issues. The Northern Arizona Council of Governments (NACOG) also recently completed a study of freight flows in and through northern Arizona to assess the viability of developing a logistics center in that region. [8]

Enforcement of licensing, size, weight, and other safety regulations pertaining to trucks is under the jurisdiction of the Motor Vehicle Division (MVD) of ADOT. The maximum weight for a commercial motor vehicle in Arizona is 80,000 pounds for a tractor-trailer combination, which is in line with federal road restrictions. Overall length of the tractor and trailer together is limited to 65 feet, and cannot be limited to less than 48 feet on the federally designated national, intercity-truck-route network, which includes all the interstate highways in Arizona and some state highways (e.g., 70 and 89).[9] The MVD also administers tests for the commercial driver's license that is required of all operators of large, commercial motor vehicles.[10]

Infrastructure Developments-Highway. ADOT has supported and/or participated in a number of initiatives to improve highway and freight-movement efficiency in Arizona. Some of these focus on border Ports of Entry and are discussed in Chapter 5. In addition:

- Arizona was an active participant in the I-10 Freight Corridor Study that was completed in 2003.
- I-10 has been designated one of five "National Freight Corridors of the Future," and thus has received Federal support to install intelligent transportation systems (ITS) that facilitate real-time traffic-information exchange and coordinated operations throughout the I-10 corridor.
- States through which I-10 passes are encouraged to experiment with truck-only toll lanes and (possibly) longer combination vehicles.[11]
- Dedicated truck climbing lanes are under construction and/or study where they may improve the flow of traffic.
- Other projects underway include widening I-40 east of Flagstaff, completing the Hoover Dam Bypass, and widening US-60 between Florence and Superior.

Infrastructure Developments – Railroads. ADOT completed the *Statewide Railroad Inventory and Assessment Report* in 2007. However, BNSF and UP own their tracks and facilities and are not subject to ADOT regulation except on safety issues. Each railroad has infrastructure improvements underway in Arizona:[12]

- By 2011, UP will complete a second, parallel track for its Sunset Line, which runs from Southern California to El Paso. This project increases UP's capacity to handle imports and exports through the Los Angeles/Long Beach port complex.
- UP also plans to build a new classification yard north of Tucson to handle the expanded Sunset Line traffic and better service the Phoenix-Tucson market. There is some local opposition to this project.
- BNSF is expanding its ability to load and unload containers in the Phoenix area with a new facility in the West Valley. This should alleviate traffic issues at the current facility near Grand Avenue in Phoenix.
- BNSF actively supports development of an industrial park near Kingman and a potential logistics complex twelve miles west of Flagstaff.

ADOT is actively working on better traffic-control measures and configurations to improve safety and relieve congestion around the main BNSF container-handling facility near 19th and Grand Avenues in Phoenix. Local governments along the UP Sunset Line are also concerned about the many "at-grade" crossings, where the railroad track intersects roads and only a signal or arm controls the intersection.

Infrastructure Developments - Air Freight. Eight airports in Arizona have some scheduled service by the major air-express companies: FedEx, UPS, and DHL. DHL has announced plans to discontinue all intra-U.S. air-freight service, but will continue to handle international traffic. Phoenix Sky Harbor and Tucson handle the vast majority of air freight in Arizona. Developments in this area include:

- Realignment of Sky Harbor Boulevard to improve access to and from the air-freight installations at Sky Harbor.
- Continued efforts to develop Williams Gateway as a reliever airport for Sky Harbor.
- Exploration of an intermodal processing zone at Tucson International Airport through the Puerto Nuevo project.[13]

Challenges

The recent economic downturn has reduced the urgency of addressing freight issues in Arizona. Less truck and rail traffic is moving to and through the state. Nevertheless, there are serious issues to be dealt with in anticipation of resumed growth.

Administration and Planning

- At this time, statewide planning for freight transportation is on an ad hoc, project-by-project basis, with some exceptions, i.e., CANAMEX and other border issues. Given that heavy truck traffic constitutes close to half of all movements in some parts of

Arizona, and that the state is the site of several major freight corridors to and from California, a more centralized approach to freight issues is probably appropriate.

- Arizona is dependent on fuel taxes for road improvements through the Federal Highway Trust Fund. The trust fund will be short $3 billion in 2008,[14] although the new administration's stimulus program may provide additional infrastructure funds. Arizona needs to evaluate whether fuel taxes and local taxes should continue to be the main source of transportation-infrastructure funds.
- Arizona needs to clarify its relationship with the two major freight railroads, UP and BNSF, which collectively run roughly 200 intermodal, general-merchandise, and bulk trains per day through Arizona. The plans and operations of these railroads can create safety, development, and environmental issues in large sections of the state.
- Arizona needs to plan for the growth that will resume when the economy recovers. This will likely mean additional traffic to and from the California ports, as well as increased north-south movement (see Ch. 5).

Congestion and Safety

- Arizona has two interchanges (the "Stack" and the "Mini Stack") that are among the 25 most congested in the United States. These two interchanges resulted in an estimated 1.6 million hours of truck waiting time.[15]
- According to the Arizona Accident Location Information System, there were over 3,000 truck crashes in 2006, including 128 fatal crashes. Seven sites were identified as high risk, and safety improvements should be instituted at those sites.[16]
- Analysis of truck crash data indicates an association between road size/geometry and accidents, especially for oversize vehicles. In particular, some two-lane roads with curves or grades exhibit higher than average accident rates.[17]
- There are many "at grade" rail crossings in Arizona where trains and motor vehicles have the potential to collide.[18]

Economic Development

- As a "pass-through" state, Arizona gains relatively little from the majority of the freight moving in the state. A continuing challenge is determining how to improve the economic yield from this traffic, either by value-added processing of goods and/or leveraging the availability of this traffic to attract new business.
- Freight traffic is generated in only a few areas of the state. The challenge is to pursue the right infrastructure projects and freight initiatives to attract business to some less-developed parts of Arizona.
- Arizona needs to decide how to use its significantly underutilized airport facilities to support economic development throughout the state.

Environmental Impact

- Freight transportation by truck and rail burns about 35 billion gallons of diesel fuel per year, or roughly 20% of all the energy used in transportation.[19] Diesel engines have a different exhaust profile than gasoline automobile engines, but it is certainly

clear that freight is a major contributor to transportation air pollution. Freight operations, particularly rail, also require large amounts of land.[20] Finally, as noted above, commercial trucks may be as much as half the traffic on rural-Arizona interstate highways, reinforcing their significant negative effect on state air quality and energy usage.

Opportunities

The huge flow of freight through Arizona represents a significant opportunity if incentives can be created for some of the traffic to stop in Arizona for value-added and support activities. In addition, there are significant opportunities to work with the Arizona transportation and warehousing industries to support the state's ongoing interest in advanced technology.

Inland Ports. Much of the freight through Arizona originates at Southern California ports or is destined for Southern California for distribution there. Congestion at the ports has led several Arizona communities to consider establishing an "inland port." Inland ports allow importers and exporters to postpone container unloading/loading and distribution of import shipments by moving the import containers off the ship and away from seaports to less congested inland-processing centers, where land and labor is less expensive. These inland ports relieve the seaports by taking over much of the freight handling that is currently done at crowded port facilities. The most prominent Arizona inland-port possibilities are:

- Puerto Nuevo in Tucson, a joint effort among Tucson International Airport, Pima County, the City of Tucson, University of Arizona, and the regional economic development organization. Its goal is to attract intermodal traffic from I-10, the UP Railroad, and the airport for re-handling, processing, and other value-added activities. It complements a federally funded training initiative to develop logistics and transportation workers in the area.
- Volunteer Mountain Industrial Park, 12 miles west of Flagstaff, touted as a potential intermodal processing installation, as well as a support facility for other industrial development.
- Kingman's industrial park that BNSF is working with as a potential intermodal terminal. The park already includes a major Wal-Mart distribution center to serve the region.
- Mesa Gateway Airport, which has been attempting to develop a freight and distribution capability as a reliever for Sky Harbor. Although the airport now has scheduled passenger service and customs processing facilities, it still handles little or no freight.
- Yuma's attempt to develop an inland port in conjunction with the expanded San Luis port of entry, as well as its airport, which has a very long runway.

Local Knowledge and Capability. Arizona is the headquarters of two of the largest and most successful trucking companies in the country, Swift Transportation and Knight Transportation, as well as major air-freight forwarders (e.g., Mach One) and large regional distribution centers for Wal-Mart, Target, Dillard's, and others. These headquarters and

distribution centers interact regularly with many of the largest companies in the U.S. economy. The state could secure their help to structure Arizona's economic development efforts and find the right partners to stimulate economic development in both the short and long term. This effort could include joint presentations to key manufacturing, retailing, and service companies to showcase the advantages of locating intermediate processing facilities in Arizona.

An initial step to engage the private sector is the proposed formation of a Freight Advisory Council, which will work with state and local governments to ensure that freight issues are an integral part of the planning and resource-allocation process.[21]

Test Bed for Advanced Technologies. Freight transportation is one of the most energy-intensive activities in the United States, and a major producer of greenhouse gases. As Arizona works to improve its position in energy conservation and other green technologies, the transportation and warehousing business is an obvious place to pilot new ideas. For example:

- Warehouses and freight terminals typically have large, flat roofs. In Arizona, with its abundant sunshine, they are obvious places for installing solar panels and testing new solar technologies. Similarly, remote parking areas, which are important for trucks, are a good place to install small, solar-powered water processing and other utilities.
- Arizona has a significant pollution problem, and certainly some of it is associated with freight transportation. The two major trucking companies could be excellent partners in developing new technologies for cleaner engines, less idling, etc.
- As UP completes its upgrade of rail infrastructure, Arizona has an opportunity to shift even more of its "through" traffic to the more energy-efficient and less-polluting rail mode. Since rail has a relatively large fixed cost per train, as well as lower service reliability and flexibility than trucks, there will always be a minimum length of haul below which rail transport is not economically viable. On the other hand, rail is three to four times more efficient than truck on a ton-miles per gallon basis. Depending on fuel costs, the minimum distance for economically viable rail transport is between 600 and 1,000 miles.[22]
- Arizona has several transportation-equipment manufacturers, including Honeywell, Boeing, and TRW. These companies could help identify transportation technologies and other products that could be developed, tested, and perhaps even manufactured in Arizona.
- Arizona's membership in the I-10 Freight Corridor of the Future Coalition should give the state access to the latest in ITS technology, which will lead to more efficient use of Arizona's transportation infrastructure.
- Freight-handling equipment represents a potential opportunity to demonstrate and lead in new technology. Arizona has large warehouse operations for companies such as Target, Wal-Mart, Fry's, etc. The forklifts used in these facilities are often propane or battery driven, but hydrogen-fuel-cell forklifts and hybrid electric-propane forklifts are beginning to penetrate the marketplace.[23]

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**MVD**	Motor Vehicle Division of ADOT
BNSF	Burlington Northern and Santa Fe Railroad	**NACOG**	Northern Arizona Council of Governments
ITS	Intelligent Transportation Systems	**PAG**	Pima Association of Governments
MAG	Maricopa Association of Governments		

Arnold Maltz is Associate Professor of Supply Chain Management in the W. P. Carey School of Business at ASU. He worked in both trucking and industrial distribution prior to obtaining his PhD in Marketing and Logistics from Ohio State University. Professor Maltz has done considerable research on logistics outsourcing and third-party logistics, transborder logistics and NAFTA, and international logistics issues. He has also studied warehousing and port issues for various industry groups. Professor Maltz has taught and/or done research in Israel, Mexico, Argentina, Peru, and Denmark.

---

[1] Arizona Multimodal Freight Analysis Study, Technical Memorandum #3, Wilbur Smith and Associates.
[2] Arizona Multimodal Freight Analysis Study, Technical Memorandum #2, Wilbur Smith and Associates, pp. 17-19.
[3] See note 2, p. 13.
[4] See note 2, p. 61.
[5] See note 2, p. 63.
[6] See note 2, pp. 87-89.
[7] See note 2, p. 102.
[8] See note 2, p. 109.
[9] Arizona Revised Statutes, Titles 28-1095 and 28-1100. www.azleg.state.az.us/FormatDocument.asp?inDoc=/ars/28/01100.htm&Title=28&DocType=ARS.
[10] See note 9, Title 28-3223.
[11] I-10 National Freight Corridor of the Future, www.i10freightstudy.org/COF/docs/I-10_COF_for_FHWA_mtg_2-12-08.pps#258,2,What is the I-10 National Freight Corridor?
[12] See note 2, pp. 86-87.
[13]Tucson Regional Economic Opportunities: A Strategic Concept for an Inland Port. www.puertonuevotucson.com.
[14] Legislative Bulletin of the Republican Study Committee, July 23, 2008. rsc.hensarling.house.gov/UploadedFiles/lb_072308_highwaytrustfund.pdf.
[15] *An Initial Assessment of Freight Bottlenecks on Highways: White Paper*; prepared by Cambridge Systematics and Battelle Memorial Institute for the FHWA Office of Transportation Policy Studies, October 2005.
[16] See note 2, pp. 46-48.
[17] See note 2, p. 46.
[18] See note 1, p. 58.
[19] Arizona Multimodal Freight Analysis Study, Technical Memorandum #1, *op. cit.*, p. 22.
[20] See note 19.
[21]See note 1, p. 5.
[22] Robert H. Knight, Jr., "We are the green solution," *CFO*, January 2009, pp. 32-34.
[23] www.ibtimes.com/prnews/20081211/pa-airproducts-grocer.htm; www.autobloggreen.com/2007/01/21/toyota-still-showing-off-fuel-cell-forklift/.

Chapter 14

TRANSPORTATION SAFETY

Simon Washington and Kangwon Shin
Arizona State University, Ira A. Fulton School of Engineering,
Department of Civil, Environmental, and Sustainable Engineering

Key Points

- The motor-vehicle crash rate in Arizona is about 50% worse than the national average. Safety issues identified as priorities in Arizona include the use of safety restraints, young and inexperienced drivers, speeding, impaired driving, lane-departure crashes, and crashes at intersections.
- Other significant safety concerns in Arizona include pedestrians and bicyclists involved in crashes, motorcycle crashes, crashes in work zones, and aggressive driving.
- Behavioral and engineering safety countermeasures focused on priority safety issues are outlined in Arizona's Strategic Highway Safety Plan.
- Challenges to improving safety include lack of funding, lack of coordination among stakeholder agencies, and lack of fundamental knowledge regarding the effectiveness of safety countermeasures.
- Opportunities for improving safety are provided by exciting new research on the effectiveness of safety investments, legislation that mandates statewide coordination of safety, and the possible significant rehabilitation of the nation's transportation infrastructure as a result of the recent economic downturn.

This chapter reviews the current status of safety in Arizona and highlights areas of future research and likely investment. The chapter summarizes the kinds of crashes occurring in Arizona and discusses safety issues, including the lack of safety restraint use, impaired driving, and motorcycle safety. The discussion is not exhaustive, but highlights some important issues facing the state. The chapter concludes with challenges and opportunities for improving highway safety in Arizona. While many of the safety effects associated with socio-demographic changes are discussed here, those associated with tribal lands and an aging population are discussed in Chapters 6 and 15, respectively.

Current Conditions

In Arizona from 2002 to 2006, an average of 136,946 motor vehicle crashes, 1,177 fatalities, and 71,869 injuries[1] occurred each year (Table 14.1). In 2006, one person was killed every 6.76 hours, and one person injured every 7.67 minutes in Arizona. The economic cost of motor vehicle crashes in Arizona was estimated at $5.8 billion in 2005.[2] These costs include medical costs (hospital, emergency department, drugs, rehabilitation, and long-term care), quality-of-life costs, and indirect costs (police, ambulance, fire, insurance administration, loss of wages, legal/court costs, and property damage).

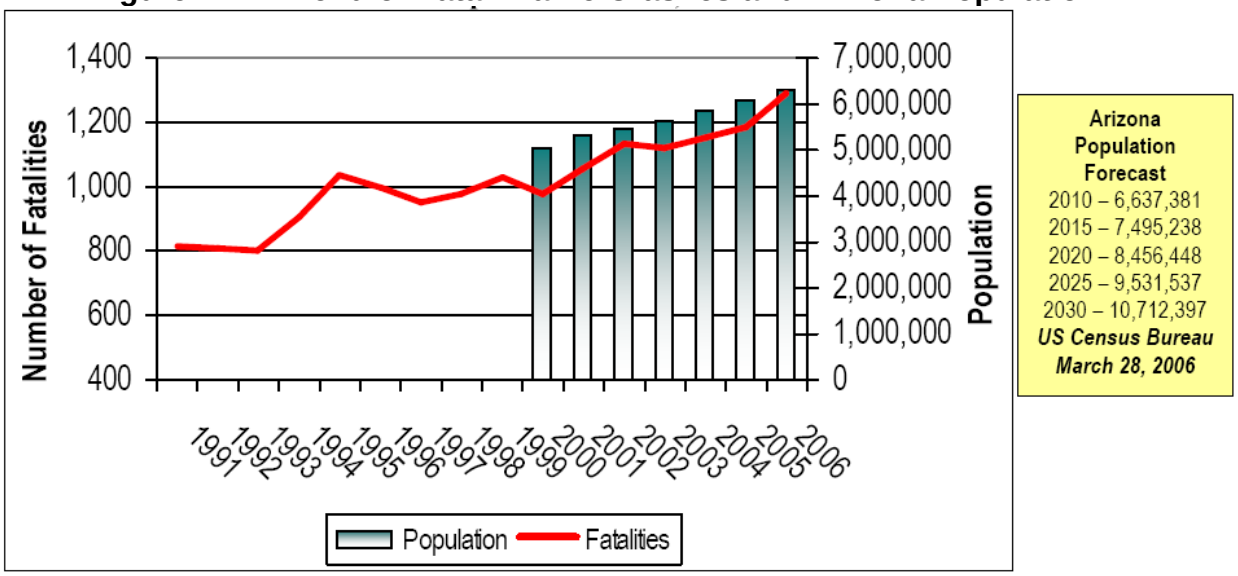
Table 14.1:
Trend of Traffic Crashes and Vehicle Miles Traveled (VMT) in Arizona

Year	Total Crashes	Total Fatalities	Total Injuries	Million VMT
2002	134,887	1,132	74,542	52,014
2003	131,170	1,121	72,081	53,345
2004	138,650	1,151	73,528	57,260
2005	139,828	1,183	70,619	58,796
2006	140,197	1,296	68,574	62,528
Average	136,946	1,177	71,869	56,789

Source: 2006 Arizona Motor Vehicle Crash Facts

Increased vehicle miles of travel have resulted in a 4% increase in crash frequency since 2002. Fatalities have increased about 15% over five years, while total injuries have decreased by about 8%. On a population basis, the statistics paint a bleak picture of safety in Arizona (Figure 14.1). Fatalities have increased steadily since 2000, faster than population growth.

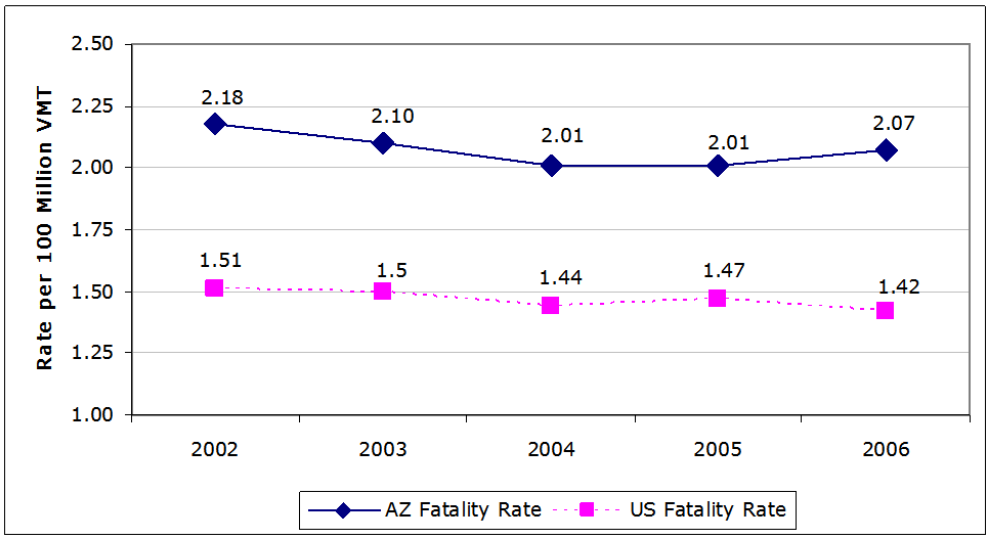
Figure 14.1: Trend of Fatal Traffic Crashes and Arizona Population



Source: Population Statistics Unit, Research Administration, Arizona Department of Economic Security

Arizona's fatality rate has decreased slightly over the past five years, but the rate of 2.07 fatalities per 100 million vehicle miles traveled in 2006 is significantly higher than the national average 1.42, as shown in Figure 14.2. This relatively high crash rate has illuminated several important transportation-policy challenges. Arizona's Transportation Safety Plan[3] and Strategic Highway Safety Plan[4] set out specific policy and operational objectives to reduce the number of fatalities occurring on Arizona roads.

Figure 14.2: Arizona vs. U.S. Fatality Rate



Source: 2006 Arizona Motor Vehicle Crash Facts

According to Arizona's Highway Safety Plan, the six safety focus areas are:

1. Restraint use
2. Young drivers
3. Speeding
4. Impaired drivers
5. Lane-departure and intersection crashes (separately)
6. Improving the quality of Arizona's safety data

These six areas were identified through careful analysis of crash data by safety stakeholders in the state. Table 14.2 shows the number of fatalities and serious injuries associated with the first five focus areas. Note that these categories overlap; e.g., a fatality could involve an unbelted and impaired driver, adding to the count in both categories.

Table 14.2: Arizona Fatalities and Injuries (2001 to 2005) by Focus Area

Emphasis Area	Number of Fatalities	Number of Serious Injuries
Lack of Restraint Use	3,437	15,100
Young Drivers	1,766	15,386
Speeding	2,194	12,670
Impaired Driving	2,385	5,728
Roadway/Roadside: Lane Departure	2,958	10, 957
Roadway/Roadside: Intersections	1,271	16,365
Data Improvement	Not applicable	Not applicable

Source: Arizona Strategic Highway Safety Plan, 2007

The first five safety issues are discussed below. The sixth, improving crash-data quality, was chosen as a focus area because inconsistencies and incomplete crash reporting make it difficult to conduct careful safety evaluations.

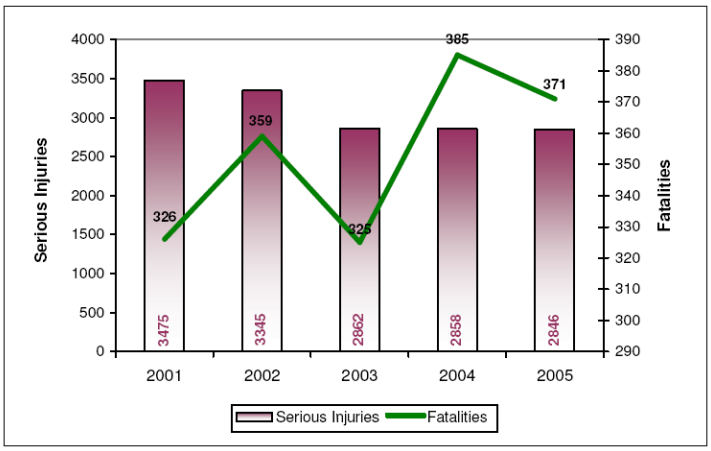
Lack of Restraint Use. The choice to use or not use safety restraints has considerable impact on highway safety. Proper use of seat belts and child restraints is enormously beneficial to vehicle occupants; choosing not to use a safety restraint significantly increases the risk of injury should a crash occur. The Arizona crash facts below are based on safety-restraint-use data from 2005.

- Of the 339,606 people in crashes for which restraint use was known, 14,564 were unrestrained (4%).
- Among the 835 fatalities for which restraint use was known, about 69% of fatalities were unrestrained.
- Of the 13,638 children (under five years old) in crashes, 416 were unrestrained (3%).
- Among the 416 unrestrained children, about 32% (134) suffered 'Possible Injury' or more severe injuries compared to about 9% of restrained children in a crash.

These facts demonstrate the importance of safety restraints in crashes. The choice not to use safety restraints is a behavioral issue that must be addressed with behavioral policies such as enforcement and education.

Young Drivers. Young drivers are inexperienced drivers who tend to engage in risky and impaired driving relative to older drivers. The combination of inexperience with risk taking or impaired driving considerably increases the risk of fatal and serious-injury crashes. Figure 14.3 shows the number of fatalities and injuries over a five-year period in Arizona. While serious injuries declined between 2001 and 2005, fatalities increased.

Figure 14.3: Fatalities and Injuries Involving Young Drivers (Age <25), 2001 to 2005

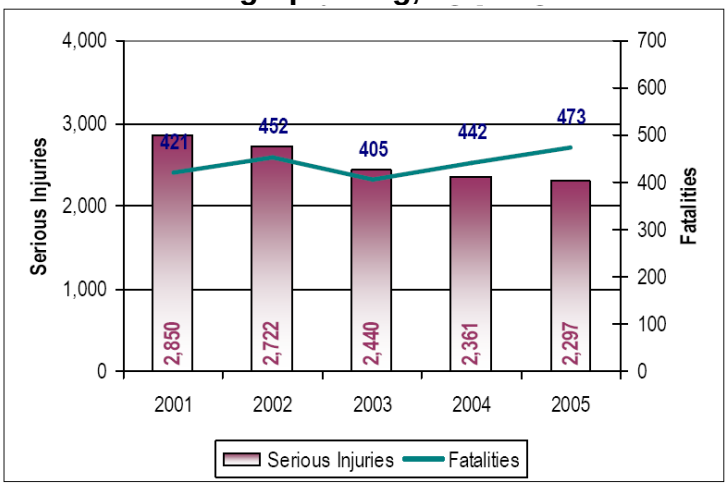


Source: Arizona Strategic Highway Safety Plan, 2007

Speeding. Driving too fast for conditions and speeding cause or contribute to motor vehicle crashes. Roads designed for specific driving speeds become unsafe at higher speeds. Higher speeds place exponentially higher loads on vehicle suspension and braking systems. Higher speeds are associated with exponentially higher impact forces and energy upon impact, leading to more severe crashes. Congestion, despite its overwhelming negative effects, generally reduces speeds and crash severity in urban areas, while rural roads see higher speeds and more severe crashes. Serious injuries involving speeding decreased slightly from

2001 to 2005 in Arizona, while fatalities increased slightly (Figure 14.4). Speeding and driving too fast for conditions are significant contributing factors in Arizona motor-vehicle crashes.

Figure 14.4: Fatalities and Injuries Involving Speeding, 2001 to 2005



Source: Arizona Strategic Highway Safety Plan, 2007

Impaired Drivers. Driving under the influence of drugs or alcohol is a serious problem in the Arizona, as it is in most states. Impaired driving is considered a behavioral problem and is often addressed with behavior-based countermeasures. The combination of impaired driving and driver inexperience is especially problematic. The Arizona crash data below, from 2006, highlights the risks of impaired driving.

- An estimated 315 people were killed in alcohol-related crashes.
- Alcohol-impaired driving fatalities accounted for about 24% of total fatalities, but only about 6% of all motor-vehicle crashes.
- The cost of alcohol-impaired driving in Arizona is approximately $547 million per year (2006$).

Lane-Departure and Intersection Crashes. When a vehicle departs the travel lane it usually enters an unforgiving environment. In urban areas, these environments often consist of man-made objects such as utility poles and walls, while in rural areas the roadside is often full of naturally occurring hazards such as trees, rocks, and steep side slopes. Lane-departure crashes can be quite severe because many vehicles roll over, harming their occupants. Lane departures can also injure or kill pedestrians.

The number of lane-departure crashes resulting in fatalities increased from 477 in 2001 to 634 in 2005—a 33% increase. Nearly 70% of all lane-departure crashes occur in rural areas; about 30% happen in urban areas. About 51% of serious-injury, lane-departure crashes occur in rural areas and 49% in urban areas.

Intersections, with their complex vehicle and pedestrian movement, make high-level cognitive demands on drivers. Intersection violations often result in crashes. Angle crashes are most common at intersections and are typically quite severe, because the human spinal cord cannot handle forceful sideways impacts at the base of the skull without being injured.

Intersections are involved in a disproportionate number of serious crashes, and therefore a safety concern for motorists in Arizona. The number of people killed at intersections in 2005 was 259; 3074 were seriously injured. About 75% of intersection fatalities occur in urban areas, and 85% of serious injuries (incapacitating or worse) occur in urban areas.

Existing Plans and Programs

To reduce Arizona crashes and their toll on the Arizona economy, and to improve public health and well being, the Arizona Strategic Highway Safety Plan identifies strategies for achieving the goal of zero fatalities on Arizona roads. Although the long-term goal is zero fatalities, it will take considerable time to achieve and requires that milestones be set and met. The first milestone is to achieve a 12% reduction in fatalities by 2012.

Achieving significant reductions in motor-vehicle crashes will require investment in both behavioral and engineering countermeasures. Behavioral countermeasures are aimed at modifying driver behavior and typically include such things as graduated driver licensing programs, traffic-law enforcement, photo speed enforcement (intersections and road segments), educational programs, and click-it-or-ticket (buckle-up) campaigns. All impaired-driving countermeasures focus on changing behavior; they include sobriety checkpoints, community-awareness programs, public-information campaigns, and educational programs.

Engineering countermeasures are focused on improving the safe operation and design of transportation facilities. Some countermeasures are focused on easing the impact should a motor vehicle depart from the road (roadside-clearance programs, safety barrels, etc.), others increase visibility (nighttime lighting, improved signal-head visibility, sign reflectivity, etc.), and some are designed to minimize conflict points (left-turn bays to an intersection, cable median barriers on highways, etc.).

Complementary behavioral and engineering countermeasures are needed to achieve safety objectives. These countermeasures will be selected, funded, and implemented through the state's strategic highway safety plan to reduce crashes. Crash types not identified as priority issues, but still significant, include those in which pedestrians are involved, motorcycle-related crashes, work-zone crashes, crashes resulting from aggressive driving, and bicycle crashes. The number of these kinds of crashes can be reduced by targeted safety investments and behavioral policies.

Challenges

The vast majority of motor-vehicle crashes are caused entirely or in part by human error; thus, human behavior modification is fundamental to improving safety. Modification of driver

behavior requires the support of appropriate laws and adjudication procedures, which may not provide sufficient incentives to modify the behavior of regular offenders. For example, a primary seat-belt law is needed for a law-enforcement officer to cite someone for failing to wear a safety restraint; Arizona currently has a secondary seat-belt law. In secondary-law states, an officer must have another cause for citing a driver before citing a restraint-use violation as a secondary offense. Drunk-driving and graduated-driver licensing laws are adopted through legislative changes, so making significant safety improvements requires the support of elected officials and their constituents. While these laws are important to improving safety, many laws are perceived to result in loss of individual freedoms, so the political will to implement such laws has to be significant and broad.

Despite years of research, there remains much to be learned about the link between safety and engineering countermeasures. Understanding the safety impacts of engineering countermeasures is extremely complex and difficult, and sometimes even counterintuitive. It is impossible to separate the effects of engineering improvements from human behavioral responses to them. For example, a recent study examined the safety impact of the Scottsdale 101 Speed Enforcement Cameras.[5] The study found that the number of crashes dropped in the photo-enforcement zone, but it is not clear how much of the reduction is due to increased driver vigilance within the zone and how much to reduced travel speeds. If some of the safety effect was due to increased driver vigilance, how much? Would driver vigilance degrade over time? Another important question is whether photo enforcement actually changes driver behavior, or whether drivers simply comply locally. This simple example illustrates some of the complexities involved in understanding the safety implications of engineering countermeasures.

Another challenge is how to fund safety improvements. Safety competes with other priorities such as congestion and air-quality issues, 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. Often, behavioral programs are administered by the Governor's Office of Highway Safety and the Department of Public Safety, while engineering countermeasures are administered by local and state transportation agencies. The historic lack of targeted safety funds combined with lack of statewide or even regional authority over transportation safety concerns has also hampered major improvements to road safety in the United States.

Opportunities

The recent adoption of Statewide Strategic Highway Safety Plans mandated in SAFETEA-LU legislation provides the opportunity to coordinate efforts among stakeholder agencies within Arizona to achieve statewide safety objectives. The economic recession that began in 2008 may push the auto industry to produce more fuel-efficient and smaller vehicles, which may yield safety benefits. Improvements to transportation infrastructure offer opportunities to significantly improve safety. Continued research on the safety effects of behavioral and engineering countermeasures and their interaction will also yield valuable knowledge about how to attain safety goals in Arizona.

Professor Simon Washington is a leading researcher in the area of transportation safety and advanced statistical and econometric methods. He has served on the faculties of the Georgia Institute of Technology, the University of Arizona, and Arizona State University. He has been Visiting Professor at Ajou University (South Korea) and the University of Sydney (Australia). Professor Washington has authored over 80 peer-reviewed technical papers, books and book chapters, and technical reports, and been principally responsible for over $8M in externally funded research. He currently serves on the editorial boards of five international safety-related journals and is Chairman of the Statistical and Econometric Methods in Transportation Committee of the U.S. Transportation Research Board, National Academy of Sciences.

Dr. Kangwon Shin has been working on safety research for the past six years. He is an Assistant Professor at Kyungsung University in South Korea.

---

[1] ADOT, 2006 Arizona Motor Vehicle Crash Facts. ADOT Traffic Record Section, 2008. www.Arizonadot.gov/mvd/statistics/crash/PDF/06crashfacts.pdf. Accessed Dec. 29, 2008.

[2] Washington, S. P. and I. van Schalkwyk. The Economic and Injury Burden of Motor Vehicle Crashes in Arizona for 2005. The Arizona Crash Outcome Data Evaluation System Project, 2007.

[3] 2005 Transportation Safety Plan of the State of Arizona. www.gtsac.org/GTSAC/Studies_Reports/PDF/Arizona_Transportation_Safety_Plan_2005.pdf. Accessed Dec. 29, 2008.

[4] Arizona Strategic Highway Safety Plan. 2007. www.gtsac.org/GTSAC/Studies_Reports/PDF/Arizona_Strategic_Highway_Safety_Plan.pdf. Accessed Dec. 29, 2008.

[5] Evaluation of the City of Scottsdale Loop 101 Photo Enforcement Demonstration Program: Final Report AZ-07-684 (2007). Simon Washington, Kangwon Shin, and Ida van Schalkwyk, Arizona State University. Arizona Department of Transportation Report.

Chapter 15

AGING AND MOBILITY

Dr. Sandra Rosenbloom
University of Arizona, School of Landscape Architecture and Planning

Key Points

- Within two decades Arizona will have almost 2.5 million people over 65, of whom 400,000 will be over 80.
- The vast majority will have been drivers for decades and will have made housing and other family decisions that will genuinely require access to a car.
- Few will have much experience or interest in alternative transportation modes thought "suitable" for them by experts.
- To address these issues, the state should develop a multifaceted transportation and mobility strategy that is responsive to how and where older people live.
- Communities should consider increasing paratransit services for the disabled, and support, expand, and improve a variety of public, non-profit, and entrepreneurial community-transport providers (from taxis to volunteer systems to voucher programs).
- Communities could also expand and improve conventional public transit in multiple ways to respond to the special needs of older people.
- Communities could expand the pedestrian network with special attention to the needs of older people, focusing on continuing enforcement and maintenance.
- To prolong safe driving, the road system could be made easier and safer for older people while developing better ways to test and improve their driving.

Current Conditions

In 2006, roughly 13% of the population of Arizona was over 65; almost 70,000 Arizonans were older than 85. The U.S. Census Bureau estimates that an astonishing age-wave will hit Arizona in the next two decades, driven both by aging of the existing population and a continuing influx of retirees from around the United States. By 2030, the older (over 65) population of Arizona will expand to 2.4 million people, a 255% increase from 2000. In a little more than 20 years, almost one of every four citizens in the state will be an older person. But that is just the leading edge of the socio-demographic tsunami soon to engulf Arizona. By 2030 the population aged 45-64 will also grow by more than 116%, ensuring successive and growing waves of Arizonans turning 65 throughout most of the 21st Century.

These trends create both challenges and opportunities. Many older Arizonans will remain in the full-time or part-time labor force long after age 65; many will be active volunteers contributing to their neighborhoods and communities, enjoying robust lifestyles facilitated by the easy access afforded by the car. And if the past is a prologue to the future, few older

Arizonans will 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; Arizonans are no exception. In 2000 the Phoenix metropolitan area had the 14th highest percentage of its suburban population over 65, and the 6th fastest growth rate of the suburban population over 65 in the nation. The Tucson metropolitan area had the 6th highest percentage of its suburban population over 65 and the 4th fastest growth rate. University of Arizona (UofA) and Arizona State University (ASU) studies show why: most older migrants to the state move to the outskirts of metropolitan areas. In fact, Tucson's elderly population actually declined between 1990 and 2000 while that of suburban and surrounding unincorporated areas more than doubled.

In 2006, 80% of men and 70% of women over 65 were licensed drivers. Licensing rates were relatively high even among those over 85. Since licensing is almost universal among those currently younger than 65, in a little over 20 years more than one out of every four Arizona drivers will be over 65 and a considerable number will be over 85. National data clearly show that licensing rates are directly related to substantial increases in all attributes of "automobility." Those 65-85 take roughly 90% of all their trips in car, usually as the driver of that car. Even those over 85 take 80% of their trips by car, driving half the time.

As the MAG *Regional Action Plan* noted:

> The primary mode of transportation for seniors is and will most likely continue to be the automobile... they are unfamiliar with other modes of transportation 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.
>
> Older people should or do stop driving for complicated reasons. Some have medical or other conditions, particularly associated with vision loss, that make them unsafe drivers. Others have physical or cognitive problems that make it hard for them to deal quickly with the demands of a fast-paced road network. Some drivers, particularly women, often lose confidence in their driving ability and some cannot afford to maintain and drive a car. As a result older drivers begin to drive less and less and avoid situations that they consider stressful, like traveling in bad weather or in congested traffic. And they generally do so some time before they entirely stop driving. Thus self-regulation itself lowers mobility and adversely affects life-style, long before driving cessation.[1]

While many older people will be able to safely drive for decades after they turn 65, on average, older people's driving skills decline as they age. Thus, some percentage of the large and growing older population of the State will need mobility alternatives to replace the freedom and independence afforded by the car. As MAG's *Regional Action Plan on Aging and Mobility* noted:

> The social isolation that results from the loss of personal mobility can lead to depression and sharp declines in physical health. Social and economic capital is lost

> too, since many that might have worked or volunteered are unable to do so without a reliable source of transportation. The overall decline in quality of life associated with limited to no-mobility options produces an increase in the demand for in-home elder care services and costly assisted living facilities. [2]

While many analysts believe that older people will come to rely on traditional public transit as they age, they are often basing their views on data that historically showed that older people used public transit more than younger people. But we know that data can reflect what is called a *cohort effect*; in the past, many people reaching 65, particularly women, had never driven and had long relied on public transit for some of their trips—they did not suddenly begin using transit upon retirement. Today, the vast majority of people 65 and over have never done anything but drive.

The second most important travel mode for older Americans is walking. Walking is necessary for all other modes of travel and it can provide a healthful physical activity geared to older people's needs. About 9% of all trips taken by those over 65 are walking trips; among non-drivers over 65, walking accounts for almost 25% of all trips and its importance goes up with age. A national study found that among respondents who reported problems in "getting around outside home," over 75% said that their major issue is *difficulty in walking.*[3] Among older people with disabilities, the most significant transportation problems mentioned were **barriers in the pedestrian environment**—they far outnumbered reported problems with transit or paratransit modes.

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.

Even those who recognize the enormity of the transportation problems that will face older Arizonans often believe that public transit or demand-responsive systems are already in place to handle them. Yet most indications are that neither of these services will come anywhere close to meeting the needs of the state's aging population. Moreover, there is likely too little focus on enhancing the travel modes that do serve most older people in Arizona and the United States: cars and pedestrian facilities.

Existing State Plans and Programs

Automobile Travel. The direct safety issues associated with older drivers are addressed in Ch. 14; this chapter discusses the mobility losses associated with increasing driver self-regulation and driving cessation. Once drivers stop driving entirely, they face very serious mobility losses—as do any older non-drivers who depended on them. Given these drastic losses, a number of studies have suggested ways to keep older drivers on the road, by helping them become or remain safe drivers.

Public Transit Services. Part of the declining reliance on public transit among those over 65 is due to conventional public transit services not being responsive to the needs of most older travelers, particularly those no longer in the full-time labor force. In many studies, older travelers have expressed a variety of safety, personal-security, flexibility, reliability, and comfort concerns about public transit, even when it is physically accessible. Since transit operators are required to provide half-fares in the off-peak to older and disabled people as a condition of receiving federal funds, operators have even less incentive to try new ways of attracting and accommodating older people unless they are provided with additional sources of funding.

Special and Demand Responsive Services. Many people assume that special services, and particularly the "complementary" (to fixed route public transit) paratransit services provided by public-transit operators under the mandates of the Americans with Disabilities Act (ADA), such as Tucson's Van Tran and Phoenix' Valley Metro Dial-a-Ride, will meet the needs of their aging relatives who do not or cannot drive. But these assumptions can be wrong.

Complementary ADA paratransit was designed to be a *temporary* alternative for most people with disabilities, until all buses and rail facilities were fully accessible.[4] As more transit vehicles, transit stops, and the pathways to them become accessible, operators will be allowed to substantially *reduce* the paratransit services that they provide.

Second, eligibility for complementary ADA paratransit services is based on disability and not age—and that disability must be severe enough to significantly interfere with the use of traditional public transit. While disabilities and their severity increase with age, the majority of the elderly are not disabled and the majority of those with disabilities are not elderly. Even among the 42% of older people with at least one disability, many remain ineligible for paratransit services. As a 2005 study by the National Center on Disability noted, many seniors are ineligible for ADA paratransit:

> because their functional impairments do not rise to the level of ADA eligibility. For example, frailty or a chronic medical condition could make travel on fixed-route transportation difficult, but this alone may not qualify an older adult for paratransit. As a result ...older adults fall through the cracks because they are not ADA eligible.[5]

It is important to recognize that simply being required to stop driving or being unable to drive does not qualify seniors for ADA services unless the disability that caused their driving cessation is *both* fairly serious *and* prevents them from using traditional transit services. The lack of transit service does not qualify older people for ADA services—in fact, quite the reverse! Transit operators are only required to provide complementary paratransit services to eligible users in a three-quarters of mile corridor paralleling their existing bus routes, and only during the same hours of service. National figures suggest that only about one-third of older people in the United States live within this distance of a bus line; even fewer make the majority of their trips within such corridors. While most of the complementary ADA paratransit systems in Arizona do not restrict service to such narrow corridors (for various political and other reasons), it is still clear that: 1) the vast majority of older people in

Arizona do not and probably will not live in areas with ADA paratransit service, and 2) even if they do, they will likely not qualify for those services for most of their lives after they turn 65.

Paratransit services are extremely expensive. It is hard to generate substantial economies of scale while carrying people within a large, low-density service area, while being forbidden by law from delaying their trips to pick up or drop off other passengers. While the state's ADA paratransit providers can make improvements to lower costs, the savings would be minor.[6]

Table 15.1 compares ridership for ordinary bus services and for demand-responsive paratransit services in Coconino County and within the city limits of Phoenix and Tucson. It clearly shows the substantial difference in costs. In Phoenix, for example, the average operating cost for a bus trip is $2.37 compared with over $35 for a paratransit trip.

Table 15.1. Paratransit Ridership and Costs, 2007

City / County System Name	Total Annual System Ridership*	Annual Paratransit Ridership	Paratransit as a % of Total Ridership	Paratransit as a % of Operating Costs	Average Cost per Paratransit Trip+
Coconino County Transport Services (Flagstaff)	753,726	22,349	3.0%	18.8%	$33.41
City of Phoenix Valley Metro RPTA	50,590,609	565,327	1.1%	13.6%	$35.33
City of Tucson City of Tucson Transit	18,205,425	439,775	2.4%	23.0%	$29.36
Average of the 50 Largest US Transit Operators#	84,294,000	432,200	0.5%	5.0%	$27.88

* = unlinked trips + = operating costs only # = includes Phoenix

Source: 2007 National Transit Database and FTA (2008) Transit Profiles: The Top 50 Agencies.

Even if we assume that all current paratransit riders are over 65 (something unlikely to be true since many younger people use the service), and that each user makes eight one-way trips per month, it appears that these three Arizona cities carry less than 40% of the older people with at least one serious disability (as classified by the Census). Note that this estimate does not assume that the systems are failing to meet their mandates under the ADA—it is possible that they are providing all the service requested by all the older people who are eligible. But that's exactly the point: Even meeting ADA mandates still leaves large numbers of older people who have serious disabilities, or cannot drive or use public transit, without a means of transportation. They are not eligible for ADA services because their disability is not severe enough to meet stringent ADA guidelines, or they don't live or need to travel within three-quarters of a mile of existing bus routes.

Many Arizona communities, with or without public transit and ADA paratransit services, are served by a host of other paratransit systems provided by other governmental agencies, non-profit organizations, faith-based groups, and advocates for the aged. We know that many community transportation systems limit their services to a small number of agency clients, often restricting travel by trip purpose (medical or agency related only). Some needy travelers are provided substantial transport service while many others are offered nothing. Most cities simply do not provide a substantial amount of demand-responsive transportation services *in total* to older people who might need those services.

Pedestrian Facilities. Current ADA regulations require that *if* local jurisdictions provide curb ramps, sidewalks, and/or bus stops, these elements must comply with the ADA. But cities are not required to provide these pedestrian elements at any specific location if they do not already exist. However, the ADA does require cities to undertake a program *over time* to provide access in their existing pedestrian facilities. Since more than 18 years have passed since the ADA requirements went into effect, many cities should have brought almost their entire pedestrian environment into compliance with the ADA.

However, without enforceable standards, many communities have done only the minimum. For example, they may provide some curb ramps (cuts) and require all new residential developments to provide accessible sidewalks, but they rarely substantially improve existing sidewalks and bus stops if they can be viewed as accessible (and in some cases when they are not accessible). Moreover, many cities have been lax in maintaining the accessibility of sidewalks and bus stops that do exist (that is, repairing broken pavement or removing weeds and debris, ice in winter, etc.), and many fail to retrofit built-up areas without sidewalks.[7]

Lack of accessible and well-maintained pedestrian facilities is a major safety issue; older people are involved in more pedestrian crashes than any group except children. When involved in a pedestrian crash, including falling on pavements or at transit stops, older people 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 they are as pedestrians in almost any environment. Some experts believe that older people are at least 15 times more likely to be injured or killed as pedestrians than as car drivers, on an exposure basis.[8]

Both Tucson and Phoenix have made major commitments to improving pedestrian facilities in their regions. In Tucson, the Transportation Improvement Program includes funding for over 96 miles of new sidewalks to be constructed by local jurisdictions, with another $5 million for pedestrian safety programs including wheelchair ramps, shade, lighting, and signalized sidewalks at key locations.

Challenges

Special and Demand-Responsive Services. Earlier we suggested that both ADA paratransit services and community transport systems might be inadequate to meet the mobility needs of a large and growing number of older Arizonans. A simple solution might be to provide additional demand-responsive services to older people who may have problems driving or using public transit, but who do not qualify for ADA services. And many Arizona systems do, to some extent, by relaxing service-area constraints or allowing all those over 80 or 85 to ride.

Table 15.2 shows the extraordinary costs of providing not very much service to the large number of older people who currently might have difficulties driving or using traditional public transit (even if it existed near where they lived). Tucson, for example, would have to spend $15.5 million per year (in 2007 dollars) just to provide four one-way trips per month to every older person within the city limits who has a severe disability.

Table 15.2. Estimated Paratransit Costs for Serving All People 65+ with Disabilities

City or County	2007 Cost per Pararansit Trip	2007 Demand-Responsive Operating Costs	Estimated* People 65+ with a Severe Disability	Potential Annual Cost for All People 65+ with a Severe Disability	
				4 One-way Trips/Month	8 One-way Trips/Month
Coconino	$ 33.41	$ 66,932	794	$ 1,273,322	$ 2,546,644
Phoenix	$ 35.33	$ 19,975,296	21,206	$ 35,961,983	$ 71,923,966
Tucson	$ 27.88	$ 12,910,431	11,588	$ 15,507,525	$ 31,015,050

* = estimated by taking Arizona's total population 65+ and multiplying it by the percent of Arizona's population 65+ who reported one or more disabilities: 24.8% (which is below the national rate, which ranges from 37% to 52% depending on source) and then multiplying it again by the US percent of those w/one or more disabilities who reported at least one severe disability: 75.6%.

It is inescapable that because of their high costs, ADA paratransit services can only be a small part of the mobility and transportation options offered to older people in the future. They will need to be limited to those older people with the most severe disabilities. For travelers with problems who are not facing severe disabilities (or only experience severe problems during certain seasons or for certain trips), it makes sense to see if there are more cost-effective ways to provide mobility.

Opportunities

Building a family of transportation services for older people will require making better use of private, for-profit and non-profit community-transport providers, and facilitating the role of private individuals as well. Here, we present some of the most important options communities should consider.

Enhancing the Role of the Private Not-for-Profit Sector. Many different kinds of community transport services are provided by NGOs and other social- and human-service agencies. In 2006, federal legislation required regional areas to develop plans for coordinating public transit and human-services transportation to make them more effective and efficient. Communities can lower costs by redistributing underutilized vehicle capacity, providing regional vehicle-maintenance facilities, developing state programs to lower insurance costs, or offering driver training programs

A transit operator or other large public agency could develop a process that allows agencies with excess capacity to "sell" that capacity to other agencies that need it. A regional facility might achieve economies of scale, and thus reduce individual maintenance costs. State or regional agencies could provide group insurance coverage or establish insurance pools to which small providers could belong. Finally, some public agency could offer driver training to agency volunteers and staff; training costs are significant for small providers.

Facilitating the Role of Private Individuals. Older people already depend substantially on riding in other people's cars. Therefore, it would be useful to develop ways to optimize the use of excess capacity in cars and the good will of volunteers to provide more services for older people, by supporting formal and informal volunteer networks and facilitating ridesharing programs.

Communities could better support a variety of *formal* volunteer ride programs already underway by helping volunteer programs solve the liability and maintenance problems they face as soon as they begin to carry any appreciable number of riders. A public agency or the transit operator could get group insurance coverage under which such volunteer programs could be covered. A public agency could also develop ways for volunteers involved in formal systems to receive auto maintenance at reduced rates.

Enhancing the Role of the Private For-Profit Sector. Many communities have a number of commercial or for-profit providers who can or already do provide mobility for older travelers. But their role can be strengthened, and made safer in some cases, by concerted community strategies, including regularizing extra-legal operations, expanding the role of taxis, or "growing" additional entrepreneurs.

Public Transit Services. A number of studies have suggested how traditional public transit services can be improved to meet the needs of an aging population. Most emphasize changes such as improving conventional services, providing additional services targeted to the elderly, increasing safety and security in all parts of the system, and enhancing communication and information provision.

Suggestions for improving conventional public transit to make it more responsive to older travelers include expanding hours and routes, improving service reliability, enhancing driver training, and operating low-floor and smaller buses. It is likely that at least the first three of these suggestions would have to be implemented together to attract older travelers to transit.

Older people may travel at different times than most transit users, and they often have different origins and destinations. Just improving conventional transit services may be insufficient to attract many elderly riders. By identifying concentrations of older people in aging-in-place neighborhoods and in formal and informal active-adult retirement communities, transit operators could provide scheduled and charter-type services, or implement neighborhood-based services. These services, if appropriately geared to the travel patterns of older people, might attract ridership even if provided only once or twice a week.

Older people often report being fearful of walking to, waiting for, and riding in transit vehicles. To provide services likely to be attractive to older travelers, transit operators could address these concerns by providing comfortable and safe waiting areas and increasing passive and active surveillance and enforcement.

Almost every study of seniors and public transit has found that older people are very concerned about better trip information both before and during travel. A number of U.S. transit systems have seen considerable increases in elderly ridership by providing either transit familiarization or training programs and improving information dissemination.

Pedestrian Facilities. Many studies have suggested measures that can facilitate walking for older people both as a mode itself and to access public transit. Most of these measures can be used to retrofit existing neighborhoods where baby boomers are aging in place; they can also be incorporated into new suburban developments, formal or informal retirement communities, and existing or new urban neighborhoods, through subdivision and zoning regulations and impact or development fees.

Cities can implement pedestrian-friendly measures like accessible curb cuts, lighting, pedestrian overpasses or tunnels at busy intersections, and measures to reduce conflict with cyclists and other path users. Intersections can be improved with better signalization and pavement markings. Traffic-calming approaches are also important, and include narrowing streets, lowering speed limits, raising crosswalks, and adding medians. Improving access to public transit is another important measure, and includes ensuring that all bus stops meet ADA requirements and are accessible.

Improving the Highway System. Since so many older people are and will be drivers until very late in their lives, policymakers and analysts have advocated modifying and enhancing the entire auto-based infrastructure so that older people can drive safely longer. Developing effective measures of driver competence, expanding appropriate driver training programs, and assisting safe older drivers to continue driving are three strategies to increase safe auto use by the elderly.

The first strategy is to develop better ways to identify which older drivers should be removed from the road, which can be re-trained in some way, and which left alone. Age-based testing of older people has proven ineffective at reducing older-driver crashes. NHTSA has conducted tests of alternative ways to measure older-driver competence. While it is not difficult to devise elaborate and lengthy tests of driving competence, such tests are too expensive to be feasible on a large scale.

The second strategy is to develop cost-effective ways to retrain older drivers. Most existing training programs, like AARP's Mature Driver, are based entirely on classroom learning; there is very little hard evidence that enrollment in such programs actually reduces driver crashes. Private driving schools across the country have long reported increased interest on the part of older people (and/or their families) in driver training programs, but most of these schools use one curriculum for both young and older drivers. There is a need to develop, test, and evaluate in-car training courses for older drivers, to which they can be referred or for which they can volunteer.

The third strategy is to assist safe older drivers who have financial difficulties to continue driving. A community can develop programs that provide assistance for maintenance or fuel, or even to purchase a car. This approach has been adopted by several European countries, most notably the UK, to assist older drivers and those with disabilities. The UK Motobility program gives grants that may be used for taxi fares, to pay for rides from others, to purchase and/or equip a personal or household car with mobility devices, or to use as collateral for a car loan.

Another way to help safe older drivers continue driving is with a car-sharing program like those for the general public that have been implemented in numerous U.S. and European cities. Large residential complexes (independent living centers, trailer parks, naturally occurring retirement neighborhoods) could cooperatively buy and operate a small fleet of vehicles, allowing residents to reserve and drive them on an hourly or daily basis. Public-sector involvement could range from simply encouraging communities to set up their own programs (much as public agencies help private firms set up carpooling and vanpooling programs), or actually helping to purchase and maintain the vehicles, and structuring the rules and payment systems. A large commercial car-share provider, ZIPCAR has now expanded to dozens of cities across the country and could play an important role.

Two important approaches to making the roadway safer for older drivers (and a mixed-age driver pool) are modifying passive network elements and enhancing active, technology-based elements. First, we can make the road network safer by altering the dimensions, marking, and contrast of streets and roads, signs, turn lanes, etc. Efforts are underway to make roadways and signage more responsive to the changing abilities of older drivers. The FHWA has developed design standards that reflect the aging of the driver pool.[9] The MAG *Regional Action Plan* makes specific reference to requiring local jurisdictions to consider the FHWA guidelines in MAG grant guidelines and in the review of federally funded projects.

The second approach is more proactive: using Intelligent Transportation Systems (ITS) technology in the road, on the vehicle, or in some effective combination. This could include

providing en-route or in-vehicle safety and congestion information to drivers. ITS technology could also help older drivers better manage the driving task, for example, by warning drivers that they are following another vehicle too closely. Technology that helps drivers decide when it is safe to make left turns might reduce crash rates, since older drivers are over-represented in left-turn crashes.

Pedestrian Improvements. Older people are over-represented in pedestrian crashes. Communities can improve the pedestrian environment for older people by ensuring that both the neighborhoods where they are or will be aging-in-place and newly developing communities have accessible sidewalks, separate cycling facilities that reduce conflict between pedestrians and cyclists, and shaded street furniture like benches that allow travelers to stop and rest as needed. But the existence of such facilities is not enough. They must be maintained so that they remain level and don't create tripping hazards. Moreover communities should seriously enforce a variety of traffic regulations from those against parked cars blocking driveways to speed limits in residential neighborhoods. Many traffic calming measures are likely to create safer and more attractive pedestrian environments for older people.

Hopefully, among this list of suggestions are options for every community's particular needs. These are difficult issues for any community to confront, though delaying action could lead to even greater costs and difficulty in the future as the aging population grows.

List of Abbreviations Used

ADA	Americans with Disabilities Act	**MAG**	Maricopa County Association of Governments
AARP	American Association of Retired Persons	**NGO**	Non-governmental organization
FHWA	Federal Highway Administration	**NHTSA**	National Highway Traffic Safety Administration
ITS	Intelligent Transportation Systems		

Dr. Sandra Rosenbloom is Professor of Planning and Adjunct Professor of Engineering and of Natural Renewable Resources at the University of Arizona where she teaches courses in land use and transportation planning and the financing of community infrastructure. Dr. Rosenbloom is internationally known for her scholarship on the transportation and land use implications of societal trends such as the aging of the population and the increasing labor force participation of women, particularly those with children. She is the author of over 50 peer-reviewed articles (the sole or senior author of most), over a dozen chapters in influential books, and multiple research studies for organizations such as the National Science Foundation, the National Research Council, AARP, the U.S. Departments of Labor, Housing and Urban Development, and Transportation, the Office of the White House, as well as the European Union, the European Conference of Ministers of Transport, and the governments of Australia, France, The Netherlands, New Zealand, Sweden, and the United Kingdom.

---

[1] Maricopa Association of Governments. *Regional Action Plan on Aging and Mobility*. 2000.
[2] See note 1.
[3] National Center for Health Statistics. *1994 National Health Interview Survey on Disability, Phase I and Phase II*. Survey and Data Collection Systems: National Health Interview Survey (NHIS-D). www.cdc.gov/nchs/about/nhis_dis/nhisddeshtm. Accessed Dec. 7, 2009.
[4] National Council on Disability. *The Current State of Transportation for People with Disabilities in the United States*. Washington, DC: NCD, 2005.

[5]See note 4, p. 41.
[6] Transit Cooperative Research Program. *Guidebook for Attracting Paratransit Patrons to Fixed Route Services*, TCRP Report 24. Washington, DC: Transportation Research Board, 1997. Also, Transit Cooperative Research Program. *Economic Benefits of Coordinating Human Service Transportation and Transit Services.* TCRP Report 91. Washington, DC: Transportation Research Board, 2003.
[7] National Council on Disability. *The Current State of Transportation for People with Disabilities in the United States*. Washington, DC: NCD, 2005.
[8] Rosenbloom, S. The Travel and Mobility Needs of Older People Now and in the Future. Chapter Four in MIT Agelab (eds.) *Living and Moving in 2021*. Springer Press: 2009 (forthcoming).
[9] Staplin, L. K. Lococ, S. Bryington, and D. Harkey. *Highway Design Handbook for Older Drivers and Pedestrians.* US Federal Highway Administration. For the Office of Safety Research and Development. Report No. FHWA-RD-01-103, 2001.

Chapter 16

ALTERNATIVE-FUEL VEHICLES

Michael Kuby
Arizona State University, School of Geographical Sciences

William Sheaffer
Valley of the Sun Clean Cities Coalition and Amereco Biofuels

Key Points

- There are different kinds of alternative-fuel vehicles (AFVs) and different ways to make each kind of alternative fuel.
- The United States is dangerously dependent on one type of vehicle and one type of fuel. With rising gasoline prices, AFVs offer an alternative that does not depend on substantial behavioral or land-use changes.
- Other benefits include local and global environmental benefits, reduced oil imports, and economic-development opportunities.
- Major advances have been made in government-mandated, "green oriented," commercial fleet operations.
- Barriers to a transition to AFVs are availability and cost of refueling-station infrastructure, availability and cost of AFVs, higher cost of purchasing AFVs, and inconsistent public policy and leadership messages.
- There is a "chicken and egg" problem with stations and vehicles. State and private fleets aim to help on the vehicle side of the problem, but this has not translated to many consumer-owned AFVs. Many states develop public-private partnerships to address the station side of the problem.

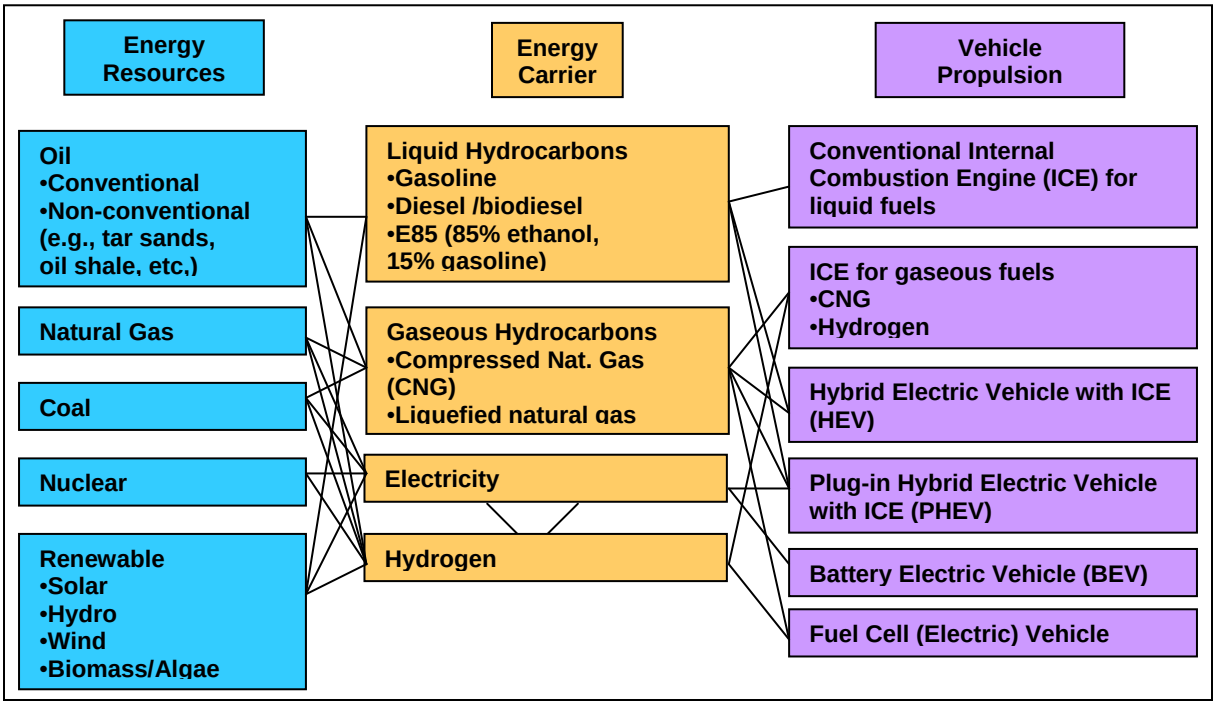
Alternative-fuel vehicles (AFVs) have gotten a bad rap in Arizona from the controversial state incentive program in 2000. However, with rising gasoline prices, over 85% of all trips made by automobile, and 96% of U.S. energy for the transportation sector coming from oil, we are dangerously dependent on one mode of transport powered by one form of energy.[1] While bus, rail, and air all play important transportation roles, we have structured our cities and our lives around the automobile. For these reasons, it is important to look again at other energy sources for cars and trucks.

Current Conditions

Types of Alternative Fuel and Vehicles. The alternative-fuel industry offers a dizzying array of current and future solutions, and there is no clear-cut best technology.[2] Different original energy resources can be processed into a variety of energy forms or "carriers," which can be used by various propulsion systems in vehicles. When discussing AFVs, scientists refer to these as well-to-wheels "pathways." Electricity[3] and hydrogen, for example, can be made from any of the energy resources in Figure 16.1, and biodiesel can be made from vegetable

oil or biomass. All energy carriers except electricity can be burned in an internal combustion engine (ICE), while hydrogen can be burned or used to generate electricity in a fuel cell.

Figure 16.1: Alternative Fuel Pathways



Source: Based on McCormick, B. 2008. Reinventing the Automobile with Hydrogen (General Motors). Presentation at Arizona State University.

Table 16.1 summarizes the advantages and disadvantages of each type of AFV. Hybrid-electric vehicles are not included because they get all of their energy from gasoline. Hybrids can save up to 25% on energy via regenerative braking and turning the engine off during stops, but this may not be enough to achieve our national goals.

Benefits of AFVs. AFVs provide options for consumers in the face of rising gasoline prices, and do so without requiring the substantial behavioral or land-use changes that other alternative modes do. Most AVFs can be produced domestically and thus reduce U.S. dependence on foreign imports and Arizona's dependence on other states. Finally, they offer varying degrees of environmental benefits by reducing local smog and global warming.

The energy efficiency and greenhouse-gas emissions of any AFV depend on its well-to-wheels pathway. The pathways are usually divided into two stages: well (or resource) to tank (or pump), and tank to wheels. A number of different institutes such as Argonne National Labs, MIT, University of California-Davis, and the European Union maintain complex models for estimating the greenhouse-gas emissions, CO_2 emissions, fossil-fuel use, and energy efficiency of various

Table 16.1: Summary Table of Alternative-Fuel Vehicles

	Energy Resource	Advantages	Disadvantages
Biodiesel	• Vegetable Oil • Tallow • Algae (soon)	• Uses renewable domestic resources • Much lower CO_2 emissions • Technology available now • Long driving range • Quick refueling	• Uses scarce farmland and water • Cannot supply entire USA
85% Ethanol 15% Gasoline Blend (E85)	• Corn (now) • Cellulose (grass, waste from wood, agricultural, and municipal sources (soon) • Algae (soon)	• Uses renewable domestic resources and agric. waste • Lower (using corn) to much lower (using algae or cellulose) CO_2 emissions • Technology available now • Flex-fuel vehicles (FFVs) can also run on gasoline • Medium driving range • Quick refueling	• Uses scarce land and water • Cannot supply entire USA • *Corn* growing uses oil for fertilizers and equipment • *Corn*-based ethanol may drive up food prices and lead to tropical deforestation • *Corn* may be a transitional source of ethanol
Compressed or Liquefied Natural Gas (CNG or LNG)	• Natural gas	• Cheap domestic resources • Technology available now • Lower CO_2 emissions • Med. driving range (CNG) • Long driving range (LNG) • Quick refueling • Low cost per mile	• Finite supplies, price could rise with greater use • Competes with home, industrial, power-plant uses • LNG uses costly specialized fueling equipment (-268°F) • Emits some CO_2
Liquefied Petroleum Gases (LPG)	• Petroleum (or nat'l gas) refining • A gas at ambient temperatures, but liquid under moderate pressure	• Cheap domestic resources • Technology available now • Liquid storage provides driving range close to that of gasoline, and fast refueling • Cleaner than gasoline • Inexpensive storage tanks	• Emits some CO_2 • Competes with home, industrial, power-plant uses • Not as clean as natural gas
Plug-in Hybrid Electric Vehicle (PHEV)	• Gasoline and grid electricity	• Most trips are short, thus possible with battery only • Long trips possible by refueling with gasoline • Power produced three ways (gasoline, braking, grid) • High efficiency • Infrastructure exists	• Still depends on gasoline • Still emits CO_2 • High cost of dual systems (ICE/tank + electric motor/battery)
Battery-Electric Vehicle (BEV)	• Grid electricity	• Zero emissions (if using renewable electricity) • High energy efficiency (battery to wheels)	• Short driving range • Slow recharging • Loses charge within days
Hydrogen Fuel Cell Vehicle (H2-FCV)	• From natural gas by steam reforming • From water by electrolysis using grid electricity	• Seen by many as the ultimate long-run solution • Emits only water vapor • Produced many ways, could supply entire US eventually • High energy efficiency (pump to wheels) • Quick refueling • Medium driving range (now)	• Currently most expensive fuel and vehicles • Commercialization in 2015? • Unfamiliar to consumers and agencies • Energy efficiency and CO_2 depend on energy source • Diverts renewable electricity from replacing coal power?

technologies, and employ different assumptions.[4] Gasoline vehicles perform well on the well-to-tank stage but not as well on the tank-to-wheel stage. Diesel and hybrids perform incrementally better than gasoline. Natural gas is cleaner than gasoline and contains less carbon per million BTUs, and is also cheaper. The models can show ethanol to be energy inefficient and environmentally unsustainable if the solar energy, fertilizers, water, and petroleum that goes into growing corn are counted, or the opposite if the free solar energy is not counted, cellulosic or algae sources replace corn, and its carbon removal from the air is considered. Vehicles that use electric motors—BEVs and H2-FCVs—have an efficiency advantage over internal combustion engines because they generate less waste heat. This advantage does not necessarily translate into longer driving range because of limits to the amount of electricity that can be stored in batteries, or to the amount of compressed gases (H2, CNG) that can be stored in tanks onboard the vehicles. Storing H2 or natural gas in liquefied form can increase the energy density, but also increases cost and complexity. BEVs and FCVs are the only zero-emission technologies, but they can only lower carbon emissions drastically if the electricity or hydrogen are made from renewable sources.

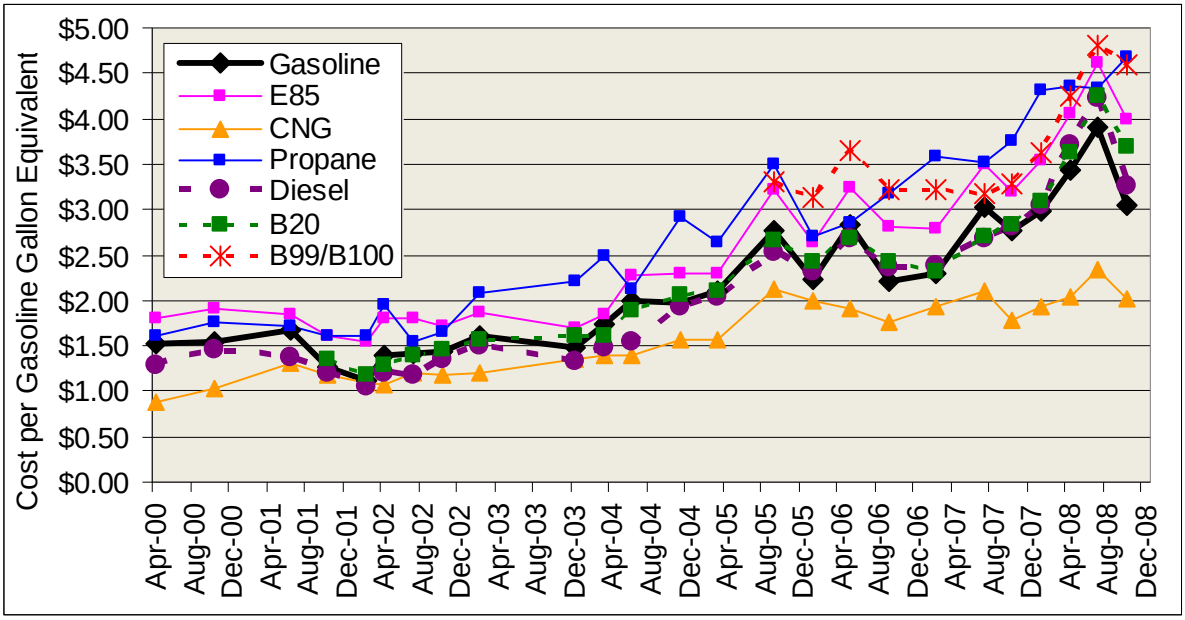
Costs. The benefits of AFVs will only be realized if the costs are reasonable. Costs, however, are difficult to estimate due to economies of scale, externalities, and technological change. Natural-gas vehicles cost about $3,000 (10-15%) more than similar conventional vehicles.[5] Flex-fuel vehicle prices are comparable to their gas-only counterparts. Mass-produced, plug-in, hybrid-electric and battery-electric vehicles will hit the market in 2010-2012, and major American, Japanese, and German auto companies are targeting 2015 for commercialization of H2 FCVs.

Station costs are highly variable. E85 stations are most plentiful and increasing the fastest. The cost of converting an existing tank at an existing station and retrofitting the dispensers averages about $21,000, while new tanks average $71,000.[6]

Figure 16.2 compares the cost of gasoline from 2005 to 2008 with the cost of an equivalent amount of energy from E85, natural gas, and propane. E85 typically sells for 25-50¢ less per gallon of gasoline equivalent, while natural gas has consistently been cheapest. Biodiesel (not shown) closely tracks the price of diesel fuel. Hydrogen (also not shown) is still quite expensive to produce, either by steam-reforming natural gas or electrolysis of water. A kilogram of hydrogen is equivalent to a gallon of gasoline.

Heat value is only one of the factors in comparing fuel costs. Internal combustion engines average 22-28% efficiency because of the large amount of waste heat, while the electric motors of BEVs, PHEVs, and FCVs can be up to 90% efficient. A second important factor is economies of scale: AFVs will become cheaper at higher production volumes. Thirdly, as discussed in Chapter 1, the external costs of gasoline-fueled vehicles arguably include the costs of smog, global warming, sprawl, and "oil security." If a global warming agreement is signed by the United States, it could help level the playing field among AFVs and gasoline-powered vehicles.

Figure 16.2: Recent Prices of Some Alternative Fuels



Source: Data from Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/.

Alternative Fuels and Vehicles. On a per-person basis, Arizona consumes substantially more alternative fuels than the U.S. average (Table 16.2).[7] This is due mainly to the extensive use of alternative fuel by fleet operations of municipalities, transit agencies, utilities, and Sky Harbor Airport, which requires all contract carriers serving the airport to use alternative fuel. The largest alt-fuel user in the United States is Valley Metro, whose LNG transit buses use an equivalent of 9 million gallons annually.

Table 16.2: Estimated Consumption of Alternative Fuels by Fuel Type, 2006
(Gasoline-Equivalent Gallons)

	CNG	Electric[a]	E85	H2	LNG	LPG	Total
Arizona Total	7,367,000	159,000	1,218,000	0	8,919,000	5,202,000	22,865,000
AZ per person	1.19	0.03	0.20	0	1.45	0.84	3.71
U.S. Total	172,011,000	5,104,000	44,041,000	41,000	23,474,000	173,130,000	417,803,000
US per person	0.58	0.02	0.15	0	0.08	0.58	1.40

Source: *Alternatives to Traditional Transportation Fuels 2006.* U.S. EIA. www.eia.doe.gov/cneaf/alternate/page/atftables/afvtransfuel_II.html. Biodiesel data not available.

The supply of AFVs in the United States is growing. In 2006, auto manufacturers and aftermarket conversions supplied 1.23 million AFVs, up from 895,000 in 2002.[8] Of these, over 1 million were flex-fuel vehicles burning ethanol-gasoline blends, and 216,000 were gas-electric hybrids. About 3,100 CNG vehicles and 2,700 BEVs were made available.

Alt-Fuel Stations. There were 167,000 retail gasoline stations in the United States in 2006, compared to 5,700 alt-fuel stations in October 2008 (latest data). Arizona had 133 alt-fuel or electric charging stations (2008) and 2,190 gas stations (2006).[9] Of the gas stations, 38% sell propane (LPG), but primarily for refilling BBQ tanks rather than vehicle tanks (Table 16.3).

Another 30% sell CNG. For these two fuels, Arizona has more stations per million people than the United States as a whole, but it lags behind in biodiesel, E85, hydrogen, and LNG. In addition, many of these stations are just for fleets and are not open to the public.

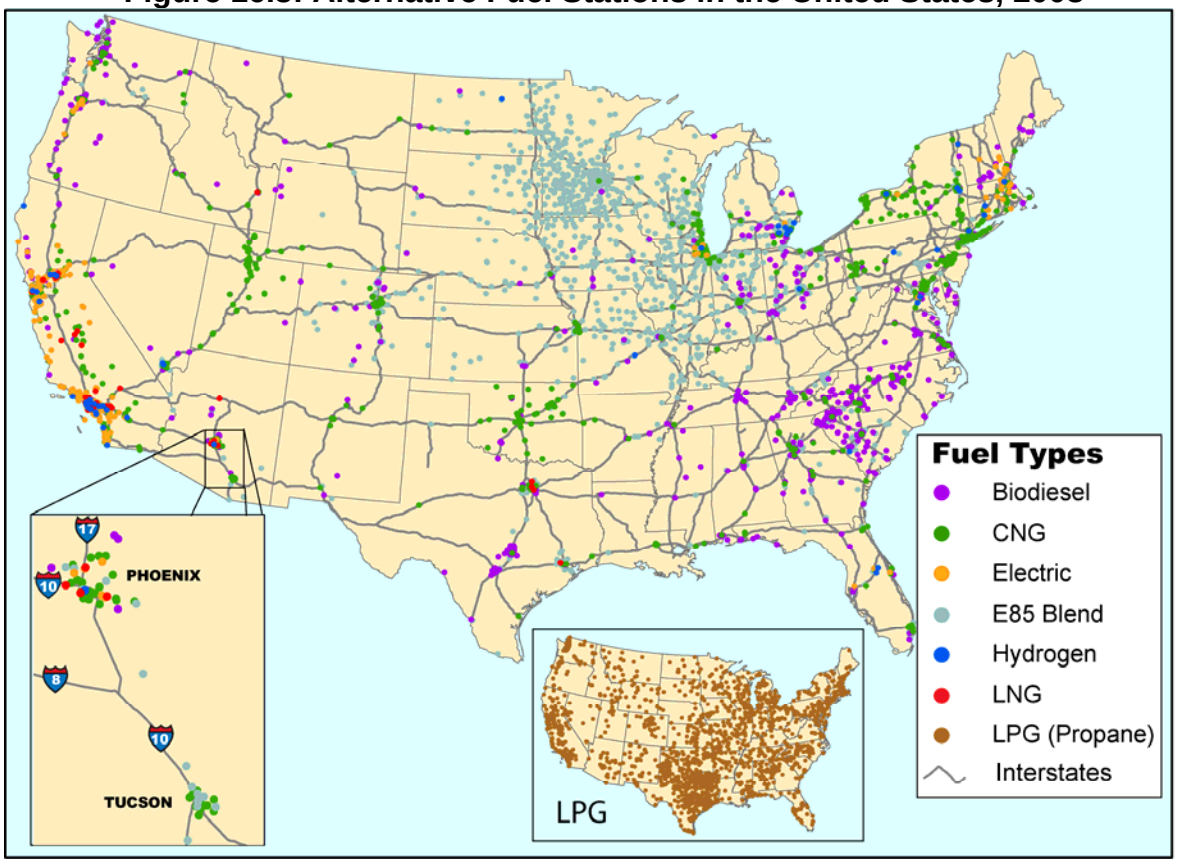
Table 16.3: Alternative Fuel Stations, October 2008

	Biodiesel	CNG	E85	Electric	H2	LNG	LPG	Total
Arizona Total	10	40	21	5	1	5	51	133
Arizona per million people	1.6	6.3	3.3	0.8	0.2	0.8	8.0	21.0
U.S. Total	625	777	1676	439	46	38	2141	5742
U.S. per million people	2.1	2.6	5.6	1.5	0.2	0.1	7.1	19.0

Source: Alternative Fuels and Advanced Vehicles Data Center. U.S. Department of Energy, www.afdc.energy.gov/afdc/fuels/stations_counts.html.

Compared with other states, the geographic distribution of stations in Arizona is highly concentrated (Figure 16.3). Arizona has a mix of station types in Phoenix and Tucson, with little connectivity to other cities or states. In comparison, the Midwest boasts broad coverage

Figure 16.3: Alternative Fuel Stations in the United States, 2008



Source: *U.S. Overview Maps.* Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy. afdcmap2.nrel.gov/Website/Stations/viewer.htm.[10]

by E85 stations. Biodiesel stations are spread widely in the southeast and linked into linear networks in the Pacific Northwest, Colorado, and Pennsylvania. California is developing clusters of hydrogen and electric stations for zero-emission vehicles. Utah, Oklahoma, California, and the Mid-Atlantic states offer networks of CNG stations.

Existing Plans and Programs

Arizona's Alt-Fuel Fiasco. Arizona's efforts to promote alt-fuels were dealt a severe setback in 2000 by a state incentive program gone awry.[11] In April 1999, a last-minute change to legislation extended a 40% rebate on purchasing AFVs to include AFV aftermarket conversions of SUVs and pickups, and eliminated some fees. The program was not monitored properly, and many consumers purchased flex-fuel vehicles and then disconnected the alt-fuel tank. The program, initially projected to cost the state $3 million, ended up costing $200 million. Many legislators and citizens who did not support alternative fuels in the first place became staunch opponents, with the media fanning the flames. To their credit, fleet managers, who can employ central fueling, continued to adapt to alt-fuels.

Current State and Federal Programs. Federal tax credits of up to $4,000 have been available to buyers of hybrid, diesel, battery-electric, alt-fuel, and fuel-cell vehicles placed in service on or after January 1, 2006, based on weight, technology, and fuel economy. The credit is phased out after the manufacturer has sold 60,000 eligible vehicles.

In October 2008, Congress passed the Energy Improvement and Extension Act, which offers many tax incentives related to fuel production and AFVs.[12] In particular, the bill expands incentive programs for biodiesel and cellulosic ethanol. In addition, plug-in hybrids qualify for a $2,500 credit, plus $417 for each kWh of battery-pack capacity, up to 250,000 vehicles per manufacturer. Electricity has been specifically included as a "clean-burning fuel" that qualifies for the AFV credit. In February, 2009, the American Recovery and Reinvestment Act established competitive grant programs with: $2 billion for Advanced Battery Manufacturing, $400 million for Transportation Electrification, and $300 million for an Alternative Fueled-Vehicles Pilot Grants. The latter program finances incremental costs for vehicles ranging from $2,000 for hybrid cars to $1 million for H2-FCV trucks, and cost sharing for refueling stations ranging from $50,000 for biofuel to $300,000 for hydrogen.[13]

Arizona is a national leader when it comes to AFV fleet requirements. Arizona applies EPA standards designed for federal fleets to all municipal fleets of 20 or more vehicles in EPA non-attainment counties. Some of the other important and effective state-level programs in Arizona for advancing alternative fuels include:[14]

- HOV-lane privileges for AFVs
- Reduced license fee for AFVs
- Law-enforcement AFVs exempted from special AFV license plate
- Neighborhood-electric vehicles (e.g., golf carts) allowed on local streets
- School-bus idle-reduction programs

Clean Cities Coalitions. The Clean Cities Coalitions in the Greater Phoenix[15] and Tucson[16] areas are charted by the U.S. Department of Energy. Their goal is to assist in the

displacement of petroleum fuels to achieve cleaner air and energy security. Clean Cities has been instrumental in promoting the use of alt-fuel vehicles through basic coordination of outreach, demonstrations, and legislative involvement.

Challenges

Barriers to Alternative Fuels. A 2006 study by the National Renewable Energy Laboratory (NREL) ranked the various barriers to alternative fuels based on the scientific literature, NREL scientists, and Clean Cities coordinators. The following barriers ranked in the top eight on the lists from all three sources:

- Availability of refueling station infrastructure
- High cost of constructing infrastructure
- Availability of AFVs
- Inconsistent public policy and leadership messages
- Higher cost of purchasing AFVs

All three sources ranked the lack of alt-fuel stations as the number-one barrier. Most consumers who purchase AFVs today face major inconveniences and detours when refueling their vehicles, or even a complete lack of stations in their area. Other barriers mentioned in the NREL report included competition against the economies of scale of conventional vehicles, lack of economic incentives, lack of customer awareness and market acceptance, lack of trained maintenance technicians and station operators, poor perceived or actual AFV performance, low oil prices, unfamiliarity with the properties of alternative fuels, and inconsistent codes, CAFE standards, and automaker warranties.[17]

A strong disincentive has been the federal government's failure to enforce (and eventual abandonment of) the progressive requirements of the EPAct fleet-management target goals. The petroleum-fuel lobby has been effective in blocking major legislative incentives. To a great degree, the vehicles are available or can be adapted to use alternative fuels. It will, however, take major support and mandates to establish the public fueling sites, as well as "truck stop" fuel availability for the long-distance freight haulers, necessary to realize the full potential of alternative-fuel use.

The "Chicken and Egg" Problem. It is often said that the transition to alternative fuels faces a chicken-and-egg quandary.[18] Auto manufacturers will not mass-produce AFVs until consumers are able to refuel the cars conveniently. Likewise, energy companies will have no market for alt-fuels until reasonably priced vehicles are available. The typical solution to this vicious cycle is government subsidies for an initial alt-fuel infrastructure, along with incentives or mandates for government and industry fleets of AFVs. This two-pronged approach is meant to provide guaranteed initial demand for vehicles and stations simultaneously. Yet, a major message from the NREL study was that the fleet market "was not sufficient to generate significant sales for vehicle manufacturers," and that "finding a way to transition from fleets to consumers is equally critical."[19]

The "Valley of Death." Introducing a new type of car is extremely costly. Manufacturers refer to the process of moving from prototypes to batch production to full-scale mass production as "crossing the Valley of Death." With the help of six automakers, Oak Ridge National Laboratory estimated that a decline from $100,000 per car to about $20,000 can be expected after 60,000 vehicles are produced, but that the first 60,000 vehicles must be sold at a large loss or be heavily subsidized.[20] Flex-fuel and HEVs are past the Valley of Death, while PHEVs, BEVs, and FCVs are just entering it.

Opportunities

The U.S. EPA and DOE maintain several web sites summarizing federal and state AFV programs by technology, type of program, and state.[21]

Fleet Requirements. Arizona is already a leader in mandating fleet conversions, but other opportunities exist. California's Safe School Bus program replaced 777 old diesel buses.[22] With a similar program, Arizona could "convert" school buses to run on biodiesel with no retrofitting of buses.

Refueling Infrastructure Development. The federal government has a fund-matching program for E85 station conversions: $30K or 30%, whichever is greater. Arizona has similar legislation, but the program has not been funded.

Picking a Winner . . . or Spreading the Bets? The sheer weight of the required fueling infrastructure has been the main roadblock to AFVs. To get Arizona consumers driving AFVs sooner, the state would need to partner with private industry to seed a minimal public-refueling infrastructure. Less assistance would be needed for E85 stations because flex-fuel vehicles are already mass-produced, while more assistance would be needed for NGVs, BEVs, and H2 FCVs. A dilemma facing Arizona is whether to spread its bets or focus investments on one type of fuel. Investing in one type of fuel would establish a critical mass of stations earlier than investing in several types.[23] A U.S. DOE study of required hydrogen infrastructure suggests that roughly 100 stations (or 7%) would break the chicken-and-egg cycle for an alt-fuel in the Phoenix area.[24]

Some areas of the country are specializing in a particular alt-fuel in which they have a comparative advantage or see unusual promise (Figure 16.3). Several examples stand out:

- California's Hydrogen Highway, proposed by Governor Arnold Schwarzenegger in 2004 based on hydrogen's zero-emission potential and California's high-tech leadership (more information below).
- Texas's dense propane-station network, based on their petrochemical industry.
- Hawaii's (and the Hawaii Electric Company's) endorsement of a comprehensive plan for BEVs with swappable batteries and intelligent charging stations. The venture capital firm, A Better Place, is rolling out networks in Israel and Denmark in 2011, and in Australia, California, and Hawaii in 2012.[25]

Arizona's advantage may lie in solar energy, which is well suited to making electricity and hydrogen, and for growing algae in tubes and ponds to make biofuels or hydrogen. Of course, there is a risk in focusing on a fuel that turns out to be a technological dead end.

Clustering and Connecting. If an alt-fuel infrastructure is to be developed in Arizona, where should stations be placed? A lesson can be learned from California's Hydrogen Highway. The initial plan called for 200 refueling stations at 20-mile intervals by 2010, at a cost of up to $100 million. By 2007, the strategy shifted to clustering stations in the densely populated, wealthier, and more polluted Los Angeles and San Francisco-Sacramento regions, thus maximizing the likely adopters.[26] Connecting these clusters with stations on interstate highways has been postponed to a second phase. Similarly, the U.S. DOE has shifted to a clustering strategy.[27] With this clustering strategy, early adopters are likely to be multi-vehicle households that would purchase one AFV for commuting and other urban trips, and keep a second, conventional vehicle for inter-city trips. To move beyond this demographic, it will be important to either coordinate with neighboring states to develop alt-fuel station corridors on heavily traveled routes, or offer flex-fuel vehicles that run on gasoline *or* alt-fuels. For long-haul truck carriers, there will need to be interstate corridors with biodiesel stations at perhaps 75-mile intervals, coupled with idle-reduction equipment to keep the truck engines turned off while drivers take their mandatory 8-10 hour rest.

Research and Economic Development. Arizona's three state universities are conducting scientific research on producing, storing, and utilizing alternative fuels and electricity. With its solar resources, Arizona has an opportunity to parlay innovation into an in-state source of alternative fuels, as well as exports of fuels and high-tech equipment. Abundant solar electricity is the key to several long-term visions of sustainable economies. The solar-hydrogen economy envisions cheap solar electricity being used to electrolyze water into hydrogen, which is then burned for heat or used in fuel cells for electricity, all with zero emissions.[28] The algae-biofuels vision calls for using the planet's oldest and most efficient form of plant life to produce ethanol, biodiesel, and jet fuel; if co-located with coal-fired power plants, algae could also capture CO_2 emissions and convert them to transportation fuels.[29] Investment in research could pay great dividends and break Arizona's dependence on transportation energy imported from other states.

Leadership. There are always doubters in the development of new technologies—a reaction that was exacerbated by Arizona's alt-fuel legislation fiasco of 2000. But if countries such as Brazil, Iran, and Pakistan can each put 1 million CNG vehicles on their roads, surely the United States can make similar progress. This is where leadership comes into play. As mentioned earlier, the NREL study on barriers highlighted the inconsistency of public policy and leadership messages. They called on leaders to convey the "significance of transition, including energy security, enhancement of domestic economy, and environmental stewardship."[30] While all of these reasons are important, they imply different implementation strategies and different priorities on specific fuels or technologies. NREL also highlighted the inconsistent and possibly conflicting objectives of federal, state, and local policy makers. Arizona needs a clear and consistent strategy for the highly challenging transition phase to alternative fuels.

List of Abbreviations Used

AFV	Alternative-fuel vehicle	**FCV**	Fuel-cell (electric) vehicle
BEV	Battery electric vehicle	**FFV**	Flex-fuel vehicle
Btu	British Thermal Unit	**H2**	Hydrogen
CAFE	Corporate Average Fuel Economy standards	**HEV**	Hybrid electric vehicle
CNG	Compressed natural gas	**ICE**	Internal combustion engine
CO2	Carbon dioxide	**LNG**	Liquefied natural gas
DOE	(U.S.) Department of Energy	**LPG**	Liquefied petroleum gases (propane)
EIA	(U.S.) Energy Information Administration	**NREL**	National Renewable Energy Laboratory
EPA	(U.S.) Environmental Protection Agency	**PHEV**	Plug-in hybrid electric vehicle
E85	Blend of 85% ethanol and 15% gasoline		

Michael Kuby received a Bachelor's degree from The University of Chicago in 1980 and a PhD from Boston University in 1988, both in Geography. He is a Professor in the School of Geographical Sciences at ASU, where he has taught since 1988. His research centers on creating optimization models for facility location or transport network design, mainly for sustainable energy and transport systems. His work with the World Bank on energy and railway transport in China was a Finalist for the 1994 Franz Edelman Award for Management Science Achievement. Kuby has served as Chair of the Transportation Specialty Group of the Association of American Geographers, and on editorial boards of the *Professional Geographer* and *Journal of Transport Geography,* and is currently Area Editor for Location Science for *Networks and Spatial Economics.*

William Sheaffer is Executive Vice President and member of the Board of Directors of Amereco Biofuels Inc. in Arlington, AZ. He serves as Executive Director of the Valley of the Sun Clean Cities Coalition, and is on the Board of Directors of the National Biodiesel Board. He earned a BA from the University of Southern California and an MBA from Pepperdine University.

---

[1] Energy Information Administration, U.S. Department of Energy. *Annual Energy Review.* www.eia.doe.gov/emeu/aer/contents.html. Accessed January 6, 2009.

[2] Good overviews of AFVs can be found on these two web sites: Alternative Fuels and Advanced Vehicles Data Center. U.S. Department of Energy, Energy Efficiency and Renewable Energy. www.afdc.energy.gov/afdc/. Accessed October 30, 2008. *Consumer Energy Center.* California Energy Commission. www.consumerenergycenter.org/transportation/afvs/index.html. Accessed October 30, 2008.

[3] Although electricity is not a fuel per se, we use the term "AFV" because it is standard terminology in the industry, but keep in mind that electric vehicles (EVs) are included.

[4] *The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model.* Argonne National Laboratory. www.transportation.anl.gov/modeling_simulation/GREET/index.html. Accessed October 30, 2008.

[5] Melendez, M. *Transitioning to a Hydrogen Future: Learning from the Alternative Fuels Experience.* National Renewable Energy Laboratory. Technical Report No. NREL/TP-540-39423, 2006. Honda makes a dedicated natural gas vehicle. Here in Arizona, AFV Tech (www.afvtech.com) performs conversions of several kinds of vehicles, with EPA certification, including a Chevrolet Impala with a 300-mile range, while Altech-Eco (www.altecheco.com/) sells a dedicated or flex-fuel converted Ford Focus for $23,995.

[6] *Cost of Adding E85 Fueling Capability to Existing Gasoline Stations: NREL Survey and Literature Search.* National Renewable Energy Laboratory. www.afdc.energy.gov/afdc/pdfs/42390.pdf.

[7] Data on vehicles, fuels, and infrastructure, as well as laws, incentives, fleets, are available at the *Alternative Fuels Data Center,* www.afdc.energy.gov/afdc/data/index.html.

[8] *Alternatives to Traditional Transportation Fuels 2006 (Part I - Supplier Data).* U.S. Energy Information Agency. www.eia.doe.gov/cneaf/alternate/page/atftables/atf14-20_05.html.

[9] *Alt-Fuels and Advanced Vehicles Data Center*. www.afdc.energy.gov/afdc/data/infrastructure.html.

[10] See also: www.afdc.energy.gov/afdc/stations/find_station.php
[11] Sherwood, R. *Anatomy of A Debacle: Arizona's Alt-Fuels Program.* Stateline.org. www.stateline.org/live/ViewPage.action?siteNodeId=136&languageId=1&contentId=14196.
[12]Green Car Congress. *Transportation and Fuel Components of the Bailout Bill.* www.greencarcongress.com/2008/10/transportation.html. Accessed October 31, 2008.
[13] Energy Efficiency and Renewable Energy Office, U.S. DOE. *EERE News.* apps1.eere.energy.gov/news/news_detail.cfm/news_id=12243. Accessed Mar. 7, 2009.
[14] Alternative Fuels and Advanced Vehicles Data Center. *Arizona Incentives and Laws.* www.afdc.energy.gov/afdc/progs/state_summary.php/AZ.
[15] *Valley of the Sun Clean Cities Coalition.* www.cleanairaz.org/. Accessed Mar. 7, 2009.
[16] Pima Association of Governments, *Clean Fuels, Clean Cities*. www.pagnet.org/Default.aspx?tabid=180.
[17] Brown, M.A., J. Chandler, M.V. Lapsa, and B.K. Sovacool. *Carbon Lock-In: Barriers To Deploying Climate Change Mitigation Technologies.* Oak Ridge National Laboratory. Report No. ORNL/TM-2007/124, 2007.
[18] National Research Council. *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs.* The National Academies Press, Washington D.C., 2004.
[19] See note 5, p. 10.
[20] Greene, D., P.N. Leiby, B. James, J. Perez, M. Melendez, A. Milbrandt, S. Unnasch, and M. Hooks. *Analysis of the Transition to Hydrogen Fuel Cell Vehicles and the Potential Hydrogen Energy Infrastructure Requirements.* Oak Ridge National Laboratory. ORNL/TM-2008/30, March, 2008. cta.ornl.gov/cta/Publications/Reports/ ORNL_TM_2008_30.pdf. Accessed Mar. 7, 2009.
[21] *State Climate Action Plans Database.* U.S. Environmental Protection Agency. yosemite.epa.gov/gw/StatePolicyActions.nsf/webpages/index.html. Accessed November 7, 2008. See also apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm, and apps1.eere.energy.gov/states/state_specific_information.cfm/state=AZ.
[22]*Safe School Bus Clean Fuels Demonstration Project.* U.S. Environmental Protection Agency. www.epa.gov/climatechange/wycd/downloads/ca_bus.pdf. Accessed November 7, 2008.
[23] Melaina, M., and J. Bremson. Refueling availability for alternative fuel vehicle markets: Sufficient urban station coverage. *Energy Policy,* Vol. 36, No. 8. 2008, pp. 3223-3231. See also Melaina MW. Initiating hydrogen infrastructures: Preliminary analysis of a sufficient number of initial hydrogen stations in the US. International Journal of Hydrogen Energy 2003;28(7):743-55.
[24] Melendez, M. and Milbrandt, A. *Geographically-Based Hydrogen Demand and Infrastructure Deployment Scenario Analysis.* www.hydrogen.energy.gov/pdfs/progress07/viii_13_melendez.pdf
[25] A Better Place. www.betterplace.com/.
[26] *California Hydrogen Highway*. www.hydrogenhighway.ca.gov/. Accessed November 7, 2008.
[27] See note 20.
[28] McAllister, R. *The Solar Hydrogen Civilization*. Mesa: American Hydrogen Association, 2003.
[29] Edwards, M.E. *Green Algae Strategy.* 2008. alextiller.com/agribusiness_resource/green_algae_strategy_ paper.pdf. Accessed Mar. 7, 2009. See also desertbiofuels.org and greenindependence.org.
[30] See note 5, p. 8

Chapter 17

PUBLIC INVOLVEMENT IN ARIZONA'S TRANSPORTATION DECISION MAKING

Keiron Bailey
University of Arizona, Department of Geography and Regional Development

Key Points

- Public participation in project planning is a basic element of a democratic society and is important to implementing effective transportation systems.
- Public involvement in transportation is a complex, often contested undertaking because of diverging stakeholder desires.
- An effective public-participation process can overcome these problems by fostering trust and communication and effectively arriving at compromises and solutions.

Current Conditions

Public involvement in transportation decision-making in Arizona and elsewhere is a complex undertaking. Projects can range in geographic scale and temporal scope from highway rehabilitation to interstate-corridor plans or new transit-system developments that take a decade or more. They also range in concept from rather nebulous planning or visioning questions to hard criteria such as design alternatives for structures such as noise walls.

Arizona Transportation Projects. A number of controversial large transportation projects are in the planning and design stages. An example is the I-10 bypass in central and southern Arizona, intended to allow heavy commercial-vehicle traffic to bypass downtown Phoenix and Tucson. For the Tucson bypass section, four potential routes are being discussed. Some of the concerns raised in various media are about the environmental impacts on each of the proposed corridors,[1] but others are related to the legitimacy of the proposal within a democratic system. For example, one source notes:

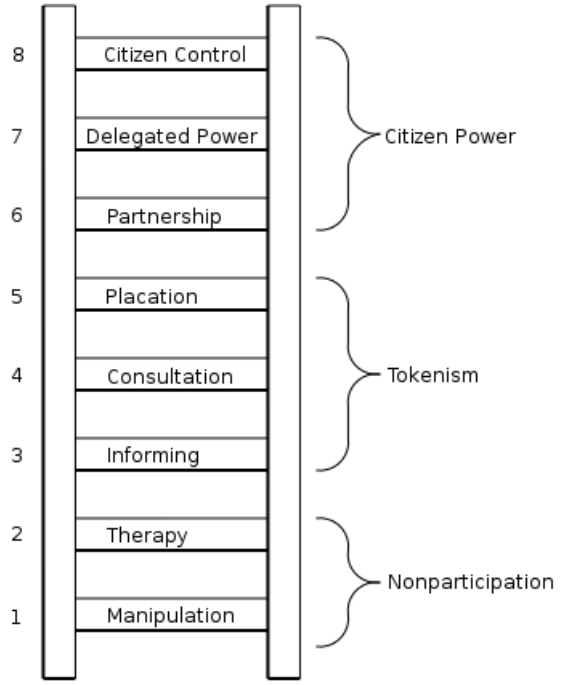
> Of course, even with the overwhelming public opposition to this road, plans may still go forward. As ADOT representative Buskirk noted on Wednesday, the State Transportation Board [does] not report to, nor are they accountable to, the state legislature.[2]

For local-scale projects, considerable time and effort has been spent gathering commentary on design and redevelopment preferences. For example, the transcript of public comments on the proposed Grant Road improvement in the Tucson area contains 400 comments totaling 58 pages.[3] In the transcript, these are categorized primarily with respect to their impact on the alignment issue being considered. But the mechanism by which specific comments are translated into design guidance is not clear.

The fact that a variety of agencies and governmental levels collaborate on planning and constructing transportation projects further complicates the public-involvement process. Two successful examples of intra-agency collaboration on public involvement are the Route 179 project near Sedona (see Opportunities, below) and the Grant Road Improvement Plan in Tucson. A key to their success was the proactive approach of regional and local stakeholders, including Metropolitan Planning Organizations (MPOs) and city transportation departments. For example, at a federal peer-exchange workshop in Tucson in 2004, agency representatives from a number of states shared their procedures for enhancing inter-agency cooperation in public involvement.[4]

Perceptions of Public Participation. Although little hard data exist by which to evaluate the quality of public involvement, there is some evidence that involvement is not perceived by stakeholders to be as meaningful as it could be. Bailey and Grossardt have gathered nationwide and Arizona data on the quality of public involvement in transportation planning and design from both public respondents and professional groups.[5] Their data use an eight-step scale proposed by planner Sherry Arnstein to describe levels of public involvement in planning (Figure 17.1).[6] The "Arnstein ladder" ranges from non-participation and a feeling of being manipulated (Step 1) to outright citizen control of project planning (Step 8).

Figure 17.1: Arnstein Ladder of Public Participation



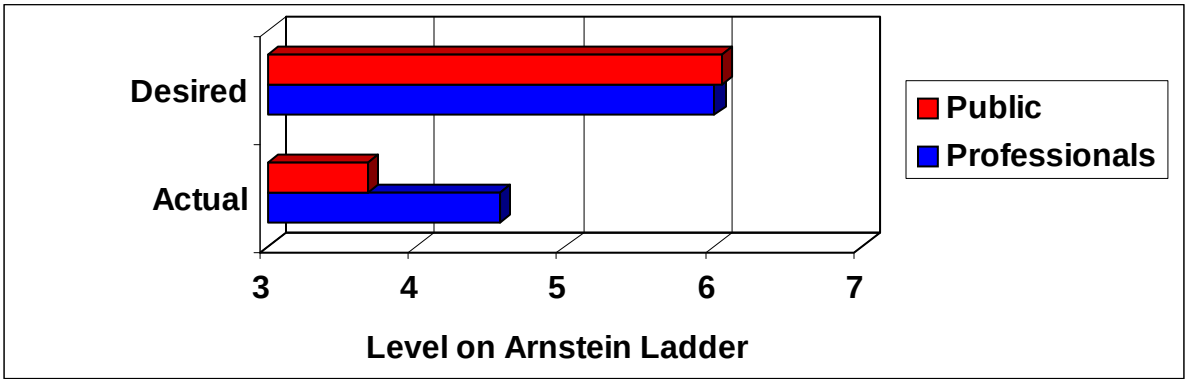
Source: Arnstein (1969)

Bailey and Grossardt[7] asked two questions at open public meetings related to transportation. The questions were "In your experience as a citizen participating in transportation planning,

where do you believe you are now?" and, "In an ideal world, where should you be?" Respondents were asked to place their answers among the "rungs" of the Arnstein ladder. The Arizona data are summarized in Figure 17.2.

The difference between the desired and actual levels of participation measures the public-involvement quality deficit, as stakeholders see it, and is known as the "Arnstein Gap." What it means is that citizens perceive the quality of their involvement in transportation decision-making, at about 3.7, to be significantly lower than they desire. Transportation professionals also acknowledge that actual public involvement is in the "tokenism" range, though they perceive participation to be one step higher (4.6) than the public does. It is also notable that citizens desire level six, "partnership," and *not* level eight, or "citizen control," as some professionals assume, and that professionals and citizens actually agree quite strongly on the ideal level of participation, namely level six—partnership. The Arnstein Gap in the data from Arizona is consistent with that obtained from other states.[8]

Figure 17.2: Stakeholder Evaluation of Public Involvement



Source: Data obtained in 2004-2006 by the author at various forums in Tucson and Phoenix (n=88).

Existing Plans and Programs

Legislative Background. At the federal level, many observers believe that the drive for public involvement began with Title VI of the 1964 Civil Rights Act. This states that, "No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." Since the National Environmental Policy Act (NEPA) of 1969, public involvement has been mandated in federally funded projects, or those that generate impacts on federally prescribed factors. Many states followed NEPA and its Environmental Impact Statement provisions with their own state mandates for public involvement in similar cases. Particularly since the passage of the Intermodal Surface Transportation Equity Act (ISTEA) in 1991, public involvement has become a more formal and prominent mandate in legislative documents. Subsequently, a series of federal initiatives level have sought to codify the relationship among the environment, stakeholders, and the transportation system. For example, context-sensitive solutions are an initiative promulgated by the federal government to improve transportation solutions by fitting them more effectively into their social and environmental contexts through collaborative planning processes.[9] The 1997 USDOT Environmental Justice mandate sought to strengthen and codify Title VI specifications,[10] causing new rules to be

adopted by both FHWA and FTA.[11] Although these initiatives contain extensive reference to the benefits of public involvement, they are couched in broad terms and lack specificity about process objectives or outcomes.

Legally, public involvement must be executed at the state or local level. Many transportation projects must be approved by, or are funded by, ADOT. Therefore, private-sector firms working on contract for state offices are hired to facilitate much public involvement. Sometimes these performing organizations are large civil-engineering firms that conduct an in-house public involvement process, and sometimes they are firms specializing in public involvement, or even marketing or public relations firms. However, 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." As with many such statutes, the precise nature and objectives of the public involvement, and the link between information obtained and planning or design output, is not specified.[12]

Visioning processes like the regional general plans developed by MPOs and/or city or county authorities include public involvement. In the early 1990s, the Pima Association of Governments (PAG) developed a public involvement plan.[13] General principles for public involvement have become increasingly codified since then. For example, ADOT has published a set of Public Involvement Guidelines.[14] The Guidelines define public involvement as "any level of participation by the public in helping to shape the outcome of a project. It includes processes to gather input from the public and using that input to make better decisions."[15]

Challenges

Improving the Quality of Public Involvement. Moving forward, public involvement faces systemic challenges. Compared with, for example, the technical qualities of engineering designs that can be assessed using standardized performance metrics, public involvement is much more challenging to execute and evaluate. As the scale of public involvement increases, the demands on the project sponsor increase. Infinite time and money are not available to conduct such involvement, creating pressure on the sponsoring agencies to distill recommendations in a short time, using few meetings.

Arizona faces some serious challenges in integrated transportation and land-use planning. There are large cultural differences in attitudes towards transportation, growth, economic development, and the environment among and within groups such as ranchers, rural dwellers, urban neighborhood groups, suburbanites, exurbanites, and incoming migrants. And with sizable populations of recent immigrants and households where a language other than English is spoken, Arizona's public agencies need to give special attention to the outreach and communication approaches they use. Because of language and cultural barriers, many people feel marginalized by the typical public process. After more than 40 years of Title VI (Civil Rights Act) experience, this is still an important and unsolved issue nationally and in Arizona. Indeed, Executive Order 13166 (August, 2000)[16] restated the importance of paying attention to including populations with limited English proficiency, and in December, 2008

the National Academy of Sciences began a project to develop methods to improve the involvement of "traditionally underserved populations."[17]

Bureaucratic Attitudes. The aforementioned Public Involvement Guidelines contain a number of useful techniques in project management and process delivery. The stipulation for project managers to be present as the "public face" of the project, for example, is certainly helpful.[18] However, engaging the public effectively is another matter. An ADOT report on *Tools to Improve Partnering and Project Delivery*[19] notes that a direct link exists between citizen trust and the value of transportation decisions, and refers to public perception as "the reality of [an] organization's value." This ADOT report provides a number of useful techniques for engagement, but it also contains areas that may benefit from some of the emerging techniques described below.

Public Attitudes. The idea of "consensus" is central to much research on public involvement. Consensus, in terms of agreement on outcome, is often difficult to reach among large numbers of stakeholder groups.[20] Many researchers have noted the problematic dynamic in transportation, one in which stakeholders refuse to participate in, or do not believe in the legitimacy of, public-involvement processes conducted at a low level on the Arnstein Ladder. Some stakeholders believe their time will be wasted by attending mandated public meetings at which the sponsors have a hidden agenda; that their choices are controlled in ways that validate designers' egos literally at public expense; and that groups with extreme positions will create a hostile climate and intimidate majority view-holders or those without formal training or knowledge. Even people more open to the process may stay away because they believe their input cannot effectively be captured in a short period of time. Then, when the process is finished and the outcome is not to their liking (or sometimes even if the outcome is acceptable to them), that reinforces their initial refusal to participate.

Unstructured public involvement often consists of adversarial public meetings driven by interest-group politics, which citizens may deem a waste of their time. This leads to what the *Arizona Star* termed "civic detachment," which "creates a situation where political and economic control of the city's future by default falls to a relatively small nucleus of natives or long-term residents."[21] Consequently, many stay home and do not contribute their valuations to the transportation-system designers. The effects of this are clear. Until such time as the Arnstein Gap is closed, severe and continuing conflicts can be expected. In a large group with strong and diverse opinions, it will never be possible to eliminate all conflict over outcomes. However, it is possible to increase the quality and legitimacy of transportation planning processes by ensuring that the mechanisms used to elicit and value public inputs are transparent, efficient in terms of time and resources, and that they are perceived by stakeholders as fair and equitable. These objectives can be achieved by designing the public-involvement process from the ground up, in accordance with basic democratic principles, and at the desired "partnership" level.

Stakeholders increasingly expect and demand a higher quality of public involvement. Achieving this will not be easy. It requires more analytic attention to public involvement. Given the enormous sums of public money being spent, taxpayers will demand more efficient processes that can produce efficient solutions. They are increasingly intolerant of

"tokenism" in public involvement. The "silent majority" that declines to participate in public forums comprises the majority of stakeholders. Therefore, the input from public meetings typically doesn't represent the range of stakeholder views, and that 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. Ultimately, closing the Arnstein gap would help ensure that every participant feels that their views have been heard and included, even if the outcomes are not in accordance with their preferences.

Opportunities

Practical, methodological, and educational steps can improve the public-involvement process. The transportation community is now paying attention to these issues. 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, using face-to-face and remote or online survey methods. Citizens and professionals need to appreciate the relative strengths and weaknesses of different public-involvement techniques, ranging from the "meeting in a bag," to more structured protocols using electronic polling at large, open public meetings.

Two developments demonstrate the significant improvements that can be made in public involvement, given the right effort and tools. ADOT recently underwent a process of "context-sensitive solutions" for the upgrade to State Route 179 from I-10 through Oak Creek Village to Sedona. An extensive outreach process with frequent regular meetings incorporated input from a range of stakeholders. Stakeholders initially defined a set of "core values" that served to guide many of the ensuing discussions and charrettes, which are collaborative sessions in which a group of designers drafts a solution to a design problem.[22] Dozens of meetings with the community produced a range of design options. Because of the outstanding outcome and support from the community, the project went on to receive 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.

Another approach when dealing with large numbers of stakeholders is the Structured Public Involvement (SPI) approach, designed by the author (see www.u.arizona.edu/~kbailey/Research2.htm). SPI is designed to sort through politically contentious and conceptually complex public-goods problems (e.g. transportation planning, bridge design, power-line placement, etc.) objectively, based on a theoretical framework of procedural justice.[23] The approach elicits input from a wide range of stakeholders along with their perspectives and concerns, using electronic polling at public meetings, and integrates these into decision-making using Geographic Information Systems, three-dimensional computer visualization, and decision modeling. SPI allows technicians, engineers, and planners to understand the social context within which their decisions are made, and illustrates technical issues to stakeholders in ways they can understand. Within SPI, the Casewise Visual Evaluation technique decomposes the public's preferences for complete designs into their preferences

for individual elements, thus helping designers, planners, and architects to narrow down public preferences for design options to specific sets of elemental combinations that are likely to be preferred. This methodology has been applied to highway design in a rural area of Kentucky and to a block-scale transit-oriented development in Louisville, KY. SPI has been applied to transportation questions across the United States ranging from the $4.5 billion Louisville Southern Indiana Ohio River Bridges project to integrated transportation and land use planning for an Indiana town. SPI projects have won numerous awards, including most recently the Transportation Research Board's 2008 Herrington Award for Excellence in Visualization. SPI protocols consistently deliver high process evaluation scores from anonymous real-time evaluation polling at open public meetings dealing with real, and often contentious, projects.

Citizens would benefit from access to best-practice examples of large-scale public involvement, so that they can evaluate the quality of their local engagement by comparing it to these examples. Another critical need is better training for civil engineers, who often design and implement public-involvement protocols or manage subcontractors without sufficient preparation in or knowledge of public involvement. With $104 billion spent nationally in 2004 on transportation infrastructure, of which 93% was taxpayer money,[24] the quality of public involvement in these processes is not a small matter.

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**MPO**	Metropolitan Planning Organization
FTA	Federal Transit Administration	**SPI**	Structured Public Involvement
FHWA	Federal Highway Administration		

Keiron Bailey is Assistant Professor in the Department of Geography and Regional Development at the University of Arizona. He earned a BS in Geography and a BEng in Mechanical Engineering from the University of Birmingham, UK; an MA in Geography from the University of Hawai'i at Manoa; and a PhD in Geography from the University of Kentucky. Professor Bailey co-developed the Structured Public Involvement (SPI) protocol and associated geovisual and geospatial analytic methods, such as Casewise Visual Evaluation and Analytic Minimum Impedance Surface. He has published over 20 peer-reviewed journal articles and his research has been funded by organizations such as the Transportation Research Board and National Science Foundation. He has led partnerships with private sector firms, State DoTs, MPOs, nonprofits, and other organizations, to apply SPI protocols to a variety of transportation infrastructure projects. Dr. Bailey co-directs Community Decisions with Dr. Ted Grossardt and Mr. John Ripy. He is listed in *Who's Who in America*.

---

[1] I-10 Bypass Proposal to be Scrutinized. *Benson News*. 8 September 2007. www.bensonnews-sun.com/articles/2007/09/09/news/news5.txt

[2] *Arizona Indymedia*. 10 December 2007. arizona.indymedia.org/news/2007/12/70994.php

[3] Regional Transportation Authority. *Grant Road Improvement Plan. Public Comments Received.* 2008. www.grantroad.info/pdf/pac_comments_11_26_08.pdf

[4] ADOT. *Public Involvement Guidelines*. 2004. knowwheretheroadsgo.com/EEG_common/documents/files/public_involvement/public_involvement_manual/02_public_involvement_chapter_one_guidelines.pdf.
[5] Bailey, K., and T. Grossardt. Addressing the Arnstein Gap: Improving Public Confidence in Transportation Planning and Design through Structured Public Involvement (SPI). *In* Schrenk, M., ed., *Proceedings of the 11th International GeoMultimedia Symposium* 11:337-341. CORP2006. Vienna, Austria, 2006.
[6] Arnstein, S. The ladder of citizen participation. *Journal of the Institute of American Planners*, Vol. 35, No. 4, 1969, pp. 216-224.
[7] See note 5.
[8] The AZ stakeholder data sets were compared with the OH, IN, and KY data using a two-sample unpaired t-test. The p-values obtained were greater than 0.7, showing that the difference in mean Arnstein Level scores between AZ and other states was statistically insignificant.
[9] Federal Highway Administration. 1997. Context Sensitive Solutions.
[10] DOT Order 5610.2, 62 Fed. Reg. 18,377. 1997.
[11] FHWA Order 6640.23. 1998.
[12] There are several such statutes containing similar provisions e.g. ARS 28-6702.
[13] Pima Association of Governments. *Public Involvement Plan*. PAG, Tucson, 1994.
[14] ADOT. 2004. Public Involvement Guidelines. knowwheretheroadsgo.com/EEG_common/documents/files/public_involvement/public_involvement_manual/02_public_involvement_chapter_one_guidelines.pdf
[15] See note 14.
[16] President Clinton. *Executive Order 13166*. August, 2000. www.usdoj.gov/crt/cor/Pubs/eolep.php.
[17] National Cooperative Highway Research Program of the Transportation Research Board. *Request for Proposals #08-72. Practical Approaches for Involving Traditionally Underserved Populations in Transportation Decisionmaking* www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=2498.
[18] See note 14.
[19] Burdick, M. *Tools to Improve Partnering and Project Delivery*. 2007. www.dot.state.az.us/CCPartnerships/Partnering/PDF/Partnering_Event_120507/Public_Involvement_and_Communication-Burdick_120507.pdf.
[20] McGann, A. *The Problem of Consensus in Habermas and Rawls: Rethinking the Basis of Deliberative Democracy*. Paper presented at the annual meeting of the American Political Science Association, Washington, DC, Sep 01, 2005. www.allacademic.com/meta/p39891_index.html. Accessed Jan. 7, 2009.
[21] Arizona Star. 28th August 2007. www.azstarnet.com/allheadlines/198372.
[22] Wikipedia Contributors. *Wikipedia, The Free Encyclopedia.* en.wikipedia.org/w/index.php?title=Charrette&oldid=271064701. Accessed Mar. 5, 2009.
[23] Rawls, J. *A Theory of Justice.* Harvard University Press, Cambridge, 1971.
[24] Bureau of Transportation Statistics. *Transportation Statistics Annual Report.* USDOT, Washington, DC, 2005. www.bts.gov/publications/transportation_statistics_annual_report/2005/html/chapter_02/government_transportation_investment.html.

Chapter 18

TRANSPORTATION FINANCE

Jeffrey Chapman
Arizona State University, School of Public Affairs

Martin L. Shultz
Pinnacle West Capital Corporation[1]

Key Points

- Transportation funding comes from overlapping federal, state, regional, and local sources.
- There is a growing imbalance between future revenues and the costs of the maintenance, operations, and system expansions that will be necessary in the future.
- The state and its regions, counties, and municipalities must evaluate the many alternative methods for funding transportation using economic analysis as well as political considerations.

Current Conditions

As the 17 previous chapters have shown, Arizona has many pressing transportation needs. Its population is expected to continue growing rapidly for the next 25 years, so there will be rapid growth in all transportation modes. According to an Arizona Investment Council (AIC) report, over the next 25 years, passenger vehicle-miles traveled (VMT) are expected to grow by 103%, rural bus ridership by 108%; air traffic by 109%; urban bus ridership by 100%; intercity bus traffic by 52%; and truck VMT by 117%.[2] System demands are outpacing investment and system maintenance costs are competing with capital improvements. Arizona cannot afford to divert its attention from transportation to other budget arenas.

In addition to population growth, the slow deterioration of roads, rail, airports, and transit facilities drives Arizona's transportation needs. The American Society of Civil Engineers (ASCE) rates the current state of Arizona's transportation infrastructure as average: roads get a C, transit a C+ and aviation a B-.[3] The ASCE estimates that it would take $1.6 trillion over the next five years to bring all U.S. infrastructure up to "good" condition. The AIC indicates that given Arizona's projected population growth of 65% from 2008 to 2032, it would take $199 -$257 billion to meet the growing demands for transportation (depending on inflation).[4] This chapter accepts that numerical range, although there is empirical evidence that "delusional optimism" is common when large infrastructure projects are originally budgeted. Around 90% of projects went over budget and ridership was less than half of that predicted.[5] In addition, there may be some moral hazard embedded when engineers forecast demand for their services. Finally, none of the estimates account for possible reductions in demand or

changes in travel mode that may result from higher, more direct pricing, such as user fees. The estimates assume the current mix of travel mode shares will continue.

The three main problems identified in a national study of infrastructure finance pertain to Arizona as well.[6]

- 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.
- Politics drives critical components of the current approach to financing infrastructure, and cost-effectiveness is not structurally important.

This chapter focuses on the financing of major roads and public transit. It ignores local-government road responsibilities. Local governments fund surface transportation through general local government revenues as well as local sales taxes, impact fees, special assessments, community facilities districts, and local debt (usually bonds that anticipate state motor-vehicle fuel taxes). It also ignores the two major freight railroads in Arizona—Union Pacific and Burlington Northern Santa Fe (see Ch. 13), as well as Amtrak, which operates three intercity rail services and leases tracks from the freight lines (see Ch. 12). Amtrak is run like a private enterprise and operates on a mixture of subsidies, fare revenues, and other income. For freight rail, the estimated capital cumulative need from 2008-2032 is about $5.9 billion. There is some federal money involved in financing these rail systems and some federal investment tax credits are available.[7] Natural gas pipelines and electricity transmission lines are operated (and self-financed) by public utilities, with rates subject to approval by the Arizona Corporation Commission. Private-sector oil and gasoline pipelines are privately financed.

Although not the focus of this chapter, many of the ideas presented here apply to aviation (see Ch. 11). There are 309 registered airports in Arizona, 92 of which are open to the public, and most of which are quite small. It is projected that Arizona airports will need about $12.1 billion during the next 25 years. This money will come from federal, state, and local funds, and is principally derived from taxes on airline tickets, flight property taxes, aviation fuel taxes, and user fees and charges. The Arizona Department of Transportation (ADOT) funds a capital improvement program, with the money allocated using a point system.[8] The state aviation program provides about 55% of the total reported need. There are also federal funds for aviation, distributed by project eligibility and priority. Passenger facilities charges ($3.00-$4.00 in Arizona) also generate revenues for airports, subject to Federal Aviation Administration limitations.

Transportation financing has societal implications, many of which are beyond the scope of this chapter. For example, we will ignore the ways in which different financing mechanisms may encourage or discourage sprawl, economic development in the long and short run, or business and labor mobility.

Existing Plans and Programs

Arizona formed the State Highway Commission in 1927 and ADOT in 1974. Governed by a seven-member State Transportation Board, ADOT is responsible for constructing and maintaining all interstate and state highways in Arizona, and for providing financial assistance to public airports.

The history of transportation finance in Maricopa County illustrates the intricacies of transportation finance. The first formal roads in Arizona were toll roads, authorized in 1864. (Even Central Avenue in Phoenix was once a toll road from McDowell Road north to the Arizona Canal.) The Legislature also declared that the existing rough roads were to be toll free, while counties were authorized to levy a road tax for construction. Counties were the principal builders of roads, even after statehood in 1912. In 1960, before the formation of ADOT, Maricopa County adopted the first long-range transportation plan for the area. This plan was re-evaluated in 1978, and the Maricopa Association of Governments (MAG) adopted a guide for regional development in 1980. New studies augmented the plan in 1984 and 1985, and in October 1985, voters in Maricopa County voters approved Proposition 300, a half-cent sales tax dedicated to construction of a freeway system. After Proposition 400 (to increase and extend the sales tax) was defeated in 1995, the freeway plan was updated three times by 1999 to reflect changes in funding streams and federal legislation. In 2004, a new Proposition 400 passed that continued the countywide half-cent sales tax for regional transportation improvement, which should raise about $14.3 billion between 2006 and 2025. Proposition 400 allocates 56.2 % of revenues to the regional-area road fund 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. The legislation also included firewalls to prohibit any transfer of the newly raised funds from one mode to another.

To finish setting the stage, several important factors affect transportation finance in the state, directly and indirectly. The federal government is in grave economic straits: there are now estimates of a potential $1 trillion national deficit. This means that the state should not anticipate any major increases in federal transit funding.[9] To illustrate the potential instability of federal funding patterns, on September 5, 2008, the Federal Highway Trust Fund temporarily declared bankruptcy due to lower-than-expected gas tax revenues, although Congress replenished it from general funds only days later.[10] The current federal transportation-funding legislation, the Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA-LU), needs to be renewed during 2009, which is a politically volatile process. Arizona is also in a poor fiscal condition due to the recession. The estimated state budget deficit for 2008-2009 is approximately $1.6 billion. For the 2009-2010 fiscal year, the deficit could be as high as $3 billion. In addition, costs such as health care and pension expenses are likely to increase.

Under the existing model, Arizona transportation plans are part of the Arizona State Transportation Improvement Program (STIP).[11] Before release of federal funds, the federal government must approve this plan, mandated by SAFETEA-LU regulations to be prepared every four years. The projects in the STIP must be consistent with the statewide long-range

transportation plan and metropolitan transportation-improvement programs. Several regional planning and development districts develop these programs, with metropolitan planning organizations (MPOs) established for the larger urban areas of Phoenix, Tucson, Flagstaff, Prescott, and Yuma. The MPOs develop long-range transportation-improvement plans and short-term transportation-investment plans. See Ch. 3 for more details about these processes, which become part of a regional transportation plan. In air-quality non-attainment areas, only "regionally significant projects," which have been determined to conform under the requirements of the Transportation Conformity Rule of 1995, may be included. Importantly, highways needs must be identified as a product of input from citizens (see Chapter 17), local governments, state legislators, councils of governments, planning organizations, chambers of commerce, the business community and ADOT professional planners and engineers. These planners and engineers rely on technical measures to identify needs, for example, traffic counts, traffic projections, truck studies, accident studies, route corridor studies, and the State Highway plan. There is no measure of the use of congestion pricing or other tools that might alter the calculated needs. Upon completion of this analysis, ADOT prioritizes the proposed projects by significance of the route, average daily travel, number of accidents, safety factors, route continuity, cost effectiveness, and expert recommendations.

Table 18.1 demonstrates the large number of sources that channel revenues into Arizona's transportation system. Nearly all of the federal funds come from SAFETEA-LU revenues, although not all of these funds go to highways. The other principle source is the State's Highway User Revenue Fund (HURF). The principal source of inflow to this fund is the gas tax, followed by the vehicle license tax, user fuel taxes on diesel, motor carrier fees and others. Article 9§14 of the Arizona Constitution requires that all of these revenues be used only for highway and street purposes. The vehicle license tax is split between local governments (55%) and HURF (45%). Some sources of ADOT revenue are not included in Table 18.1. For example, the Maricopa County Transportation Excise Tax (Prop 400) generates about $393 million per year (of which over half goes to freeways); vehicle fees and the state's General Fund also provide revenue.

Several facts are apparent from these and other data. First, Arizona relies on the motor-fuel tax for about 34 % of highway revenues (in 2004). This is below the U.S. median of 47%. The motor-fuel tax is a per-gallon tax, so tax revenues do not increase as the price of gas or diesel increases, but rather are likely to fall as these prices increase. Second, Arizona has been innovative in generating money for capital in the past. For example, in the mid-1990s, using the State Infrastructure Bank, ADOT developed a Highway Expansion and Extension Loan Program (HELP), which worked with a creative financing mechanism called Board Funding Obligations. In partnership with local governments, HELP cut seven years off the completion date of the Maricopa Freeway system.[12] Another creative example is the Statewide Transportation Acceleration Needs (STAN) program, which in 2007-2008 received $307 million to expedite new highway construction in Maricopa and Pima Counties.[13] Third, highway construction costs rise faster than inflation, which implies increasing future cost pressures. Rising environmental-mitigation costs are likely to exacerbate cost pressures. The AIC study indicates that increasing construction costs may lead to complete cessation new infrastructure building within seven years. Fourth, as the population increases, there will be increased demand for roadways and increased delays during peak travel hours. Because of these demand factors, the percentage of road passenger

Table 18.1: ADOT Funding Sources and FY 2007 Actual Revenue (in millions)

State Sources:	
Highway User Revenue Fund	$1,382.5
Vehicle License Tax	$875.7
Regional Area Road Fund (RARF) & MAG	$392.5 (less $8.1 for RPTA)
Local Transportation Assistance Funds	$39.5
State Aviation Fund	$28.1
Safety Enforcement and Transportation Infrastructure Fund	$3.2
Federal Sources	
SAFETEA-LU Funds (total Obligation Authority)	$637.5
Other	$16.5
Financing Options	
HURF Bonds	$325.0
RARF Bonds	$0.0
HELP Bonds	$14.0
Grant Anticipation Notes	$0.0
Board Funding Obligations	$0.0
Transportation Infrastructure Finance and Innovation Act	$0.0

Source: Arizona Department of Transportation, Funding Sources and Authorities, FY 2007. www.azdot.gov/inside_ADOT/fms/PDF/ADOTFUNDING07.pdf.

travel at an acceptable "level of service" (i.e., congestion) is expected to drop from 78 % statewide in 2002 to 38 % in 2025, increasing the average delay per trip six-fold.

Although the state has calculated that there will be about $101 billion available for road and highway infrastructure for 2008-2032, this projection appears to be based on optimistic assumptions.[14] For example, the compound growth rate of HURF funds is assumed 5.1%. Assumptions about the re-enactment of SAFETEA-LU may be inaccurate. A national study from the Brookings Institution states that the national transportation-financing program is fundamentally broken because it distributes funds to states without adequate purpose, oversight, or accountability, and without tying the funds to goals.[15] The study also argues that increasing federal revenues to the states may lead states to use the new federal money for funds they otherwise would have to raise for themselves—essentially becoming a state-tax relief program. Regardless of these concerns, estimated Arizona revenues for 2008-2032 would be insufficient to cover the estimated needs of $199-$257 billion.

Challenges

The AIC identifies several challenges confronting the state, all of which have financial components. They project new transportation corridors, new connections to emerging population centers, new alternative routes around congestion, additional multi-modal options for commuting, and new facilities for commercial vehicles.[16] Although the AIC does not emphasize maintenance expenditures in this list of challenges, they will become increasingly important as the current infrastructure ages.

All of these additions to the transportation system will require new funding sources, since the state will be highly constrained in its ability to fund new capital improvements. Inflation is eroding the purchasing power of the 18-cents-per-gallon (cpg) fuel tax, while the improving

fuel efficiency of automobiles simultaneously reduces the number of gallons consumed (see Ch. 2). It may be politically difficult to either increase this tax (perhaps by indexing for inflation), or to apply the general sales tax to gasoline, from which it is currently excluded. (This is done in California.)

Increased federal aid is also unlikely. The national infrastructure funding-gap may reach $134 billion in 2017. Total revenues are predicted to fall roughly 21% short of the funds needed to adequately maintain the existing system, and 35% short of what is needed to improve the system. Since in Arizona, 25 % of all highway revenues and 46 % of highway capital investments come from these declining federal funds, pessimism seems justified. For federal highway projects, the mean length of time it took to get a road from planning stages to completion was 13.1 years.[17]

We must confront four basic questions before examining opportunities to solve them:

1. What are the best ways to evaluate specific transit projects and different funding mechanisms in a world of financial constraints? In a world of unlimited resources, all public-transit projects for which the current value of benefits exceeded the current costs would be implemented.[18] We do not live in that world. When there are limits to public funds, it is justifiable to prioritize funding decisions based on the ratio of benefits to costs. Arizona does not use this procedure. It first allocates funds, based on politically negotiated percentages, to different levels of government (HURF gets a portion and regional planning agencies get a portion). Then projects are ranked using a complex system of awarding points. Transit projects seldom go through a formal economic-evaluation process.

In *The Path Forward*, 15 different evaluation criteria for funding sources are listed; in the Arizona Investment Council report, five criteria are developed (Table 18.2).[19] While there is a great deal of overlap, there are some subtle differences between the lists. For example, "sustainability" in the AIC

Table 18.2: Criteria for Evaluating Funding Sources in Two Recent Studies

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); Interim Report of the National Surface Transportation Infrastructure Financing Commission (2008).

report refers to the level of security of the funding source; "sustainability" in the *Path Forward* refers to the how easily the source can be adjusted to meet needs. A close examination and ultimately an explicit prioritization of a set of criteria to evaluate funding mechanisms would facilitate decision-making in the future.

2. *What does efficiency mean and how important is it?* Financial efficiency has multiple dimensions. First, financing mechanisms should be designed to maximize economic benefits. This means encouraging the use of financing tools, such as tolls and congestion charges, to help discover what citizens want in terms of size, placement, and investment timing. These pricing mechanisms would encourage citizens to demand a level of service that reflects an efficient level of resource allocation. This service level would include not only new capital construction but also operating practices of existing facilities so that service would be provided to those who value the service more highly than the costs of producing it.[20] Efficiency is also concerned with cross-generational resource allocation. For example, pay-as-you-go financing saves future generations money, and maintains government's credit capability. Debt financing, on the other hand, allows faster construction (with 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.[21] Efficiency also relates to aligning the responsibilities of federal, state, and local governments so that the lowest level of government representing the parties who directly benefit from a transportation facility takes responsibility for funding and providing that facility.[22] 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. However, federal grants to state and local governments do not always serve their intended purposes. In response to federal highway grants, states have offset roughly one-half of the increases by reducing their own funding. This rate of substitution seems to have increased during the 1990s.[23]

3. Who are the beneficiaries of transportation infrastructure and who should pay for it? There are at least two groups of people who should pay for surface-transportation infrastructure: the people who use it and the general populace, who receive "public-good" benefits from infrastructure. Both pay in the current system through different financing mechanisms; however, the linkages between those paying for the infrastructure and the beneficiaries of the infrastructure are indirect and unclear.

Payment by users is the most common form of highway finance. Arizona charges an excise tax on gasoline and diesel fuel, and vehicle licensing fees to generate these revenues. Underlying this approach is the assumption that people who drive more should pay more (through gas taxes) for road construction and maintenance, and for the external costs of driving borne by society as a whole (e.g., air pollution). The state vehicle-fuel tax has not been increased since 1991, and with improved fuel economy and the increased price of gasoline, it is unlikely that large increases in revenues will occur without increasing the tax per gallon. To send the correct economic "signals" to consumers and firms, an efficient level of pricing should equate the price of use with the full marginal cost of use. This clearly does not occur. While a straight fuel tax does make users pay 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 imposed by the truck, which is related to total weight *per axle*, not

total weight (which drives fuel consumption).[24] The costs of congestion and environmental damage caused by increased driving are usually ignored in the tax-setting process.[25,26]

The second group that benefits from transportation infrastructure is the general public. Because of the positive economic-development effects that a good transportation system generates, even non-users of the system benefit. Nationally, public investments have been show to stimulate economic growth.[27] All residents share the benefits of this growth, and thus all should pay for a portion of this infrastructure. This does happen at the national level, because SAFETEA-LU is financed by nationally collected gasoline taxes and general federal revenues. In Arizona, HURF is financed entirely by transportation users, rather than by the general public. Even people who walk to work receive benefits from the economic development and transportation cost-savings generated by new infrastructure (reflected in their salaries and the goods and services they consume); thus, they should contribute some tax revenues to these projects. Several counties implement this idea by using a one-half cent sales taxes to finance transportation, though the right balance between user fees and sales tax is not addressed directly and openly in debate.

4. *How do we address equity concerns?* We cannot ignore the possibility that the less wealthy bear a larger tax burden under certain types of financing mechanisms. It is difficult to determine the extent to which this occurs. It is often argued that sales taxes are regressive, meaning that low-income households pay a larger share of their income for sales tax; thus, the financing of much of Arizona's existing transportation infrastructure is probably regressive. Furthermore, low-income travelers tend to own older cars with lower gas mileage, which means that a gas tax is regressive. Of course, if low-income travelers take public transit, which is heavily subsidized, some of these concerns disappear.

Equity also varies geographically (e.g., rural drivers tend to drive longer distances than urban drivers, see Ch. 4) and generationally (e.g., leaving debt or decayed infrastructure to our children to payback or maintain). HELP funds appear to be used mostly in metropolitan areas. There are calls for increasing the use of HELP funds on federal lands.

Equity concerns are also relevant to toll roads and have contributed to the failure of many congestion-pricing 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.[28] In any case, equity concerns are important, but the assumption that tolls are always inequitable may not be correct.[29]

Opportunities

The Government Accountabilty 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.[30] Many of the concerns at the federal level are similar to those at the state level, and give the state an opportunity to confront them. To develop an effective, comprehensive funding system we should re-examine the rationale for the politically negotiated percentage distribution of funds, determine criteria for funding mass transit (including commuter rail) versus highways, and decide if congestion pricing is a legitimate method for determining the optimum level of construction.

We do know that: 1) the current funding system is inadequate over the long term, 2) the weak link between driving and taxes does not promote efficient use of the system, and 3) facing major problems can force a reexamination of the entire transportation funding system. The last section of this chapter will offer a menu of options that can help solve this problem. Some are traditional, and some require a willingness to face political consequences that might be uncomfortable. All can be part of the solution package.

Doing More of What We Do Now—Tax.

Option 1: Increase the excise taxes on gas and diesel fuels, which have not been increased since 1991. In Arizona, both taxes are currently set at 18 cpg, slightly below the weighted national averages of 18.4 and 18.9 cpg for gas and diesel, respectively.[31] Excise taxes, however, are not the only taxes states levy on fuel. Arizona's total tax on gasoline comes to 19 cpg, compared with a weighted national average of 30 cpg. For diesel fuel, Arizona's 28 cpg is more in line with the national average of 29.4 cpg. At the very least, fuel taxes should be indexed for inflation so that they rise as costs of construction and maintenance rise.

Option 2: Expand the standard sales tax to gasoline and diesel. California does this. 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.

Option 3: Increase (and in some cases, allow) add-on sales taxes at the local and regional level. The Transportation and Infrastructure Moving Arizona's Economy (TIME) initiative would have added a penny to the state sales for 30 years. Maricopa, Pima, and Pinal Counties have added half-cent sales taxes.

Doing More of What We Do Now—Debt

Option 4: Continue and expand the use of infrastructure bank loans for segments of surface transit. These banks complement the traditional Federal-Aid highway and transit programs, and allow accelerated completion of projects, as well as flexible project financing. SAFETEA-LU financing can capitalize these banks.[32]

Option 5: Continue to use Grant Anticipation Revenue Vehicles (GARVEE) financing. GARVEE funding occurs when the recipient borrows money to advance highway construction, with the debt service funded by anticipated receipts of aid from the federal government. Arizona does an admirable job of using available GARVEE funds.

Option 6: Make use of other revenue streams to finance debt service. In 2007, ADOT showed no actual funding from RARF Bonds, Grant Anticipation Notes, Board Refunding Obligations, or the Transportation Infrastructure Finance and Innovation Act.

Learning from Others

Option 7: Implement congestion pricing wherever possible. Congestion pricing is not a new idea. Many governments, in the United States and abroad, have experimented with and implemented congestion-sensitive toll systems to reduce peak-hour traffic on intercity highways. These systems can allocate road space efficiently, reduce peak-hour congestion by spreading traffic to off-peak times, produce additional revenues for transportation improvements, and reduce emissions.[33] 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.[34] The FHWA suggests that this is the same amount as the annual appropriation needed to keep transportation services at current levels.

Option 8: Adopt other types of more narrowly defined congestion charges. First, "High Occupancy Toll" (HOT) lanes can be established, in which drivers can choose a HOT lane and pay a charge for that use, while carpoolers and bus riders can use the lanes for free or at a reduced cost. This saves travel time, and drivers would decide whether the time spent in congestion on the "free" lanes would offset the charge for using the HOT lane. Transceivers mounted on cars would automatically activate as the car made the lane choice. Two California highways use these. The charge can be easily changed according to time of day or amount of congestion. A second type of charge, which is local, is a cordon charge on all vehicles entering the congested central zone. It has been used successfully in London, but was recently rejected by the New York State Legislature, preventing New York City from adopting it; New York may revisit the issue in light of growing fiscal problems. In addition to raising funds from the users who contribute most to congestion, the cordon charge would 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 is based on VMT using GPS. Once some of the technical problems with GPS are worked out, it becomes feasible to charge cars based on how many miles they have been driven.

Option 9: Use tolls for financing maintenance and new construction. Tolls for road maintenance and construction are relatively common along parts of the interstate highway system in many of the eastern states, and bridge tolls are common throughout the United States. However, trip length often 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.[35]

Option 10: Impose land (parcel) taxes for benefits. Landowners often see an increase in the value of their land when new highways reduce the time to get to their property.[36] It is equitable to have these beneficiaries pay for at least a portion of the construction costs

through a tax on the increase in land value. A land tax is not only progressive but has the fewest economic distortions of any major tax. Note that this is not a form of tax increment financing—the focus is only on land, and the boundaries would be drawn with respect to new infrastructure construction. Legally, a land tax is a special assessment, and property owners would have a right to a hearing. Politically, of course, this may be a non-starter in the short term, although as its use increases in other places, it may gain some support in Arizona.[37]

Option 11: Involve the private sector through Public-Private Partnerships (PPPs or P3), whereby the private sector may finance, construct, manage, or even operate specific infrastructure, such as a freeway under contract and oversight from a local public agency. There is a wide variety of PPP arrangements for roadways. At least 22 states have formal legislation that allows some form of PPP. PPPs are legal in Arizona for county and private toll roads.[38] 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.[39]

Option 12: Establish a "Blue Ribbon" Commission focused solely on transportation finance. Unlike earlier Blue-Ribbon *Tax Reform* Commissions, which covered a broad set of issues, there may now be a need for a more narrowly focused Commission concerned solely with transportation finance. Such a commission could focus first on planning needs, and then, choosing from the menu above, recommend the mix (including choice and amount) of potential new funding sources.

List of Abbreviations Used

ADOT	Arizona Department of Transportation	**MPO**	Metropolitan Planning Organization
AIC	Arizona Investment Council	**NACOG**	Northern Arizona Council of Governments
ASCE	American Society of Civil Engineers	**PAG**	Pima Association of Governments
cpg	Cents per gallon	**PPP**	Public-Private Partnerships
GARVEE	Grant Anticipation Revenue Vehicles	**RARF**	Regional Area Road Fund Bonds
HELP	Highway Expansion and Extension Loan Program	**SAFETEA-LU**	Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users
HOT	High Occupancy Travel	**STAN**	Statewide Transportation Acceleration Needs
HURF	Highway User Revenue Fund	**STIP**	State Transportation Improvement Program
MAG	Maricopa Association of Governments	**VMT**	Vehicle-Miles Traveled

Jeff Chapman is the Foundation Professor of Applied Public Finance at ASU. He earned an MA and PhD in economics from the University of California, Berkeley, and holds an AB in Economics from Occidental College. Dr. Chapman is the editor of *Long Term Financial Planning: Creative Strategies for Local Government, California Policy Choices, Vol. 9*, and the author of *Proposition 13 and Land Use.* Scholarly journals and periodicals that have published his work include *Public Administration Review, The Journal of Urban Economics,, Land Economics, Policy Studies Review, Public Budgeting and Finance, National Tax Journal, Urban Interest, Public Finance, The University of Southern California Law Review, Public Choice,* and *Public Finance Quarterly.* His current research interests are land taxes, the different types and effects of arcane infrastructure financing instruments, and local fiscal sustainability.

Martin L. Shultz is Vice President of Government Affairs for Pinnacle West Capital Corporation in Phoenix. In that role he manages public affairs and government relations for Pinnacle West Capital Corporation and its wholly-owned subsidiaries APS, APS Energy Services and SunCor. Before that he served as chief of staff to three Phoenix mayors; John Driggs, Tim Barrow, and Margaret Hance, and was a financial systems consultant to the Arizona Legislature. A graduate of Arizona State University with a master's degree in Educational Administration, he has done post graduate work at UCLA, ASU and the JFK School of Public Administration and Politics at Harvard University. He has written extensively on issues including electric utility, transportation, business and health care industry policies. He is a Member of the National Surface Transportation Infrastructure Financing Commission, Chairman of the Governor's Transportation Vision 21 Task Force, and a Founding Member of MAG Transportation Policy Committee.

---

[1] The authors thank Jung Wook Seo for his excellent research assistance.
[2] Arizona Investment Council. (2008) *Infrastructure Needs and Funding Alternatives for Arizona: 2008-2032*, page xiii.
[3] See www.azsce.org/downloads/AZSCE_2004_Infrastructure_Report_Card_f3.pdf. The average U.S. grade is a D.
[4] $18 billion of this total goes for railroads and airports.
[5] Flyvberg, B. From Nobel Prize to project management: Getting the risks right. *Project Management Journal*, Vol. 37, No. 3 (August), 2006, pp. 5-15.
[6] National Surface Transportation Infrastructure Financing Commission. *The Path Forward: Funding and Financing Our Surface Transportation System.* Interim Report, Feb. 2008. financecommission.dot.gov/ Accessed Oct. 21, 2008.
[7] State and Federal data come from: Benouaich, M. A. *The Changing Landscape of Highway Finance in the U.S.* (November 7). Paper given at the International Road Federation 2nd European Road Congress, Brussels, Belgium; DOT—Case Study—SIB (n.d.) Arizona's Help Program, 2006. www.fhwa.dot/innovativefinance/ifp/csariz.htm; Downloaded 10/14/2008; Arizona Investment Council. *Infrastructure Needs and Funding Alternatives for Arizona: 2008-2032: Water, Energy, Communications and Transportation (May).* Prepared by L. William Seidman Research Institute, W.P. Carey School of Business, ASU, 2008.
[8] In 2007, the Phoenix Airport System did have depreciation charges of $86.2 million.
[9] Note that part of this $1 trillion is a potential stimulus package that might include some infrastructure expenditures. As of this writing, the existence and magnitude have not been determined.
[10] Blasius, M. *Fund Bankrupt; Highway Plans on Hold*. Azcentral.com. September 5, 2008.
[11] This following section is taken from: ADOT. *(2008) DRAFT: Arizona State Transportation Improvement Program*. tpd.azdot.gov/pps/introduction.asp. Accessed Sept. 23, 2008.
[12]Regional Area Road Fund Bonds (RARF) can also be used to accelerate the construction of controlled access facilities on the Maricopa Regional Freeway System and since 2006 can be issued to accelerate arterial street projects in the Regional Transportation Plan.
[13] www.azdot.gov/adot_and/ctoc/PDF/2007/Min092507.pdf
[14] From July 2007 through June 2008, HURF revenues have fallen by 2.7%.
[15] Puentes, R. *Don't Raise that Gas Tax…Yet! Brookings Institution, Metropolitan Policy Program*. 2007. www.Brookings.edu. Accessed Aug. 27, 2008.

[16] Again, note internal to municipality roadways are ignored in this chapter. There are an immense set of financing problems associated with municipality provision of roads to local residents, including incorrectly set impact fees—which do not cover maintenance, community facility district debt, lack of tax increment financing availability, and so on.
[17] See note 6.
[18] Present value means that the time value of money is taken into account. Thus, a dollar received in the future is discounted to a value of today in the analysis.
[19] See note 6.
[20] Transportation Research Board of the National Academies. *The Fuel Tax and Alternatives for Transportation Funding*, Special Report 285, 2006.
[21] Pagano, M. A., and D. R. Shock. (2007) Capital budgets: The building blocks for government infrastructure. *Government Finance Review*, Vol. 23, No. 3, June 2007, pp. 16-23.
[22] Transportation Research Board. 2006.
[23]Congressional Budget Office. *Issues and Options in Infrastructure Investment.* May 2008.
[24] See note 23.
[25] Increasing the fuel tax will lead to a decline in miles driven, which should lead to a decline in congestion. However, since this tax does not vary by the amount of congestion, this congestion decrease will be a second order effect.
[26] Payment for streets and highways using the concept of who is benefiting by their provision is mostly done at the local level using of local benefit assessment districts, community facilities districts, local property taxes, and impact fees, among other devices. For a summary of many of the ways of local infrastructure finance, see Chapman, J.I. The fiscalization of land use: The increasing role of innovative revenue raising instruments to finance public infrastructure. *Public Works Management and Policy*, Vol. 12, No. 4, April 2008, pp. 551-567.
[27] See, for example, Pedro R., D. Bom and J. E. Lighthart. *How Productive is Public Capital? A Meta-Analysis. Center Discussion Paper Series*, Discussion Paper No. 2008-10 (January). ssrn.com/abstract=1088651. They find that the marginal productivity of public capital was about 17% in 2001. See also, Cohen, J. P., and C. J. Morrison Paul. Public infrastructure investment, interstate spatial spillovers, and manufacturing costs. *Review of Economics and Statistics*, May 2004. In addition, Cohen and Paul argue that the value of intrastate public investment is associated with lowering transportation costs.
[28] Transportation Research Board of the National Academies. *The Fuel Tax and Alternatives for Transportation Funding*. Special Report 285, 2006.
[29] Parry, I.W.H. *Pricing Urban Congestion*. Discussion Paper 08-35, November 2008. Resources for the Future, (November) elaborates upon this and concludes that congestion tolls are likely to be regressive and attention needs to be paid to compensate lower-income drivers. ssrn.com/abstract=1309814.
[30] Dalton, P. A. *Physical Infrastructure: Challenges and Investment Options for the Nation's Infrastructure.* Government Accountability Office testimony, May 8, 2008.
[31] American Petroleum Institute. *Notes to State Motor Fuel Excise and Other Taxes.* October 1, 2008. www.api.org/statistics/fueltaxes/upload/State_Motor_Fuel_Excise_Taxl_Notes.pdf
[32] USDOT, Federal Highway Administration. State Infrastructure Bank Review. Feb., 2002.
[33] PPIC. Rethinking infrastructure policy for the 21st century. *Research Brief*, #34, June 2000.
[34] See note 23.
[35] Section 129 loans can provide Federal funding for toll facilities that are not part of the Interstate system. The loan recipients can be a public or private entity and are selected according to each state's specific laws and process. www.innovativefinance.org/topics/revenue_sources/user_charges/tolls/innovative_tolling.asp. Accessed Oct. 23, 2008.
[36] People who live near freeway entrances/exits also experience some negatives—more traffic, more noise, more pollution, higher-speed traffic, and cars cutting through their neighborhoods to get to the freeway.
[37] For use in other countries, see Bird, R. M., and E. Slack. Taxing land and property in emerging economies: Raising revenue…and more? *In* Gregory K. Ingram and Yu-Hung Hong, eds. *Land Policies and Their Outcomes*. Lincoln Institute of Land Policy, Cambridge, MA, pp. 204-233, 2007. For an example of its application in the United States, see Chapman, J. I., G. C. Cornia, R. L. Facer, and L. C. Walters. Alternative financing models for transportation: A case study of land taxation in Utah. *Public Works Management and Policy*. Forthcoming.

[38] ARS, Title 28, Chapter 19, Article 4 and Title 28, Chapter 21, Article 1. Other legislative proposals have been advanced.

[39] Brown, K. Are public-private transactions the future of infrastructure finance? *Public Works Management and Policy*, Vol. 12, No. 1, July 2007, pp. 320-324. Also, see *RBC Capital Markets* at www.gfoaz.org/resources/attach/presentations/07wc_dralle_streetrs_hwys.ppt.

Appendix 1

TIMELINE OF ARIZONA TRANSPORTATION HISTORY

	ROADWAY	RAILWAY	TRANSIT	AVIATION	MARITIME/ CANAL/ PIPELINE	FEDERAL AND STATE REGULA-TIONS
1840s	1848--Gila Trail used during California goldrush				1849--Yuma ferry service across Colorado River	
1850s	1858--El Paso-Fort Yuma Wagon Road opens 1858--Butterfield Overland stageline crosses AZ				1853--Colorado River steamer service initiated	
1860s	1869--Central Ave toll road opens north of PHX townsite					1864--Toll roads authorized by Territorial Legislature, but existing rough roads to be free
1870s					1871--Hayden's ferry service across Salt R. 1873--Maricopa Canal opens	
1880s		1881--Southern Pacific RR crosses southern AZ 1883--Atlantic & Pacific (Santa Fe)RR crosses N AZ 1887--Maricopa & Phoenix RR links Phoenix by rail	1887--First horse-drawn streetcars in Phoenix		1887--Arizona Canal opens	1887--Interstate Commerce Commission established, in part to regulate RR robber barons
1890s		1895--Phoenix linked to Northern & Southern rail lines	1893--First electric streetcars in Phoenix 1898--Tucson mule-drawn streetcars in service			

	ROADWAY	RAILWAY	TRANSIT	AVIATION	MARITIME/ CANAL/ PIPELINE	FEDERAL & STATE REGULATION
1900s	1900--First automobile arrives in Phoenix	1901--Grand Canyon Railway carried first passengers 1903--PHX & Eastern RR Phoenix-Tempe steamtrain	1906--Tucson electric trolley			1903-1910--Elkins Act and others shore up ICC powers to regulate RRs
1910s	1910--First automobile dealership in Phoenix	1910--Southern Pacific Nogales-Tucson line opens	1910--Phoenix trolley car barn fire 1911--Phoenix streetcar system reorganiza-tion	1919--Tucson first municipally-owned airport	1917--Salt River Project established	1912--Statehood 1912--Office of State Engineer established
	1913--Original Mill Avenue bridge built in Tempe	1912--Verde Valley Railroad completed				1916--Federal Aid Road Act authorizing federal funds for roads to compete with RRs
1920s	1926--Route 66 designated across northern AZ	1923--Phoenix Union Station opens	1925--Phoenix streetcar system sold to city for $20K	1927--Sky Harbor air service begins on Scenic Airways		1921--Federal Highway Act requires 50-50 state matching
	1929--Apache Trail to Roosevelt Dam opens	1926--Phoenix S. Pacific mainline service opens	1929--Phoenix streetcar system most profitable year	1928--Tucson scheduled air service begins on Standard Airlines		
1930s	1931--Mill Avenue bridge opens in Tempe 1939--First issue of Arizona Highways magazine		1934--Phoenix streetcar & bus employees unionize	1935--City of Phoenix purchases Sky Harbor		1935--Motor Carrier Act regulates trucking 1937--Civil Aeronautics Board created

	ROADWAY	RAILWAY	TRANSIT	AVIATION	MARITIME/ CANAL/ PIPELINE	FEDERAL AND STATE REGULA-TIONS
1940s			1947--Phoenix streetcar barn fire 1948--Phoenix streetcars removed from service			1949--United States vs. National City Lines court case (collusion to eliminate streetcar lines)
1950s				1952--Sky Harbor Terminal 1 opens		1955--Air Pollution Control Act first clean air act initiated
	1957--First segment of Black Canyon Freeway opens				1955--S. Pacific pipelines link Arizona to West Texas	1956--Interstate Highway Act, 90% Fed funding 1956--Highway Revenue Act created Highway User Trust Fund
1960s	1969--I-40 opens to Flagstaff	1968--Scheduled train service to Grand Canyon cancelled	1964--Urban Mass Transit Act authorizing federal funding up to 2/3 of initial cost	1962--Sky Harbor Terminal 2 opens		1962--Federal Aid Highway Act mandated urban planning 1966--US Department of Transporta-tion created
	1969--I-17 completed	1969--Last Sante Fe passenger train departs PHX		1963--Tucson opens new terminal	1968--CAP canal project approved	1969--National Environmental Policy Act (NEPA): Environmental Impact Statements needed

	ROADWAY	RAILWAY	TRANSIT	AVIATION	MARITIME/ CANAL/ PIPELINE	FEDERAL AND STATE REGULA-TIONS
1970s	1973--I-15 completed through AZ 1978--I-19 completed	1960s-70s--many RR bankruptcies 1971--Amtrak takes over remaining intercity routes 1976--Government-owned Conrail begins operation in US northeast	1974--"Bug Line" operates free PHX crosstown service 1978--Phoenix dial-a-ride service initiated	1979--Sky Harbor Terminal 3 opens		1971--EPA issues first air quality standards 1973--Metropolitan Planning Organiza-tions (MPOs) authorized 1974--federal funds approved for mass transit operating cost subsidies 1974--Regional Rail Reorganizing Act 1978--Airline Deregulation Act
1980s	1980--Salt River bridges destroyed by flooding 1984--I-40 completed 1985--Route 66 decommis-sioned 1985--AZ Prop 300 (1 1/2 cent sales tax) approved	1980--"Hattie B" emergency commuter train due to Salt R. flood 1987--Amtrak resumes service to Tempe 1989--Grand Canyon Railway reopends for passenger service	1985--AZ Prop 300 creates regional transit authority 1989--Valtrans Proposition fails at ballotbox	1982--Southwest Airlines begins service to Phoenix 1983--America West Airlines begins operations	1985--Gasoline pipeline links Phoenix via Yuma to S. California	1980--Staggers Rail Act deregulates RRs 1990--Clean Air Act Amendments (CAAA) designated non-attainment areas

	ROADWAY	RAILWAY	TRANSIT	AVIATION	MARITIME/ CANAL/ PIPELINE	FEDERAL AND STATE REGULA-TIONS
1990s	1990--I-10 and Stack transition completed in PHX 1992--US 60 completed 1994--Paradise Parkway cancelled	1996--Phoenix Amtrak service cancelled	1993--ValleyMetro name/logo adopted in Phoenix 1994--Prop 400 freeway/bus plan defeated 1996--Tempe passes Prop 400 transit improve-ments	1990--Sky Harbor Terminal 4 opens	1991--CAP canals completed to Tucson	1990--Americans with Disabilities Act (ADA) 1991--Intermodal Surface Transporta-tion Efficiency Act (ISTEA) allows greater spending flexibility& mandates public participation 1997--Kyoto Protocol on global climate change developed 1998--Transporta-tion Equity Act (TEA-21) continues ISTEA w/min guarantee for each state
2000s	2001--US 101 completed 2006--Santan freeway completed 2008--Red Mountain freeway competed		2000--Phoenix first city to adopt overlay zoning ahead of light-rail construction 2004--Maricopa County voters approve Prop 400 2008--Metro light rail begins operation	2000--Sky Harbor third runway opens 2005--America West merger with US Airways	2003--Gasoline pipeline rupture near Tucson disrupts flows to Phoenix	2005--Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)

Appendix 2

EXCERPT FROM ARIZONA CLIMATE CHANGE ACTION PLAN[1]

Impacts in Arizona and the West

Over the past 50 years, the climate in the western United States has warmed on average by 1.4 degrees Fahrenheit. IPCC climate models predict that further June to August temperature increases of 3.6 to 9.0 degrees Fahrenheit are possible by 2040 to 2069 for western North America,[2] while the most extreme warming scenario currently considered possible suggests that annual mean temperatures in the southwestern United States could increase potentially by up to 14 degrees Fahrenheit before the end of the century.[3] A warmer climate could mean less winter snowfall, more winter rain and a faster, earlier snowmelt in Arizona's mountains.

Higher temperatures and increased evaporation also could lower reservoir levels, lake levels, and stream flows in the summer. Lower stream flows could concentrate pollutant levels and increase salinity, a critical water quality problem in Arizona. Less water would be available to support irrigation, hydropower production, public and industrial supply, fish and wildlife habitat, and recreation. More winter rain, coupled with more rapid snowmelt, could contribute to winter and spring flooding. Meanwhile, less spring and summer aquifer recharge could exacerbate already-declining water levels in parts of the state that depend on groundwater withdrawals for irrigation and municipal supply. With continued population growth, water demand could outpace water supply in areas of the State.

Even conservative estimates of climate change predict significant potential impacts on the Colorado River system by the end of this century due to decreased snowfall and snow pack and increased evaporation, including a 15% reduction in annual runoff; a 40% decrease in basin storage; and a decline in hydroelectric power production to 45 to 56% of the historical average. The date of peak spring runoff could continue to advance, coming more than a month earlier in many Western rivers by the century's end.[4]

Further, climate change could reduce Arizona's forested areas by 15 to 30%, with hotter, drier weather conditions increasing the already-high potential for more frequent, intense wildfires that threaten both forests and property.[5] Milder, drier winters could also increase the likelihood of insect outbreaks and wildfires that result from the accumulation of dead wood on the forest floor.

Arizona is already experiencing the effects of a hotter, drier climate. Due in part to a decade-long drought and warmer temperatures, Arizona's fire season began earlier (in February) this year (2006) than ever before. Moreover, the two worst wildfires in Arizona history have occurred in just the last few years: the Rodeo-Chediski fire in 2002, which consumed nearly 500,000 acres; and the Cave Creek Complex fire in 2005, which burned

nearly 250,000 acres.[6] The drought and warmer winter temperatures also have contributed to bark beetle infestations in the State's forests, killing thousands of pine trees and adding to the already-severe fire risk. The State's two driest years in more than a century occurred in 2002 and 2006, respectively, and coincided with the two lowest levels of run-off ever recorded due to decreased snowfall. The 2006 spring runoff season, which measures snowmelt from January through May, provided just 121,000 acre-feet of water this year (2006), as compared to 665,000 acre-feet normally.[7]

Climate change could likewise significantly alter Arizona's agricultural crop production, which is heavily dependent on irrigation.[8] Cotton yields could decline by 5 to 11% and wheat yields by as much as 70% as temperatures rise beyond the tolerance levels for the crop, particularly with reduced water availability. Livestock production, which accounts for about half of the State's annual agriculture industry, could also suffer, as livestock tend to gain less weight in hotter, drier conditions and when pasture yields decline, limiting forage.[9] The potential increased susceptibility of crops and livestock caused by these stressors, combined with reduced die-back of pests and diseases resulting from milder winters, could exacerbate these impacts.

A changing climate also could exacerbate Arizona's air pollution problems. During the winter of 2005-06, the Phoenix metropolitan area suffered a record-breaking 143 consecutive days without measurable precipitation, which contributed to unprecedented levels of particulate matter pollution (referred to as PM10) in the area. Between November 1, 2005 and March 15, 2006, the Phoenix metropolitan area exceeded the federal standard for PM10 on 30 days, and the Arizona Department of Environmental Quality (ADEQ) issued 25 High Pollution Advisories, more than in the previous decade combined. Increased temperatures also could contribute to increased ozone concentrations in the Phoenix metropolitan area during summer months.

---

[1] Arizona Climate Change Advisory Group (CCAG) *Arizona Climate Change Action Plan.*, 2006. pp. 27-28. www.azclimatechange.gov/. Accessed Mar. 7, 2009.
[2] Running, S. Numerical Terradynamic Simulation Group, University of Montana; published July 6, 2006 in *ScienceXpress*, the online version of the journal *Science*; 10.1126/science.1130370.
[3] Stainforth et al., *Nature*, Vol 433, 27 January 2005; www.nature.com/nature.
[4] From presentation of Dr. Andrew Comrie, Professor of Atmospheric Sciences, University of Arizona, to the CCAG. See http://www.azclimatechange.us/ewebeditpro/items/O40F7043.pdf.
[5] U.S. Environmental Protection Agency Fact Sheet 236-F-98-007c, "Climate Change and Arizona" yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/SHSU5BNJMV/$File/az_impct.pdf.
[6] A July 6, 2006 study published in *ScienceXpress*, the online version of the journal *Science*, linked climate change to larger, longer-lasting wildfires in the Western United States and found that the worst fires (1,000 acres or more) occurred in years with warmer springs and earlier snowmelts. More acreage and larger fires burned in the West between 1987 and 2003 than in the previous 16-year span. See "Warming and Earlier Spring Increases Western U.S. Forest Wildfire Activity" www.sciencemag.org/cgi/rapidpdf/1128834.pdf. Dr. Thomas Swetnam of the University of Arizona's Tree Ring Research Laboratory, a CCAG member, was a co-author of the study.
[7] Arizona Republic, June 16, 2006.
[8] U.S. Environmental Protection Agency Fact Sheet 236-F-98-007c, "Climate Change and Arizona" yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/SHSU5BNJMV/$File/az_impct.pdf.
[9] See note 8.

Appendix 3

LATEST REGIONAL TRANSPORTATION PLAN MAPS FOR ARIZONA'S METROPOLITAN PLANNING ORGANIZATIONS

Appendix 3 contains maps of the freeway, arterial and high-capacity improvements for the five Metropolitan Planning Organizations. In addition, for MAG, tables A-3.1 and A-3.2 show a breakdown of funding by transportation mode.

Table A-3.1: SOURCES AND DISTRIBUTION OF REGIONAL REVENUES: FY 2008-2028
(Year of Expenditure Dollars in Millions)

	Uses						
Sources	**Highways/ Freeways**	**Arterial Streets**	**Bus Transit**	**Light Rail Transit**	**Bicycle/ Ped.**	**Air Quality**	**Total**
Proposition 400: Half Cent Sales Tax Extension (RARF)	10,055.1	1,878.6	3,381.5	2,576.4			17,891.7
ADOT Funds (Includes HURF and Federal)	8,605.1						8,605.1
STAN Funds	193.5						193.5
Federal Transit (5307 Funds)			1,881.1				1,881.1
Federal Transit (5309 Funds)			291.9	1,423.8			1,715.7
Federal Highway (MAG STP)	285.5	1,115.7					1,401.2
Federal Highway (MAG CMAQ)	247.1	173.3	39.1	425.4	220.1	189.0	1,294.0
Total	**19,386.3**	**3,167.6**	**5,593.6**	**4,425.6**	**220.1**	**189.0**	**32,982.3**

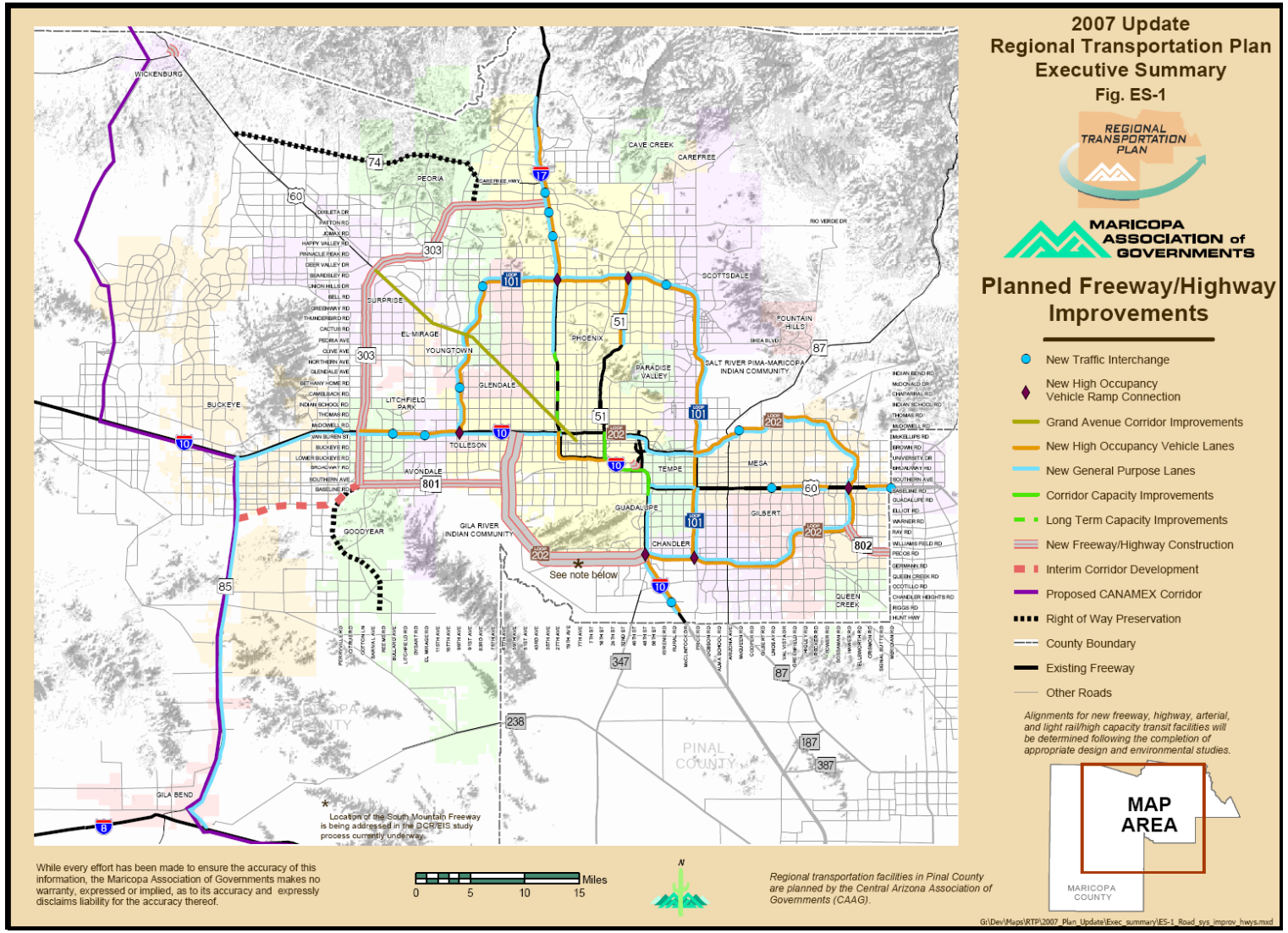
Source: MAG 2007 RTP Update, 20-year Projected Financing

Table A-3.2: PERCENT DISTRIBUTION OF REGIONAL REVENUES: FY 2008-2028
(Percent of Funding Source Total)

	Uses						
Sources	**Highways/ Freeways**	**Arterial Streets**	**Bus Transit**	**Light Rail Transit**	**Bicycle/ Ped.**	**Air Quality**	**Total**
Proposition 400: Half Cent Sales Tax Extension (RARF)	56.2%	10.5%	18.9%	14.4%			100.0%
ADOT Funds (Includes HURF and Federal)	100.0%						100.0%
STAN (Funds)	100.0%						100.0%
Federal Transit (5307 Funds)			100.0%				100.0%
Federal Transit (5309 Funds)			17.0%	83.0%			100.0%
Federal Highway (MAG STP)	20.4%	79.6%					100.0%
Federal Highway (MAG CMAQ)	19.1%	13.4%	3.0%	32.9%	17.0%	14.6%	100.0%
Total	**58.8%**	**9.6%**	**17.0%**	**13.4%**	**0.7%**	**0.6%**	**100.0%**

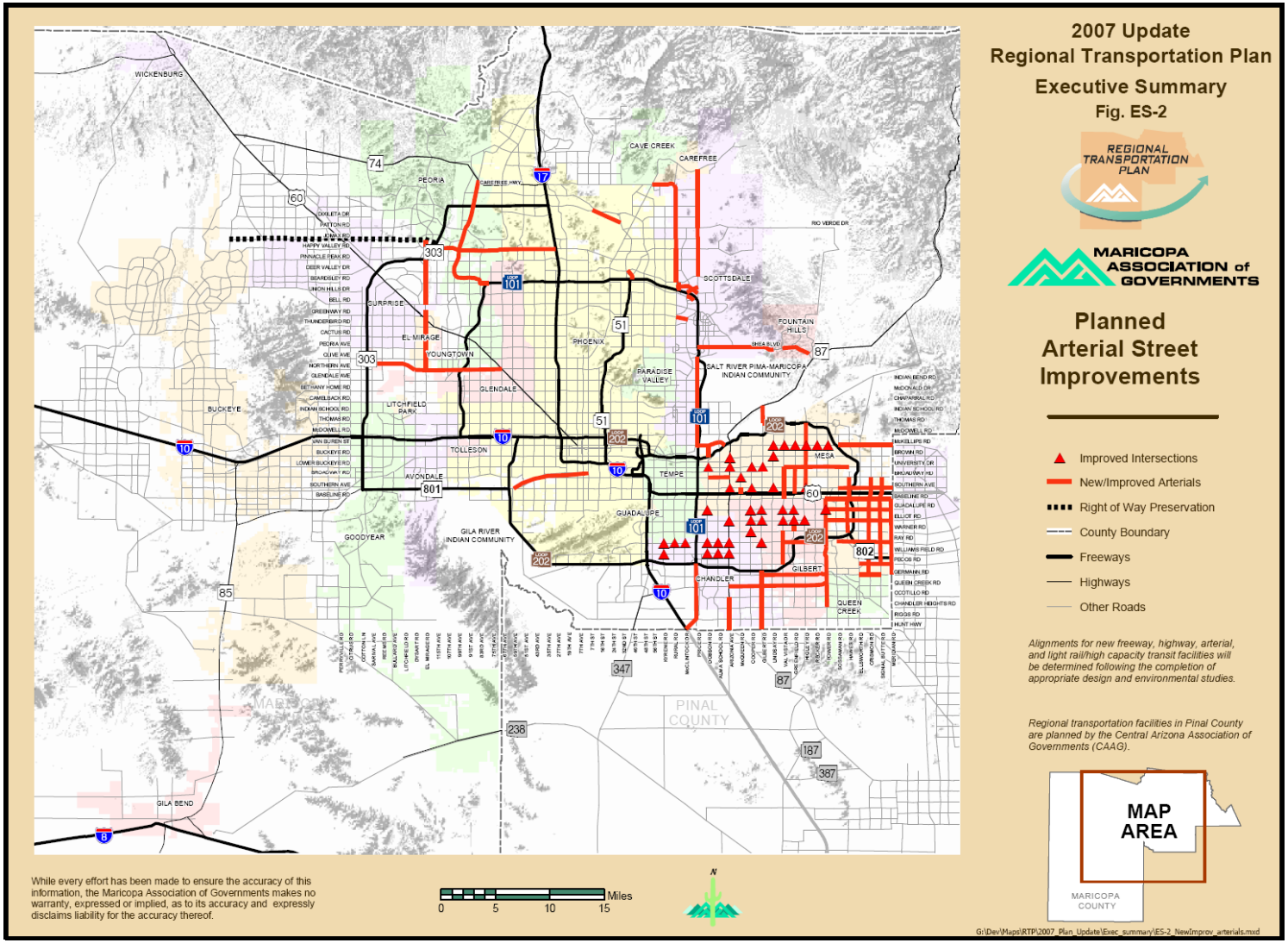
Source: MAG 2007 RTP Update, 20-year Projected Financing

Figure A-3.1: Planned Freeway/Highway Improvements



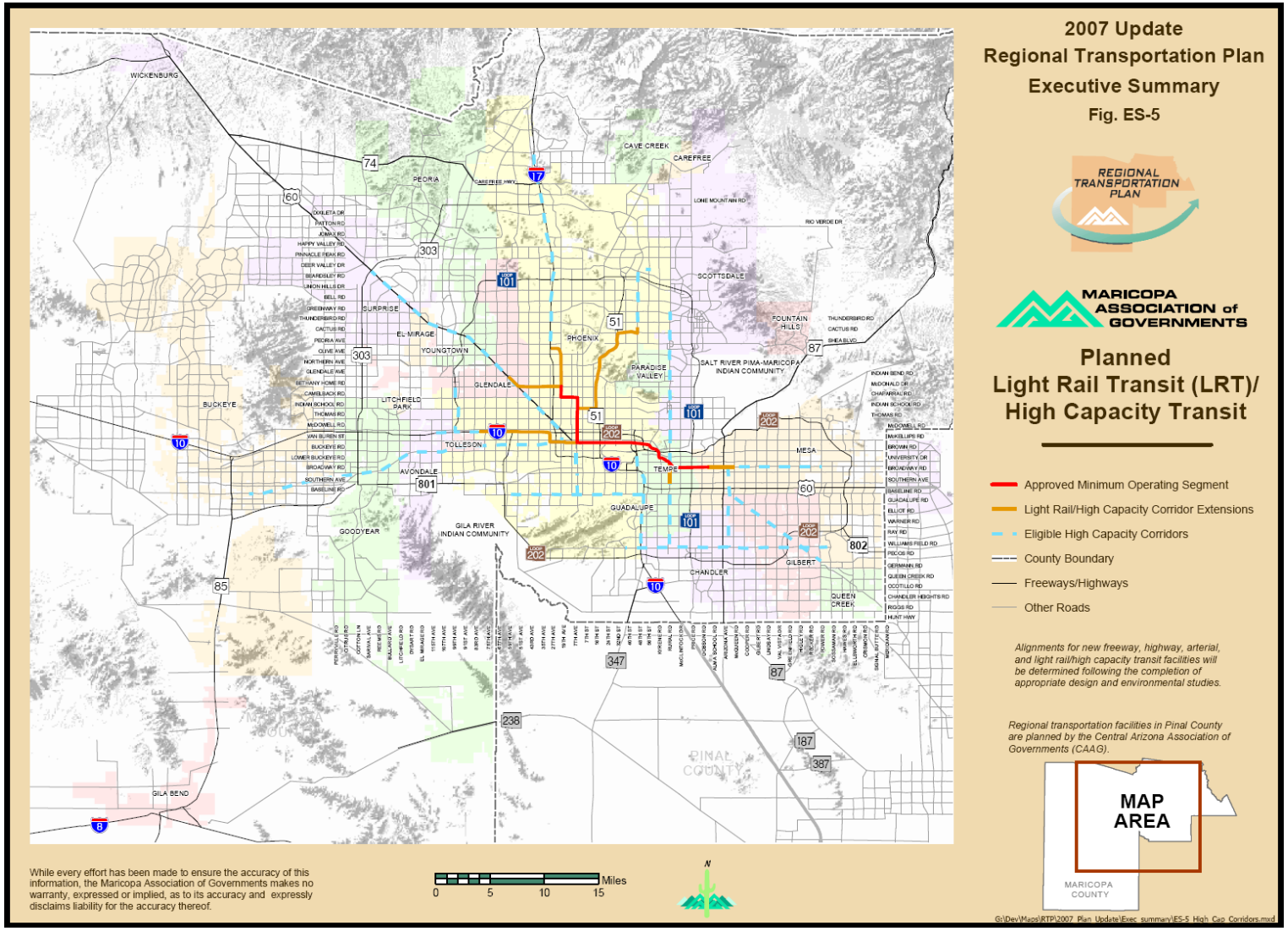
Source: MAG 2007 RTP Update

Figure A-3.2: Planned Arterial Street Improvements



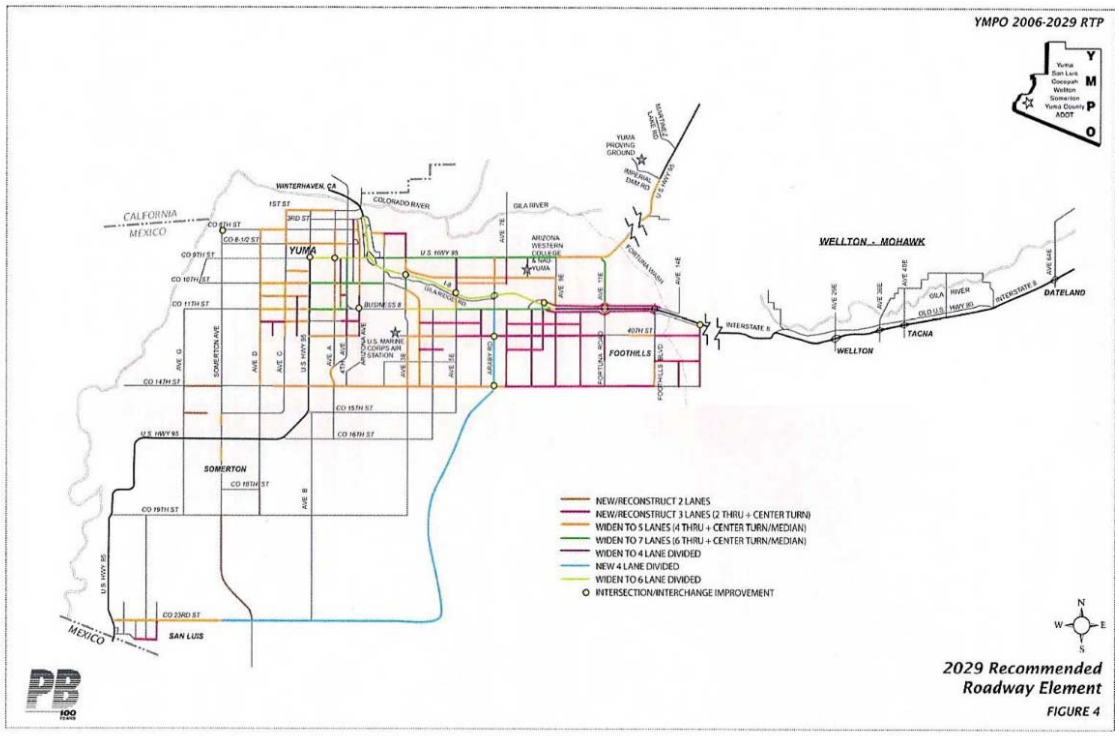
Source: MAG 2007 RTP Update

Figure A-3.3: Planned Light Rail Transit (LRT)/High Capacity Transit



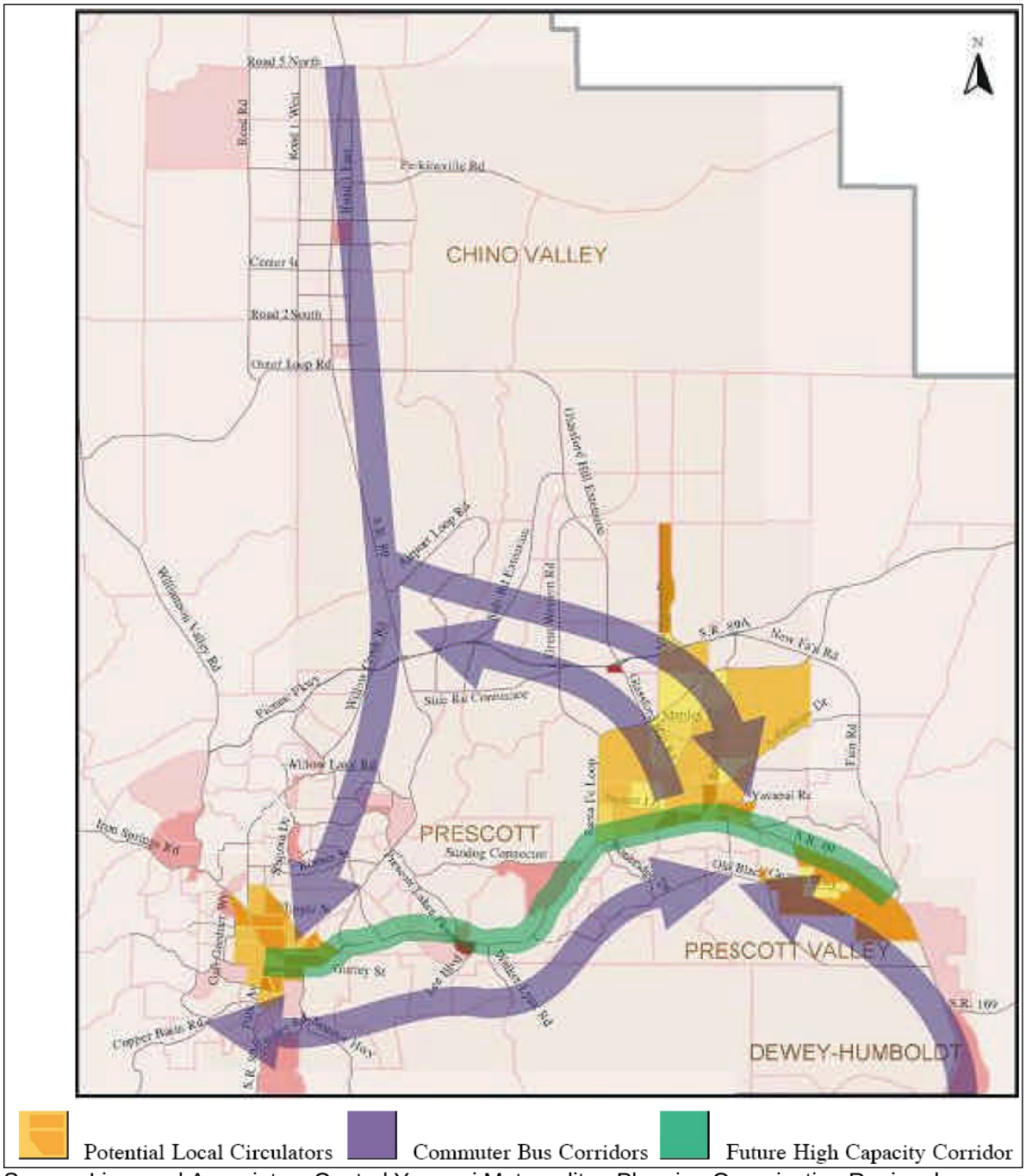
Source: MAG 2007 RTP Update

Figure A-3.4: Proposed Yuma Roadway Improvements



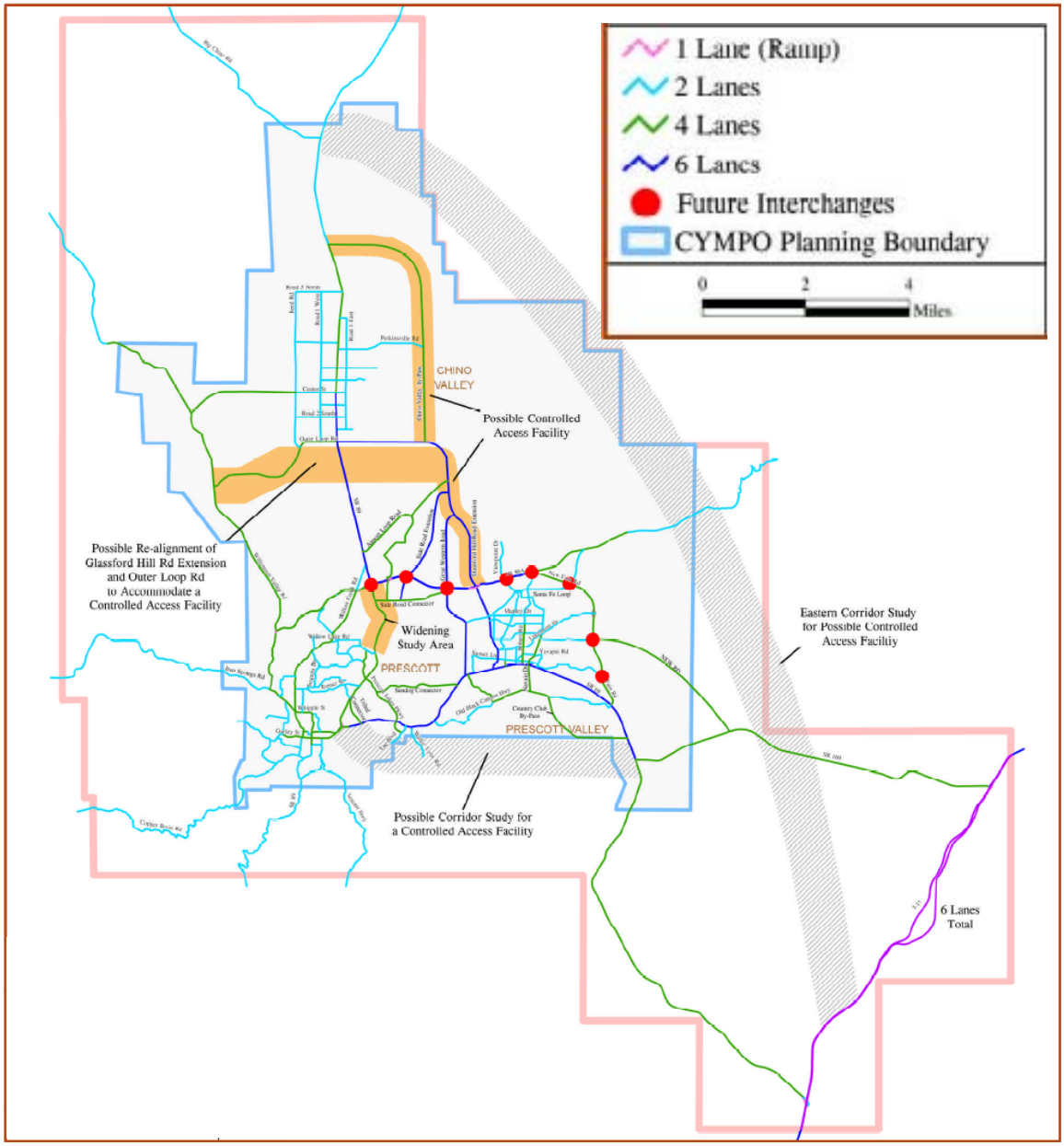
Source: PB. Yuma MPO 2006-2029 RTP Executive Summary, page 10. Proposed roadway improvements.
http://www.ympo.org/services/SERVICES/regional_transportation/regionalt_10.html

Figure A-3.5: Strategic Transportation Corridors of Central Yavapai County



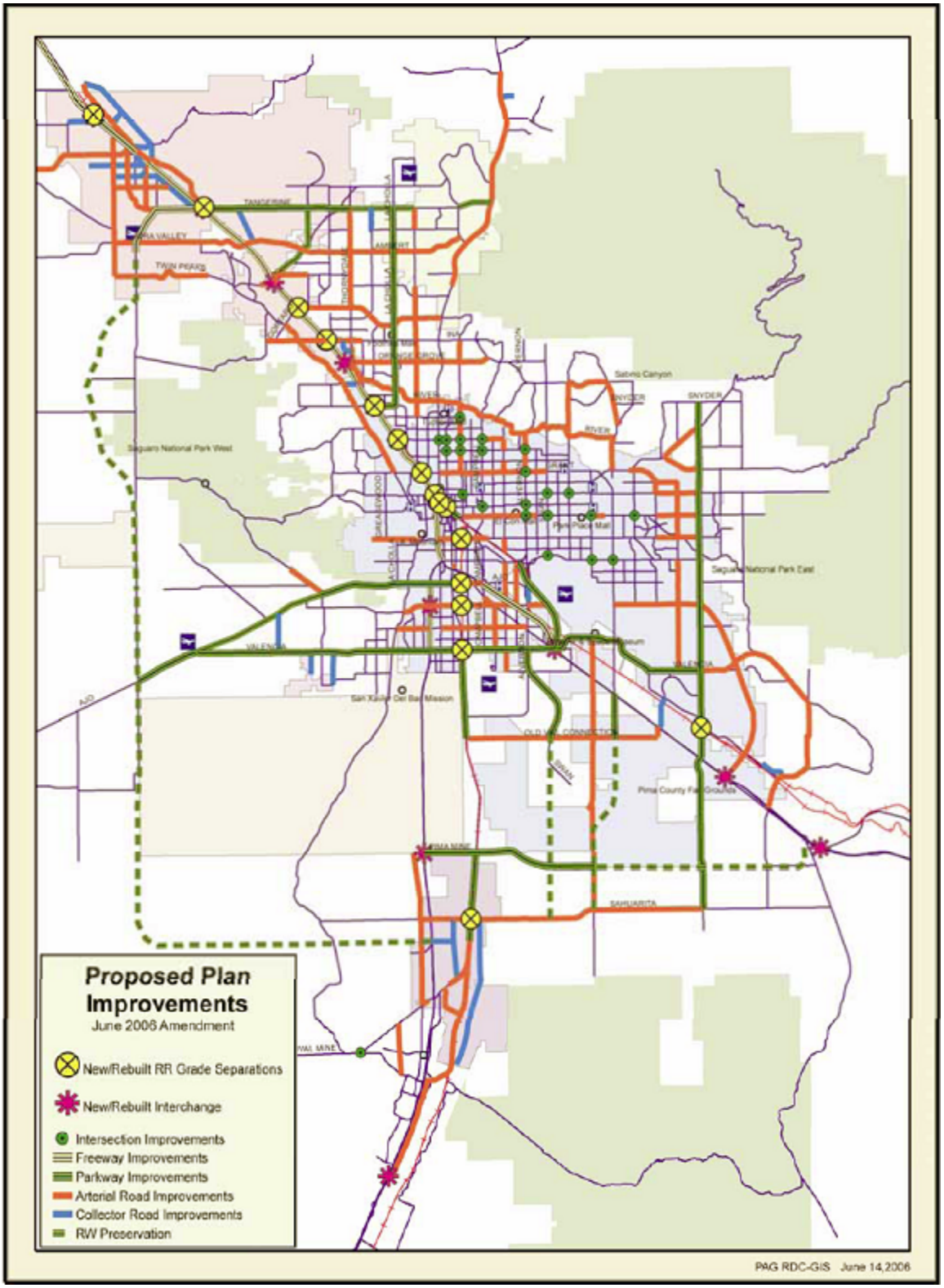
Source: Lima and Associates. Central Yavapai Metropolitan Planning Organization Regional Transportation Study Executive Summary (October, 2006)

Figure A-3.6: Planned Central Yavapai County Roadway Improvements



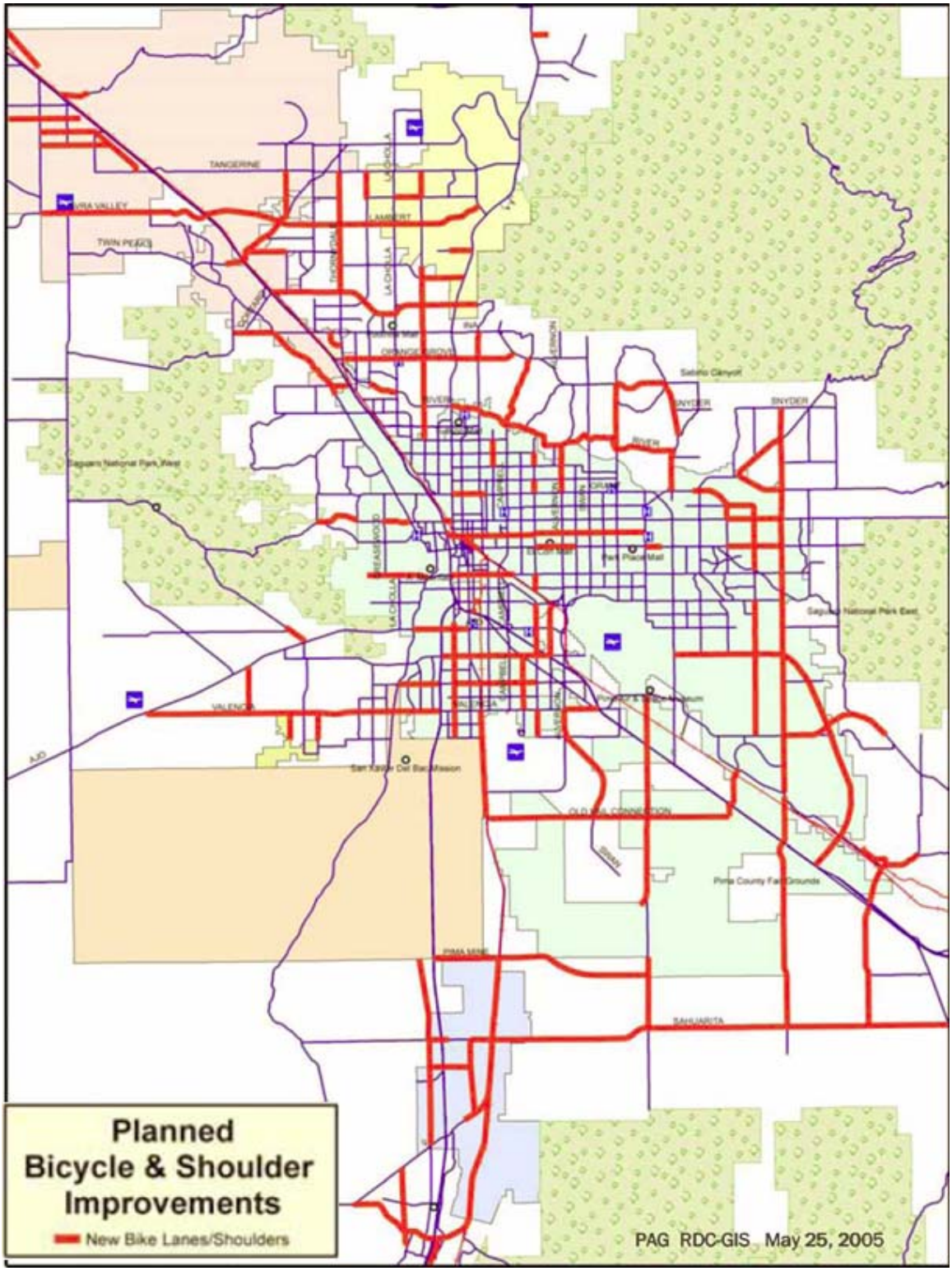
Source: Lima and Associates. Central Yavapai Metropolitan Planning Organization Regional Transportation Study Executive Summary (October, 2006)

Figure A-3.7: Proposed Pima County Roadway Improvements



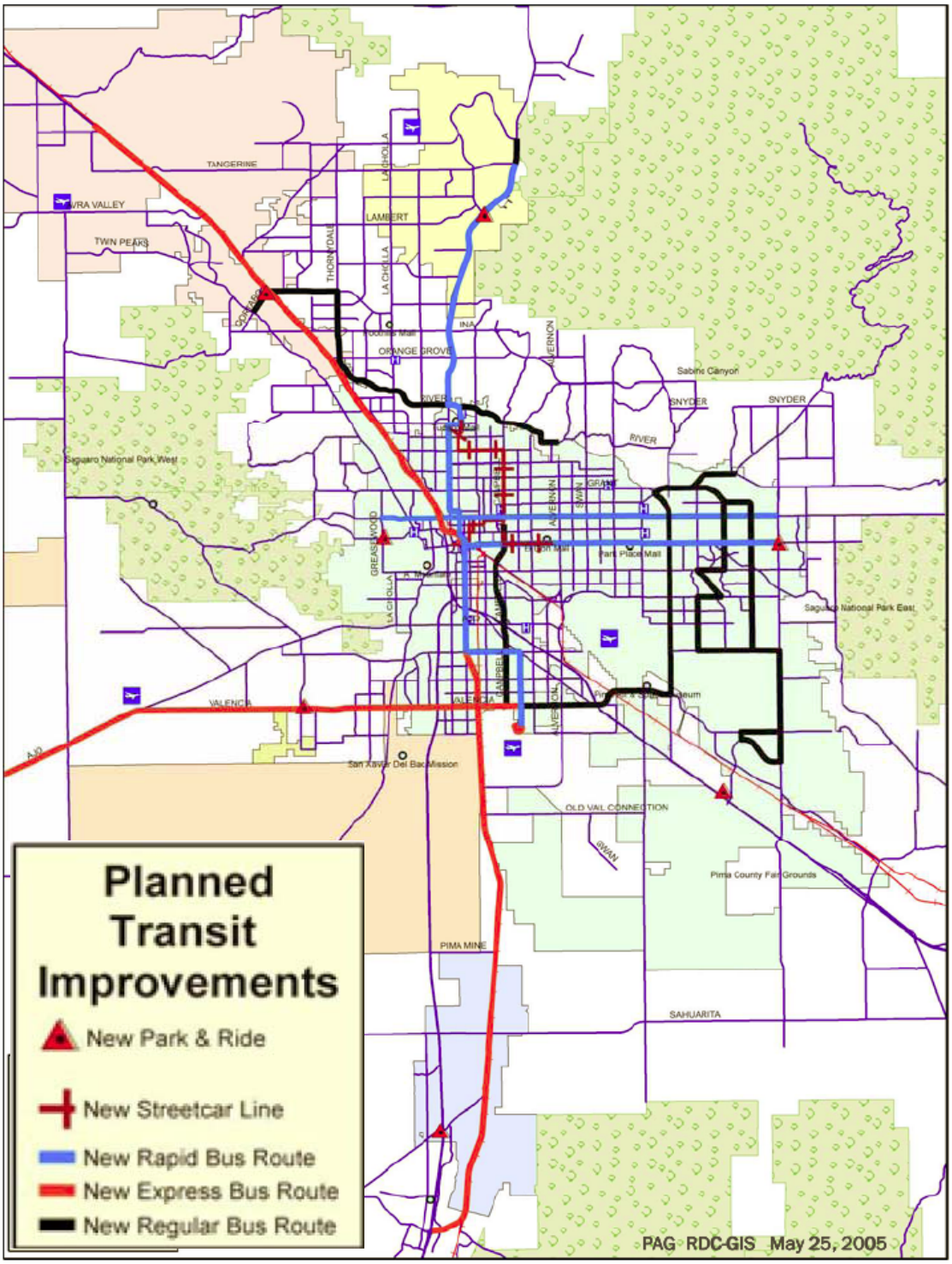
Source: Pima Association of Governments 2030 Regional Transportation Plan. 2006.
http://www.pagnet.org/documents/RTP/RTP2030/RTP2030FullUpdateSeptember2006.pdf

Figure A-3.8: Planned Bicycle and Shoulder Improvements



Source: Pima Association of Governments 2030 Regional Transportation Plan. 2006.
http://www.pagnet.org/documents/RTP/RTP2030/RTP2030FullUpdateSeptember2006.pdf

Figure A-3.9: Planned Transit Improvements



Source: Pima Association of Governments 2030 Regional Transportation Plan. 2006.
http://www.pagnet.org/documents/RTP/RTP2030/RTP2030FullUpdateSeptember2006.pdf

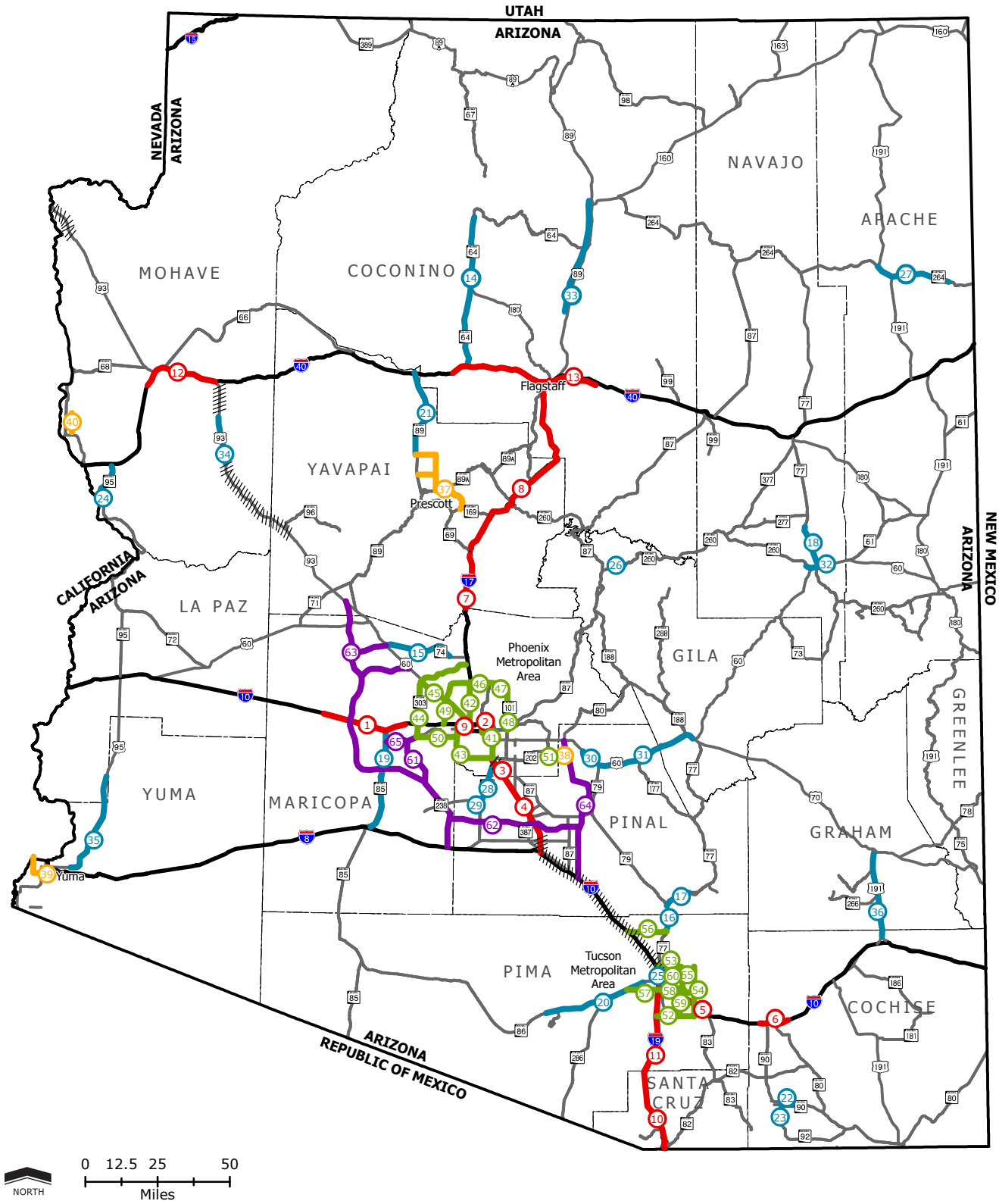
Appendix 4

ARIZONA STATEWIDE TRANSPORTATION INVESTMENT STRATEGY

This appendix contains the county maps with project locations, project lists and cost estimates from the Arizona Statewide Transportation Investment Strategy.[1] This study was carried out between 2007 to 2008. The contents are presented first with statewide investments, and then by county, in alphabetical order:

- Statewide roadway investments
- Statewide rural public transportation program
- Apache County
- Cochise County
- Coconino County
- Gila County
- Graham County
- Greenlee County
- La Paz County
- Maricopa County
- Mohave County
- Navajo County
- Pima County
- Pinal County
- Santa Cruz County
- Yavapai County
- Yuma County

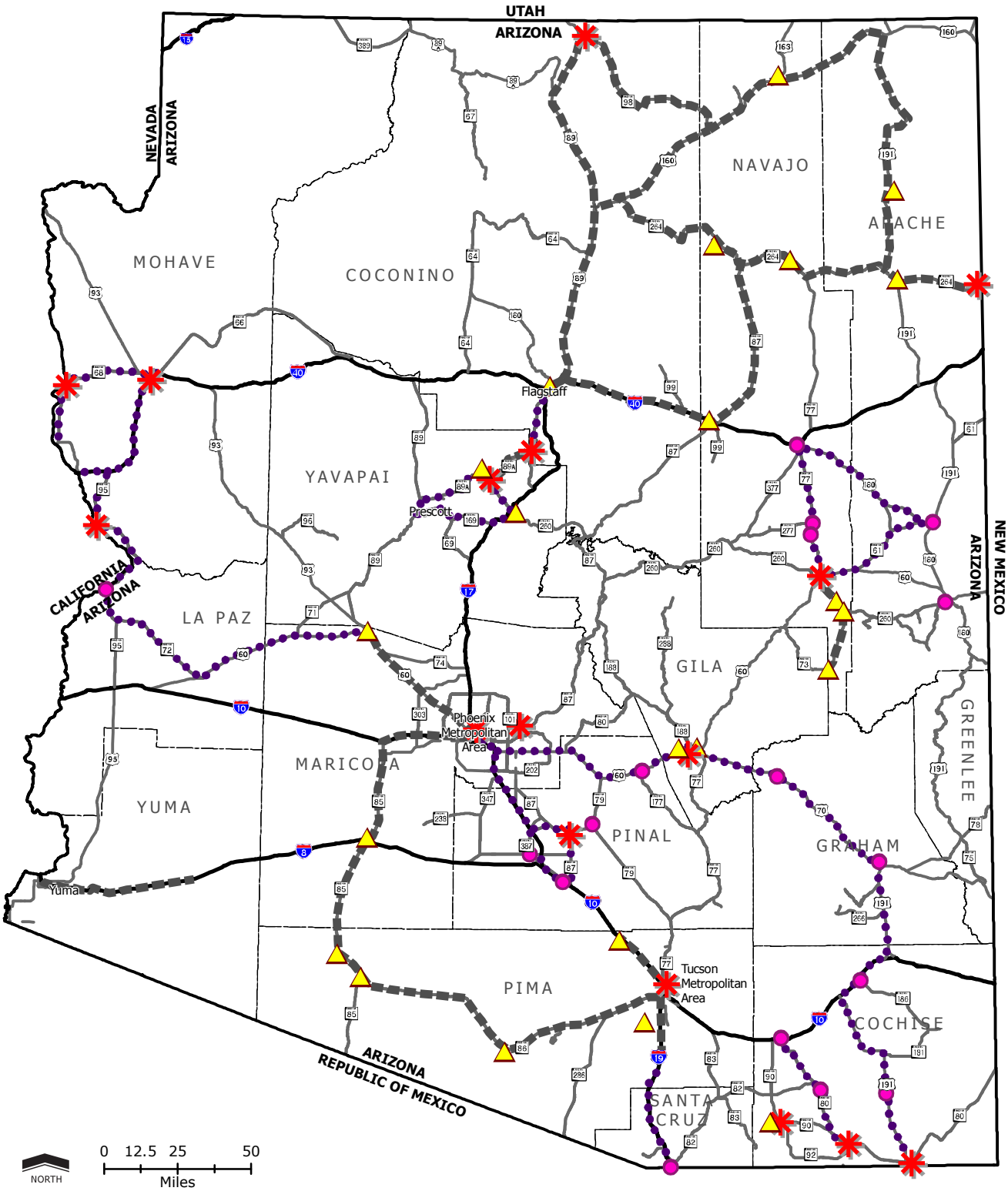
[1] Arizona Department of Transportation. *Arizona Statewide Transportation Investment Strategy*. azdot.gov/Statewide_Transportation_Investment_Strategy/PDF/Final_Report_061908.pdf. Accessed: Mar. 7, 2009.



Statewide Transportation Investment Strategy

Roadway Investments

- Interstate Improvements
- US/SR Improvements
- New Corridors
- Potential PPP Roadway Projects
- Acceleration/Expansion of Programmed Projects
- Programmed or Recently Completed Improvements for State Trade Corridors

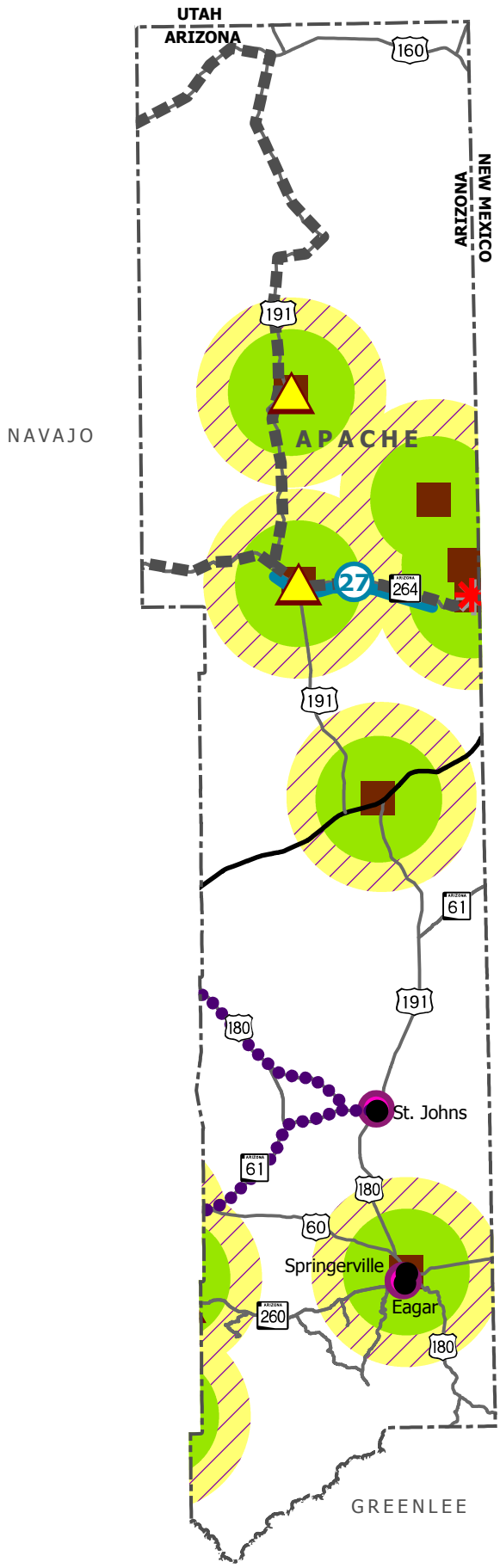


Statewide Transportation Investment Strategy

Rural Public Transportation Program

- Current Connectors
- Potential New Connectors
- Public Transit Service Provider
- Additional Community Served by Provider
- Potential New Service Provider

Apache County Transportation Investment Strategy



Strategic Highway Projects

US/SR Improvements

Rural Public Transportation Program

Potential New Connectors

Current Connectors

Public Transit Service Provider

Additional Community Served by Provider

Potential Service Provider

Elderly and Persons with Disabilities Program

Primary Transit Service

Secondary Service Area

Potential Growth

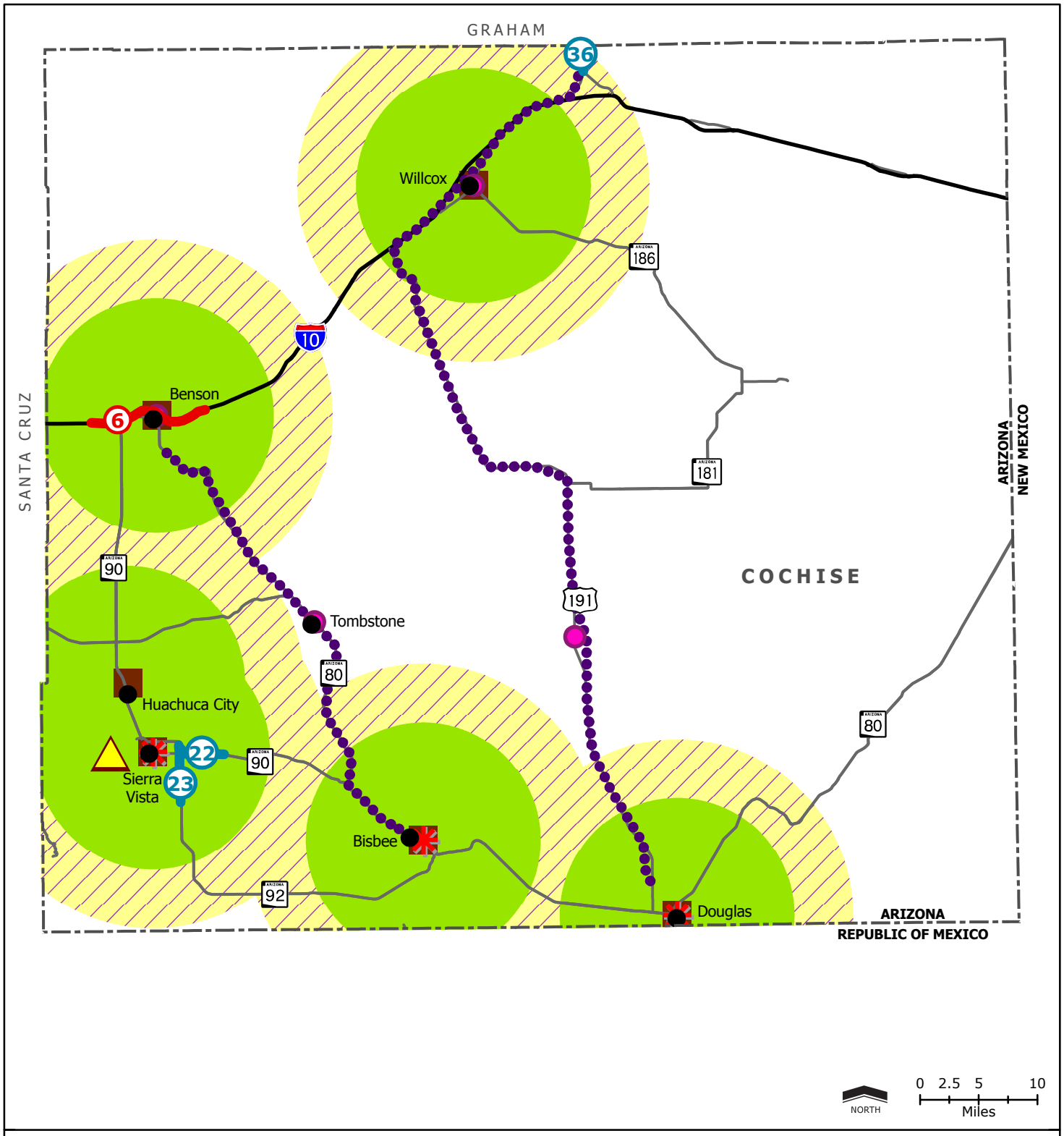
Local Mobility Project City

NORTH

0 4.5 9 18
Miles

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
US/SR Improvements		
27	SR 264: Widen to 4-lane from Burnside Junction to Summit	411,000,000
Strategic Highway Projects Total		411,000,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	10,000,000
67	Enhancing Public Transportation Programs	11,462,484
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	3,246,624
69	Statewide Vanpool and Rideshare Programs	4,613,320
70	Transit/Rail Planning, Marketing and Other Related Programs	369,066
Strategic Rail and Transit Projects and Program Total		29,691,494
	Local Mobility Projects and Programs	
Apache County		86,040,958
Eagar		10,360,451
Springerville		4,823,976
St Johns		9,028,894
White Mountain Apache Tribe		373,753
Navajo Nation		55,020,465
Local Mobility Projects and Programs Total		165,648,497
	Transportation Enhancement and Walkable/Bikeable Communities	
Apache County		2,392,170
Eagar		1,237,666
Springerville		576,275
St Johns		1,078,597
White Mountain Apache Tribe		103,253
Navajo Nation		15,199,945
Transportation Enhancement and Walkable/Bikeable Communities Total		20,587,905
Apache County Total		626,927,896

June 19, 2008



Cochise County Transportation Investment Strategy

Strategic Highway Projects

- Interstate Improvements
- US/SR Improvements

- Local Mobility Project City

Rural Public Transportation Program

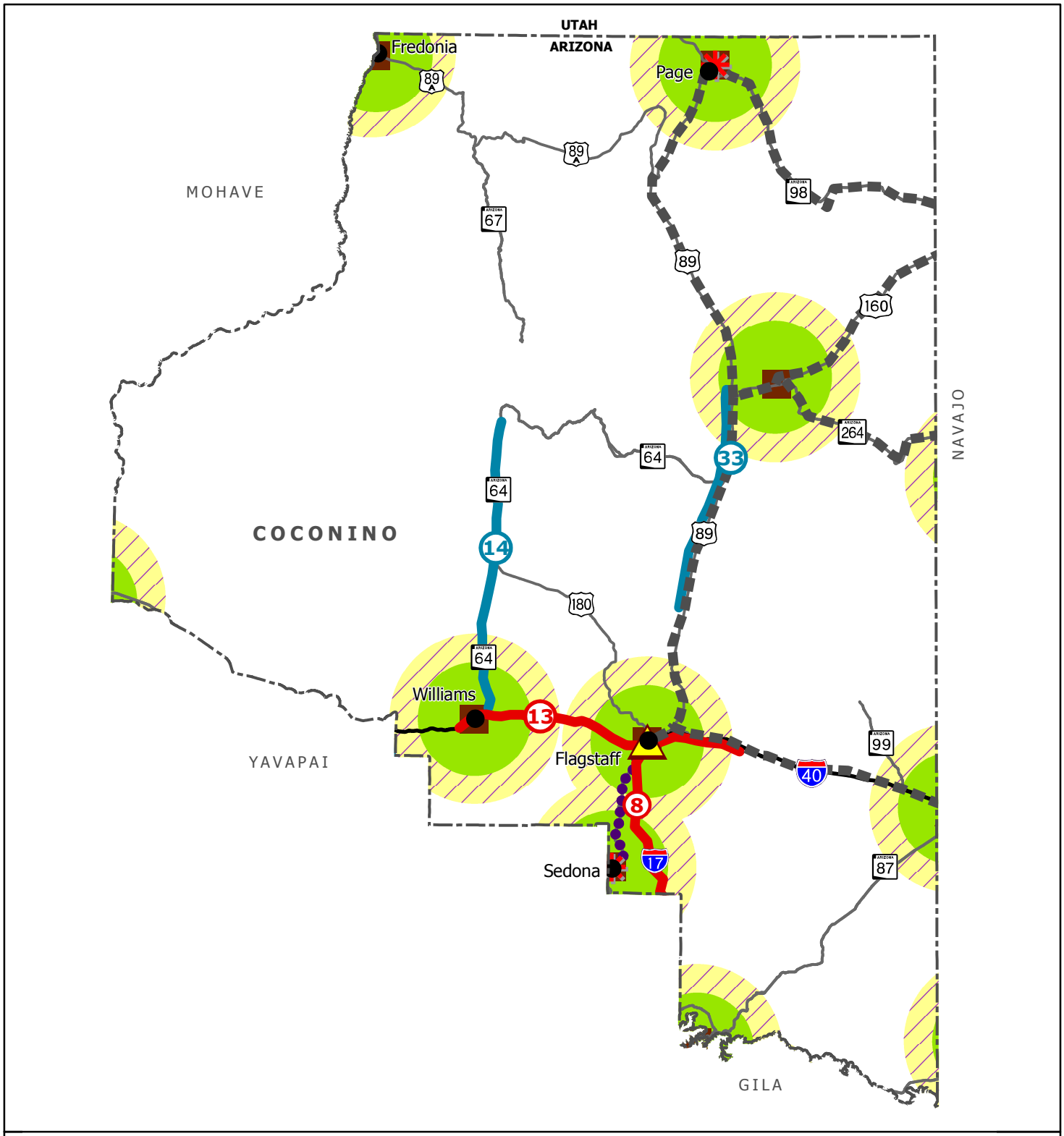
- Potential New Connectors
- Public Transit Service Provider
- Additional Community Served by Provider

Elderly and Persons with Disabilities Program

- Primary Transit Service
- Secondary Service Area
- Potential Growth

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
Interstate Improvements		
6	I-10: Widen to 6-lane in Benson	212,917,000
US/SR Improvements		
22	SR 90: Widen to 7-lane from Jct SR 92 to Central	15,000,000
23	SR 92: Widen to 7-lane from Campus Drive to Glenn/Kachina	30,000,000
36	US 191: Widen to 4-lane from I-10 to the County Line	11,481,000
Strategic Highway Projects Total		269,398,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	15,000,000
67	Enhancing Public Transportation Programs	20,591,306
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	5,832,264
69	Statewide Vanpool and Rideshare Programs	8,287,409
70	Transit/Rail Planning, Marketing and Other Related Programs	662,993
Strategic Rail and Transit Projects and Program Total		50,373,972
	Local Mobility Projects and Programs	
Cochise County		104,543,442
Benson		4,664,533
Bisbee		6,465,396
Douglas		16,921,232
Huachuca City		1,800,864
Sierra Vista		42,994,394
Tombstone		1,584,367
Willcox		3,823,145
Local Mobility Projects and Programs Total		182,797,373
	Transportation Enhancement and Walkable/Bikeable Communities	
Cochise County		14,586,876
Benson		1,322,782
Bisbee		1,833,476
Douglas		4,798,572
Huachuca City		510,694
Sierra Vista		12,192,474
Tombstone		449,299
Willcox		1,084,179
Transportation Enhancement and Walkable/Bikeable Communities Total		36,778,352
Cochise County Total		539,347,697

June 19, 2008



Coconino County Transportation Investment Strategy

Strategic Highway Projects

- Interstate Improvement
- US/SR Improvements

- Local Mobility Project City

Rural Public Transportation Program

- Current Connectors
- Potential New Connectors
- Public Transit Service Provider
- Additional Community Served by Provider

Elderly and Persons with Disabilities Program

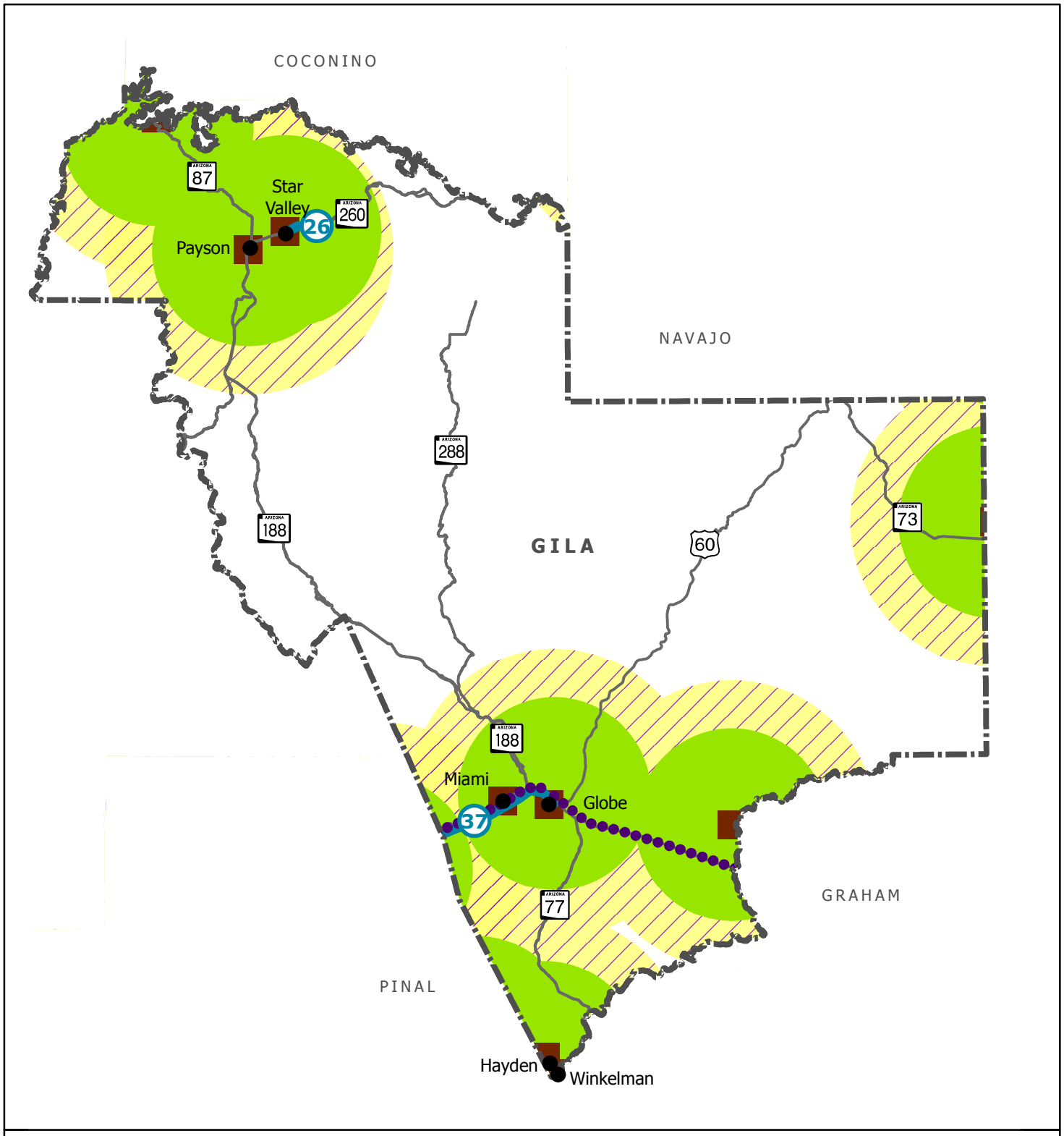
- Primary Transit Service
- Secondary Service Area
- Potential Growth

NORTH

0 5 10 20
Miles

Project/ Program	Project/Program Description	Estimated Cost
Strategic Highway Projects		
Interstate Improvements		
8	I-17: Widen to 6-lane from the County Line to Flagstaff	382,000,000
13	I-40: Widen to 6-lanes from Golf Course Road to Townsend Winona Road	1,041,000,000
US/SR Improvements		
14	SR 64: Passing Lane System from I-40 to Tusayan	30,000,000
33	US 89:Widen to 4-lane from I-40 to Tuba City	438,000,000
Strategic Highway Projects Total		1,891,000,000
Strategic Rail and Transit Projects and Programs		
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	15,000,000
67	Enhancing Public Transportation Programs	20,139,370
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	5,704,258
69	Statewide Vanpool and Rideshare Programs	8,105,518
70	Transit/Rail Planning, Marketing and Other Related Programs	648,441
Strategic Rail and Transit Projects and Program Total		49,597,587
Local Mobility Projects and Programs		
Coconino County		120,970,288
Flagstaff		87,627,231
Fredonia		1,589,707
Page		10,182,718
Williams		4,504,170
Sedona		4,439,722
Havasupai Tribe		508,102
The Hopi Tribe		1,145,102
Hualapai Tribe		2,020
Kaibab Paiute Tribe		5,051
Navajo Nation		23,451,478
Local Mobility Projects and Programs Total		254,425,589
Transportation Enhancement and Walkable/Bikeable Communities		
Coconino County		8,377,617
Flagstaff		17,074,766
Fredonia		309,765
Page		1,984,172
Williams		877,668
Sedona		865,110
Havasupai Tribe		140,368
The Hopi Tribe		316,456
Hualapai Tribe		558
Kaibab Paiute Tribe		1,395
Navajo Nation		6,478,702
Transportation Enhancement and Walkable/Bikeable Communities Total		36,426,577
Coconino County Total		2,231,449,753

June 19, 2008



Gila County Transportation Investment Strategy

Strategic Highway Projects

- US/SR Improvements
- Local Mobility Project City

Rural Public Transportation Program

- Potential New Connectors
- Public Transit Service Provider
- Additional Community Served by Provider

Elderly and Persons with Disabilities Program

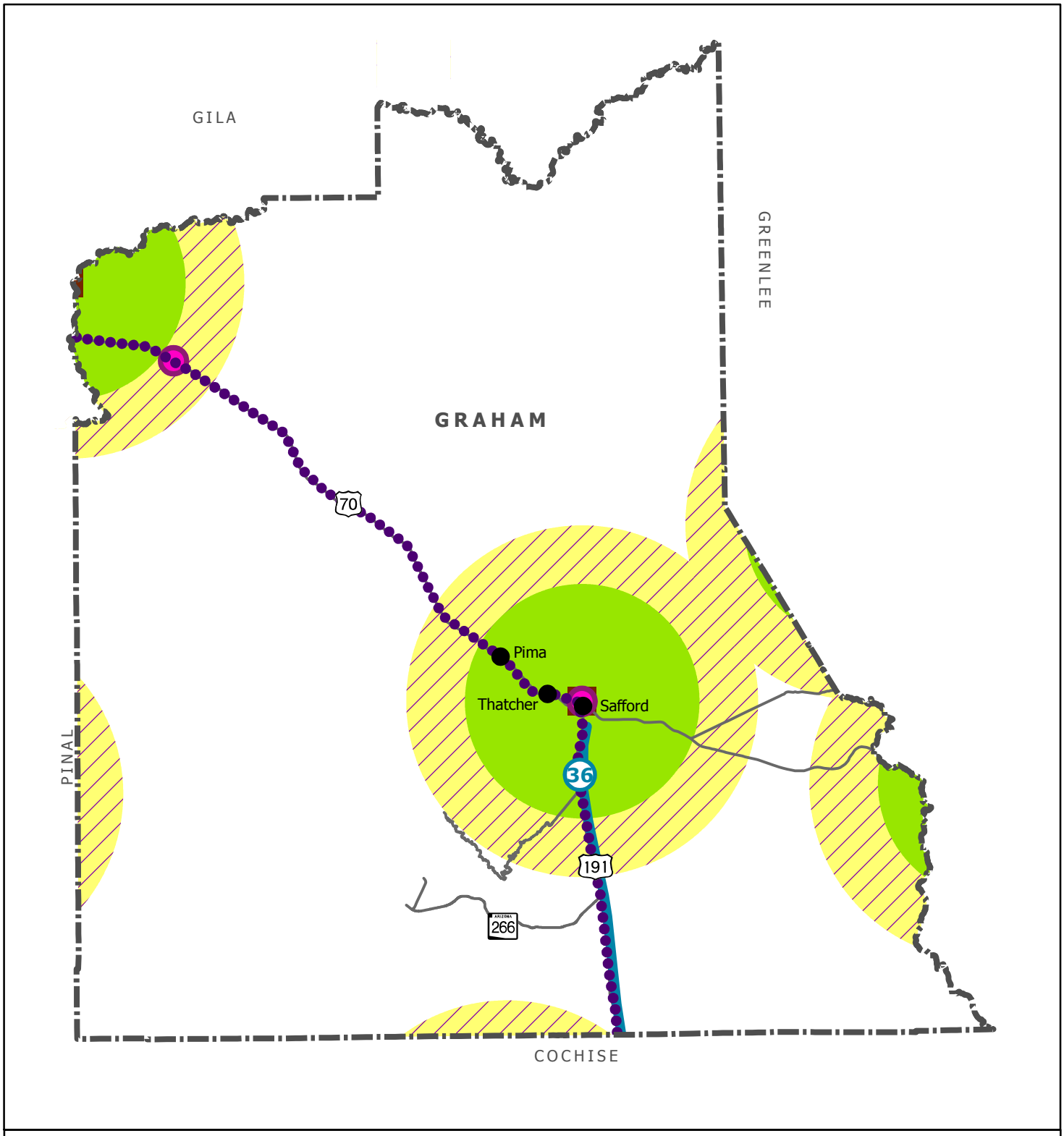
- Primary Transit Service
- Secondary Service Area
- Potential Growth

NORTH

0 3 6 12 Miles

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
US/SR Improvements		
26	SR 260: Widen to 4-lane (Lions Springs Draw Section)	44,000,000
31	US 60:Widen to 4-lane from the County Line to Globe	144,000,000
Strategic Highway Projects Total		188,000,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	10,000,000
67	Enhancing Public Transportation Programs	8,414,815
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	2,383,405
69	Statewide Vanpool and Rideshare Programs	3,386,721
70	Transit/Rail Planning, Marketing and Other Related Programs	270,937
Strategic Rail and Transit Projects and Program Total		24,455,878
	Local Mobility Projects and Programs	
Gila County		48,676,133
Globe		9,642,948
Hayden		1,147,633
Miami		2,515,272
Payson		19,851,993
Winkleman		564,810
Star Valley		2,580,888
White Mountain Apache Tribe		1,529,356
San Carlos Apache Tribe		4,832,524
Tonto Apache Tribe		133,339
Local Mobility Projects and Programs Total		91,474,896
	Transportation Enhancement and Walkable/Bikeable Communities	
Gila County		6,096,237
Globe		2,091,614
Hayden		248,929
Miami		545,578
Payson		4,306,017
Winkleman		122,511
Star Valley		559,810
White Mountain Apache Tribe		422,500
San Carlos Apache Tribe		1,335,032
Tonto Apache Tribe		36,836
Transportation Enhancement and Walkable/Bikeable Communities Total		15,765,064
Gila County Total		319,695,838

June 19, 2008



Graham County Transportation Investment Strategy

Strategic Highway Projects

US/SR Improvements

Local Mobility Project City

Rural Public Transportation Program

Potential New Connectors

Potential Service Provider

Elderly and Persons with Disabilities Program

Primary Transit Service

Secondary Service Area

Potential Growth

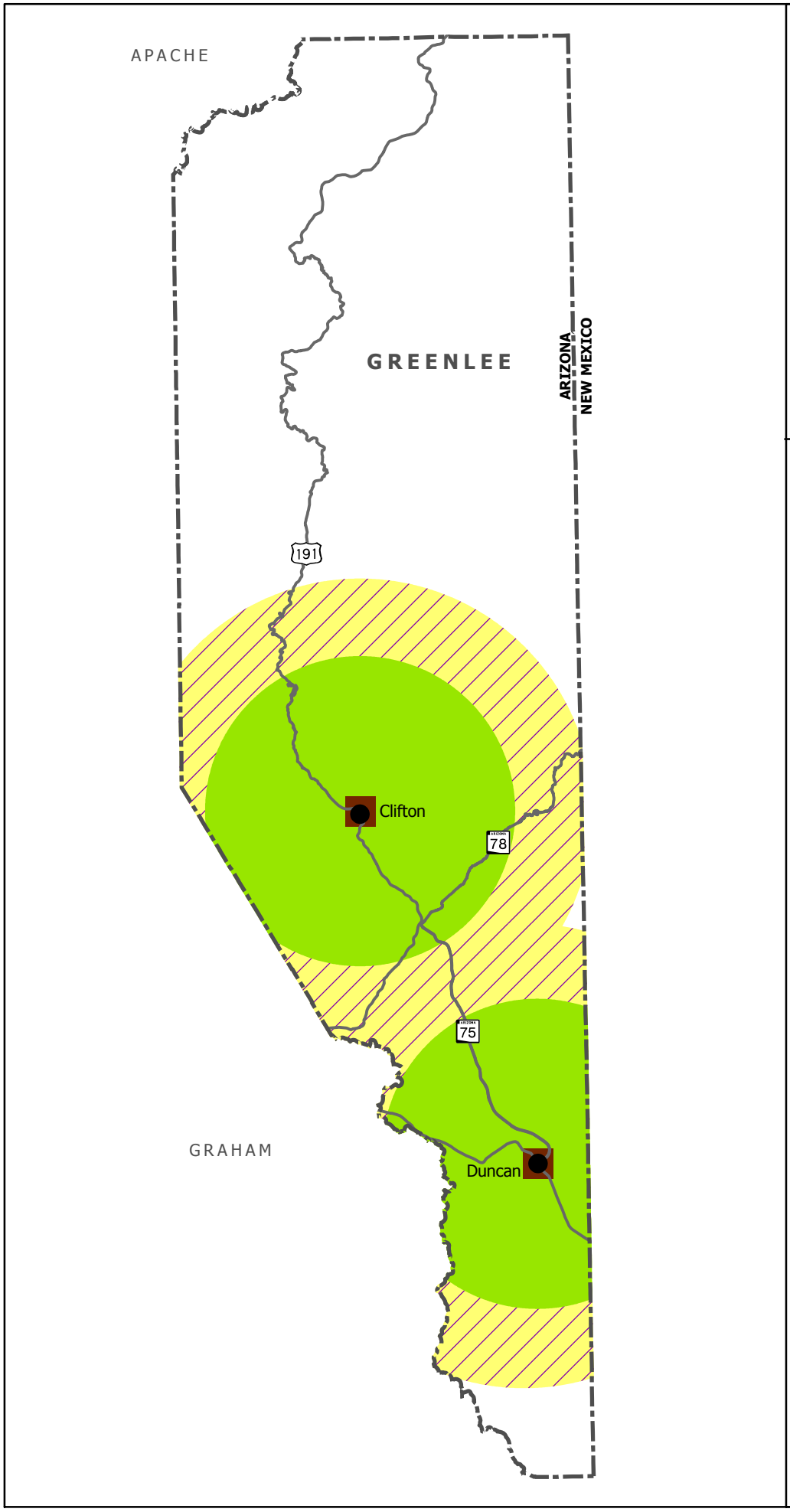
NORTH

0 2.5 5 10

Miles

June 19, 2008

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
US/SR Improvements		
36	US 191: Widen to 4-lane from the County Line to Jct US 70	143,519,000
Strategic Highway Projects Total		143,519,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	10,000,000
67	Enhancing Public Transportation Programs	5,425,169
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	1,536,620
69	Statewide Vanpool and Rideshare Programs	2,183,475
70	Transit/Rail Planning, Marketing and Other Related Programs	174,678
Strategic Rail and Transit Projects and Program Total		19,319,942
	Local Mobility Projects and Programs	
Graham County		31,053,856
Pima		2,096,812
Safford		9,413,025
Thatcher		4,575,776
San Carlos Apache Tribe		4,647,668
Local Mobility Projects and Programs Total		51,787,137
	Transportation Enhancement and Walkable/Bikeable Communities	
Graham County		4,146,669
Pima		581,856
Safford		2,612,075
Thatcher		1,269,759
San Carlos Apache Tribe		1,283,964
Transportation Enhancement and Walkable/Bikeable Communities Total		9,894,323
Graham County Total		**224,520,402**



Greenlee County Transportation Investment Strategy

Elderly and Persons with Disabilities Program

- Primary Transit Service
- Secondary Service Area
- Potential Growth

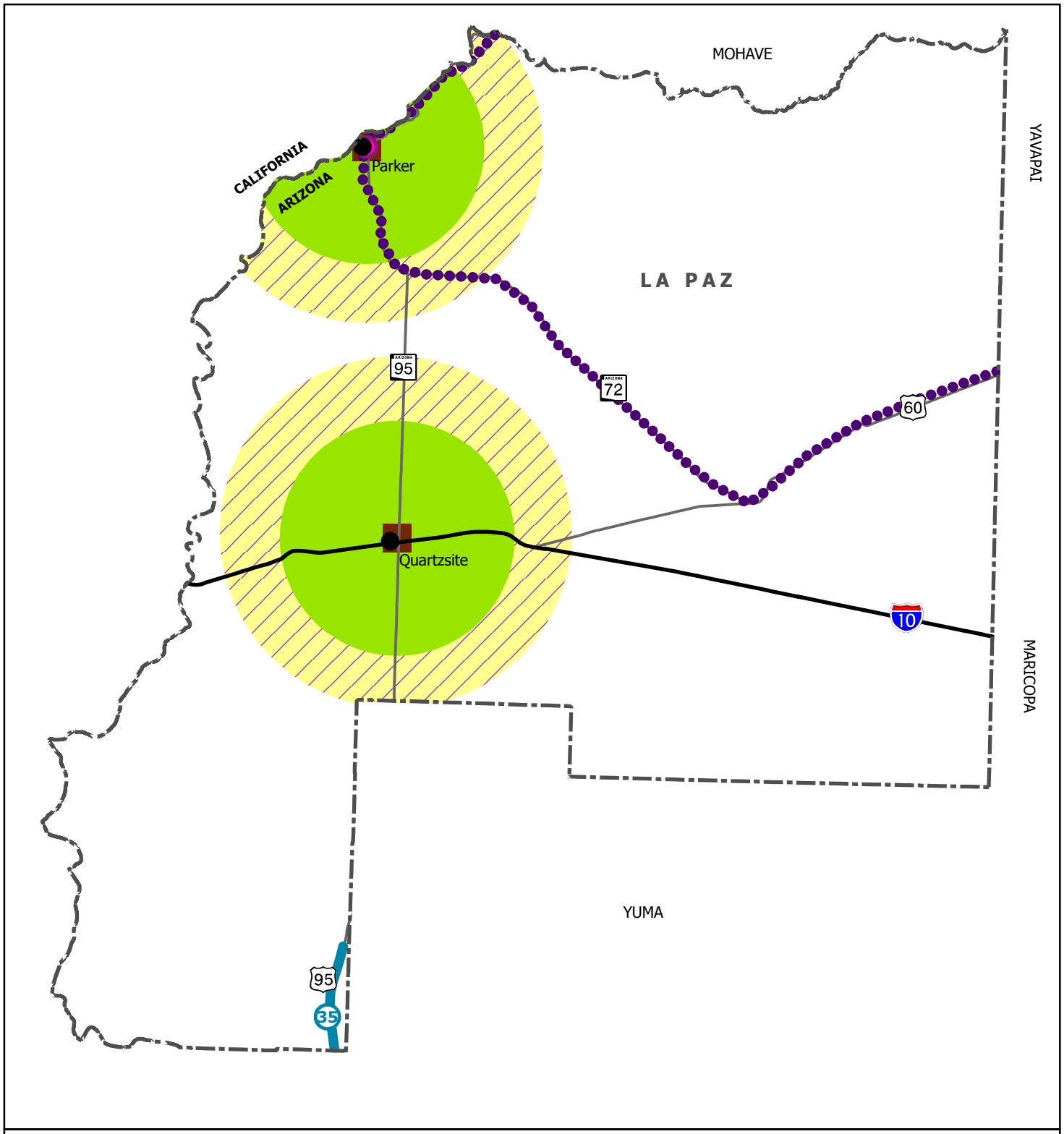
- Local Mobility Project City

NORTH

0 2 4 8
Miles

Project/ Program	Project/Program Description	Estimated Cost
Strategic Rail and Transit Projects and Programs		
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	10,000,000
67	Enhancing Public Transportation Programs	1,247,177
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	353,249
69	Statewide Vanpool and Rideshare Programs	501,953
70	Transit/Rail Planning, Marketing and Other Related Programs	40,156
Strategic Rail and Transit Projects and Program Total		12,142,535
Local Mobility Projects and Programs		
Greenlee County		10,841,533
Clifton		2,985,394
Duncan		933,798
Local Mobility Projects and Programs Total		14,760,725
Transportation Enhancement and Walkable/Bikeable Communities		
Greenlee County		1,434,130
Clifton		724,460
Duncan		226,603
Transportation Enhancement and Walkable/Bikeable Communities Total		2,385,193
Greenlee County Total		29,288,453

June 19, 2008



La Paz County Transportation Investment Strategy

Strategic Highway Projects

US/SR Improvements

Local Mobility Project City

Rural Public Transportation Program

Potential New Connectors

Elderly and Persons with Disabilities Program

Primary Transit Service

Secondary Service Area

Potential Growth

NORTH

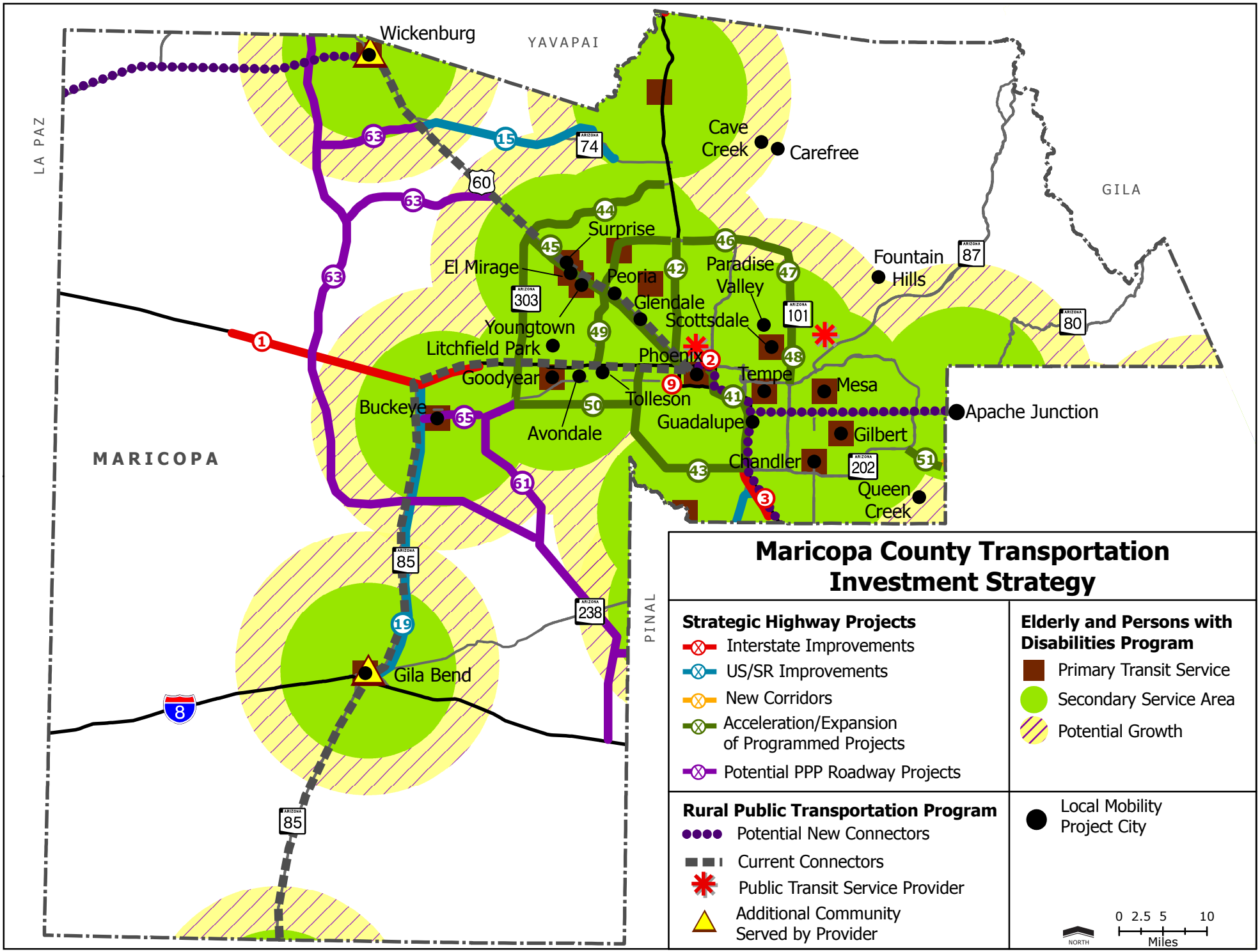
0 2.5 5 10

Miles

June 19, 2008

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
US/SR Improvements		
35	US 95: Widen to 4-lane from the County Line to the County Line	transportation benefits accrue to Yuma County
Strategic Highway Projects Total		0
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	10,000,000
67	Enhancing Public Transportation Programs	3,264,772
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	924,711
69	Statewide Vanpool and Rideshare Programs	1,313,977
70	Transit/Rail Planning, Marketing and Other Related Programs	105,118
Strategic Rail and Transit Projects and Program Total		15,608,578
	Local Mobility Projects and Programs	
La Paz County		48,267,129
Parker		13,731,386
Quartzsite		15,071,034
Colorado River Indian Tribes		7,541,727
Local Mobility Projects and Programs Total		84,611,276
	Transportation Enhancement and Walkable/Bikeable Communities	
La Paz County		1,909,940
Parker		915,343
Quartzsite		1,004,644
Colorado River Indian Tribes		2,083,476
Transportation Enhancement and Walkable/Bikeable Communities Total		5,913,403
La Paz County Total		106,133,257

June 19, 2008


Maricopa County Transportation Investment Strategy
Strategic Highway Projects
Interstate Improvements
US/SR Improvements
New Corridors
Acceleration/Expansion of Programmed Projects
Potential PPP Roadway Projects
Elderly and Persons with Disabilities Program
Primary Transit Service
Secondary Service Area
Potential Growth
Rural Public Transportation Program
Potential New Connectors
Current Connectors
Public Transit Service Provider
Additional Community Served by Provider
Local Mobility Project City
0 2.5 5 10
Miles
NORTH
MARICOPA
YAVAPAI
GILA
LA PAZ
PINAL
Wickenburg
Cave Creek
Carefree
Fountain Hills
Surprise
El Mirage
Peoria
Paradise Valley
Glendale
Scottsdale
Youngtown
Litchfield Park
Phoenix
Goodyear
Tolleson
Tempe
Mesa
Buckeye
Avondale
Guadalupe
Apache Junction
Gilbert
Chandler
Queen Creek
Gila Bend

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
Interstate Improvements		
1	I-10: Widen to 6-lane from Verrado Way to 459th Avenue	450,000,000
2	I-10 Mini-stack Capacity Reconstruction	619,000,000
3	I-10: Widen to 6-lane from SR 202L to Riggs Rd	150,000,000
9	I-17 Durango Curve	1,100,000,000
US/SR Improvements		
15	SR 74: Widen to 4-lane from I-17 to US 60	600,000,000
19	SR 85: Widen to 6-lane from I-10 to I-8	501,000,000
Acceleration/Expansion of Programmed Projects		
41	I-10: Broadway Curve from SR 202L to SR 51	900,000,000
42	I-17: McDowell Road to SR 101L	1,053,000,000
43	SR 202L: South Mountain Freeway from I-10 W to I-10 E	1,100,000,000
44	SR 303L: Enhanced Local Access from SR 801 to I-17	1,400,000,000
45	US 60: Grand Avenue Spot Projects	13,000,000
46	SR 101L: Pima Freeway, HOV and General Purpose Lanes from I-17 to SR 51	93,000,000
47	SR 101L: Pima Freeway, General Purpose Lanes from SR 51 to Shea Boulevard	135,000,000
48	SR 101L: Pima Freeway, General Purpose Lanes from Shea Boulevard to SR 202L	36,000,000
49	SR 101L: Agua Fria Freeway, HOV and General Purpose Lanes from I-10 to I-17	257,000,000
50	SR 801 from SR 202L to SR 303L	1,800,000,000
51	SR 802 from SR 202L to Pinal County Line	177,000,000
Potential PPP Projects		
61	SR 303L: Extension from SR 801 to I-8	368,000,000
63	Hassayampa Freeway Network	588,750,000
65	SR 801 Extension from SR 85 to SR 303L	94,000,000
Strategic Highway Projects Total		11,434,750,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	20,000,000
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	172,019,449
69	Statewide Vanpool and Rideshare Programs	244,432,610
70	Transit/Rail Planning, Marketing and Other Related Programs	19,554,609
High Speed Intercity Rail/Commuter Rail/Light Rail		
71	High Speed Urban-Urban Rail Connections Commuter Rail in Urban Corridors	2,115,000,000
72	Light Rail, Modern Streetcar and Related High Capacity Transit	600,000,000
Strategic Rail and Transit Projects and Program Total		3,171,006,668

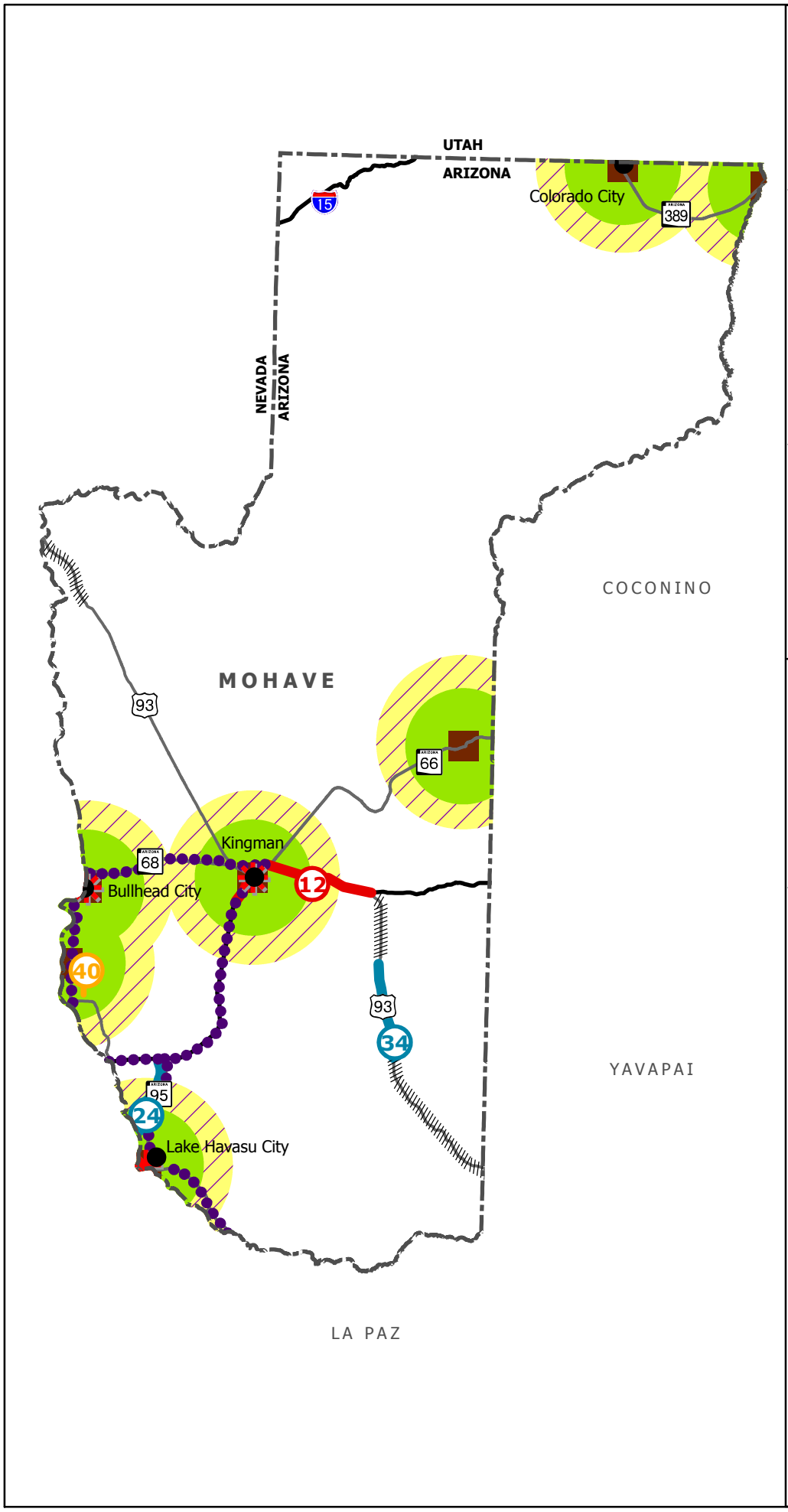
Project/ Program	Project/Program Description	Estimated Cost
	Local Mobility Projects and Programs	
Maricopa County		313,017,478
Avondale		95,798,816
Buckeye		35,092,345
Carefree		5,088,570
Cave Creek		6,583,095
Chandler		318,857,454
El Mirage		44,284,645
Gila Bend		2,734,899
Gilbert		239,057,798
Glendale		334,775,119
Goodyear		63,832,266
Guadalupe		7,672,911
Mesa		618,938,031
Paradise Valley		19,148,437
Peoria		190,764,730
Phoenix		2,038,513,600
Scottsdale		324,254,045
Surprise		121,917,101
Tempe		229,007,734
Tolleson		8,975,441
Wickenburg		8,393,930
Youngtown		8,512,718
Litchfield Park		6,254,355
Queen Creek		21,984,168
Fountain Hills		33,829,872
Apache Junction		379,847
Fort McDowell Yavapai Nation		1,138,160
Gila River Indian Community		3,728,026
Salt River Pima-Maricopa Indian Communtiy		8,846,984
Tohono O'odham Nation		617,425
Local Mobility Projects and Programs Total		5,112,000,000

Project/ Program	Project/Program Description	Estimated Cost
	Transportation Enhancement and Walkable/Bikeable Communities Total	
Maricopa County		63,241,518
Avondale		19,355,030
Buckeye		7,089,998
Carefree		1,028,086
Cave Creek		1,330,037
Chandler		64,421,417
El Mirage		8,947,194
Gila Bend		552,554
Gilbert		48,298,831
Glendale		67,637,395
Goodyear		12,896,562
Guadalupe		1,550,222
Mesa		125,049,186
Paradise Valley		3,868,718
Peoria		38,541,781
Phoenix		411,857,818
Scottsdale		65,511,735
Surprise		24,631,924
Tempe		46,268,333
Tolleson		1,813,383
Wickenburg		1,695,895
Youngtown		1,719,895
Litchfield Park		1,263,619
Queen Creek		4,441,644
Fountain Hills		6,834,930
Apache Junction		76,744
Fort McDowell Yavapai Nation		229,952
Gila River Indian Community		753,204
Salt River Pima-Maricopa Indian Communtiy		1,787,430
Tohono O'odham Nation		124,743
Transportation Enhancement and Walkable/Bikeable Communities Total		1,032,819,778

Maricopa County Total	20,750,576,446

June 19, 2008

Mohave County Transportation Investment Strategy



Strategic Highway Projects

- Interstate Improvements
- US/SR Improvements
- New Corridors
- Programmed or Recently Completed Improvements for State Trade Corridors

Rural Public Transportation Program

- Potential New Connectors
- Public Transit Service Provider

Elderly and Persons with Disabilities Program

- Primary Transit Service
- Secondary Service Area
- Potential Growth

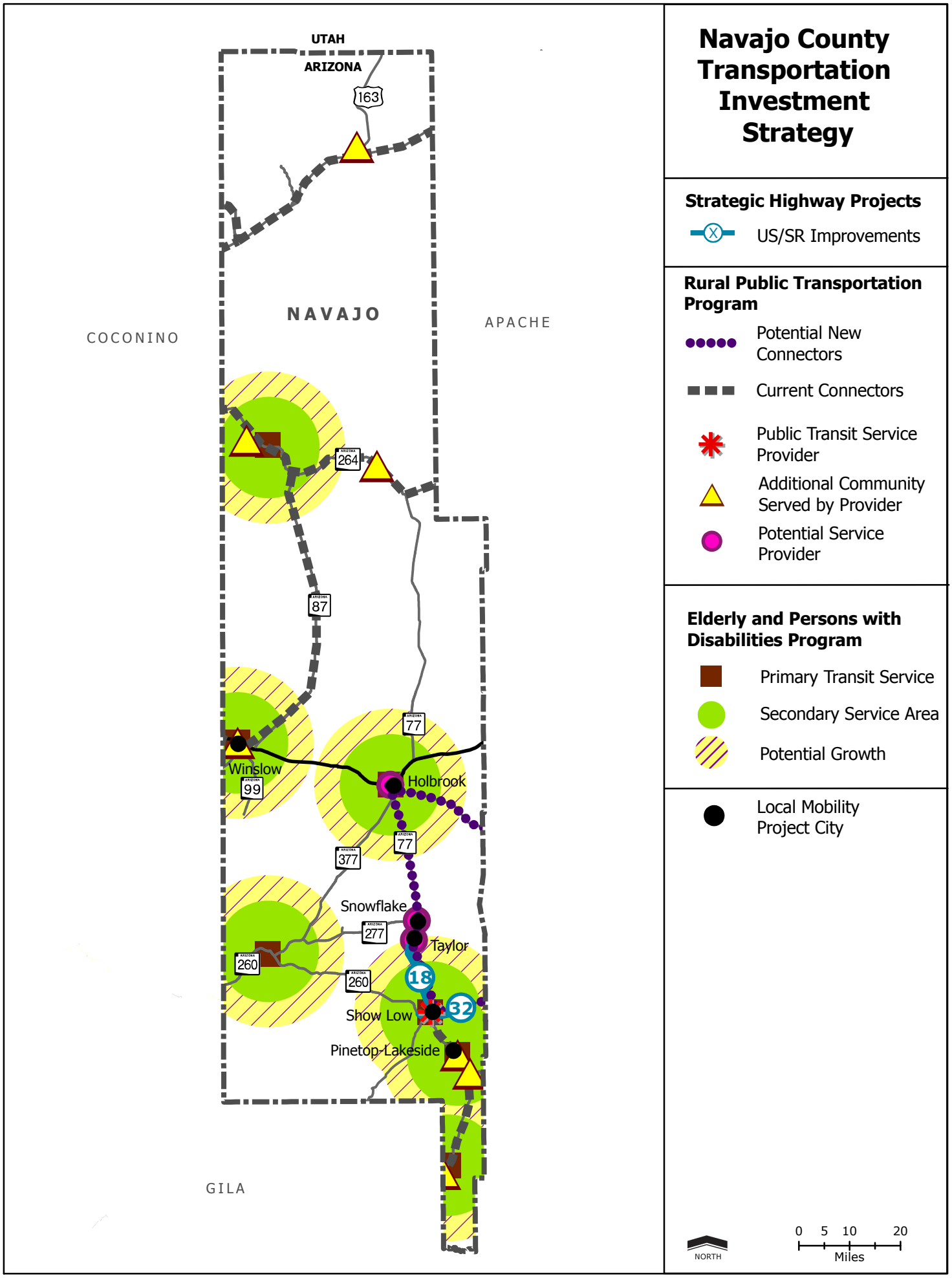
- Local Mobility Project City

NORTH

0 5 10 20
Miles

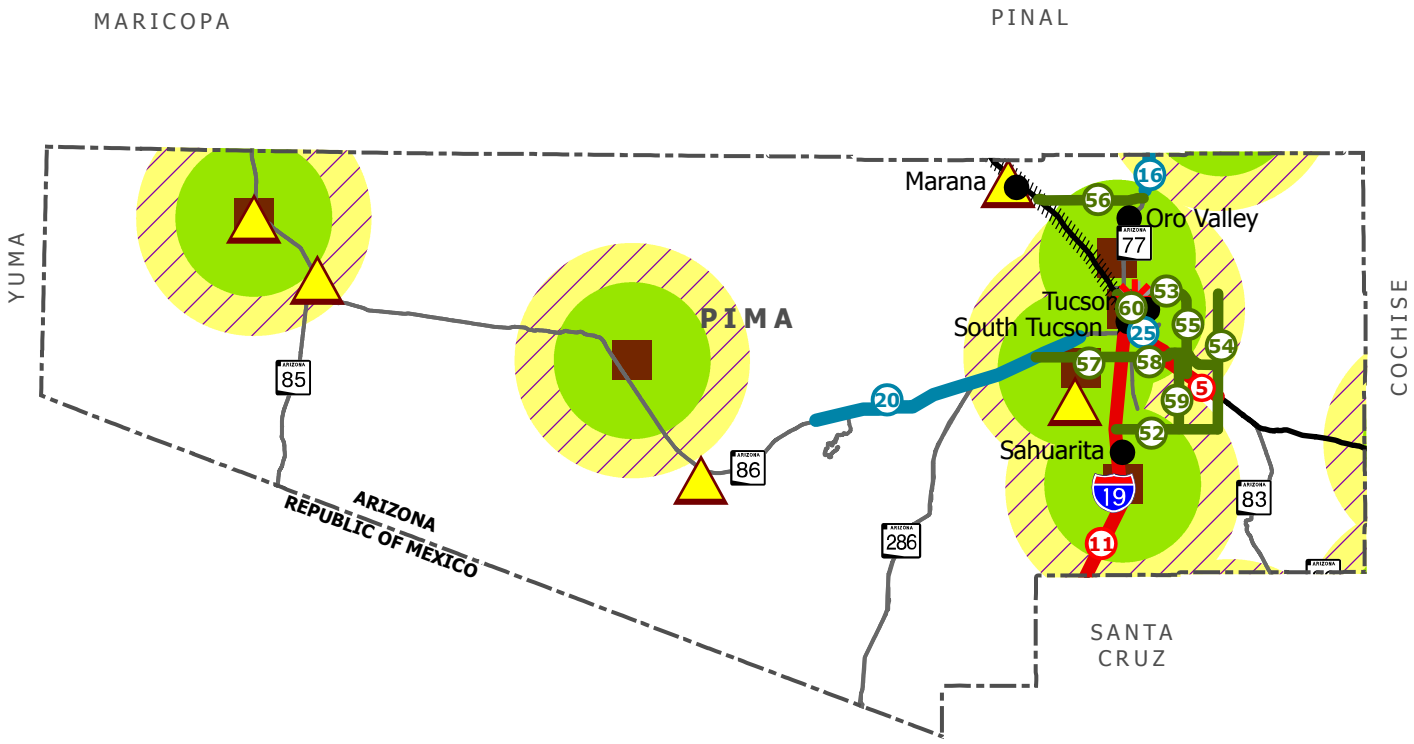
Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
Interstate Improvements		
12	I-40: Widen to 6-lane from McConnico TI to Jct US 93 South	577,000,000
US/SR Improvements		
24	SR 95: Widen to 4-lane from I-40 to Lake Havasu City	130,000,000
34	US 93:Widen to 4-lane SB Ranch Road to Carrow Stephens	320,000,000
New Roadway Corridors		
40	Vanderslice Road from Courtwright Road to Bullhead Parkway	30,000,000
Strategic Highway Projects Total		1,057,000,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	15,000,000
67	Enhancing Public Transportation Programs	31,112,525
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	8,812,285
69	Statewide Vanpool and Rideshare Programs	12,521,897
70	Transit/Rail Planning, Marketing and Other Related Programs	1,001,752
Strategic Rail and Transit Projects and Program Total		68,448,459
	Local Mobility Projects and Programs	
Mohave County		144,776,890
Bullhead City		43,510,560
Colorado City		4,645,985
Kingman		29,447,345
Lake Havasu City		60,847,599
Fort Mojave Indian Tribe		780,840
Hualapai Tribe		1,364,703
Kaibab Paiute Tribe		192,937
Local Mobility Projects and Programs Total		285,566,860
	Transportation Enhancement and Walkable/Bikeable Communities	
Mohave County		17,898,016
Bullhead City		10,663,182
Colorado City		1,138,597
Kingman		7,216,695
Lake Havasu City		14,911,990
Fort Mojave Indian Tribe		215,715
Hualapai Tribe		377,013
Kaibab Paiute Tribe		53,301
Transportation Enhancement and Walkable/Bikeable Communities Total		52,474,508
Mohave County Total		1,463,489,827

June 19, 2008


Navajo County Transportation Investment Strategy
Strategic Highway Projects
US/SR Improvements
Rural Public Transportation Program
Potential New Connectors
Current Connectors
Public Transit Service Provider
Additional Community Served by Provider
Potential Service Provider
Elderly and Persons with Disabilities Program
Primary Transit Service
Secondary Service Area
Potential Growth
Local Mobility Project City
UTAH
ARIZONA
163
NAVAJO
COCONINO
APACHE
GILA
264
87
77
99
377
277
260
18
32
Winslow
Holbrook
Snowflake
Taylor
Show Low
Pinetop-Lakeside
NORTH
0 5 10 20
Miles

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
US/SR Improvements		
18	SR 77: Widen to 4-lane from Deuce of Clubs to Pinedale Road	150,000,000
32	US 60: Widen to 4-lane from Rim Road to Bourdon Ranch Road	100,000,000
Strategic Highway Projects Total		250,000,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	10,000,000
67	Enhancing Public Transportation Programs	17,954,796
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	5,085,501
69	Statewide Vanpool and Rideshare Programs	7,226,290
70	Transit/Rail Planning, Marketing and Other Related Programs	578,103
Strategic Rail and Transit Projects and Program Total		40,844,690
	Local Mobility Projects and Programs	
Navajo County		102,848,529
Pinetop/Lakeside		6,770,431
Holbrook		8,818,628
Show Low		16,068,597
Snowflake		8,022,107
Taylor		6,664,770
Winslow		15,987,319
White Mountain Apache Tribe		10,651,957
The Hopi Tribe		5,870,951
Navajo Nation		27,153,652
Local Mobility Projects and Programs Total		208,856,941
	Transportation Enhancement and Walkable/Bikeable Communities	
Navajo County		7,926,085
Pinetop/Lakeside		1,162,318
Holbrook		1,513,943
Show Low		2,758,586
Snowflake		1,377,200
Taylor		1,144,178
Winslow		2,744,632
White Mountain Apache Tribe		2,942,708
The Hopi Tribe		1,621,908
Navajo Nation		7,501,463
Transportation Enhancement and Walkable/Bikeable Communities Total		30,693,021
Navajo County Total		530,394,652

June 19, 2008



Pima County Transportation Investment Strategy

Strategic Highway Projects

- Interstate Improvement
- US/SR Improvements
- New Corridors
- Acceleration/Expansion of Programmed Projects
- Programmed or Recently Completed Improvements for State Trade Corridors

Rural Public Transportation Program

- Public Transit Service Provider
- Additional Community Served by Provider
- Local Mobility Project City

Elderly and Persons with Disabilities Program

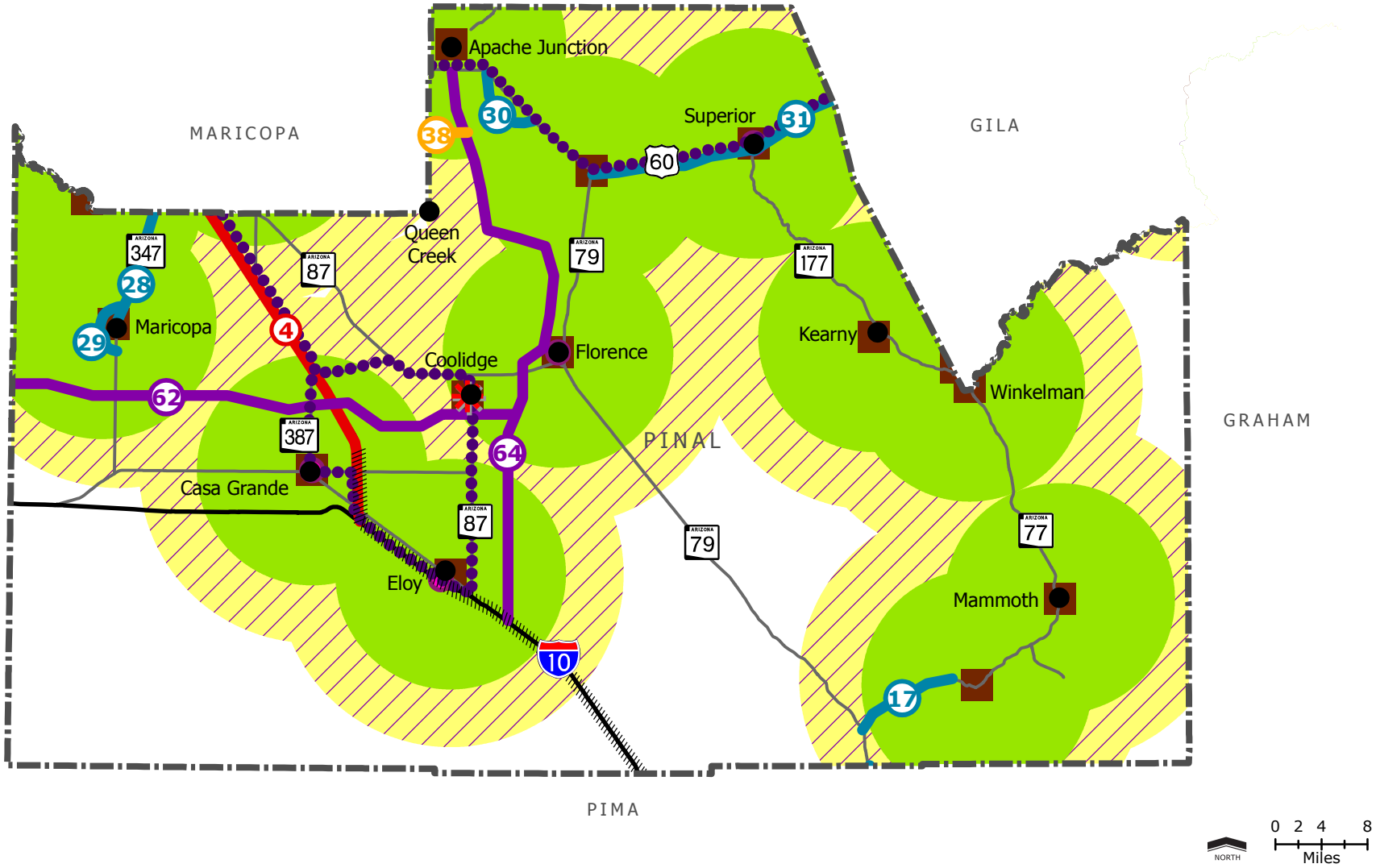
- Primary Transit Service
- Secondary Service Area
- Potential Growth

NORTH

0 4 8 16
Miles

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
Interstate Improvements		
5	I-10: Widen to 6-lane from I-19 Junction to Houghton Road	198,000,000
11	I-19: Widen to 6-lane from Tucson to the County Line	1,088,000,000
US/SR Improvements		
16	SR 77: Widen to 6-lane from Tangerine Road to the County Line	59,500,000
20	SR 86: Widen to 4-lane from Kinney to Kitt Peak Turnoff	247,000,000
25	SR 210: Extension from Alvernon Way to Valencia Road	295,000,000
Acceleration/Expansion of Programmed Projects		
52	SR 982/Sahuarita Corridor on Pima Mine Road from I-19 to Houghton Road	231,000,000
53	Grant Road/SR 110 from I-10 to Tanque Verde Road	92,565,125
54	Houghton Road/SR 983 from Pima Mine Road to Tanque Verde Road	116,821,125
55	Kolb Road/SR110 from I-10 to Tanque Verde Road	40,604,125
56	Tangerine Road/SR 989 I-10 to Oracle Road	42,827,625
57	Valencia Road/SR 910 from Ajo Way to I-19	87,042,625
58	Valencia Road/SR 910 from I-19 to Houghton Road	51,210,125
59	Wilmot Road/SR 210 from Pima Mine Road to Valencia Road	143,316,125
60	22nd Street/SR 210 from I-10 to Aviation Parkway	59,696,125
Strategic Highway Projects Total		2,752,583,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	20,000,000
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	43,202,589
69	Statewide Vanpool and Rideshare Programs	61,389,114
70	Transit/Rail Planning, Marketing and Other Related Programs	4,911,129
High Speed Intercity Rail/Commuter Rail/Light Rail		
71	High Speed Urban-Urban Rail Connections Commuter Rail in Urban Corridors	1,435,000,000
72	Light Rail, Modern Streetcar and Related High Capacity Transit	400,000,000
Strategic Rail and Transit Projects and Program Total		1,964,502,832
	Local Mobility Projects and Programs	
Pima County		499,450,081
Marana		23,047,196
Oro Valley		33,977,906
Sahuarita		12,064,744
South Tucson		4,855,219
Tucson		555,736,317
Pascua Yaqui Tribe		3,348,624
Tohono O'odham Nation		9,641,814
Local Mobility Projects and Programs Total		1,142,121,901
	Transportation Enhancement and Walkable/Bikeable Communities	
Pima County		91,885,880
Marana		7,458,088
Oro Valley		10,995,273
Sahuarita		3,904,159
South Tucson		1,571,152
Tucson		147,841,774
Pascua Yaqui Tribe		925,090
Tohono O'odham Nation		2,663,646
Transportation Enhancement and Walkable/Bikeable Communities Total		267,245,062
Pima County Total		6,126,452,795

June 19, 2008



Pinal County Transportation Investment Strategy

Strategic Highway Projects

- Interstate Improvements
- US/SR Improvements
- New Corridors
- Potential PPP Roadway Projects
- Programmed or Recently Completed Improvements for State Trade Corridors

Rural Public Transportation Program

- Potential New Connectors
- Public Transit Service Provider
- Potential New Service Provider

Elderly and Persons with Disabilities Program

- Primary Transit Service
- Secondary Service Area
- Potential Growth

- Local Mobility Project City

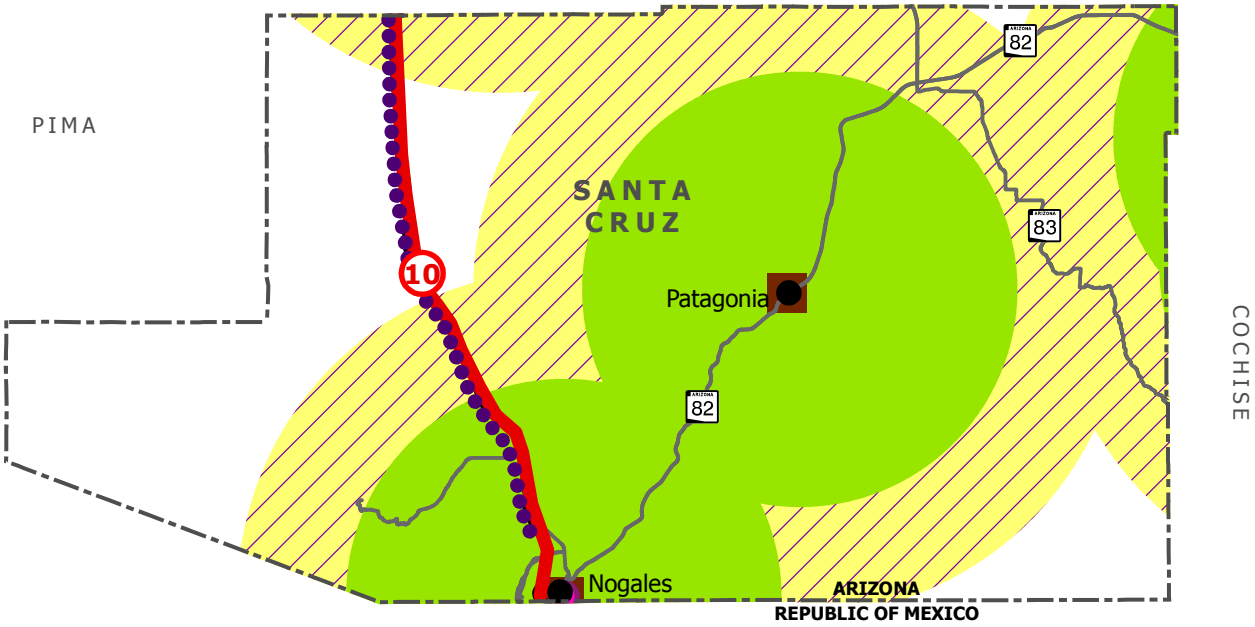
June 19, 2008

Project/ Program	Project/Program Description	Estimated Cost
Strategic Highway Projects		
Interstate Improvements		
4	I-10: Widen to 6-lane from Riggs Rd to I-8	500,000,000
US/SR Improvements		
17	SR 77: Widen to 4-lane from Oracle Junction to Oracle	70,000,000
28	SR 347: Widen to 6-lane from Maricopa to I-10	208,000,000
29	SR 347: UPRR Overpass	35,000,000
30	US 60: Gold Canyon Reroute	300,000,000
31	US 60:Widen to 4-lane from Jct SR 79 to the County Line	207,000,000
New Roadway Corridors		
38	SR 802 from the County Line to N-S Corridor	328,000,000
Potential PPP Projects		
62	Val Vista Freeway from SR 303L to N-S Corridor	228,500,000
64	Pinal County N-S Corridor from US 60 to I-10	360,000,000
Strategic Highway Projects Total		2,236,500,000
Strategic Rail and Transit Projects and Programs		
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	20,000,000
67	Enhancing Public Transportation Programs	43,688,087
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	12,374,176
69	Statewide Vanpool and Rideshare Programs	17,583,200
70	Transit/Rail Planning, Marketing and Other Related Programs	1,406,656
High Speed Intercity Rail/Commuter Rail/Light Rail		
71	High Speed Urban-Urban Rail Connections Commuter Rail in Urban Corridors	1,600,000,000
Strategic Rail and Transit Projects and Program Total		1,695,052,119

Project/ Program	Project/Program Description	Estimated Cost
Local Mobility Projects and Programs		
Pinal County		188,654,077
Apache Junction		35,705,900
Casa Grande		34,305,980
Coolidge		8,642,529
Eloy		11,754,051
Florence		21,690,846
Kearny		2,376,167
Mammoth		1,861,630
Superior		3,437,994
Queen Creek		526,159
Winkleman		4,226
Maricopa		16,834,970
Gila River Indian Communtiy		8,644,803
Ak-Chin Indian Community		749,526
Tohono O'odham Nation		803,064
Local Mobility Projects and Programs Total		335,991,922
Transportation Enhancement and Walkable/Bikeable Communities		
Pinal County		31,558,388
Apache Junction		9,431,098
Casa Grande		9,061,333
Coolidge		2,282,775
Eloy		3,104,630
Florence		5,729,263
Kearny		627,624
Mammoth		491,718
Superior		908,087
Queen Creek		138,976
Winkleman		1,116
Maricopa		4,446,667
Gila River Indian Communtiy		2,388,212
Ak-Chin Indian Community		207,064
Tohono O'odham Nation		221,854
Transportation Enhancement and Walkable/Bikeable Communities Total		70,598,805

Pinal County Total	4,338,142,846

June 19, 2008



Santa Cruz County Transportation Investment Strategy

Strategic Highway Projects

- Interstate Improvement
- Local Mobility Project City

Rural Public Transportation Program

- Potential New Connectors
- Potential New Service Provider

Elderly and Persons with Disabilities Program

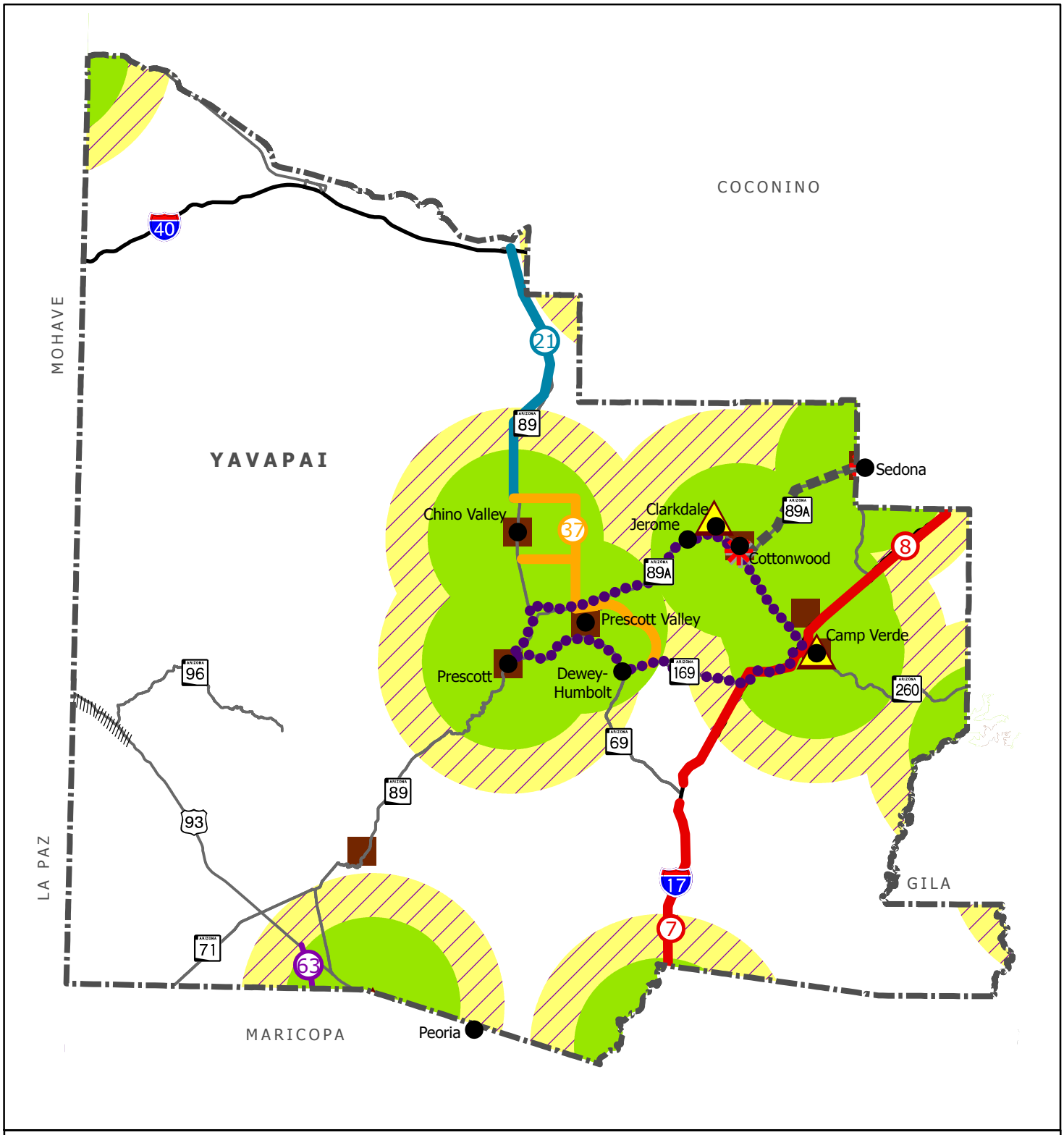
- Primary Transit Service
- Secondary Service Area
- Potential Growth

NORTH

0 2 4 8
Miles

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
Interstate Improvements		
10	I-19: Widen to 6-lane from Nogales to the County Line	510,000,000
Strategic Highway Projects Total		510,000,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	10,000,000
67	Enhancing Public Transportation Programs	6,943,443
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	1,966,655
69	Statewide Vanpool and Rideshare Programs	2,794,536
70	Transit/Rail Planning, Marketing and Other Related Programs	223,563
Strategic Rail and Transit Projects and Program Total		21,928,197
	Local Mobility Projects and Programs	
Santa Cruz County		39,783,018
Nogales		28,928,423
Patagonia		1,219,155
Local Mobility Projects and Programs Total		69,930,596
	Transportation Enhancement and Walkable/Bikeable Communities	
Santa Cruz County		5,945,540
Nogales		6,092,051
Patagonia		256,742
Transportation Enhancement and Walkable/Bikeable Communities Total		12,294,333
Santa Cruz County Total		**614,153,126**

June 19, 2008



Yavapai County Transportation Investment Strategy

Strategic Highway Projects

- Interstate Improvements
- US/SR Improvements
- New Corridors
- Potential PPP Roadway Projects
- Programmed or Recently Completed Improvements for State Trade Corridors

Rural Public Transportation Program

- Potential New Connectors
- Current Connectors
- Public Transit Service Provider
- Additional Community Served by Provider
- Local Mobility Project City

Elderly and Persons with Disabilities Program

- Primary Transit Service
- Secondary Service Area
- Potential Growth

NORTH

0 3.5 7 14
Miles

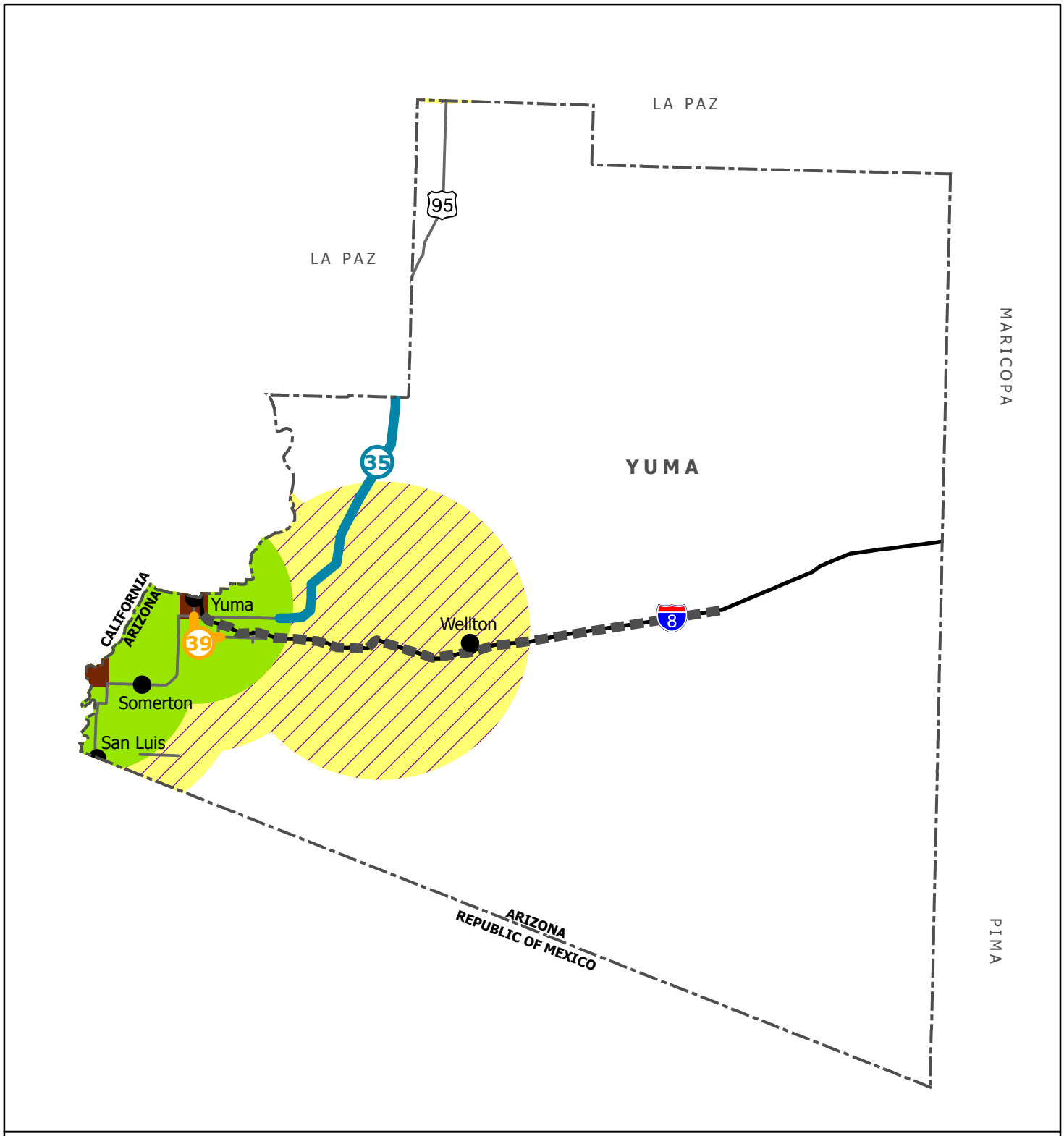
June 19, 2008

Project/ Program	Project/Program Description	Estimated Cost
Strategic Highway Projects		
Interstate Improvements		
7	I-17: Widen to 6-lane from New River to Cordes Junction	525,000,000
8	I-17: Widen to 6-lane from Cordes Junction to County Line	633,000,000
US/SR Improvements		
21	SR 89: Widen to 4-lane from Chino Valley to I-40	340,000,000
New Roadway Corridors		
37	Fain Connector/Fain Road/SR-89A/ Great Western Corridor	289,000,000
Potential PPP Projects		
63	Hassayampa Freeway Network	41,250,000
Strategic Highway Projects Total		1,828,250,000
Strategic Rail and Transit Projects and Programs		
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	20,000,000
67	Enhancing Public Transportation Programs	33,526,773
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	9,496,095
69	Statewide Vanpool and Rideshare Programs	13,493,563
70	Transit/Rail Planning, Marketing and Other Related Programs	1,079,485
High Speed Intercity Rail/Commuter Rail/Light Rail		
71	High Speed Urban-Urban Rail Connections Commuter Rail in Urban Corridors	350,000,000
Strategic Rail and Transit Projects and Program Total		427,595,916

Project/ Program	Project/Program Description	Estimated Cost
Local Mobility Projects and Programs		
Yavapai County		138,419,563
Camp Verde		10,520,746
Chino Valley		12,084,640
Clarkdale		3,608,233
Cottonwood		10,648,210
Jerome		323,564
Prescott		39,974,911
Prescott Valley		32,920,227
Sedona		7,682,203
Peoria		33,337
Dewey-Humboldt		3,951,408
Yavapai-Apache Tribe		750,536
Yavapai-Prescott Indian Tribe		183,846
Local Mobility Projects and Programs Total		261,101,424
Transportation Enhancement and Walkable/Bikeable Communities		
Yavapai County		22,335,195
Camp Verde		2,994,398
Chino Valley		3,439,511
Clarkdale		1,026,970
Cottonwood		3,030,677
Jerome		92,092
Prescott		11,377,596
Prescott Valley		9,369,703
Sedona		2,186,497
Peoria		9,488
Dewey-Humboldt		1,124,643
Yavapai-Apache Tribe		207,343
Yavapai-Prescott Indian Tribe		50,789
Transportation Enhancement and Walkable/Bikeable Communities Total		57,244,902

Yavapai County Total	2,574,192,242

June 19, 2008



Yuma County Transportation Investment Strategy

Strategic Highway Projects

- US/SR Improvements
- New Corridors
- Local Mobility Project City

Rural Public Transportation Program

- Current Connectors

Elderly and Persons with Disabilities Program

- Primary Transit Service
- Secondary Service Area
- Potential Growth

NORTH

0 2.5 5 10
Miles

Project/ Program	Project/Program Description	Estimated Cost
	Strategic Highway Projects	
US/SR Improvements		
35	US 95: Widen to 4-lane from Avenue 9E to the County Line	280,000,000
New Roadway Corridors		
39	Initiate Yuma Expressway: from Avenue D to Avenue 15E	170,000,000
Strategic Highway Projects Total		450,000,000
	Strategic Rail and Transit Projects and Programs	
Public Transit Projects and Programs		
66	Connecting Communities Bus Transit Program	15,000,000
67	Enhancing Public Transportation Programs	30,229,283
68	Transit Serving Elderly, Persons with Disabilities and Tribal Populations in Rural Areas	8,562,116
69	Statewide Vanpool and Rideshare Programs	12,166,418
70	Transit/Rail Planning, Marketing and Other Related Programs	973,313
Strategic Rail and Transit Projects and Program Total		66,931,130
	Local Mobility Projects and Programs	
Yuma County		133,686,535
Somerton		9,807,871
San Luis		23,066,101
Welton		1,981,693
Yuma		89,301,922
Cocopah Tribe		1,035,396
Fort Yuma-Quechan Tribe		36,365
Local Mobility Projects and Programs Total		258,915,884
	Transportation Enhancement and Walkable/Bikeable Communities	
Yuma County		18,137,736
Somerton		2,720,912
San Luis		6,399,026
Welton		549,764
Yuma		24,774,248
Cocopah Tribe		286,038
Fort Yuma-Quechan Tribe		10,046
Transportation Enhancement and Walkable/Bikeable Communities Total		52,877,771
Yuma County Total		828,724,784

June 19, 2008

Appendix 5

TRANSPORTATION STIMULUS FUNDING

As we went to press in early March, the final plan for spending Arizona's roughly $622 million of stimulus monies for transportation infrastructure from the American Recovery and Reinvestment Act of 2009 was still being decided. About $270 million of the total funds go directly to metro areas, and the remaining $350 million is distributed through ADOT. The total state funding, as well as those funds directed to metro areas are summarized in Table A-5.1.

Table A-5.1: Funding breakdowns for total statewide, and metropolitan-area specific funding for transportation from the American Recovery and Reinvestment Act of 2009

Total State Transportation Investment			
Highways and Bridges	Transit Capital	Fixed Guideway Modernization	
$521,958,401	$99,921,878	$640,070	
Highway Infrastructure Funds to Large Urbanized Areas with Populations Greater than 200,000			
Phoenix-Mesa	Tucson		
$88,723,493	$ 21,987,460		
Transit Capital Grants to Large Urbanized Areas with Populations Greater than 200,000			
Phoenix-Mesa	Tucson		
$64,421,217	$16,022,390		
Transit Capital Grants to Small Urbanized Areas with Populations Between 50,000 and 200,000			
Avondale	Flagstaff	Prescott	Yuma
$1,333,602	$989,946	$1,031,987	$1,940,082
Transit Fixed-Guideway Modernization Grants to Large Urbanized Areas with Populations Greater than 200,000			
Phoenix-Mesa			
$640,070			

Source: Chicago Metropolitan Agency for Planning. CMAP Economic Recovery Update. Feb. 17, 2009. www.cmap.illinois.gov/blog_template.aspx?id=14152&blogid=126. Accessed Feb. 27, 2009.This table was prepared by the Committee on Transportation and Infrastructure Majority staff based on technical assistance provided by the U.S. Department of Transportation and the U.S. Environmental Protection Agency. It includes "Additional Transportation and Infrastructure Committee Infrastructure Investment Formula Funding provided under P.L. 111-5, the American Recovery and Reinvestment Act of 2009." The Territorial Highway Program receives $45,000,000 under P.L. 111-5.

As of this writing (March 6, 2009), the State Transportation Board has released a spending plan that we summarize here. There may be changes before the Town Hall meeting in mid-April. The State Transportation Board decided to distribute the $349,712,000 total as follows:

- Maricopa Association of Governments - $129,393,000
- Pima Association of Governments - $ 45,462,000
- Total for Other Counties - $174,856,000

Detailed maps showing the locations of the projects, shown below, are from the following document:

> State Transportation Board. American Recovery and Reinvestment Act Implementation. Mar. 3, 2009. www.azdot.gov/board/agendas/PDF_2009/030309_STB_Recovery_Presentation.pdf. Accessed Mar. 7, 2009.

Maricopa County

The map of planned projects, totaling $131 million, is shown below in Figure A-5.1.

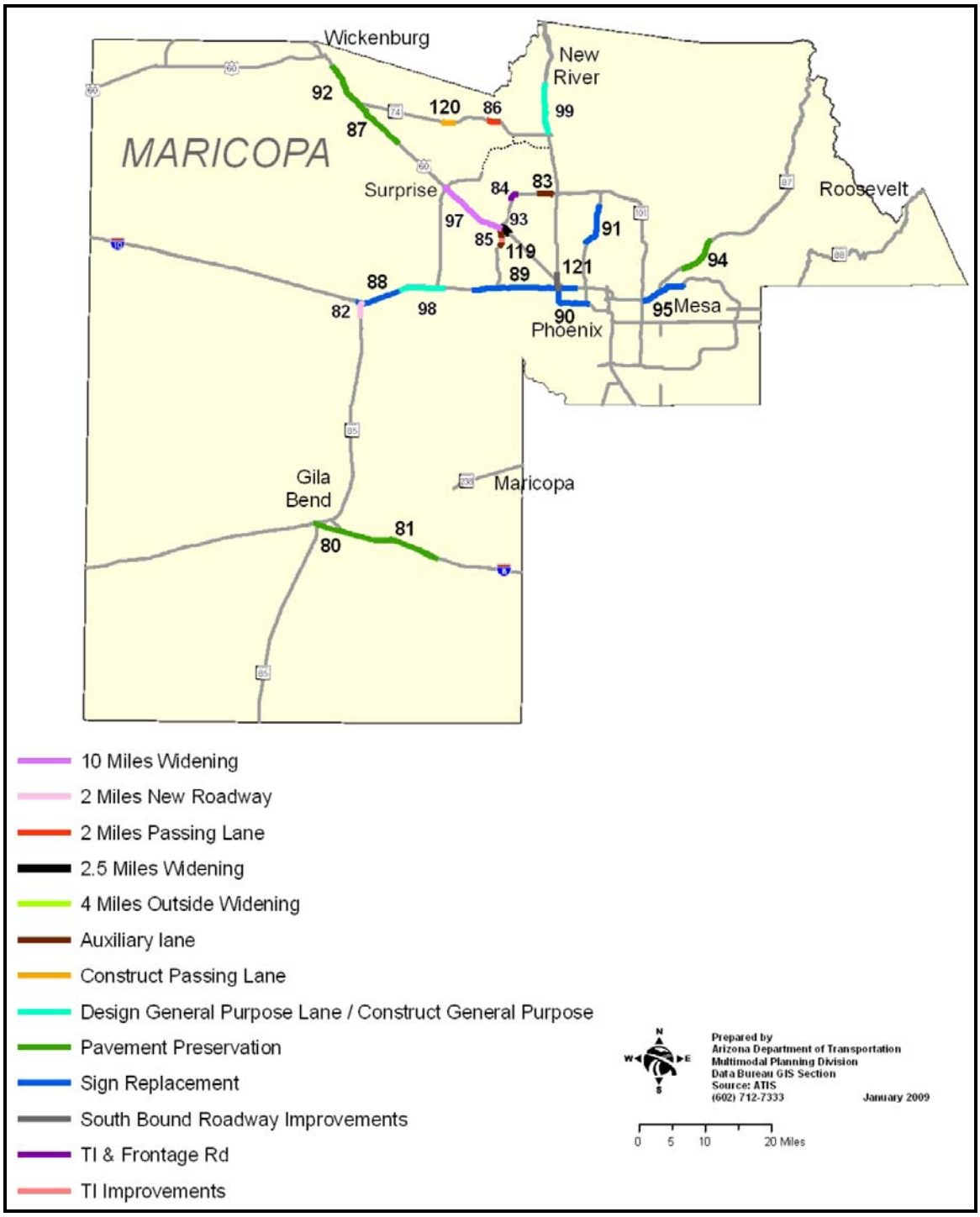
Pima County

The map of planned projects, totaling $46 million, is shown below in Figure A-5.2.

Statewide – 13 Other Counties

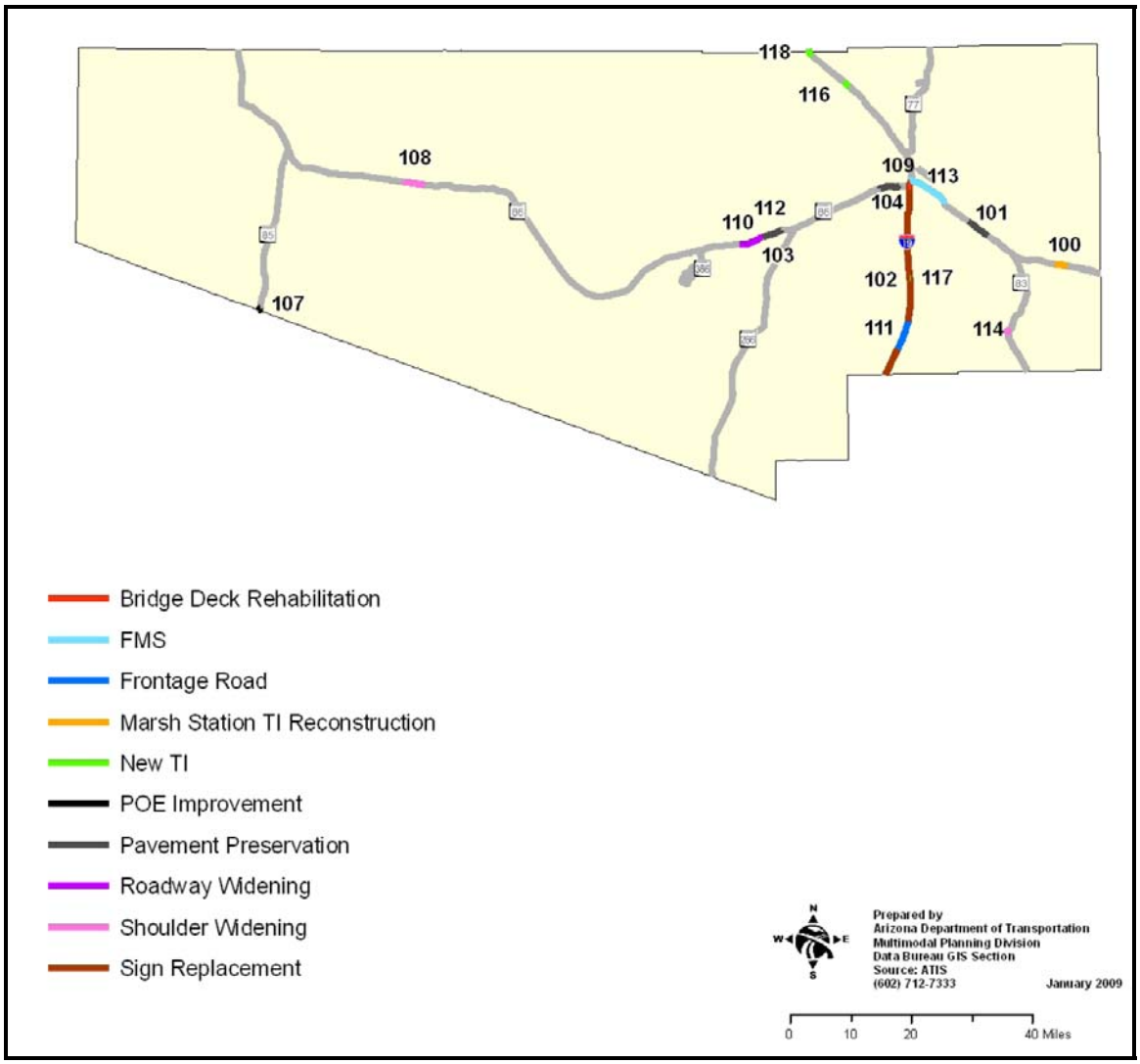
The map of planned projects across the 13 other counties, totaling $175 million, is shown below in Figure A-5.3.

Figure A-5.1: Prioritized Economic Recovery Plan (Draft: 3-4-09) Maricopa Association of Governments



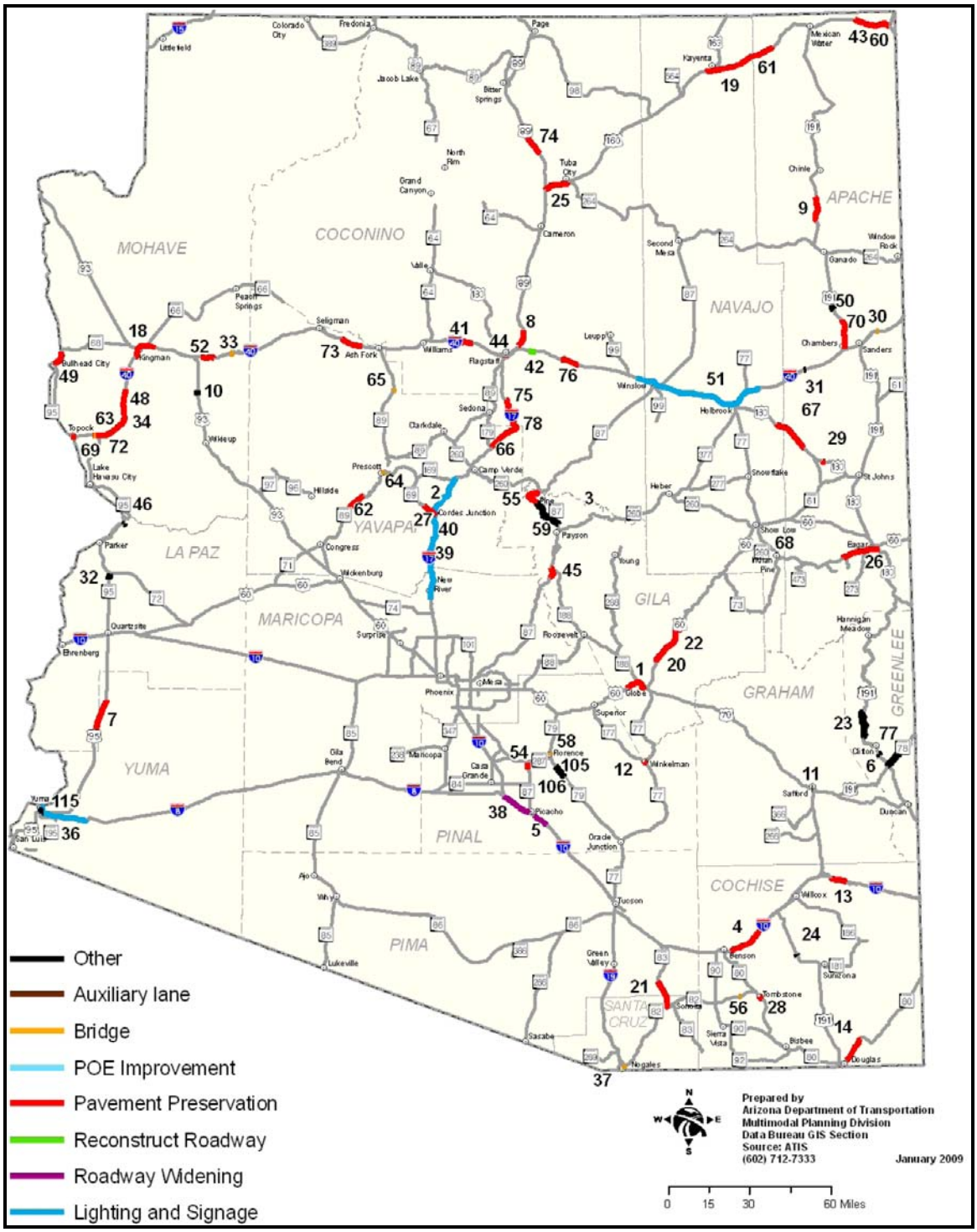
Source: www.azdot.gov/board/agendas/PDF_2009/030309_STB_Recovery_Presentation.pdf

Figure A-5.2: Prioritized Economic Recovery Plan (Draft: 3-4-09) Pima Association of Governments



Source: www.azdot.gov/board/agendas/PDF_2009/030309_STB_Recovery_Presentation.pdf

Figure A-5.3: Prioritized Economic Recovery Plan (Draft: 3-4-09) 13 Other Counties in Arizona



Source: www.azdot.gov/board/agendas/PDF_2009/030309_STB_Recovery_Presentation.pdf