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TRANSPORTATION MODES AND TECHNOLOGIES
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KEY FINDINGS AND ISSUES

- In recent years, automobiles (and other light-duty passenger vehicles) have continued to saturate the American culture, while driving alone has increasingly become the dominant mode of travel to work. The number of trips per person has increased, although the average trip length has not. Suburb-to-suburb commuting has risen much faster than commuting from suburbs to the central core. During the last three decades, the most dramatic increase in vehicle miles of travel (VMT) has occurred among personal vehicles other than passenger cars (pick-up trucks, vans, sport utility vehicles).

- Travel demand has grown much faster than the physical capacity of the roadway system, with a resulting rise in traffic congestion. However, adaptations made by the American population have kept average commute times surprisingly stable. Such adaptations, ranging from locational choices to changing driving habits that affect highway capacity, will no doubt continue in the future, but their ability to keep pace with further growth in demand and congestion is questionable.

- In Maricopa County, vehicle trips are projected to increase by 140% and VMT by 160% over the next 40 years. Substantial construction of new roads and improvements to existing facilities are planned to help meet the demand. However, a large gap exists between available transportation funds and projected costs to build and maintain the transportation system. This shortfall will grow over time unless new revenue sources are secured and existing sources are indexed to inflation. Expiration of the current half-cent sales tax in 2006 will leave the Valley without a dedicated regional source of funds for construction of limited-access facilities.

- Between 1982 and 1994, delay per driver increased far less in Phoenix than in similar cities — a temporary phenomenon due in large part to construction of the Maricopa Association of Governments (MAG) freeway and expressway system.

- As opportunities for new roadway construction in the region become more limited because of funding, right-of-way and environmental constraints, more emphasis will be placed on multimodal planning and design, transportation system management, grade separation of intersections and Intelligent Transportation Systems (ITS). ITS shows particular promise as a way to manage and limit non-recurring delays due to incidents. In the longer term, vehicle automation technologies are likely to improve highway safety long before full automation brings substantial improvements in highway capacity.

- Congestion pricing has been widely advocated as an economically efficient solution to peak period congestion, but a variety of institutional and policy issues

remain unresolved. Perhaps the biggest unknown is the political will to charge user fees high enough to significantly reduce peak period travel by single-occupant vehicles, although High Occupancy & Toll lanes in congested corridors appear to hold promise. Telecommunications may or may not prove to be a large-scale substitute for transportation, although it will certainly have major impacts on travel in the United States. The growth of the mobile workplace could increase rather than decrease overall travel.

- Traffic congestion is an inevitable by-product of an urbanized society in which people pursue many objectives other than minimization of commute time. Congestion can be managed, but never eliminated, at a price that Americans would accept. Various improvement projects and related mitigation measures can at most keep congestion from worsening as much as it otherwise would.

- Transportation accounts for roughly two-thirds of U.S. petroleum consumption, and U.S. transportation relies on petroleum for 97% of its energy supply. The principal danger facing us in the 21st Century is not running out of fuel, but rather an overdependence on imported oil, leading to potential price shocks and economic instability. A variety of alternative fuels are available or exploitable in the near future. However, strong incentives and policies will be needed in the short term to reduce our dependence on Middle Eastern oil. Similarly, technologies that greatly improve vehicle fuel economy are available, but their widespread adoption will require appropriate public policy or economic incentives.

- The United States has made great strides in reducing vehicle tailpipe emissions, primarily due to cleaner-burning engines and fuels. Continuing growth in VMT threatens to wipe out these gains during the next century. Emission of carbon dioxide, which causes a buildup of greenhouse gases, remains a major concern.

- Public transit's percentage of work trips has been falling nationwide, although overall ridership has increased in some cities. With the growing prevalence of suburb-to-suburb commuting, innovative paratransit or other non-traditional services may hold promise. Transit systems increasingly recognize the need to serve commuting patterns other than suburb to central city, but these multiple patterns are difficult to serve effectively. Light rail is in service or under development in numerous cities, and technological innovations are improving system performance and user convenience. Because of its inherent flexibility and ability to take advantage of many of the same technological opportunities as light rail, bus rapid transit may come to play a greater role in urban transportation systems.

- Locally, mass transit has taken a great leap forward with voter approval of dedicated funding sources in Tempe and Phoenix, and with design and

impending construction of the Valley's first light rail transit line. However, expansion of these improvements outside a few of the largest cities will probably not occur until a regional funding source for transit is developed.

- In freight transportation, deregulation has generally succeeded in stimulating competition, despite substantial consolidation, especially in the railroad industry. ITS is playing an increasing role in truck transport, and the North American Free Trade Agreement (NAFTA) has had important impacts on the transportation system, especially in border states such as Arizona.

- In commercial (air carrier) aviation, escalating flight delays are currently the cause of rising customer dissatisfaction. With passenger traffic expected to double in the next 10 to 15 years, delays are likely to worsen, especially given the lack of significant systemwide investments in aviation infrastructure during the last 20 years. Several technological innovations do, however, hold out hope of improving operational safety and efficiency, and somewhat mitigating the delay problem. Advances in air traffic control may increase the capacity of existing airports.

- In the Phoenix area, traffic at Sky Harbor International Airport will continue to grow dramatically, with air cargo experiencing the highest growth rate. Availability of direct overseas flights will most likely increase, but whether the current strong competition for Phoenix passengers will continue is unknown. Although Sky Harbor has ambitious expansion plans, increased use of reliever airports in outlying areas may eventually prove necessary.

THE VEHICLE/HIGHWAY SYSTEM

Urban Travel Characteristics and Trends

- **National Findings:** The "saturation" of American society with automobiles continues. From 1969 to 1995, households without automobiles declined from 20% to 8% of the total, while households with two or more vehicles doubled from 30% to 60% (despite a decline in the average household size).[1]

  - From 1969 to 1997, the number of annual person trips increased by 72% and person miles of travel increased 65%, while the U.S. population grew only 21%. Hence, person trips per capita rose 42% and miles of travel per capita rose 36%. The average person trip length declined slightly, from 9.67 miles to 9.45 miles. Nearly 22% of all person trips are made as part of earning a living; i.e., commuting and other job-related trips.[2]

  - From 1960 to 1990, the private vehicle (drive alone plus rideshare) mode share for journey to work increased from 67% to 87%. The drive-alone share of work trips rose from 64.4% in 1980 to 73.2% in 1990. All alternatives to driving alone experienced declines in mode share in each of the last three decades, except for working at home. The number of carpooling workers declined 19% from 1980 to 1990, while the carpooling mode share fell from 19.7% to 13.4% during the same period. Both the number and mode share of persons walking to work dropped substantially from 1960 to 1990.[2]

  - Suburb-to-suburb commuting has become increasingly prevalent in metropolitan areas, accounting for about 15% of work trips in 1970 and 44% in 1990.[1] As a result, work trips are becoming harder to serve by conventional transit.

  - Transportation remains the leading cause of accidental deaths and injuries in the United States. Approximately 95% of the deaths and 99% of the injuries attributable to transportation in 1998 were due to highway crashes. However, the number of annual highway fatalities declined from 53,000 to 41,000 between 1970 and 1998, despite an increase of 131% in total VMT (1970-1997). The fatality rates for occupants of passenger cars, light trucks, large trucks and motorcycles have all fallen substantially.[3]

  - The increase in annual VMT from 1970 to 1997 was greatest among two-axle, four-tire vehicles other than passenger cars, at 591%. This category includes pick-up trucks, vans and sport utility vehicles. VMT increased 64% for passenger cars, 137% for motorcycles, 146% for single-unit trucks and 255% for combination trucks.[3]

- **Regional Findings:** Somewhat surprisingly for an area known for its dependence on the private auto, metro Phoenix ranked only 31st among the nation's 50 largest metropolitan areas in vehicles per household, as of 1990. Of the top 50, Houston and San Antonio were the only western metro areas with fewer vehicles per household than Phoenix.[4]

    - Currently in Maricopa County, there are approximately 13 million vehicle trips on an average workday, covering a total of 67 million miles (and representing an average trip length of just over 5 miles). The number of trips is expected to increase by 140%, to over 31 million, by 2040. This is considerably higher than the projected 40-year population growth of approximately 110%. Daily VMT is expected to reach 175 million (a 160% increase from 2000) by 2040. This is about the same amount of vehicle travel as currently occurs in the greater Chicago region, the third most populous in the United States.[5]

    - As a result of the growth in person trips and VMT, the percent of total freeway lane miles that are congested in the PM peak hour will more than double, the number of congested intersections will triple, and total PM peak-hour delay will more than triple, from 42,000 to 141,000 hours, by 2040, assuming continuation of current trends.[6]

Implications for Travel Time and Congestion

- **National Findings:** Roadway capacity, in terms of physical infrastructure, has not kept pace with demand in the late 20th Century. Between 1990 and 1997, highway lane miles increased by 4%, while registered motor vehicles increased by 31% and VMT rose by 67%. The Texas Transportation Institute estimates that the average annual hours of delay per vehicle in the 68 largest U.S. urban areas increased between 100% and 300% from 1982 to 1997.[1] The average amount of lost time (due to congestion) per one-way work trip in 1997 was 4.25 minutes, with Los Angeles drivers experiencing the most lost time — 10.25 minutes per one-way trip.[7]

- **Regional Findings:** According to the Texas Transportation Institute, Phoenix's roadway congestion in 1994 was 16th worst (tied with Dallas) among the nation's 50 largest metro areas. Annual person hours of delay per driver in metro Phoenix increased from 30 in 1982 to 38 in 1994. This 27% rise was far less than the average of 62% for similar cities, perhaps partially because of new freeway construction since 1985.[4]

    - In 2000, approximately 20% of major intersections and 17% of freeway miles were congested during peak periods. By 2040, these levels of congestion could triple, and areas affected by congestion may extend throughout the

region, instead of being concentrated in the central portion of the metropolitan area as they are today.

- If current trends continue unchecked, point-to-point peak period travel times will more than double over the next 40 years. For example, a north-south, peak-hour trip between downtown Phoenix and Deer Valley Road could take 93 minutes in 2040 instead of 43 minutes today. A rush-hour trip from Chandler to north Scottsdale could take 2 hours. The average peak-hour freeway speed is projected to decline from 46 miles per hour (mph) today to 16 mph by 2040, while the average speed on arterials would fall by 50%, from 24 to 12 mph.

- These forecasts of travel congestion and speed assume completion of all transportation investments in the current MAG 20-year plan, of which only 60% can be funded by committed revenue streams. The forecasts also assume a continuation of current socioeconomic and land use trends, particularly in the location of new residences and jobs. These rather dire 2040 projections for transportation mobility may not be fully realized, as people may adapt in a variety of ways, including decisions about where they live and work based on various quality of life issues.[5]

Implications for Infrastructure and Roadway Needs

- **National Findings:** Rapidly increasing usage, especially by heavy vehicles, has taken a toll on the nation's roadway system. In 1995, only 36% of urban freeways, arterials and collectors were reported to be in good or very good condition, and the trend since 1990 has been toward fewer roadway miles in these categories. The percent of urban roadways in better than fair condition in 1995 was 39% for interstate highways, 31% for other freeways and expressways, 28% for other principal arterials, 43% for minor arterials and 34% for collectors.[4] A recent report from the American Society of Civil Engineers stated that more than one-fourth of U.S. bridges needs repairs.

- **Regional Findings:** Much of Arizona's infrastructure is in relatively good shape. A recent article in the *Arizona Republic* reported that Arizona leads the nation in the overall condition of its bridges. As the state's transportation systems age, however, repair and rehabilitation needs will multiply and become increasingly critical.

    - In outlying portions of the MAG urbanized area, substantial new roadway construction will be needed to provide both mobility within these areas and connections to the rest of the region. The MAG street plan includes over 4,000 lane miles of major street construction, for a 57% increase in major street lane mileage. As development in outlying areas increasingly encroaches on natural transportation barriers (e.g., watercourses, mountainous or hilly

terrain), building and maintaining a strong arterial street grid system will be more difficult. This may result in the need for higher design standards in areas where the grid system cannot be maintained. In central portions of the region, increasing population density will result in increasing traffic densities and a traffic mix with more buses, light rail vehicles, bicycles and pedestrians.[6] Higher traffic densities will result in added maintenance requirements.

- As opportunities for new road construction become more limited, especially in the central area, attention will increasingly focus on maximizing the capacity of existing streets through ITS technologies, transportation system management techniques, and design plans that provide for a variety of modes. The grade separation of some key intersections may be required to remove major bottlenecks and help concentrate traffic in key arterial street corridors. The design of these interchanges will have to require minimal additional right-of-way, in order to minimize neighborhood and business impacts.[6] The Arizona Department of Transportation (ADOT) will construct seven such grade separations in the Grand Avenue corridor during the next five years.

- Transportation funding in Maricopa County and throughout Arizona is heavily dependent on the Highway User Revenue Fund (HURF), which is constitutionally restricted to highway purposes. This fund currently collects approximately $1 billion annually statewide and is distributed according to complex formulas in state law. HURF consists mainly of motor fuel taxes, supplemented by motor carrier taxes, vehicle registration fees and a portion of the vehicle license tax. Except for the vehicle license tax, which is based on the value of each vehicle, none of these sources are indexed to inflation. The flat gasoline tax of 18 cents per gallon would require a periodic increase and annual adjustment to keep pace with inflation and improvements in vehicle fuel economy. Increasing use of alternative fuels will also impact the HURF. The half-cent sales tax for freeway construction in Maricopa County will expire on December 31, 2005.

- Since the imposition of Maricopa County's 20-year, half-cent sales tax for freeways in 1985, the number of freeway miles in the MAG region has more than doubled. However, the Valley still has one of the smallest freeway systems (per capita) among the nation's large metropolitan areas. The regional freeway system to be funded from the existing half-cent tax will be completed by 2007, with construction of the South Mountain Parkway and completion of SR 303 occurring after that date. While new funding will have to be found for high-speed facilities in outlying areas, substantial resources must also be earmarked to increase the capacity of existing freeways through interchange improvements, auxiliary lanes, high occupancy vehicle (HOV) lanes, and freeway management systems.[6] The recently completed I-17 widening project, which added HOV and auxiliary lanes, will be followed by the construction of

HOV lanes on US 60 and SR 51. HOV lanes are also planned for other freeways, but funding has not yet been secured.

- Completion of all transportation investments in the current MAG 20-year plan (for 2000-2020) will cost $23.5 billion, of which over $9 billion will have to come from sources not currently on the books, such as an extension of the existing transportation sales tax and an increase in the state gasoline tax. Without added transportation revenue sources, the shortfall between financial needs and committed resources could be $20 billion for the period 2000-2040.[5]

Management of Travel Demand and Congestion

- **National Findings:** Americans have adapted to changes involving their transportation options. For example, highway capacity has increased steadily as drivers have been willing to tolerate shorter gaps between vehicles when operating at high speeds. Freeway lane capacity was reported as 2,000 passenger cars per hour per lane in the 1985 edition of the *Highway Capacity Manual*, 2,200 in the 1994 edition and 2,300 in the 2000 edition. The estimated speed at 1,800 cars per hour per lane was 48 mph in the 1985 edition and 59 mph in the 2000 edition.[1]

  - Similarly, average home-to-work travel times have been surprisingly stable despite growing highway congestion. The overall average travel time rose from 21.7 minutes in 1980 to 22.3 minutes in 1990, despite a steady rise in congestion as measured by the Texas Transportation Institute. This modest growth in travel time presumably results from individual adjustments in residential location, employer's location, time of travel and choice of mode. Such adjustments and adaptations may continue to mitigate congestion to a degree that is hard to predict. This does not mean that new infrastructure will not be needed, or that the choices individuals make will always be desirable for society as a whole.[1]

  - Under various names such as "congestion pricing" and "value pricing," charging motorists variable fees to use highways based on the level of demand or congestion has been advocated by many economists since the 1920s. Such variable pricing is taken for granted in the airline and utility industries, and in some public transit systems (e.g., the Washington Metro). It has recently been embraced by environmental organizations and policy analysts who see it as an effective way to manage congestion. A Transportation Research Board study concluded that road pricing is technically feasible and could produce net benefits to society. However, implementation would require addressing a complex set of institutional issues, and even then would face uncertain political feasibility. In addition to likely public resistance, institutional and

political issues include scope (e.g., limited-access roadways only, all primary arterials), collection methods, price-setting algorithms, allowable uses of the revenues collected, and equity across income groups. On State Route 91 in Southern California, single-occupant vehicles pay variable congestion-based tolls to use high-occupancy lanes, known as "high occupancy and toll" (HOT) lanes.[1] HOT implementation is likely to continue in areas suffering from severe congestion.

- Information technology (e.g., telecommuting, video conferencing) can be a substitute for travel, but perhaps more important, it reduces the need for concentration of employment, especially as the United States increasingly becomes a service economy. It provides the same access to information at home as at the office, and can serve as a powerful force for dispersal of employment just as the industrial revolution promoted concentration.[1] Other forces may continue to promote concentration of employment, however. These include clustering of high-tech industries in order to access a pool of skilled labor, and the tendency of workers in specific industries to cluster for the sake of career mobility. Because workers are more mobile than in the past, they will tend to locate in areas with multiple firms that can use their skills.

- The introduction of new information technology is occurring rapidly. The number of U.S. households with a personal computer has increased from 33 million in 1994 to 57 million in 2000, and is projected to be 64 million by 2003. The number of U.S. households with access to the Internet has increased from 5 million in 1994 to 42 million in 2000, and is projected to be 60 million in 2003. Business-to-business commerce on the Internet is projected to rise thirteenfold in a four-year period, from $100 billion in 1999 to $1.3 trillion in 2003.[1] Rising Internet use has placed strains on the Internet infrastructure, with service disruptions and access problems becoming more frequent.

- The potential of telecommunications technology to affect travel behavior has been recognized since the invention of the telephone. However, the so-called information revolution has not been accompanied by a noticeable decrease in travel. Some studies have indeed found telecommunications and travel to be substitutes, but others have found them to be complements (i.e., use of one mode encourages or involves the use of another, or the use of one mode makes use of another more efficient). The enhancement and efficiency effects of telecommunications on travel may outweigh the substitution effects.[8]

- Telecommuting has not been adopted as rapidly as some have predicted, and even once adopted it is only a temporary choice for many; one study found a median telecommuting duration of nine months. The choice of whether to telecommute depends on both external constraints (lack of job suitability,

management willingness, appropriate technology) and internal constraints (desire for workplace interaction, insufficient self-motivation, concern about visibility for advancement). Given these inherent barriers, telecommuting may continue to be a relatively small phenomenon, even though external constraints may diminish over time. On the other hand, the growth of mobile work and self-employment, often in home-based businesses, and their effects on travel have not been sufficiently studied. Although studies have focused on the shift of work from one specific place (the regular office) to another specific place (home or a telecenter), a much greater transformation might be occurring toward working "anytime, anyplace." Within the context of both self-employment and conventional salaried employment, work has become more mobile. The impacts of teleshopping and e-commerce on travel also remain uncertain.[8]

- The telecommunications revolution also has safety implications for highway transportation. These are both negative (e.g., drivers distracted by cell phone use) and positive (e.g., use of cell phones by passing motorists to call for help and report accidents).

- Employers want to (1) operate during similar hours each day for efficient operation of the economy, which causes rush hours, and (2) operate mainly in low-density workplaces spread throughout the metro area, for reasons of mobility, cost and better access to suburban workers and markets. Employees generally want to (1) have access to a wide range of choices of where to work and live, (2) combine multiple purposes by linking trips, (3) live in relatively low-density communities, and (4) separate their own dwellings spatially from families with lesser incomes and lower social status. This last tendency appears especially strong for households with school-aged children. It is not possible to pursue all of these objectives effectively without generating substantial traffic congestion, especially during peak travel times. Yet most people will endure considerable congestion rather than give up any of these objectives. Therefore, congestion is not a soluble problem; rather, it is an inherent condition in the quality of metropolitan life. Traffic congestion is a worldwide phenomenon, and it is worse in most of the rest of the world than in the United States.[7]

- Expanding capacity can reduce the duration of peak-hour congestion and better serve areas where population is growing. It cannot eliminate congestion, however, because when a road's capacity is expanded, additional drivers converge onto the added space from other roads, other times and other modes. (In some circumstances, new trips may be generated as well.) This phenomenon of "triple convergence" soon raises traffic density back to congested levels.[7]

Intelligent Transportation Systems

- **National Findings:** ITS encompass a wide range of systems that use advanced computer, information and communications technology to improve the performance of transportation systems. The federal government has supported a comprehensive program of ITS research, development and implementation over the past decade. A variety of systems are now in place in cities throughout the nation. One example of ITS consists of advanced traffic control and management systems, which range from traffic signal coordination to incident detection and response. Another example is performance measurement and information dissemination, giving drivers accurate real-time information about travel times on their intended routes and providing incident information via variable message signs, in-vehicle devices or the Internet. In the long run, such information may produce better informed, more demanding customers, who will be more supportive of public investments in operational improvements when they deliver real benefits. These ITS technologies all offer the advantage of allowing "real time" responses to changing or unexpected traffic situations on the roadway network.[1]

  - Vehicle-highway automation technologies and systems are on the leading edge of ITS. They can be described in four categories: warning systems that sense and then advise drivers of potential hazards, control assistance systems that augment the driver's ability to control the vehicle, control override systems that intervene in some aspect of vehicle control during unsafe conditions and automated control systems that control all motions of the vehicle. These systems may be implemented by technology contained entirely within the vehicle (i.e., autonomously), or by combinations of in-vehicle and infrastructure technologies (i.e., cooperatively). They promise substantial benefits to society and individuals in productivity, mobility and safety. In the latter area especially, these technologies have the potential to exceed human performance in attentiveness, consistency of responses and reaction time.[9]

  - Some argue that we are so heavily invested in our current infrastructure that small changes at the margin are all we can expect. The opposing argument is that automation has enough inherent advantages to contribute significantly to surface transportation systems in the 21st Century. The rate of future vehicle-highway automation will reflect market forces governing the services that suppliers think people need, tempered by consumers' capacity to accept and afford them. Automated collision warning systems are already available, and in the near future such systems may actually apply the brakes in certain situations. Systems that warn or assist drivers of vehicles about to run off the road may follow. Two other possible safety systems that offer great promise in the coming years are guidance of maintenance vehicles in bad weather and roadside obstacle detection. Some commercial trucks already use forward and side collision warning systems, which will soon be joined by lane-departure

warning and adaptive cruise control systems. Future truck-only lanes could become automated truck lanes, with a large potential fuel savings from close-formation, automated platoon driving. The economics of truck automation could become particularly attractive if the reduced stress and driving responsibilities justified the relaxation of driver duty-time limits.[9]

- Another potentially important beneficiary of automation is bus rapid transit. Within bus transit corridors, vehicles could be fully automated using lateral guidance and longitudinal control. Automated docking, together with alternative bus designs (low floors, wide doors), would reduce dwell times at stops. When operated outside the automated corridors, buses could be either manually controlled or operated using partial automation such as electronic guidance.[9]

- Research to date indicates that fully automated vehicle operation in controlled-access lanes can safely reduce the average spacing among vehicles at highway speeds. There are many challenges to be solved and questions to be answered, however. For example, relatively little is understood about human interaction with vehicle technologies. More research is needed on issues such as driver attentiveness during partially and fully automated driving; making successful transitions among manual, partially automated and fully automated driving; potential changes in driving behavior when these systems are available; and the acceptability to drivers of different levels of warning, control assistance and automation.[9]

- Another unanswered question is whether advancing technology will price low-income people out of the market for automobiles. Even today, an entry-level vehicle is almost one year's pay for many people. We may need to improve other modes of transportation, provide financial assistance to low-income auto buyers or both.

- Preservation of privacy in an ITS world is also a concern. ITS technologies can track a vehicle and, by extension, the movements of the driver.

➢ **Regional Findings:** MAG and its member jurisdictions are national leaders in the design and deployment of ITS, especially with regard to freeway management systems. In 1996, the U.S. Department of Transportation selected Phoenix as one of four U.S. cities for a large-scale ITS demonstration. The AzTech™ Model Deployment Initiative, as the Phoenix-area project was called, involved multiple jurisdictions with the Maricopa County Department of Transportation (MCDOT) as the lead agency.

- In September 1999, MAG embarked on an update of the region's ITS Strategic Plan originally prepared in 1995. This recently completed update,

emphasizing advanced systems and effective management strategies, will serve as the area's road map for investments in ITS infrastructure.

- The ITS Strategic Plan Update[10] recommends the following projects for deployment or expansion in the MAG region, at an estimated cost (for short-, mid- and long-term projects) of $325,000,000:
  - Traveler Information Systems
  - Freeway Management System
  - Arterial Management Systems (including SMART corridors)
  - Transit Management System (e.g., signal priority programs, transit stop arrival times)
  - Incident, Emergency and Event Management System
  - Telecommunications Infrastructure
  - Planning and Outreach Support
  - Commercial Vehicle Operations (e.g., ADOT ITS/Commercial Vehicle Operations Program)
  - Information Management

Alternative Fuels and New Energy Sources/Technologies

- **National Findings:** The market alone will not adequately address the challenges of oil dependence, air pollution and greenhouse gas emissions. New policies will need to be developed to guide technological and institutional changes toward a transportation system that provides mobility along with energy resource security and environmental sustainability.[11] The transportation sector accounts for approximately two-thirds of petroleum consumption in the United States.[4] U.S. transportation relies on petroleum for 97% of its energy.[11]
  - In 1997, personal mobility (passenger transportation) consumed 62% of the energy used for transportation in the United States. Personal highway vehicles consumed 84% of the energy used for personal mobility, followed by air travel with 13%. Bus and rail travel together accounted for less than 2%, about the same amount of energy used for recreational boating.[11]
  - Running out of energy is not the problem facing transportation as it enters the 21st Century. The current world petroleum consumption rate is approximately

27 billion barrels a year. Conventional oil reserves total approximately one trillion barrels, with up to another trillion remaining to be discovered. Economically recoverable unconventional petroleum resources (tar sands, oil shale, heavy oil) are believed to be at least as large. Additional unconventional resources, not presently recoverable, raise the total to nearly 20 trillion barrels. Moreover, liquid fuels can be made from natural gas at close to current market prices. Adding up known and speculative gas resources suggests a total of more than 150 trillion barrels of oil-equivalent energy resources. At a production rate of 100 billion barrels per year, roughly four times the current rate, these potential sources of liquid fuels would last 1,500 years.[11]

- However, the geopolitical concentration of resources and the existence of an organized cartel (the Organization of Petroleum Exporting Countries or OPEC) to exercise monopoly power can result in economic risk. Further, the interaction of strong demand growth with the long investment cycles needed to exploit any major new energy resource can cause price volatility and transient disruptions, with the potential to cause major economic damage. Energy security remains a serious concern, as the near-term outlook is for increasing U.S. dependence on imported oil and increasing world dependence on Middle Eastern oil controlled by OPEC. OPEC's share of world production is expected to grow from approximately 40% today to more than 50% by 2020. Avoiding future shocks by reducing transportation's dependence on oil and by increasing its ability to respond to fuel price rises could be worth tens of billions of dollars annually to the U.S. economy.[11]

- Any fuel that displaces petroleum in the transportation sector will have to perform well according to numerous criteria, such as sustainability, contribution to greenhouse gas, emissions on a life-cycle basis, contribution to emissions of key pollutants, toxicity, effect on land use, cost competitiveness and infrastructure requirements. Because technological advances have enabled vehicles burning conventional fuels to meet increasingly stringent emissions standards, alternative fuel use for environmental purposes may not become as widespread as previously thought.[12]

- Potential substitutes for conventional petroleum consist of both fossil and non-fossil fuels. The list includes other fossil fuel resources (heavy oil, oil shale, tar sands), natural gas based fuels, liquefied natural gas and synthetic liquids, methane hydrates, electricity derived from fossil fuels, ethanol or methanol from biomass, hydrogen and electricity from renewable resources. Many analysts consider hydrogen the ultimate energy carrier because of its non-polluting characteristics. It can be used in internal combustion engines, combustion turbines or fuel cells. While hydrogen has great potential as a replacement fuel in the next millennium, it must overcome many barriers, especially the high cost of producing pure hydrogen.[12] Similarly, all-electric

vehicles need to overcome energy-density and range issues associated with current storage battery technology.

- It is widely expected that concerns for carbon emissions (greenhouse gases) will provide the greatest incentive for the widespread use of sustainable fuels, which offer substantial reductions in carbon emissions compared to fossil fuels. However, given the availability of low-cost fossil fuels, strong policies will be needed to induce large-scale transitions to low-carbon fuels such as hydrogen or renewables. Without effective policies to induce transitions to low-carbon products, it is likely that natural-gas-derived fuels will see a steady but gradual increase in use in the transportation sector.[12]

- In the 1980s, advancing vehicle technology was harnessed to improve light-vehicle fuel economy. During the past decade, technical progress continued; however, in the absence of countervailing regulations, market forces have pulled technologies toward other amenities, such as higher vehicle capacity and performance (as represented in the sport utility vehicle, for example). Nevertheless, the potential exists for further incremental improvements in light-vehicle fuel economy of 30% or more. Ambitious research and development efforts hope to achieve much greater improvements. The U.S.-based Partnership for a New Generation of Vehicles is aiming for tripled fuel economy, with similar programs underway in Europe and Japan.[11]

- Hyrbid powertrains combine a combustion engine with electric drive components. Honda and Toyota have introduced practical ultra-low-emission hybrid vehicles to the U.S. market, with gas mileage of up to 70 miles per gallon. Direct-injection light-duty diesel engines, which have 40% better fuel economy than conventional gasoline engines, have gained a substantial market share in Europe. In addition, all major auto makers now have research and development programs for hydrogen-powered fuel cells, which are inherently more efficient than combustion engines and almost pollution-free. Substantial hurdles remain regarding on-board fuel storage and fuel supply infrastructure, however.[11]

- Most approaches to major improvements in fuel economy also involve reduced vehicle mass, along with streamlining and other energy-saving techniques. Concepts that involve intensive use of aluminum and other lightweight materials can cut vehicle mass 40% without compromising size or crashworthiness. However, the overall safety outcome will depend on how lightweight technologies are deployed. Focusing first on heavier segments of the light-duty fleet could enhance safety, but making cars lighter while leaving light trucks unchanged could increase safety risks.[11]

- Modes of transportation other than light-duty vehicles consume 40% of transportation energy. Freight trucks are the second largest energy users, and some options exist for both improving efficiency and reducing emissions. Technological advances for heavy trucks and jet aircraft are especially needed, because their energy use is growing steadily. Developing and implementing energy-saving technologies for these modes is an important task.[11]

➢ **Regional Findings:** Arizona state law requires public agencies to convert their vehicle fleets to alternative fuels over a period of years. All new transit buses must be powered by alternative fuels; the City of Phoenix has chosen liquefied natural gas for its bus system. These buses have proved very reliable, but the existence of a refueling station at only one of the city's two bus maintenance facilities has caused some logistical difficulties. More generally, the scarcity of alternative fueling stations throughout Maricopa County constitutes a deterrent to more widespread private use of alternative fuels, even though alternative-fueled vehicles enjoy special advantages with regard to the vehicle license tax and use of freeway HOV lanes.

- The 2000 Arizona legislature passed an alternative fuels incentive bill that was poorly written and threatened to deplete the state treasury through abuse of its provisions, while providing little environmental benefit. The bill's passage demonstrated a troubling lack of oversight by the legislative and executive branches. Despite subsequent damage limitation efforts, the fiscal and political harm caused by this legislation may set back the acceptance of alternative fuels in Arizona for many years.

Vehicle Emissions Reduction Technology

➢ **National Findings:** In the United States, transportation vehicles are responsible for 78% of all carbon monoxide emissions, 45% of nitrogen oxide emissions, 37% of hydrocarbon emissions, and 27% of human-caused emissions of fine particulate matter. Because of technological improvements to vehicles and fuels, however, motor vehicles produce less total pollution today than 25 years ago, despite a more than doubling of travel activity. Even so, transportation sources contribute substantially to unhealthy air in many parts of the United States, and the harm caused by some pollutants is far from fully reflected in emissions standards.[11]

- For the past 30 years, the United States has relied heavily on cleaner engine technology, driven by more stringent federal (and sometimes state) regulations, to reduce or limit air pollutant emissions. Given the dramatic growth in motor vehicle travel, the gains have been remarkable. From 1970 to 1997, tons of pollutants emitted by all sources have declined as follows: volatile organic compounds, 38%; carbon monoxide, 36%; particulate matter under 10 microns in diameter (PM-10), 32%; and lead, 98%. Only nitrogen dioxide

emissions increased, by 9%. Nevertheless, more must be done, as continued traffic growth threatens to overwhelm the gains made from cleaner-burning internal combustion engines.[1]

- The most promising way to deal with emissions (including carbon dioxide, which is linked to global warming although not technically a pollutant) still appears to be through the continued evolution of automotive engine technology. The advent of hybrid engines, new battery technology and hopefully fuel cell technology in the not-too-distant future is promising, but there are currently no strong economic or regulatory incentives for automobile companies to aggressively develop these technologies or for consumers to purchase cleaner, more fuel-efficient vehicles.[1]

➢ **Regional Findings:** The beneficial impact of lower-emission vehicles has been somewhat offset by the requirement for vehicle emission testing only in Maricopa County, and not in neighboring counties. As the metro region continues to expand, the number of untested and potentially non-compliant vehicles entering the county will rise, as people from adjacent counties commute in to work.

Roadway Design, Maintenance and Operations

➢ **National Findings:** Context-sensitive design, or flexible design, is a commitment to safety and mobility coupled with a commitment to preserve and protect the environmental and cultural values affected by transportation facilities. The objectives of context-sensitive design are to simultaneously advance safety, mobility, enhancement of the natural environment and preservation of community values. Designs need to meet the needs of specific sites rather than attempt to use centralized and standardized solutions. Designers should take advantage of the flexibility in the current design guidelines; however, more research is needed on the safety and liability implications of such flexibility.[13]

- Roadway design issues and initiatives in the 21st Century will include use of sophisticated design visualization tools, development of a *Highway Safety Manual* (similar to the existing *Highway Capacity Manual*), road safety audits, simultaneous vehicle and infrastructure design, special use highways (e.g., separate facilities for large trucks, automated highways), the Federal Highway Administration's Interactive Highway Safety Design Model and traffic calming (how can street design be used to control speed and volumes without compromising safety?). Areas in which additional research is needed to fill gaps in the state of the practice include:

  – Clear-zone design guidelines for modern landscaping practices

  – Design of at-grade intersections near railroad grade crossings

- Innovative designs for congested intersections
- Impacts of roadway design elements on traffic calming
- Implications of ITS, including in-vehicle systems, for design of roadway surfaces
- Improved design of freeway on-ramps and acceleration lanes
- Re-evaluation of horizontal curve design for comfort and safety
- Safety consequences of flexible design standards[13]

- Roadway infrastructure growth is slowing, so the maintenance and rehabilitation of existing infrastructure is becoming increasingly important. Preservation of assets and mobility are high-priority challenges for a highway system that is essentially in place. As the interstate highway system was completed, the federal government belatedly instituted a program of reconstruction, rehabilitation, resurfacing and restoration, and slowly expanded its role in funding these activities. The emphasis on maintaining and operating our existing system in lieu of new construction will continue well into the next century.[14]

- ITS, which provides real-time surveillance of the road network, and other new technologies promise numerous benefits in operating and maintaining the infrastructure, but also create a maintenance need quite different from that of the past. Managing technology-based assets requires skilled technicians and a proper preventive maintenance program to ensure maximum operability and cost-effectiveness. Maintenance personnel in the 21st Century will need technical skills in electronics, robotics, computerized systems, virtual reality, expert diagnostics and related areas to maintain our technology-based infrastructure.[14]

PUBLIC TRANSPORTATION

- **National Findings:** In 1990, only 50% of urban U.S. households lived within one-fourth mile (typically considered the maximum acceptable walking distance) of a transit route. Only 65% lived within one-half mile and 71% within one mile of a route.[4]

  - Transit's share of work trips fell from 6.4% in 1980 to 5.3% in 1990. This is not surprising given increasing auto ownership rates, dispersion of job locations, suburb-to-suburb commuting and the needs of many commuters to make stops enroute to or from work. Many transit agencies have, however,

reported ridership increases in absolute terms.[1] In some cities, such as Portland, Oregon, these increases have been quite dramatic.

- The transit mode share for work trips differs substantially by region. In 1991, the Northeast had by far the highest share at approximately 11%, followed by the West at 4%, the Midwest at 3.5%, and the South at 2.5%.[2] The older northeastern cities tend to be densely populated and have a long history of large-scale transit usage.

- Except in a few of the nation's largest cities, buses provide most public transportation services. In 1997, buses carried 61% of all unlinked transit passenger trips and accounted for 47% of transit passenger miles.[15]

- In the early part of this century, trends such as the decline in population of many central cities, the growth of suburbs, the dispersion of employment and the increase in automobile ownership will continue to negatively affect bus ridership levels. Suburban areas, where most metropolitan residents now live, are not conducive to bus transit because of dispersed population and employment. However, factors contributing to an improved climate for bus transit will include an increasing desire to avoid congestion and suburban sprawl, and to revitalize cities and alleviate air pollution. Although this revival is unlikely to match the heyday of bus transit after World War II, bus ridership in the 21st Century has the potential to increase significantly.[15]

- Rail transit systems account for more than half of all peak-hour entrants into downtown New York, Chicago, Philadelphia and Toronto. In 1995, traditional and regional rapid transit lines accounted for 23% of transit boardings in the United States, and commuter rail for another 9%. Many regional and commuter rail systems are attempting to adapt to the concentration of population and job growth in suburbs and "edge cities." For example, Caltrain, the commuter rail line linking San Francisco and San Jose, has restructured its service to enable people living in its service areas to reach destinations other than downtown San Francisco, and not just during rush hours. Chicago's Metra and New York's Metro-North have embarked on similar efforts. New commuter rail systems in Southern California and South Florida, while focused on central business districts, carry substantial traffic between suburban points. The newest light rail line to open in San Diego (Mission Valley) operates through an edge city environment, connecting two regional malls, numerous office buildings, several hotels, multi-family housing complexes and a stadium. There is a substantial and growing transit ridership to all of these destinations throughout the day.[18]

- The long-term implications of rail system development for urban areas are hard to predict, but as a prerequisite, land development in the United States

will need to begin creating patterns more conducive to a rail environment. Population pressures, combined with growing public concern about the impacts of sprawl, could favor higher density construction near primary and secondary urban centers. If congestion costs rise and automobile travel becomes more expensive and more difficult, economic forces could favor higher density development, with a resulting growth in the demand for higher capacity transit.[18]

- Light rail transit, a modernized version of the at-grade metropolitan electric railway or streetcar, has enjoyed a renaissance in the United States during the last two decades. Since 1980, when only seven American cities retained this mode, new light rail systems have opened in Baltimore, Buffalo, Dallas, Denver, Los Angeles, New Jersey (Hudson and Bergen counties), Portland, Sacramento, St. Louis, Salt Lake City, San Diego and San Jose. All but one of these cities have subsequently expanded their original system or are currently doing so. Several other cities are currently planning and designing light rail. In contrast, no heavy rail transit systems (fully grade-separated subways) are planned in cities that do not already have such systems.

- Light rail benefits from great locational flexibility, which permits compatibility with many physical environments and right-of-way types: fully grade-separated, semi-exclusive and shared. A light rail train can be operating on a reserved alignment as high-speed rapid transit, and then moments later in a surface street lane shared with other traffic.[19] In addition, light rail is generally the least expensive form of rail transit to build.

- Basic light rail technology is being greatly improved through significant enhancements in passenger comfort, conveniences and electronics. Low-floor vehicles are increasingly being used (as they are in bus transit) to make boarding easier and faster. Future innovations in light rail vehicle design may include high-performance partial low-floor cars; new car-body fabrication materials and methods to reduce capital costs and energy consumption; energy absorption designs for better crashworthiness; and multiplexing of train lines to reduce onboard wiring requirements. Ticket vending machines provide better bill readers and debit and credit card sales ability. Use of both contact and contactless "smart cards" will increase. Developments in fiber-optic communications and personal computer-based databases will lead to significant improvements in managing multimedia, seamless fare structures among multiple transit carriers. For the track and roadbed, the emphasis will be on durability, ride quality, and reduction of noise and vibration, with increasing use of concrete cross ties and innovative "direct fixation" systems in the placement of tracks. Another innovation will be the match of low-profile girder rail and a reduced-vertical-profile supporting slab, which together will

help reduce the amount of excavation and related utility relocation required for in-street trackage.[19]

- The designs of light rail overhead contact system elements may be refined to reduce visual intrusion and to include wider use of higher voltages. Other alternatives will continue to be researched and tested in order to develop ground level and buried methods of power distribution. Communications-based train control is undergoing field trials. Finally, improved computers and fiber-optic data transmission technologies will continue to reduce costs and expand the amount of management information available to light rail operators. Automated, real-time train location will become common, and all major stations will have real-time train arrival information to enhance customer convenience.[19] Many non-guideway-related improvements, such as smart cards and real-time arrival information, are equally applicable to bus transit.

- Bus rapid transit is increasingly becoming recognized as a practical alternative to light rail for high-speed, high-capacity service. Buses can be used successfully on a fully or partially separated right-of-way, as is the case on sizeable busway networks in Ottawa and Curitiba, Brazil. In the United States, Pittsburgh and Miami have smaller busway systems. A guided bus system operates in Adelaide, Australia. All of these operations benefit from full separation from other traffic on substantial portions of their lines, although, like light rail, they generally are not separated over their entire length. They also take advantage of buses' ability to branch out on outer sections of lines.[20] Buses operating on streets can be given the same types of stations, exclusive travel lanes and traffic signal priority as light rail vehicles.

- Automated people movers (APMs) provide high quality circulation within major activity centers, as well as connections between such centers and longer-distance modes. Their exclusive rights-of-way and driverless operation allow frequent and unimpeded service, enhancing their attractiveness to riders. Nearly 100 APMs are in service worldwide: roughly half are in airport and leisure settings, one-fourth operate as mass transit, and the remainder are operated by non-transit institutions such as hospitals, retail malls, special districts and development districts. Some have been in operation for 30 years or longer. APMs can be constructed very quickly compared with conventional rail transit, but the capital costs are substantial.[21] Such a system is under consideration as a long-term project to serve Sky Harbor International Airport as an internal circulator with a connection to regional light rail.

- Personal rapid transit involves the use of small, taxi-sized vehicles to provide on-call, nonstop service using an automated fixed guideway system. Unlike more conventional APMs, personal rapid transit is not a mature technology,

and there are varying opinions about its potential feasibility and cost-effectiveness.[21]

- Proposals for new high-speed trains, such as the French TGV or Japanese bullet train, and magnetically levitated (maglev) systems in the United States have been advanced many times over the last 15 years. Barriers to the development of extensive networks include: dispersed travel patterns, a mature air carrier system, cost (can we afford another network even if it is superior to existing highway and air networks?), and local opposition to any transportation system that will require new rights-of-way and operate near existing communities. However, public interest in high-speed trains and maglev systems remains strong. A Transportation Research Board committee suggested that selected high-speed rail or maglev lines integrated with the air system are more promising than extensive networks of such lines. Rail lines in corridors with high air traffic volumes, such as San Francisco to Los Angeles, might substitute for added airport capacity. But they would require unprecedented intermodal and public-private partnerships, and this represents a major challenge, as the abortive Florida high-speed rail plan demonstrates.[1]

- A more likely scenario for the immediate future is the incremental upgrading of existing passenger rail lines with electrification, selected alignment improvements, track improvements and "tilt trains" such as Amtrak's new Acela, which will enhance passenger comfort by reducing the effects of centrifugal force. Amtrak has already implemented this less costly approach to high-speed rail service in the Northeast Corridor (Washington-New York-Boston).[1] However, the prospects for similar improvements in other corridors are diminished by the lack of state and regional funding mechanisms, and the uncertain future of Amtrak under its current mandate to achieve independence of operating subsidies.

- The use of existing freight lines for higher-speed rail service is problematic for several reasons, including the opposition of freight rail operators who own the track, the need to substantially rebuild existing track and signal systems after years of minimal maintenance, and safety issues associated with roadway grade crossings. The Federal Railroad Administration limits most Amtrak service to a maximum speed of 79 mph, and lower speed limits exist in many areas.

- The Americans with Disabilities Act (ADA) now requires all transit systems to offer complementary paratransit (dial-a-ride and similar services) to all eligible persons who, either because of the nature of their disability or because of the inaccessibility of streets or stops, cannot use fixed-route bus transit. Many transit systems also provide paratransit for others, especially non-ADA-certified seniors and persons with disabilities. From 1990 to 1996, paratransit's share of

the overall transit market grew from 0.77% to 1.2% of passenger trips.[16] This trend is likely to continue, reflecting an aging population that will increasingly require door-to-door service. On the other hand, the high cost (per passenger trip) of paratransit has induced many transit agencies to restrict these services to ADA-eligible riders only. As a result, social service agencies may find themselves saddled with rising demands for transportation services. The lack of reasonable alternatives leads some senior citizens to continue driving when they can no longer do so safely.

- Paratransit generally faces the challenge of increasing service intensity while reducing cost. The operating cost of today's demand-responsive services is about $13 per passenger trip, versus about $2 for fixed-route bus service.[17] As long as the vehicles require human drivers, labor costs will remain a major issue, particularly for this very labor-intensive type of public transportation.

- **Regional Findings:** MAG currently projects the share of regional person-trips carried by transit to increase from 0.8% today to 1.3% in 2040, with the total number of transit trips in the region more than tripling from 78,000 (origin-destination trips, not vehicle boardings) to 254,000. Much of this projected increase will depend on expansion of the transit system into areas not currently served.[5] This projection is based on the low level of transit service provided until very recently throughout Maricopa County, and continuing today except in Tempe and Phoenix.

  - The current MAG long-range transportation plan includes tripling local bus and dial-a-ride service, quadrupling express bus service and building a regional fixed guideway transit system. However, development of an effective metropolitan transit system is hampered by the lack of a regional funding source for public transportation. Two attempts to enact a countywide sales tax for transit, in 1989 and 1994, were defeated by voters. Large-scale transit improvements, including light rail, are therefore being implemented city by city, with Tempe and Phoenix taking the lead after successful sales tax elections. Such funding of improved transit systems through local sales tax increases is not always a fiscally or politically viable option for smaller cities. The already large differences in transit service levels between Maricopa County jurisdictions are only likely to increase until a regional funding mechanism can be found.

  - The cities of Phoenix, Tempe and Mesa are currently designing the 20-mile Central Phoenix/East Valley light rail system from Chris-Town Mall to the East Valley Institute of Technology via downtown Phoenix, the Sky Harbor International Airport area and downtown Tempe. This line is scheduled to open in late 2006. Extensions east to downtown Mesa, north to Metrocenter and west to downtown Glendale are planned; of these, only the Metrocenter

route is currently funded. High-capacity transit system planning for the rest of the MAG area continues despite the current lack of dedicated funding outside Phoenix and Tempe. Scottsdale and Tempe have joined forces for a north-south rapid transit corridor study, while Chandler is initiating a Major Investment Study. More efforts such as these can be expected in the future, especially if the Central Phoenix/East Valley line is perceived as a success.

BICYCLE AND PEDESTRIAN TRANSPORTATION

- **National Findings:** In 1990, the Federal Highway Administrator described bicycling and walking as "the forgotten modes" of transportation. For most of the preceding decade, these two non-motorized transportation options had been largely overlooked by federal, state and local agencies. An average of just $2 million of federal transportation funds was spent each year on bicycle and pedestrian projects, and the percentage of commuting trips made by bicycling and walking fell from a combined 6.7% to 4.4% between 1980 and 1990 (U.S. Census data). Relatively low costs of driving, low-density land uses, lack of non-motorized access across large commercial and residential developments, lack of facilities and programs and lack of integrated land uses contributed to this trend.

  - Also in 1990, the U.S. Department of Transportation adopted a new national transportation policy that, for the first time, specifically sought to "increase use of bicycling, and encourage planners and engineers to accommodate bicycle and pedestrian needs in designing transportation facilities for urban and suburban areas," and to "increase pedestrian safety through public information and improved crosswalk design, signaling, school crossings, and sidewalks."

  - The National Bicycling and Walking Study was a landmark report that ushered in a period of unparalleled progress for bicycling and walking. Soon after Congress commissioned the study, it passed the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which permitted the use of extensive federal highway funding for bicycle and pedestrian improvements. Spending of federal transportation funds on these two modes rose from $6 million in 1990 to more than $238 million in 1997.

  - By 1999, virtually all major federal transportation funding programs could be used for bicycle and pedestrian activities, in contrast to 1990, when many of the federal-aid funding programs were closed to bicycle and pedestrian improvements, and no state was allowed to spend more than $4.5 million of federal funds annually on bicycle and pedestrian projects. Despite this remarkable change, expenditures on bicycling and walking are still only 1% of

total transportation spending, even though these modes account for 7.9% of all trips and approximately 16% of traffic fatalities.

- In February 1999, the Federal Highway Administration issued a Guidance Memorandum regarding the bicycle and pedestrian provisions of the Transportation Equity Act for the 21st Century, which succeeded ISTEA. The memorandum is very supportive of bicycling and walking, and clearly establishes that these modes are an important component of the transportation system, stating that:

  – "To varying extent, bicyclists and pedestrians will be present on all highways where they are permitted and it is clearly the intent of [the legislation] that all new and improved transportation facilities be planned, designed, and constructed with this fact in mind";

  – "We expect every transportation agency to make accommodation for bicycling and walking a routine part of their planning, design, construction, operations and maintenance activities"; and

  – "Bicycling and walking ought to be accommodated as an element of good planning, design and operation."

➢ **Regional Findings:** The City of Tempe has a bicycle mode split of 4.5% for work trips, in large part due to investment in bicycling infrastructure, the location of Arizona State University and other large employers within Tempe, and relatively compact and mixed land uses. Within the past five years, Tempe has begun to invest extensively in its bicycle and pedestrian infrastructure (sources: Maricopa County Department of Transportation By-Cycle Newsletter, March 2000; City of Tempe Bicycle Program). Other major cities in the MAG region also made substantial progress in expanding their bikeway systems during the 1990s.

- MAG has taken an active role in fostering the use of non-motorized modes of travel. Recent projects include the Pedestrian 2000 Plan, which contains design guidelines for the development of pedestrian-friendly facilities; the 2001 Regional Off Street System Plan, which defines a system of off-street bicycle and pedestrian paths throughout the county; the Regional Bike Map, which identifies paved multi-use paths, bike lanes and bike routes throughout the metro area; and the Regional Bicycle System Plan. The region's climate makes bicycles a viable form of transportation for much of the year. All transit buses in the region are equipped with bike racks.

- In Maricopa County, approximately 40,000 adults travel to work by bicycle each day. The estimated total distance ridden in the county by bicycle

commuters is nearly 450,000 miles per day (source: By-Cycle Newsletter, March 2000).

FREIGHT TRANSPORTATION

- **National Findings:** The roadway system is the primary infrastructure not only for passenger transportation but also for freight. These freight services are provided by thousands of private trucking firms.[1] Freight is also carried by rail, ship and increasingly by air.

  - Economic deregulation starting in the late 1970s, together with information technology and the globalization of industry, has prompted a re-engineering and reorganization of service delivery and an integration of transportation into the supply chain of manufacturers. Just-in-time delivery and airline hub-and-spoke systems illustrate the changes (in passenger as well as freight transportation). Companies are increasingly outsourcing their logistics. There has also been considerable consolidation, downsizing and streamlining, particularly in the railroad industry. From 1985 to 1997, Class I railroad ton-miles handled increased by 59% while employment declined by 41%. Competition appears generally healthy despite consolidation, and productivity has been growing.[1]

  - In addition to deregulation, another national level policy change that has affected urban freight was NAFTA of 1992. Its purpose was to lower trade barriers among the United States, Canada and Mexico so that import/export activity would increase. In many places, especially at border crossings, the result was exacerbated congestion that actually inhibited the movement of freight across the border. NAFTA has also placed an even greater demand on the urban transportation systems that lacked expansion plans to handle the increased volume.[22]

  - Many other factors and trends are influencing urban freight movement. For example, the combination of increased shopping from home (via catalogs, cable television shows and the Internet) and efficient package delivery companies (Federal Express, United Parcel Service) has increased trips to local businesses and homes. One study estimates that the percentage of retail sales occurring in stores, as opposed to non-store retailing, will decline from 85% in 1992 to 45% in 2010. An increasing proportion of all types of retailing will require next-day delivery and door-to-door express service; this will drive freight demand and supply away from long-haul carriers and toward air carriers, coupled with less-than-truck load or smaller-class truck freight shipments.[22]

- The adoption of "just in time" inventory systems based on express shipping has substantially reduced the need for warehousing. Freight volumes are increasing while per unit profitability has declined. This results from the growing influence of freight "integrators," such as United Parcel Service and Federal Express, that provide door-to-door service and control all aspects of freight movement.

- The Internet has allowed some shipping companies to make better use of their facilities: trucks that would once have deadheaded after dropping off their cargo may now be carrying goods in both directions, as facilitators match up cargo loads with available space.

- ITS will play an increasingly important role in improving traffic flow and improving the logistics of urban goods movement. The use of global positioning systems for tracking and communication will expand in the future, as trucking firms and package delivery companies increasingly use such systems to track vehicle and parcel flow. These systems will provide information about incidents and help reroute vehicles more efficiently. Automated vehicle location, automated bills of lading and electronic vehicle tagging will also enhance freight transport in and through cities.[22]

➢ **Regional Findings:** Most freight is carried to and through Maricopa County by truck, although the two Class I railroads — Union Pacific and Burlington Northern Santa Fe — will continue to play key roles in the region's freight transportation system. I-10 in the MAG region is a major east-west route for interstate freight traffic, although through truck traffic is now being encouraged to use bypass routes around the Phoenix area. One major issue affecting the MAG region is the need to designate a route for the CANAMEX corridor, created under NAFTA to link Mexico with Canada, from I-10 west of Phoenix to US 93 near Wickenburg. Another issue involves safety standards and enforcement for the large number of Mexican trucks that will use Arizona and Maricopa County roadway systems in accordance with NAFTA.

COMMERCIAL AVIATION

➢ **National Findings:** In 1995, 16% of all intercity trips of greater than 100 miles occurred by air.[1] Approximately four-fifths of all non-automobile intercity trips are made by air.[2]

- In aviation as in the vehicle/highway system, capacity has not kept pace with traffic growth. Although several older airports have added runways, Denver International is the only new U.S. carrier airport opened in the last 25 years.[1]

- With many industry analysts predicting a more than doubling of passenger traffic in the next 10 to 15 years, the current and much publicized delay problem will only worsen. Obsolete technologies in such areas as air traffic control and navigational aids compound the problem. There are particular concerns about Federal Aviation Administration staffing and outdated equipment, with partial or full privatization proposed by some as a remedy.[23]

- Key questions include: What are the implications of the changing fleet mix and new technology, such as the Global Positioning System? What will be the future aircraft mix at commercial service airports? Will super-jumbo aircraft be landing in large numbers? Will a technology breakthrough eliminate the wake vortex problems that keep the spacing of landing and departing aircraft far apart? Advances in precision guided-instrument approaches are on the near horizon, with Differential Global Positioning Systems and precision runway monitoring. Opportunities exist for improved taxiway guidance and flight deck management systems to reduce aircraft separation requirements. These new advances will offer some mitigation of increasing delays in the near term.[23]

- One issue concerning aircraft and airport compatibility involves the potential introduction of new super-jumbo aircraft. Market forces will determine whether the new large aircraft proposed by Airbus and Boeing, with a wing span of nearly 60 meters and a capacity of 600 to 1,000 passengers, will ever be built in large quantities.[23] Getting so many people on and off the plane in a reasonable time could present a challenge.

- In the next century, technological advances in satellite-based communications and computer technology will keep air traffic moving safely along more efficient routes than are available today. Powerful computers will monitor or control virtually every function of the plane, often with little interaction by the cockpit crew. The flight crew will exchange information with air traffic controllers over high-speed digital data links. On-board collision avoidance and advanced traffic display systems will allow the pilot to be an active participant with the controller in ensuring the safe separation of aircraft. The cockpit will be so "information rich" that pilots will be able to operate their aircraft under conditions of free flight, in which long-term route, speed or altitude clearances are no longer necessary.[24]

➢ **Regional Findings:** During the period from 1987 to 1997, Phoenix Sky Harbor International Airport experienced an increase in annual commercial enplanements of two-thirds, from 8.79 million to 14.65 million, raising Phoenix's ranking from fourteenth to eighth in the United States in 10 years.[3] Annual passenger boardings are projected to more than triple, from 19.0 million to 58.1 million, over the next 40 years, with total aircraft operations nearly doubling during the same period. The most dramatic increase in aviation activity, however,

will be in freight traffic, with the amount of cargo rising from one-half million tons in 2000 to nine million in 2040.[5] Sky Harbor is also one of the busiest general aviation facilities in the nation.

- Because of the extensive Phoenix operations of two major airlines (America West and Southwest), Phoenix has become a major hub for passenger connections. Currently, about one-fourth of air passengers who travel through Sky Harbor are connecting from one flight to another.[6] Maricopa County residents, indeed all Arizonans, currently benefit from the keen competition between these two carriers, and also from the wide variety of destinations served directly from Phoenix due to the city's "hub" status. The continuation of these advantages in the future depends largely on the vicissitudes of the airline industry, rather than on any decisions made by local policymakers. Indications of an impending wave of airline mergers give cause for concern. Sky Harbor and its users will continue to enjoy the advantages of a central metropolitan location, however.

- The predominant air carrier aircraft in the fleet currently serving Sky Harbor is the Boeing 737. While this aircraft is expected to remain the principal aircraft type in the near future, the addition of more international service may result in a higher proportion of larger aircraft.[6] Two airlines now provide direct, daily flights from Phoenix to London and Frankfurt, and the City of Phoenix is working hard to attract more overseas service.

- The City of Phoenix recently opened a third runway at Sky Harbor to accommodate air traffic increases. A fourth runway is under consideration, as are extensive landside improvements, such as construction of a very large passenger terminal to replace existing Terminals 2 and 3. In the longer run, a fixed-guideway people mover will connect various airport locations with the Central Phoenix/East Valley light rail transit system.

- Despite these ambitious improvements, increasing commercial traffic at Sky Harbor will tend to divert more general aviation traffic to the 15 other civilian airports throughout the region. The MAG Regional Aviation System Plan Update, adopted in December 1993, recommended runway extensions at Buckeye, Glendale, Mesa and Wickenburg; transformation of Williams Gateway Airport into a supplemental commercial service airport as demand warrants; and development of new general aviation airport sites after 2015. Potential projects beyond the normal 20-year planning horizon include construction of a new commercial service airport and the development of more public-use heliports.[6]

- Increasing activity at Sky Harbor means that jet aircraft noise will continue to be an issue for adjacent communities. Although future generations of aircraft

will be quieter than today's, it may take several decades for the existing fleet to turn over.

- Competition between air cargo flights and passenger flights for limited takeoff slots at Sky Harbor could become an issue in the long-term future. This problem is usually avoidable where night operations are unrestricted, but complaints from communities affected by aircraft noise have led to late-night closure or restrictions at other airports (e.g., San Diego). If this ever happens at Sky Harbor, freight operations might have to be relocated to Williams Gateway or another facility.

ABBREVIATIONS

ADA	Americans with Disabilities Act
ADOT	Arizona Department of Transportation
APM	Automated People Mover
HOT	High Occupancy and Toll
HOV	High Occupancy Vehicle
HURF	Highway User Revenue Fund
ISTEA	Intermodal Surface Transportation Efficiency Act
ITS	Intelligent Transportation Systems
MAG	Maricopa Association of Governments
maglev	magnetically levitated
MCDOT	Maricopa County Department of Transportation
mph	miles per hour
NAFTA	North American Free Trade Agreement
OPEC	Organization of Petroleum Exporting Countries
PM-10	Particulate matter pollutants under 10 microns in diameter
VMT	Vehicle Miles of Travel

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