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Arizona State Freight Plan

(ADOT MPD 085-14)

Future Scenarios and Implications for Freight Transportation

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Solutions for growing economies

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Working Paper

This working paper summarizes the results of a freight forecasts through 2040 and the potential implications on Arizona's transportation system.

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Executive Summary

This working paper summarizes the results of freight scenarios forecasted through 2040 and their potential implications on the Arizona transportation system. The scenarios include the Base Case and three alternative scenarios developed during the freight scenario planning workshop, held in Phoenix on November 5th, 2015. The scenario planning process intentionally produces very different and extreme alternative futures that are developed to cover a wide breadth of possible futures. The alternative scenarios are referred to as Domestic Bliss, #Urbanizona, and SOBO (South of the Border). The key assumptions, and major transportation system implications of the scenarios are summarized below.

• **Base Case:** This scenario has Arizona experiencing a significant growth in population and an increasing number of exports in high-tech industries. Arizona maintains its reliance on population growth to stimulate economic growth and its economic linkages with Mexico stay much as they are now, resulting in tonnage and value continuing to grow.



- Key Commerce Corridors (KCC) such as I-10, I-19, I-17, I-10 and I-11 show significant truck growth.
- Trade between Arizona and Mexico will almost triple, requiring action to address port of entry capacity and congestion on primary corridors (i.e. SR 189, I-19, I-10).
- 1% of rural and 13% of urban miles are at Level of Service F.

• **Domestic Bliss**: This scenario manifests itself in a dampening of international trade and instead a re-focusing on domestic markets. There are many smaller scale urban clusters all along the Sun corridor. These populations are dense – but at a small scale.





- Compared to the 2040 Base Case, Domestic Bliss is anticipated to have two percent overall truck growth.
- Slightly less congestion than Base Case in metro areas as population is distributed more evenly (e.g. both rural and urban growth).
- This scenario exacerbates some of the issues freight flows already experiences in rural areas of the state (e.g. lack of redundancy in the network, lack of climbing and passing lanes, and peak period congestion at rural junctions and population centers).
- #Urbanizona: This scenario manifests itself in tremendous growth in the populations of Phoenix and Tucson. The majority of the new population are younger, highly skilled professionals, choosing to live in urban condos. The shared economy has taken full root in Phoenix and Tucson and the number of vehicles owned per capita has been reduced. Arizona is still a major distribution hub for retailers bringing product from the coasts to the interior.



- Compared to the 2040 Base Case, #Urbanizona will experience six percent overall truck growth.
- Increasing use of air cargo (for higher value goods).
- Last mile deliveries serving concentrated population in metro areas are plagued by urban congestion.
- Approximately 16 percent of roadway miles operating at Level of Service F (ties for highest with SOBO).



• **SOBO (South of the Border):** This scenario manifests itself in a re-focused economy looking south to Mexico and other Latin American countries for markets and products. Mexico has replaced China as the primary manufacturing hub for North America. There are more border communities serving this huge and still growing cross boarder economic activity.



- Compared to the 2040 Base Case, SOBO will experience 11 percent overall truck growth.
- Highest overall freight growth of any scenario, resulting in greatest percentage of Arizona system operating at an unacceptable level (16 percent of roadway miles operating at Level of Service F).

The future scenarios and forecasts are intended to position the Arizona State Freight Plan to effectively *prepare* for an unknown future. Each scenario reveals a different set of potential economic outcomes and different transportation system impacts. Taken as a whole, the scenarios reveal the following:

- All scenarios increase congestion and delay on the roadway network, resulting in additional travel time. Congestion and delay directly affect the timeliness and reliability of freight transportation, increasing cost and decreasing economic productivity.
- Though the actual change in congested miles within rural areas does not vary substantially for the various scenarios, congestion and delay in urban areas is exacerbated by all scenarios.
- Overall, truck vehicle miles of travel increase in all scenarios, as trucks will likely travel longer distance using alternative routes.
- The sketch-level modeling exercise reveals that **congestion is primarily driven by the growth of population and employment**. Trucks are a component of this congestion, and therefore, affected by this congestion (both local and through). Because the origins and



destinations of the truck component of congestion are largely in urban areas, truck traffic is inexorably linked to them.

Next Steps

The freight scenarios inform upcoming phases of the Arizona State Freight Plan, including the identification of strengths, weaknesses, needs, projects and the development of a prioritization approach to focus future planning and implementation efforts.



Acronyms and Abbreviations

ADOA	ARIZONA DEPARTMENT OF ADMINISTRATION
ADOT	ARIZONA DEPARTMENT OF TRANSPORTATION
AZTDM2	ARIZONA TRAVEL DEMAND MODEL VERSION 2
CG	CONSUMER GOODS
DCS	DISTRIBUTION CENTERS
EPS	OFFICE OF EMPLOYMENT AND POPULATION STATISTICS
FAF	FREIGHT ANALYSIS FRAMEWORK 3 (FAF3)
GDP	GROSS DOMESTIC PRODUCT
TIL	JUST-IN-TIME
LOS	LEVEL OF SERVICE
LTL	LESS THAN TRUCKLOAD
MN	MANUFACTURING
MPO	METROPOLITAN PLANNING ORGANIZATION
NHTS	NATIONAL HOUSEHOLD TRAVEL SURVEY
NR	NATURAL RESOURCES
POES	PORT OF ENTRY
SOBO	SOUTH OF THE BORDER
STEEP	SOCIAL, TECHNICAL, ECONOMIC, ENVIRONMENTAL AND POLITICAL
TAZ	TRAFFIC ANALYSIS ZONE
TL	TRUCKLOAD
ТРР	TRANS-PACIFIC PARTNERSHIP
TR	TRANSPORTATION AND LOGISTICS
U.S.	UNITED STATES
V/C	VOLUME TO CAPACITY
WIP	WORK IN PROGRESS



Introduction

Key Messages

The Arizona Department of Transportation, Multimodal Planning Division, retained a team lead by CPCS Transcom Inc. to assist in the development of Arizona's State Freight Plan.

The State Freight Plan will define immediate and long-range investment priorities and policies that will generate the greatest return for Arizona's economy.

This working paper summarizes the results of the freight forecasts developed as part of Phase 6 of the Work Plan. The forecasts include a Base Case and three alternative forecasts to illustrate a potential range of outcomes affecting future freight transportation needs and issues in the state.



1.1 Arizona State Freight Plan Objectives

The Arizona State Freight Plan will define immediate and long-range investment priorities and policies that will generate the greatest return for Arizona's economy, while also advancing other key transportation system goals, including national goals outlined in MAP-21. It will identify freight transportation facilities in Arizona that are critical to the state's economic growth and give appropriate priority to investments in such facilities.

The State Freight Plan will ultimately provide Arizona with a guide for assessing and making sound investment and policy decisions that will yield outcomes consistent with the state's visions, goals, and objectives, and notably, promote regional competitiveness and economic growth.

1.2 Purpose of this Working Paper

This brief working paper summarizes the results of a scenario planning workshop, held in Phoenix on November 5th, 2015. The resulting scenarios are to inform the development of future forecasts and resulting implications for the Arizona freight transportation system (in Phases 6 and 7 in the development of the State Freight Plan). These future scenarios will complement Base Case forecasts and are intended to position the Arizona State Freight Plan to effectively *prepare* for an unknown future.

1.3 Framework for Scenario Development

1.3.1 Introduction to Scenario Planning

Unlike forecasting, which projects historic trends into the future, scenario planning imagines alternative but plausible futures and "backcasts" them to the present. Rather than try to predict the future, as is done in forecasting, scenario planning provides a means of preparing for alternative futures. The scenarios are intentionally extreme to cover a wide range of alternative futures, providing ADOT with a variety of contexts to place future infrastructure investments.



Future Scenarios Driving Factors "Backcasting" Social Future 1 to the Present Today Technological What future(s) should Arizona Economic Future 2 be preparing Environmental for, how? Future 3 Political

Figure 1-1: Backcasting Future Scenarios to the Present

Source: MIT Center for Transportation & Logistics; adapted by CPCS

1.3.2 Identification of Key Drivers of Future Scenarios

Many factors influence the competitiveness and growth of Arizona's freight sectors and associated freight flows, as well as Arizona's broader economy. Beyond the transportation issues identified in the Economic Context Report (Phase 3), these factors can be organized using the "STEEP" (Social, Technical, Economic, Environmental and Political) drivers framework.

Figure 1-2: The STEEP Framework

Driver	Description
Social	Broad societal factors including demographics, income, consumption patterns, population location and density, among others.
Technological	Technological factors that may generate new (alternative) products or services, increase the availability/lower the cost of current products or services, or change the nature of production processes, transportation and distribution activities, information flows, etc.
Economic	Economic factors that influence the ability of individuals' or businesses' capacity to invest or purchase goods or services, such as overall economic growth (global, regional) or the distribution of that growth, commodities prices, etc.
Environmental	Prevailing environmental factors that may influence the demand for or the production of goods and services, either positively or negatively.
Political	Political or legal factors that could influence the production, sourcing, flow or trade of goods (e.g. trade agreements), or investments in public infrastructure, such as highways, among other factors.

Source: Kyler; Competia.com; CPCS



1.3.3 From Drivers to Effects on Freight Flows

The STEEP drivers manifest themselves in five freight flow effects, as summarized in the figure below. These five effects are also used as a basis for assessing the implication of alternative future scenarios. This is done by assessing the expected impact of each effect with respect to the Base Case scenario forecast.

Effect	Description
Sourcing	Where are the products sourced from?
Flow	Where are products going to (where is the demand located)?
Routing	How are the products routed from source to destination (route, mode)?
Volume	How will the total volume of goods shipping into and through the region change?
Value Density	How will the product characteristics and related value density change?

Figure 1-3: Translating Events into Effects

Source: MIT Center for Transportation & Logistics; CPCS

1.4 Scenario Development Process

Three alternative scenarios were developed during an all-day scenario planning workshop, held in Phoenix on November 5th, 2015. There were more than 50 participants, representing a range of stakeholder groups from ADOT, Metropolitan Planning Organizations (MPO), shipper and carrier organizations and associations, academia, and the consultant community.

Figure 1-4: Arizona State Freight Plan Scenario Planning Workshop



Source: Leslie Dornfeld





Source: Leslie Dornfeld

The process started with a review of the potential drivers identified in a pre-workshop survey. The key hallmarks of these drivers were that they are not influenced, controlled or known in advance by the planning entity. These external (from the outside in) factors are the ones best used in framing and developing scenarios.

The potential driving forces were categorized into the STEEP groupings and ranked by the participants. Also, new potential driving forces were introduced and discussed. The net result was a priority ranking of those driving forces thought to have the most impact (positive or negative) on Arizona's freight mobility in the future. The top three-four driver forces under each STEEP grouping are noted in the table below.

Figure 1-5: Top STEEP Drivers as Identified by Participants

Driver	Top Drivers
Social	Increased urbanization in Phoenix-Tucson corridor
	Labor shortage for key industries professions (e.g. vocational training)
	 Bilingualism (for retailers)
	Rise of the shared economy
	 Immigration policies (skilled and unskilled labor)
Technological	Internet of things (how ecosystem ties together)
	• Alternative fuels (implications – whole funding system for transport based on fuel tax,
	capacity to deliver)
	Autonomous trucks
	Flexible manufacturing/automation/robotics
Economic	Water demand/supply



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Driver	Top Drivers					
	Increase in extreme weather events					
	New federal environmental/emissions regulations					
Environmental	Canamex Corridor					
	National economic conditions in the U.S.					
	Opening of additional Mexican container ports					
	Fuel prices					
Political	Funding (more or less)					
	Competition with neighboring states					
	Land use regulations and restrictions					
	Shifting of user fees instead of taxes					

Source: Scenario Planning Workshop, November 5, 2015

These driving forces were then organized into three coherent initial scenarios by the facilitating team. The idea was to create three rough initial scenarios that the larger participant base could then debate and further flesh out. That was accomplished in the afternoon breakout sessions where each scenario was thoroughly debated, vetted, and improved by a breakout group.

Figure 1-6: Breakout Group Discussions



Source: Leslie Dornfeld



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Source: Leslie Dornfeld



Source: Leslie Dornfeld



Following the breakout group sessions, representatives from each group reported back to the plenary workshop group on what their respective future scenarios looked like.



Figure 1-7: Breakout Groups Reporting Back

Source: Leslie Dornfeld



Source: Leslie Dornfeld

A description of the Base Case scenario, upon which the future scenarios are developed, follows. Each of the future scenarios are described in the following chapter.



1.5 Model Development

To evaluate the scenarios, a high-level sketch planning travel demand modeling tool was developed to conduct truck traffic assignment for existing (2013), future base year (2040), and three freight scenario alternatives. The Arizona Travel Demand Model Version 2 (AZTDM2) roadway network, consisting of major roadways in the Southwest region of the U.S. and northern part of Mexico (provinces of Sonora, Baha California and part of Chihuahua), were used for the analysis.

Transearch data was used as the basis for this analysis. Transearch is a database of U.S. countylevel freight movement data. The Transearch data also forecasts freight flow into the future (2040), and this was used as the basis for the freight modeling and forecasting for our planning horizon (2040). An origin-destination trip table for existing and future years was developed based on Transearch data. To develop the freight forecasts in the scenarios, the trip-tables were modified based on the scenario descriptions.

Within Arizona, the geographic units of analysis (traffic analysis zones, or TAZ) of the Transearch data are consistent with the Maricopa Association of Governments regional travel demand model. Specifically, Transearch TAZs are more granular within the urbanized areas of Maricopa, Pinal and Pima Counties. Outside these three counties, TAZs are larger as they cover more geography. Consistent with the Transearch data, the sketch planning model area encompassed the entire nation, including Canada and the northern part of Mexico.

A sketch-planning technique was used to prepare existing, future base and three scenario alternatives model runs (for truck volumes only). Truck growth from existing to future base year was estimated by Transearch using their internal algorithm. Net growth from the various scenarios was applied on the future base year trip table, and the trip distribution was conducted using the Frater method. Transearch only estimates truck traffic and does not include any estimate on passenger cars. A truck-only trip table was assigned using all-ornothing traffic assignment along the roadway segments in this approach. This tool did not estimate auto passenger vehicles. Figure 1-8 displays a base case comparison of 2013 and 2040 total daily truck units on Arizona's roadways".





Figure 1-8: Growth in Truck Volume (units of trucks) 2013 – 2040

1.6 Base Case Scenario

The **Base Case** scenario has Arizona experiencing significant growth in population and increasing exports in high-tech industries. Arizona maintains its reliance on population growth to stimulate economic growth and its commercial relations with Mexico stay much as they are now.

According to the Arizona Department of Administration's (ADOA) Office of Employment and Population Statistics (EPS), Arizona's population will increase by 50 percent by 2040, with growth particularly strong in the Phoenix metro area. Immigration is the main reason for population growth, just over a half of which is due to domestic immigration from other states and almost a quarter of which is due to foreign immigration. Employment in private service industries¹ grows in line with population.

This growth in population has a significant impact on the growth of consumer goods sectors and other industries. In the **Base Case**, the tonnage of food and beverage sector freight flows heading or remaining in Arizona increases by more than two thirds. The production of food and beverage sector goods enjoys similar growth. General manufacturing freight flows destined for Arizona, in tonnage, more than double. The production of general manufacturing goods also doubles.

In the **Base** Case, Arizona carries on the trend towards becoming a center for high-tech and transportation manufacturing, particularly in electronics, telecommunications manufacturing and defense-oriented manufacturing. Important investments by high-tech companies maintain the strong manufacturing base in Phoenix. By 2040, the **Base Case** forecasts production of high-tech manufacturing increases by a factor of almost 2.5 and transportation equipment production doubles compared to their current volumes. These industries have become increasingly export-oriented. Employment in manufacturing does not significantly increase, reflecting advances in technology.

By 2040 the **Base Case** forecasts the transportation and logistics sector to have the largest increase of tonnage produced and utilized in Arizona of the sector groups analyzed. The Arizona production and consumption of transportation and logistics sector goods almost triples. Just as in 2013, this sector is almost entirely focused upon in-state distribution and its growth reflects the increase in goods moved to, from and within the state.



¹ Service industries include financial, informational, educational, health care, professional services, leisure, hospitality services, retail trade based, wholesale trade, transportation warehousing and utility industries.

East-west freight flows through Arizona continue to grow through 2040. The **Base Case** sees Arizona and California trade growing by more than three quarters (in tons) of their current volumes, with Arizona importing a third more than it exports to California. Arizona and Texas trade grows roughly at the same magnitude (tonnage increasing by three quarters of current volume) with Arizona importing approximately 40 percent more than it exports to Texas.

By 2040, the **Base Case** forecasts that trade between Arizona and Mexico will almost triple, with Arizona exports to Mexico dwarfing imports from Mexico. Arizona imports transportation equipment, food and beverage goods, as well as general manufacturing from Mexico. Nogales port of entry (POE) continues to be the main POE for this trade.

Region	County	Characteristics
	Yavapai	Primarily imports mining goods
		Mostly producing mining and general manufacturing goods
Control Arizona	Maricopa	 Mostly imports and exporting mining, general manufacturing goods and a wide array goods
Central Anzona	Dinal	Primarily imports mining goods
	Filia	Mostly producing agricultural and general manufacturing goods
	Gila	Mostly imports mining and general manufacturing goodsPrimarily producing mining goods
Northeastern	Apache	 Does not primarily draw in on any of the top 10 sector goods Mostly producing agricultural and mining goods
Arizona	Navaio	Imports mining and forestry goods
		Mostly producing agriculture and forestry goods
Northwestern	Mohave	Primarily imports and exports mining goods
Arizona	Coconino	Mostly imports mining and general manufacturing goods
		Mostly producing energy and general manufacturing goods
Southwestern	La Paz	Primarily produces agricultural goods
Arizona	Yuma	Mostly imports energy and mining goods
		Mostly producing agricultural and mining goods
	Graham	Imports mining, energy and general manufacturing goods
Eastern Arizona		Mostly producing agricultural and mining goods
	Greenlee	Mostly imports energy and general manufacturing goods
		Primarily producing primarily mining goods
	Santa Cruz	Primarily imports mining goods
		Mostly producing agricultural and general manufacturing goods
Southeastern	Cochise	Primarily imports mining goods
Arizona		Nostly producing agricultural and general manufacturing goods
	Pima	Mostly imports mining and general manufacturing goods
		 Producing energy, general manufacturing and a wide array of goods

Figure 1-9: Base Case: Freight Flows to and from Arizona Counties



1.6.1 Base Scenario: STEEP Economic Drivers

Figure 1-10 displays the impacts of the **Base Case** on the STEEP drivers.

Figure 1-10: Base Case Effects on STEEP Economic Drivers

Drivers	Overview of Key Drivers
Social	 Majority of growth enjoyed by urban areas, particularly the Phoenix metro area Agricultural sector heavily dependent on temporary legal immigrants to harvest winter crops Construction will add the largest number of jobs due to strong demand for housing The share of population below 34 years of age in Phoenix will be above the national average
Technological	 Arizona moves towards high-tech industries Manufacturing goods production outpaces employment suggesting greater automatization
Economic	 Arizona continues a steady course of growth Low level of economic diversification as a result of dependency on population growth Boom in Arizona manufacturing and transportation industries Companies offering back-office type of operations prefer Arizona due to relatively low business costs and well-educated workforce Government and higher education provide stability to the city of Phoenix Gaming industry supports northwest corner of state Strong international trade links with Mexico will be maintained, but not further developed
Environmental	• Retirement hotspot due to climate, wide-open spaces and abundance of recreational amenities
Political	• Land use policies needed to accommodate growth in cities cause agricultural producers to move to Mexico as a result of decline in land available for farming

1.6.2 Base Case: Implication for Key Arizona Sector Groups

Figure 1-11 displays the overall anticipated effects of the **Base Case** on freight flows associated with Arizona's top freight sector groups by 2040.

Figure 1-11: Base Case Effects on Arizona freight sector groups

Sector Group	Freight Flow Effects
Consumer Goods	 Arizona production of food and beverage goods increases by 63 percent. Freight flows of general manufacturing (such as furniture and household goods) heading or remaining in Arizona increases by 108 percent and production increases by 111 percent.
Manufacturing	• Tonnage production of high-tech manufacturing increases by 144 percent and transportation equipment production rises by 104 percent.
Natural Resources	 Agricultural production enjoys moderate increases by 2040. This is not surprising as the increasing residential use of land in Arizona reduces the availability of farming land. Production of energy (oil and gas) goods within Arizona falls by 2 percent, presumably reflecting decreasing supplies and the Arizona economy rebalancing towards high-tech/transportation and logistics manufacturing. Production of forestry goods increases by 97 percent and Arizona consumption increases by 77 percent. Mining (except oil gas) production increases by 65 percent.
Transportation and Logistics	• Arizona production and utilization of transportation and logistics sector goods increases by 188 percent. Just as in 2013, this sector is almost entirely devoted to Arizona.



Figure 1-12, Figure 1-13, and Figure 1-14 display the tonnage and value of the base case in years 2013 and 2040.

Category	Outbound (AZ to Other)	Inbound (Other to AZ)	Internal (AZ to AZ)	Through (Other to Other)	Total
Tonnage (000's)	25,600	32,000	89,900	93,700	241,200
Value (Million \$)	\$39,977	\$69,522	\$68,495	\$307,979	\$485,973

Figure 1-12: 2013 Tonnage and Value of Arizona's Freight Flows under the Base Case

Source: Arizona State Freight Plan: Condition and Performance Report

Figure 1-13: 2040 Tonnage and Value of Arizona's Freight Flows under the Base Case

Category	Outbound (AZ to Other)	Inbound (Other to AZ)	Internal (AZ to AZ)	Through (Other to Other)	Total
Tonnage (000's)	48,400	68,400	157,200	205,100	479,100
Value (Million \$)	\$138,637	\$208,258	\$157,210	\$765,359	\$1,269,464

Source: HDR analysis of Transearch data, received in November 2015

Figure 1-14: Percent Growth in Tonnage and Value from 2013 to 2040 under the Base Case

Category	Outbound (AZ to Other)	Inbound (Other to AZ)	Internal (AZ to AZ)	Through (Other to Other)	Total
Tonnage	89%	114%	75%	119%	99%
Value	247%	200%	130%	149%	161%

Source: HDR analysis of Transearch data, received in November 2015

Figure 1-15 shows the output of this tool, which was used to determine the truck growth between the existing year and future base year conditions. The figure illustrates that the Key Commerce Corridors (KCC) such as I-10, I-19, I-17, I-10 and I-11 show significant truck growth.





Figure 1-15: Base Case Scenario: 2040 Future Truck Units



Arizona State Freight Plan Future Scenarios

Key Messages

The scenario planning workshop yielded three alternative future scenarios:

- **Domestic Bliss** envisions Arizona's growth largely driven by domestic trade and migration from California.
- #Urbanizona envisions urban areas of Arizona excessively grow while rural areas contract and emerging technologies reduce the tonnage of freight flows.
- **SOBO (South of the Border)** envisions a world were Mexico has replaced China as the primary manufacturing hub for North America.

All three scenarios envision significant growth in freight and passenger traffic, affecting system performance, and Arizona's freight-dependent industries.



2.1 Scenario 1: Domestic Bliss

The **Domestic Bliss** scenario envisions Arizona's growth largely driven by domestic trade and migration from California.

This scenario assumes a breakdown in international trade resulting in a low volume of Arizona imports of agricultural, food and beverage and general manufacturing sector goods from Mexico. Midwestern states and those adjacent to Arizona will meet the demand previously filled by Mexican imports.

California's higher taxes and increasingly stringent regulations have encouraged retirees and firms to move to Arizona. The number of Californians, mainly retirees, trying to avoid California's higher taxes by moving to Arizona almost equals the current population of Arizona. The only limit to this migration is, that despite the relative wealth of this group, the labor rates in Arizona have not kept pace with the increase in population. Labor shortages in healthcare in turn discourage further migration to Arizona. Compared to the **Base Case** scenario, Arizona's population has still increased significantly. However, if it was not for the labor shortages this population increase could be vastly greater. California manufacturing firms have begun to move to the counties of Mohave, La Paz and Yuma to reduce their tax burden while maintaining easy access to their existing markets.

The majority of the top ten market sector groups have benefited in this scenario. Agriculture, despite the further population increase, grows in this scenario due to the reduced competition from Mexico. The only real exception is the mining sector, which has fallen due to the effects of protectionism, outweighing other effects. While the NAFTA agreement is still in effect, multiple decisions will dampen trade, for example, the domestic segments of the Canamex corridor have been completed, but the international segments have not been maintained.

2.1.1 Scenario 1: Methodology

Using the high growth forecast of the ADOA-EPS,² **Domestic Bliss** represents a ten percent increase in total state population over the **Base Case**. This factor estimates the increased consumption due to the "Second Gray Wave" of retirees relocating to Arizona. The incoming freight flows, per county, of consumer goods and natural resources increase according to this factor.



² Arizona Department of Demographics and Population Office of Employment and Population Statistics forecasts

Only in the more sparsely populated western counties, where California manufacturing firms relocated to avoid higher California taxes and regulation, has there been any significant immigration of working age individuals to Arizona compared to the **Base Case**. Based on the high volume forecast of net domestic migration for Arizona as whole, the populations of the counties bordering California increase; with modest population increase in Mohave and La Paz Counties, and nearly 3 percent in Yuma County. This growth in the working age population resulted in a similar growth in consumer consumption of goods, manufacturing consumption of goods and exports to California.

In **Domestic Bliss**, Arizona experiences an 18 percent decrease in exports to Mexico compared to the **Base Case**.³ The reduction of exports from Mexico to Arizona is replaced with an increase in exports from California, Texas, New Mexico and the Midwest.



³ Trade with Canada fell by the same reduction factor of 18% to reflect the reduction in NAFTA trade.

2.1.2 Scenario 1: STEEP Economic Drivers

Figure 2-1 shows the impacts of **Domestic Bliss** on the STEEP drivers.

Figure 2-1:	Domestic	Bliss	Effects	on STEEP	Economic Drivers
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Drivers	Overview of Key Drivers
Social	 Cluster of urban growth along Sun Corridor – Series of urban pockets (Tucson, Phoenix, Marana, Casa Grande, Prescott, etc.) Influx of retirees from U.S. Midwest and resulting 'graying' consumer base Potential massive immigration from California (4-5) million Slowing immigration from Mexico
Technological	 Internet of things advances but privacy issues and associated regulations have dampened pace of progress Widespread implementation of autonomous vehicles is slowed by government safety regulatory hurdles
Economic	 Intermountain regional economy flourishes Increasing trade with states, particularly California, Texas, Midwest Less trade with Mexico, South America and Asia-Pacific region Growth of high tech and medical tech continues Agricultural clusters (Yuma, Nogales, Pinal County, Prescott) with products shipped to metro areas
Environmental	Increased extreme weather events
Political	 Restrictive immigration policies Federal regulations on privacy and safety have thwarted widespread adoption of autonomous vehicles, advanced robotics, and the internet of things. California becomes overregulated and businesses move to Arizona

2.1.3 Scenario 1: Implication for Key Arizona Sector Groups

The overall anticipated effects of the **Domestic Bliss** scenario on freight flows associated with Arizona's top freight sector groups are as follows.

Sector Group	Freight Flow Effects
Consumer Goods	• Sourcing : Retailing continues to be a large segment of the economy and related flows are largely inbound. Increasing flow of consumer goods and food products from California, Texas, Midwest at the expense of former flows from Mexico, Latin America and the Asia-Pacific Region.
	• Flow : Drop in international exports. Modest exports to California, New Mexico and Texas through inbound consumer goods dominate.
	• Routing : I-10 to California is the dominant corridor. Virtually all this traffic moves by truck. Some rail flows to markets in the Midwest and Northeast U.S. There is increased flow to the Intermountain states.
	• Volume : The overall volume of consumer goods sector flows is tied primarily to population growth. Overall ton-miles decrease due to more geographically concentrated market base.
	• Value Density: The growing population of retirees in Arizona moving into smaller homes

Figure 2-2: Domestic Bliss Effects on Arizona Freight Sector Groups



Sector Group	Freight Flow Effects
	and apartments has led to a general increase in the quality/value of consumer goods products, marketed towards those in retirement.
	Other effects:
	 More complicated delivery in urban areas. Growth of distribution hubs outside of
	California – serving that state, but from outside its own boundaries.
	 More distributed population leads to more super stores in rural areas.
Manufacturing	• Sourcing : Increasing share of manufacturing from neighboring states and the Midwest coupled with a drop in international sources. Manufacturing businesses that relocated to Arizona from California have also added to the regional manufacturing base, particularly along I-10.
	• Flow: Growth of manufacturing in western part of state to serve California (some of which is actually former California-based manufacturers). Within Arizona, most manufacturing sector flows are tied to markets in urban clusters in the Sun Corridor. The tech sector continues to flourish, serving markets throughout the U.S.
	• Routing : Truck predominates, using combination of Truckload (TL) and Less than Truckload (LTL). Some rail of heavier manufacturing inputs and outputs to and from the Mid-West. Some air for high value product destined to Eastern U.S.
	• Volume: Overall volume not substantively different than in 2015, but total ton-miles have
	dropped due to shorter distances of trips.
	Value Density: No substantive change.
Natural Resources	• Sourcing : Drop in natural resources from international sources, notably agriculture from Mexico. Sourcing has largely been replaced by production in Arizona and neighboring states.
	• Flow : Drop in export of mining product (e.g. copper) to Mexico and other international destinations. Aggregate and other construction-related resources continue to be focused on urban clusters in Sun Corridor.
	• Routing : More regional production of agriculture, particularly in Yuma region, moving to markets in Sun Corridor and neighboring states by truck. Some limited rail transportation of copper material to markets in the Midwest.
	• Volume: Overall drop in volumes driven in large part by the loss of international markets for heavy mining. More internal flows of agricultural products. Construction boom in Sun Corridor urban islands drives aggregate flows, but are very localized.
	• Value Density: Water shortage has led to a shift in higher value agriculture and crops requiring less water.
Transportation	• Sourcing: Major drop in container flows from Ports of Los Angles and Long Beach and
and Logistics	Mexico. DCs and warehouses in Arizona shift from Phoenix centric to mix of smaller and medium DCs and warehouses throughout the Sun Corridor. There is also a growing cluster of DCs and warehouses along I-10 near the California border.
	• Flow: Local market focus in the Sun Corridor with some increased flow between California and Texas. Shifting of facilities to serve northern markets in Intermountain states.
	Routing: Almost all TL/LTL truck.
	• Volume : High growth in transportation in the intermountain region– mainly trucking.
	Value Density: N/A



Figure 2-3: Main Components in Analysis of Domestic Bliss Freight Flows and their Relative Impact







Figure 2-4: Domestic Bliss Change in Truck Numbers



2.1.4 Scenario 1: Results

General manufacturing drives the change in tonnage (relative to the **Base Case**) in **Domestic Bliss**, which is manifested in the consumer goods sector, representing 73 percent of the change in tonnage flows. Mining (except oil and gas) freight tonnage flows have fallen relative to the **Base Case**. However, the increase in demand of energy (oil and gas) more than offsets this change.

There is a decrease in the number of trucks entering Arizona at the Nogales and Douglas ports of entry with Mexico, compared to the **Base Case**. This reduces the number of Trucks on I-19, I-10, SR 80, 82, 90, 75 and 78. The adjacent states (California, Texas, New Mexico, Colorado, Utah and Nevada) and the Midwest have increased their exports to Arizona to offset the falling imports from Mexico, a general increase in truck numbers throughout Arizona occurs.

The increase in freight flows in Phoenix and Tucson reflect the boom in consumption due to the Second Gray Wave of retirees moving to Arizona. The number of trucks along I-10, State Routes 60, 70, 87 and 93 increase due to this consumption.

Yuma and La Paz Counties experience an additional increase in freight flows due to Californian firms moving there. The number trucks along I-10, I-8 and SR 95, increases due to this consumption.



2.2 Scenario 2: #Urbanizona

Two major trends define the **#Urbanizona** scenario; urban areas of Arizona excessively grow while rural areas contract and emerging technologies reduce the tonnage of freight flows.

The Phoenix and Tucson metro areas, as well as the corridor between them, have flourished due to a tremendous growth in young and well-educated workers migrating to them. High-income professionals, attracted by growing high-tech industries, have settled in the urban areas of Arizona and this has begun to increase the birth rates in these areas. The resulting demand for lower-wage workers and the introduction of new policies results in a significant increase in the number of day workers from Mexico.

Rural areas of Arizona have ever-diminishing water reserves, partly due to a historical lack of water usage regulation and partly due to climate change. The majority of investment in crucial infrastructure occurs in the major metro areas resulting in water usage being highly concentrated in cities. The introduction of market based pricing mechanisms in water usage allows these differences in water reserves to be reflected in the wider Arizona economy, further widening the disparity between urban and rural Arizona. Combined with the booming economies of metro areas, the lack of investment in rural Arizona encourages a migration from rural areas to urban areas, restrained only by lower demand for blue-collar and middle class jobs in metro areas.

The concentration of the population in urban areas results in the concentration of freight flows to the Phoenix and Tucson metro areas. Compared to the **Base Case**, the per good tonnage of these freight flows will be reduced due to new technologies either removing the need of these goods to be physically moved or reducing the weight of the good. However not all segments of the population in the state will be able to fully leverage these new technologies.

The result of Arizona manufacturing rebalancing towards high-tech and bio-industries is a booming economy, at least for Arizona as a whole. The rest of the U.S. and various trading partners are also booming, leading to an optimistic forecast for Arizona exports. However, some industries are in decline, such as forestry sectors, as new materials and "Apps" replace these goods with lighter/digital equivalents.



2.2.1 Scenario 2: Methodology

Based on the growth forecasts of the ADOA-EPS,⁴ a 0.88 reduction factor represents the decrease in consumption from the deterioration of rural Arizona. To represent the sustained growth of the working age population of metro areas and the investment they experience, the consumption in the counties of Maricopa and Pima increased by a factor of 1.18. The consumption in Pinal County was unaltered. A minor reduction to the tonnage of the production and consumption of forestry, high tech and transportation and logistical goods represents technological growth.

Multiple conflicting shocks affect Arizona trade. Arizona is less restricted in how goods move between states and countries, reducing freight tonnage via traditional sources. However, the ease of moving goods leads to new opportunities for trade. Arizona increases its exports in mining, food and beverage, general manufacturing, transportation equipment, high-tech manufacturing and logistics, however, the tonnage of this flow reduces due to new technology. Imports from Mexico fall due to Mexican imports to Maricopa, Pinal and Pima counties being significantly lower than that to the rest of Arizona (combined with the population shift to these counties). Canadian producers would be at least as capable as Arizonian ones at leveraging the new technology, so a fall in the tonnage exported and imported to Arizona is expected.



⁴ Arizona Department of Demographics and Population Office of Employment and Population Statistics forecasts

2.2.2 Scenario 2: STEEP Economic Drivers

As developed during the scenario planning workshop break-out sessions, the drivers of the **#Urbanizona** scenario are as follows.

Drivers	Overview of Key Drivers
Social	Increased urbanization in Phoenix and Tucson.
	Labor shortage for high tech professionals.
	• Rise of the shared economy (e.g. Uber, Lyft, Airbnb, etc.).
	Increased environmental awareness – but not translated into formal regulations.
	Younger, more educated population in cities.
	Alienation and growing disparity between urban vs. suburban/rural dwellers.
	Increasing shift to vegetarian, vegan, and generally less beef-intensive diets.
Technological	 Internet of things fully functioning – although not all segments of the population fully leverage their value or potential.
	Alternative fuels are widely used to include electric vehicles.
	• Tax base for fuel taxes has been degraded.
	 Autonomous trucks are widely used – addressing some portion of projected truck driver labor shortage
	 Elevible manufacturing/automation/robotics are in wide use leading to decentralization of
	manufacturing and distribution into smaller facilities
	Availability of advanced 3D printing technologies-reducing the need for traditional logistics
	services for certain high value products that can be produced at location.
Economic	National economic conditions in the U.S. are generally positive over the long run.
	• Arizona is growing in terms of GDP – shifting from raw material and agriculture to more
	high-tech and bio-engineered products and services.
	Retail distribution still a major component of the economy.
Environmental	Water usage is highly concentrated in the cities.
	Growing policy disconnect between urban areas and Greater Arizona.
	• Series of market based pricing mechanisms are being used to better allocate water – but
	this leads to further alienation between the major and minor consumers.
	 Increase in extreme weather events and general warming continues – but not at the level initially predicted.
	 Shift in land use from cattle and dairy to hardy vegetables and grains since diets include less meat.
Political	There has been a general shifting to user fees instead of taxes.
	• Market based mechanisms are in place for water allocation and other scarce resources.
	• New population is generally socially liberal, financially conservative, and overall apolitical.
	• Government regulations are generally very loose with a focus on market efficiency.

Figure 2-5: Effects of #Urbanizona on STEEP Economic Drivers



2.2.3 Scenario 2: Implications for Key Arizona Sector Groups

The overall anticipated effects of the **#Urbanizona** scenario on freight flows associated with Arizona's top freight sector groups are as follows:

Sector Group	Freight Flow Effects
Consumer Goods	 Sourcing: Increased global sourcing, via the Ports of Los Angeles and Long Beach, Mexico, and basically everywhere, including through the "matternet", though increasing local production of hipster consumable products. Flow: Some of what was produced and shipped in the past now sent via the internet to 3-D printers. Condo lobbies have become the new DCs, where building manager becoming effective DC managers, managing packages received from online orders. Routing: Air is a major mode for increasingly high value goods destined to the Phoenix/Tucson mega-region.
	 Volume: Decrease in volume, but greater concentration of flows destined to consumer base in Phoenix/Tucson. Increased volume of delivery vehicles in downtown, but fewer passenger cars.
	 Value Density: Increasing value density with high tech. Except for lattes which continue to get larger. Other effects:
	 Other effects. National distribution efforts have become much more efficient. Autonomous vehicles and enhanced flexibility for automation have lowered costs. Lower levels of employment in logistics and transportation as technology encroaches. Last mile delivery to urban areas a rising concern – costs increase.
Manufacturing	• Sourcing : Raw material sourcing over much longer distances as the basic materials required have changed but sourcing of work in progress (WIP) is much closer as suppliers have entered the Arizona ecosystem. Much of what is sourced for the high tech sector is sourced regionally except for rare earths and other highly specialized products that are shipped in by plane from Asia.
	Flow: Major increase in outbound trade from Arizona.
	• Routing : Regionally, smaller cube vans dominate – some with ironic spoilers, particularly for local deliveries. Air has become increasingly important for international trade and trade with states in the Eastern U.S.
	• Volume: Though trade-in manufactured goods is increasing, the size of what is being physically shipped has decreased. "There's an app" for much what was physically delivered in 2015.
	• Value Density: Higher value added manufacturing within the state. New flexible manufacturing has enabled smaller scale facilities – able to locate closer to urban areas to be near populations.
	• Other effects:
Natural Pasaursas	O Labor shortages for high end technical positions, but not for entry or blue collar work.
Natural Resources	• Sourcing: Local agriculture (the 10 mile diet) is favored, which has resulted in a drop of basic food imports.
	• Flow: Copper is highly demanded in many industries and has robust growth – much of which destined flourishing cities in Africa which has been growing at a consistent rate of 15 percent per year since 2020.
	Routing: Agriculture moves from around Arizona to Phoenix and Tucson by truck.

Figure 2-6: Effects of #Urbanizona on Arizona Freight Sector Groups



Sector Group	Freight Flow Effects
	 Volume: Higher demand for many materials – construction aggregate is in high demand for growing urban construction – e.g. condos and related urban infrastructure. Forestry sector is diminishing as paper demand is falling due to the digital economy. Value Density: No notable change. Other effects: Automation has significantly increased the efficiency of mining and agriculture operations. The need for low income workers in these industries have been shrinking for years as automation replaces low cost labor.
Transportation and Logistics	 Sourcing: Mix of local and international. Flow: Mix of local and international. Routing: Significant change from being mainly a pass through function to focusing on last-mile delivery. Volume: Overall increase in concentration serving Phoenix/Tucson but net reduction in volumes, driven in large part by consolidation of local deliveries and constrained condo space for "stuff." Value Density: Increasing leverage of technology. What can't they put on Google Glass 4.0? Other effects: Lower employment rates as automated warehouses and autonomous trucks become more common.











Figure 2-8: #Urbanizona Change in Truck Numbers



2.2.4 Scenario 2: Results

General manufacturing continues to drive the change in tonnage (relative to the **Base Case**) seen in the consumer goods sector, representing 69 percent of the change in tonnage flows. Mining (except oil and gas) represents around 79 percent of the change in tonnage of the natural resources sector goods. Transportation equipment represents around 65 percent of the change in tonnage of transportation sector goods.

Mohave County sees the largest decrease in tonnage relative to the **Base Case** in the production of natural resource goods, and Yavapai County sees the largest decrease in tonnage relative to the **Base Case** in the production of consumer goods.

The strong growth in the population of the major metro areas in Arizona, Phoenix and Tucson, can be seen in the sharp increase their trucks numbers. This population growth is higher than that of **Domestic Bliss** due to labor rates in **#Urbanizona** keeping steady after the population increase. I-8, I-10, I-17, State Routes 89, 160, 70, 60 and 191 are the main routes this traffic takes to support Arizona's new consumption and production.

The large percentage increase in trucks on I-19 reflects the increase in exports. Overall imports from Mexico fall, despite optimistic trade assumptions, because the metro areas of Arizona do not import as heavily as the rural areas from Mexico.

The general reduction in growth in rural Arizona leads to a reduction in the trucks numbers on rural routes, which do not primarily serve the metro areas. This causes truck numbers on I-40 to remain relatively flat.

2.3 Scenario **3**: SOBO – South of the Border

The **SOBO** scenario envisions a world were Mexico has replaced China as the primary manufacturing hub for products consumed in North America.

Working with base product manufacturers in Mexico, Arizona manufacturing have developed sophisticated industries of customization and the final assembly of products. The population of Arizona is booming thanks to the strength of the Mexican economy.

The removal of previous restrictions between Arizona and Mexico has allowed greater integration of the two economies, particularly in Phoenix, Tucson and Nogales. Mexican imports flow throughout Arizona to meet demand previously met by China and other Arizona counties. Arizona exports to Mexico have increased to meet the growth in the Mexican economy, which has seen the number of manufacturing clusters more than triple. The transportation and logistics sector reaches new heights to meet the growing Arizona-Mexican trade and the wider U.S.-Mexican trade. In the **Base Case** Arizona exports to Mexico dwarf



Mexican exports to Arizona, while in the **SOBO** scenario the growth in Mexican exports begins to reduce this imbalance.

A significant portion of the Arizona agricultural industry, as well as a few other industries, have shifted from Arizona to Mexico. This shift reflects the increasing demand for residential land in Arizona and the increasing demand for goods in Mexico.

2.3.1 Scenario 3: Methodology

SOBO has the largest population increase of the three scenarios. Not only does the population of metro areas increase by a factor of 1.14 to 1.18, but so do the border counties in response to greater integration with the Mexican economy, with population growth factors from 1.09 to 1.15. This population increase in turn increases the consumption of consumer goods, natural resources and general manufacturing.

In the **Base Case** Maricopa, Pinal and Pima do not import heavily from Mexico. However, in **SOBO** the greater integration with Mexico results in Mexican imports spreading throughout the state. The average percentage of tonnage of goods imported from Mexico for the rest of the state, 1.06 times, applied to the tonnage consumption of Maricopa, Pinal and Pima to calculate the new consumption from Mexico.

Above the increase in imports due to greater consumption, imports from Mexico increase due to out-sourcing. Mexican production meets the new consumption of agricultural, food and beverage goods. Exports to Mexico quadruple to meet the new demand from Mexico. International trade decreases in favor of Mexico. Transportation and logistics production and consumption increases due to the increase in goods moving from, to and through Arizona.

2.3.2 Scenario 3: STEEP Economic Drivers

As developed in a breakout group, the drivers of the **SOBO** scenario are as follows.

Drivers	Overview of Key Drivers
Social	Increased immigration from Mexico and South America (porous border).
	US commuters to Mexico resulting in more border communities.
	Shortage of vocational skills (machinists, etc.).
	Increase in Mexican middle class/consumer base.
	Some health issues relating to spread of disease across U.SMexican border.
Technological	Sonora water-electricity/power intermittency addressed.
	Deeper penetration of manufacturing in Sonora.
Economic	National economic conditions in the U.S.–boom.
	Boom in Arizona component parts manufacturing.
	All border areas grow.
	The State of Texas experiences off-the-charts growth.
	Decrease in Asian/rest of world trade.
	AZ benefits from Mexican ports for inbound/outbound trade.

Figure 2-9: Effects of SOBO on STEEP Economic Drivers



Environmental	Increase in extreme weather events.		
	• Environmental bills increasing regulations are not passing in state or national legislatures.		
Political	New/Bigger POEs.		
	• TPP continues with additional similar agreements on the horizon.		
	• Government regulations have generally been more about free trade and market efficiency		
	and less about social issues over the last several years.		
	Mexico has invested heavily in infrastructure.		
	• Mexican port labor resists unionization and performs at globally competitive levels of		
	seaport productivity.		



2.3.3 Scenario 3: Implications for Key Arizona Sector Groups

The overall anticipated effects of the **SOBO** scenario on freight flows associated with Arizona's top freight sector groups are as follows:

Sector Group	Freight Flow Effects			
Consumer Goods	• Sourcing : Significant share of consumer goods manufactured and sourced in Mexico and elsewhere in Latin America (supplants Asia as major source of consumer goods).			
	• Flow : Some export of consumer goods from Arizona to Mexico, though not significant in the first place.			
	• Routing: Most product movement shifted from east-west to north-south. Significant			
	imports/exports via Mexican ports. Truck remains dominant mode though increasing rail flows			
	between Arizona and Mexico. Also lots of trade with Texas and California – mostly by truck.			
	• Volume: Steady flows, keeping pace with population growth. Shifting consumer demand			
	leads to increase in inventory selection.			
	Value Density: No notable change.			
Manufacturing	Sourcing: Tighter ties to Mexican counterparts. More closely intertwined Just-in-Time (JIT)-			
	style supply chains, particularly for general manufacturing and aerospace. High tech sector remains dominant in Arizona manufacturing			
	Flow: As above.			
	Routing: Shift from east-west trade to north-south, thought linkages to California and Texas			
	remain significant. North-south rail corridor to/from Mexico becomes very important.			
	Volume: Increasing trade activity on the north-south axis.			
	Value Density: No dramatic change.			
	Other effects : Shifting from pure manufacturing to assembly and customization.			
Natural	• Sourcing : Major shift of agricultural sourcing to Mexico, and the expense of Arizona and other			
Resources	domestic sources.			
	Mexico and other markets in Latin America.			
	Routing: North-south trade dominates.			
	• Volume: Growing construction south of border for aggregates.			
	Value Density: No dramatic change.			
Transportation	• Sourcing : North-south demand increasing to include rail and trucking modes.			
and Logistics	• Flow: As above.			
	• Routing : Tremendous traffic increases from south to I-10 and then in all directions.			
	• Volume: There is increased demand for heavier truck size and weight limits to handle the			
	Increased flow from Latin America and Mexico.			
	• Value Density: Tremendous volume at both the high and low ends of the value density scale. The transportation systems have grown to be able to handle all levels and classes of freight			
	Other effects:			
	• Lessening of importance of I10 east-west traffic from West Coast ports-but there is			
	more traffic sending material from Mexico to both points east and west.			
	 Ability to serve more remote population places strains on network. 			
	 Labor shortages for logistics workers. 			

Figure 2-10: Effects of SOBO on Arizona Freight Sector Groups



Figure 2-11: Main Components in Analysis of SOBO Freight Flows and their Relative Impact







Figure 2-12: SOBO Change in Truck Numbers



2.3.4 Scenario 3: Results

In **SOBO**, I-10 sees a strong increase in the number of trucks travelling along the east-west corridor. This freight flow serves the population increase, primarily in the southern half of Arizona, which stems from the growth in Arizona and Mexico. The decrease on I-40 reflects the overall decrease in east-west traffic.

From Nogales along I-19, via Tucson, and I-10, Mexican imports can now meet the growth in consumption in Phoenix. Unlike in **#Urbanizona**, the integration of the Arizona and Mexican economy allows Mexican imports to spread throughout the state. Two conflicting shocks drive the changes in freight flows to the north of Phoenix, sourcing shifting from the north to Mexico and from the increased consumption of the state of Arizona.



B Impacts of Future Scenarios on Freight Transportation System

Key Messages

Scenario planning aids in the identification of locations that might be affected if conditions develop consistent with the various scenarios. The analysis demonstrates potential freight bottlenecks, differences in population and impacts to Arizona's key commodity flows for each scenario.

The intent of developing future scenarios and forecasts is to position the Arizona to effectively prepare for an unknown future. To that end, the freight scenarios will inform several upcoming phases of the Arizona State Freight Plan, including the identification of strengths, weaknesses, identification of needs and projects, and the development of a prioritization approach to focus future planning and implementation efforts.



3.1 Future Impacts on the Freight Transportation System

The scenario planning exercise is informative in identifying those locations that might be affected if conditions develop consistent with the various scenarios. Identifying freight bottleneck locations for each of the scenarios will provide additional insights to the scenario planning exercise. Bottleneck locations are a result of the congestion caused by total traffic volume; therefore it is important to understand both the passenger cars and truck volumes to evaluate congestion.

To evaluate congestion, a hybrid modeling approach was used that incorporates sketch planning truck volumes with the results from the statewide travel demand model.⁵ Ultimately, the most likely outcome is some combination of the effects discussed in the scenarios.

Understanding the potential transportation impacts of each scenario will help inform planning as trends emerge.

Modeling Approach

The AZTDM2 uses National Household Travel Survey (NHTS)-based trip generation rates and trip distribution to conduct the passenger car traffic assignment. For the future **Base Case**, ADOT uses socioeconomic data to estimate population and employment which are the primary model input in AZTDM2 for the planning horizon of 2040. For each of the three scenarios, the population and employment growth were calculated at the county level, then disaggregated to the TAZ level, and applied to the population and employment data. Using the adjusted socioeconomic data as model input, model runs for each of the three scenarios were conducted to estimate passenger cars by each scenario. The passenger cars estimate using the AZTDM2 model reflects the population and employment growth consistent with the assumptions in the scenario planning.

AZTDM2 model estimates truck traffic based on Freight Analysis Framework 3 (FAF3) data,⁶ however, for this modeling exercise – and to be consistent with freight information reported elsewhere in the State Freight Plan – instead of using the FAF3 data, the trip table developed from the Transearch data was used, and assigned as a preload to the model. The model output will consist of traffic volume estimate by vehicle classification, vehicle miles and hours of travel, congested travel time and and volume to capacity (V/C).



⁵ The truck assignment was based on Transearch data and the auto component was from the second generation AZTDM2

⁶. FAF3 data is assigned as a preload using All-or-Nothing assignment in the AZTDM2 model.

The modeling of the **Base Case** and future scenarios produced forecasted traffic flows on the AZTDM network. Using the modeling tools, the potential future performance of the Arizona highway system becomes visible, most notably the level of congestion on specific corridors.

3.2 Congestion

Congestion can be measured as the ratio of volume to capacity V/C, which indicates the total traffic volume (passenger car plus trucks) exceeding the roadway capacity. V/C from the model output for each scenario was used to identify the congested segments and potential locations for freight bottlenecks. Level of Service (LOS) may then be calculated based on the V/C ratio, using the following thresholds:

LOS Level	Volume to Capacity Ratio	Rural (<50,000 Population)	Urban (>50,000 Population)
LOS C or better	< 0.71	Acceptable	Acceptable
LOS D	0.71 to 0.89	Unacceptable	Acceptable
LOS E	0.89 to 1.0	Unacceptable	Unacceptable
LOS F	> 1.0	Unacceptable	Unacceptable

Figure 3-1: Level of Service Ratings and Acceptable Ranges

Locations having unacceptable LOS are considered bottlenecks for both passenger cars and truck traffic, resulting in increased travel time and delay.⁷

3.2.1 Base Case

Figure 3-2 shows the level of service along the roadway segments for 2040 for the **Base Case**. For the most part, projected congestion is limited to urban areas. By 2040, the greater Phoenix and Tucson areas are anticipated to experience heavy congestion and mostly operate at unacceptable LOS E or F. Congestion is also anticipated in a number of other urban areas such as Flagstaff, Yuma, Prescott, Bullhead City and Nogales.



⁷ The AZTDM2 model results are not necessarily representative of the forecast for the metro Phoenix and Tucson areas, the MPOs in the respective metro regions conduct their own modeling for conformity analysis and planning purposes. Rather the AZTDM provides a sketch level understanding of the impact of the scenarios in these regions. Project identification in these MPO regions would be informed through the respective agencies own modeling efforts and processes.



Figure 3-2: Base Case Level of Service in 2040



3.2.2 Future Freight Scenarios

Using the **Base Case** as a starting point, the model is used to define the V/C for each scenario. Figure 3-3 through Figure 3-5 display the future LOS of roadway segments under each scenario. Future LOS levels are used to identify future congestion and potential locations for freight bottlenecks.

In the urban areas, where congestion is projected to be greatest, truck traffic alone accounts for a relatively small percentage of overall traffic. That is because through and local truck traffic may only account for a fraction of overall flow during peak hours, when congestion is greatest. Overall, truck traffic will increase on certain routes relative to the 2040 **Base Case**. **Domestic Bliss** is anticipated to have a two percent overall truck growth, **#Urbanizona** will have experience a six percent overall truck growth, and **SOBO** will see 11 percent overall truck growth.

If Arizona does not address growing capacity constraints within the statewide transportation network, Arizona employers will likely be disadvantaged in their ability to move products to consumers.





Figure 3-3: Domestic Bliss Level of Service in 2040





Figure 3-4: #Urbanizona Level of Service in 2040





Figure 3-5: SOBO Level of Service in 2040



3.3 Commodity Flows

To better understand the impacts to freight that may result from each of the scenarios, the greatest affected commodities (in terms of growth between the base and 2040 planning horizon) and their anticipated O/D pairs were examined. Figure 3-6 presents the results of this analysis. Sectors are grouped into consumer goods (CG); natural resources (NR); manufacturing (MN); and transportation and logistics (TR) based on transportation needs.

Figure 3-6: Change in Commodity Flows for Origin/Destinations by Scenario and Sector Types

Origin-	Imported Corridor and Sector	Sector Growth by Ranking			
Destination	impacted corridor and Sector	CG	NR	MN	TR
Pinal to Maricopa County	Areas of Congestion: I-10 (L202 to Eloy); locally within the Casa Grande and Eloy areas; all KCCs within greater Phoenix area; US 60 to Apache Junction. Consumer goods and natural resources see substantial growth across all scenarios; impacted by congestion along I-10 and US 60, and minor routes throughout Pinal County.	1 2 3	1 2 3	1 2 3	1 2 3
Maricopa County	Areas of Congestion: All KCCs and other major corridors (I-10, I-17, US-60, Loops 101, 202 and 303, SR 87) within greater Phoenix area.	1	1	1	1
internal freight flow	#Urbanizona and SOBO: 35- and 37-percent more roadway miles anticipated to be congested (LOS F) in Maricopa County.	3	3	3	3
Gila to Maricopa County	Areas of Congestion: Due to increase in mining and forestry, US 60 and SR 87 will be more congested in all scenarios. Local congestion on US 60 in Globe and SR 87 in Payson will be noticeable.	1 2 3	1 2 3	1 2 3	1 2 3
Yavapai to Maricopa County	Areas of Congestion: Additional 20 percent Maricopa County roadway lane miles will be congested.	1	1	1	1 2
	Domestic Bliss: High growth in natural resources will result in local congestion within Prescott and Sedona; US 60 from Phoenix to Wickenburg	3	3	3	3
Other States and Canada to Maricopa County	Areas of Congestion: I-40 and I-17 system interchange, I-40 within Flagstaff and Kingman area; US 89 from Flagstaff to Cameron. SR 95 within Yuma area. SR 95 within Lake Havasu City and City of Bullhead.	1 2	1 2	1 2	1 2
	SOBO : Manufacturing in SOBO is anticipated to have very high growth, impacted by I-10 and I-19 congestion.	3	3	3	3
California- Maricopa County, AZ	Areas of Congestion: I-10: SR 85 to Phoenix, SR 85: Buckeye to I-8; I-8 thru Yuma will be impacted by moderate growth in consumer goods and manufacturing sector. Domestic Bliss, #Urbanizona and SOBO: Urban congestion within Maricopa		1 2 3	1 2 3	1 2 3
	respectively.				

Source: Transearch Data, 2013; AZTDM2 Scenario Planning Model, 2016; HDR Engineering, Inc., 2016

Number inside the box represent scenarios: Scenario 1 - Domestic Bliss; Scenario 2 - #Urbanizona; Scenario 3 - SOBO.

 Thresholds (increase over baseline
 >500%
 100 – 500%
 <100%</th>
 (no significant change from baseline)

 Width of the box provides relative growth of sector trade ranking between scenarios:
 1st
 2nd
 3rd



Figure 3-7: Change in Commodity Flows for Origin/Destinations by Scenario and Sector Types

Origin-	Impacted Corridor and Sector	Sect	th by Ran	anking	
Destination		CG	NR	MN	TR
Cross border: Mexico to U.S.	 Areas of Congestion: SR 189 corridor; SR 189 and I-19 interchange; local congestion at Nogales in Santa Cruz and San Luis in Yuma County. I-19 is congested. Urban congestion will be much higher in greater Phoenix and Tucson area. Transportation with perishable food and time sensitive items will be greatly impacted. SOBO and #Urbanizona: significant growth in consumer goods (food and beverage), natural resources (agriculture and forestry) and general manufacturing; under SOBO, I-19 operates at LOS F from I-10 to Duval Mine Road, and delay along SR 189 will increase significantly. 	1 2 3	1 2 3	1 2 3	1 2 3
Cross border:	Areas of Congestion: (see Cross border: Mexico to U.S. above).	1	1	1	1
Arizona to Mexico	SOBO: High growth is anticipated in consumer goods and natural resources while moderate growth in manufacturing.	2 3	2 3	2 3	2 3
Cross border:	Areas of Congestion: (see Cross border: Mexico to U.S. above).	1	1	2 3 1 2 3 1	1
U.S. to Mexico	SOBO and #Urbanizona: Cross border trade in all sectors in these scenarios will be impinged by congestion noted above.	- 2 3	2 3	2 3	2 3
Cross border: Mexico to Arizona	Areas of Congestion: (see Cross border: Mexico to U.S. above).	1	1	1	1
	SOBO: High growth is anticipated in consumer goods and natural resources while low growth in manufacturing.	2 3	2 3	2 3	2 3
Pima County-	Areas of Congestion: Greater Tucson area; I-10 and I-19 TI, I-19 south of I-10 to Valencia Rd; I-10 from Avra Valley Rd to Houghton Rd.	1	1	1	1
freight flow	#Urbanizona and Domestic Bliss scenarios: increased transportation and logistics growth impacted by local traffic.	3	3	3	3
Santa Cruz County to – Mexico Cross border activity	Areas of Congestion: SR 189 corridor; SR 189 and I-19 interchange; local congestion at Nogales area. Congestion and delay along SR 189 will increase significantly in SOBO with the heaviest traffic volumes. Cross-border activity including truck delay at the U.SMexico is anticipated to accelerate.	1 2 3	1 2 3	1 2 3	1 2 3
	SOBO: Very high growth in general manufacturing sector.				
Source: Trans	search Data, 2013; AZTDM2 Scenario Planning Model, 2016; HDR Engineering, Inc., 2016				

Thresholds (increase over baseline	>500%	100 – 500%	<100%	(no significant change from baseline)
Width of the box provides relative growth of sector trade ranking between scenarios:	1 st	2nd	3rd	

Number inside the box represent scenarios: Scenario 1 - Domestic Bliss; Scenario 2 - #Urbanizona; Scenario 3 - SOBO.



Figure 3-7 shows that the increase in cross border trade that is envisioned with the **SOBO** scenario will result in significantly more freight traffic across the Arizona Mexico border. At the current time, over 80 percent of freight traveling between Mexico and Arizona crosses at the Mariposa POE. The **Base Case** forecasts that trade between Arizona and Mexico will almost triple, with Arizona exports to Mexico dwarfing imports from Mexico. Significant expansion of the existing POE infrastructure (both at Mariposa and ultimately other POEs) will be necessary to address this trade, as the existing primary corridor (i.e., SR 189, I-19 to I-10) is projected to be heavily congested.

In the **Domestic Bliss** scenario, the distribution of population to both rural and urbanized areas alleviates some of the congestion experienced in metro areas, and takes better advantage of the existing statewide infrastructure. However, this scenario will likely exacerbate some of the issues freight flows already experience in rural areas of the state, e.g., lack of redundancy in the network, lack of climbing and passing lanes, and peak period congestion at rural junctions and population centers.

Even with significant changes in mode choice of freight (e.g., higher value goods being shipped by air), the **#Urbanizona** scenario – with its concentration of population in the metro areas – will result in congestion due to the last mile delivery plagued by urban congestion.

As noted previously, the composite sketch-level modeling exercise reveals that congestion is primarily driven by the growth of population and employment. Trucks are a component of this congestion, and therefore, affected by this congestion (both local and through). Because the destinations and originations of the truck component of congestion are largely in urban areas, truck traffic is inexorably linked to them.

Figure 3-8 shows an overall summary of the model output. Total roadway miles operating at LOS F in rural areas are insignificant (<1 percent) compared to total rural network miles. Overall, 13 percent of urban areas roadway network miles are congested in the 2040 **Base Case**, which is forecast to increase as a result of the growth assumed in the scenarios.

With the highest growth in **SOBO**, the model shows the miles of local, arterial and state facilities operating at an unacceptable level of service will increase to 16 percent (resulting in unacceptable congestion on 16 percent of total roadway miles). Overall, truck vehicle miles of travel increase with all scenarios as trucks will likely travel longer distance using alternative routes.

Description	Base Case		Domestic Bliss		#Urbanizona		SOBO	
Description	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
%-All roadway miles at LOS F	1%	13%	1%	15%	1%	16%	1%	16%
Truck VMTs (000's) at LOS F	286	13,778	11%	17%	9%	32%	1%	35%

Figure 3-8: Comparison of Lane Miles of Level of Service F Roadways

Source: ADOT AZTDM2 Scenario Planning Model Output, 2016

Note: Area type is consistent with AZTDM2 model where urban area comprises central business districts, urban and suburban areas. Rural and small towns are included in rural area type. **Base Case** socioeconomic data is consistent with the AZTDM2 model.



Though the actual change in congested miles within rural areas does not vary substantially for the various scenarios, congestion and delay in urban areas is exacerbated by the scenarios. Already congested segments in **Base Case** become more congested and delay will increase as a result. Trucks operating within urban areas will be largely impacted by this urban congestion, and specific sectors, as noted in Figure 3-8, will be commensurately affected.

3.4 Population Changes Across Scenarios

The percentage changes in population shown in Figure 3-9 relate the change in population from the year 2040 base planning horizon to the scenarios. It is worth noting that the **Base Case** identifies several rural Arizona counties that experience little, if any growth (Apache County actually loses population). In the **Base Case**, the majority of growth occurs in the Sun Corridor region, which consists of all of Maricopa, Pinal and Pima counties, along with parts of Yavapai and Santa Cruz counties.

Domestic Bliss depicts a uniform change in population across all of Arizona; **#Urbanizona** identifies the concentration of population in the urbanized areas of Tucson and Phoenix (at the expense of the outlying counties); and **SOBO** focuses the growth in the Sun Corridor, and to a lesser degree the border communities serving the greater cross-border activity envisioned.

County	Base Case Population* (1,000s)		Domestic Bliss Population (1,000s)		#Urbanizona Population (1,000s)		SOBO Population (1,000s)	
	2015	2040	2040	Change	2040	Change	2040	Change
Apache	72.2	66.4	73.0	10%	58.5	-12%	73.6	11%
Cochise	129.1	149.0	163.8	10%	131.2	-12%	162.1	9%
Coconino	141.6	167.9	184.5	10%	147.9	-12%	173.8	4%
Gila	54.4	54.5	59.9	10%	48.0	-12%	54.5	0%
Graham	38.5	49.9	54.8	10%	44.0	-12%	49.9	0%
Greenlee	10.6	10.8	11.9	10%	9.5	-12%	12.1	12%
La Paz	21.2	22.4	24.9	11%	19.7	-12%	22.4	0%
Maricopa	4,076.4	6,031.0	6,628.0	10%	7,130.9	18%	7,160.2	19%
Mohave	205.7	280.8	310.5	11%	247.3	-12%	280.8	0%
Navajo	109.7	120.1	132.0	10%	105.8	-12%	120.1	0%
Pima	1,009.4	1,276.7	1,403.1	10%	1,509.5	18%	1,469.8	15%
Pinal	406.5	800.7	880.0	10%	800.7	0%	915.2	14%
Santa Cruz	50.3	66.2	72.8	10%	58.3	-12%	76.2	15%
Yavapai	217.8	302.8	332.8	10%	266.7	-12%	302.8	0%
Yuma	215.0	307.7	346.4	13%	271.0	-12%	350.5	14%
ARIZONA	6,758.4	9,706.9	10,678.2	10%	10,849.1	12%	11,223.9	16%

Figure 3-9: Population Growth to 2040 for the Base Case and Scenarios

Source: Transearch, HDR (2015). * Population estimates (2015 and 2040 medium growth) are from the Arizona Department of Administration Office of Employment and Population Statistics.



3.5 Next Steps

The intent of developing future scenarios and forecasts is to position the Arizona to effectively *prepare* for an unknown future. To that end, the freight scenarios will inform several upcoming phases of the Arizona State Freight Plan, including the identification of strengths, weaknesses, identification of needs and projects, and the development of a prioritization approach to focus future planning and implementation efforts.

