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Arizona State Freight Plan

(ADOT MPD 085-14)

Performance and Condition of Arizona Freight Transportation System

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Solutions for growing economies

CPCS Ref: 14325
May 13, 2016

Working Paper

This Working Paper presents the condition and performance of Arizona's freight transportation system. It provides a system assessment that will inform subsequent phases of the plan including project identification. It also provides a baseline for future monitoring and evaluation of the Arizona's freight transportation system.

Acknowledgements

The CPCS team would like to thank the Arizona Department of Transportation (ADOT) for its guidance and input in developing this Working Paper.

Opinions

Unless otherwise indicated, the opinions herein are those of the author and do not necessarily reflect the views of ADOT, the Technical Advisory Committee, the Freight Advisory Committee, or the State of Arizona.

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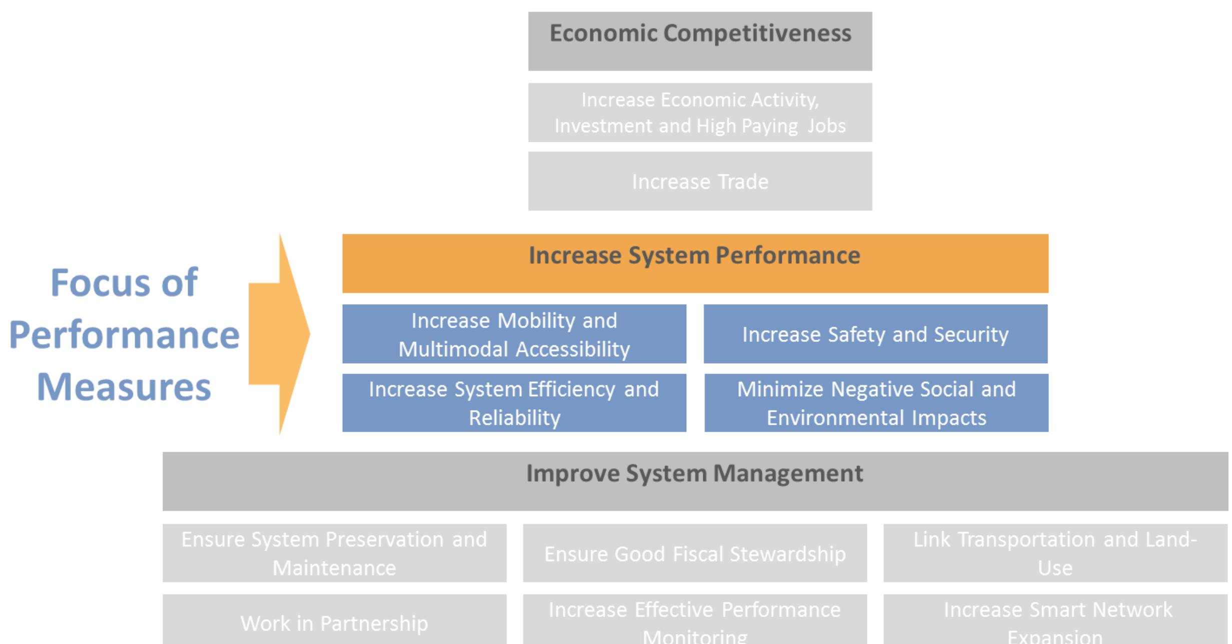
Executive Summary

Arizona's freight transportation system generally provides efficient, reliable, and safe movement of goods statewide but experiences some recurring congestion and bottlenecks in and around urban centers, particularly Phoenix, and non-recurring delays associated with road construction, crashes, and weather events. Despite this overall positive appraisal, system users suggest that travel times and costs of moving freight in the state are increasing and that conditions are less safe due to traffic congestion and weather events (e.g. dust storms).

This report assesses the condition and performance of the state's freight transportation system using a combination of quantitative and qualitative measures grounded in the Freight Plan's goal of *increasing system performance*.

The quantitative measures utilize hard data collected by ADOT and other sources while the qualitative measures rely on a survey of more than 50 freight system stakeholders—including system managers (transportation agencies) and system users (Arizona businesses, shippers, carriers). Each performance measure relates to one or more of the objectives shown in ES 1-1 that comprise the goal of increasing system performance.

ES 1-1: Focus of the Arizona State Freight Plan's Performance Measures



Freight Performance Measures

ES 1-2 displays the four system performance goals and the associated quantitative and qualitative performance measures. The quantitative performance measures use ADOT data and are supplemented by qualitative measures or value judgment indicators, which provide insight into topics for which little or no data are available and extend the usefulness of quantitative performance measures.

The value judgment indicators were compiled from a survey of ADOT's Freight Advisory Committee (FAC), which asked survey respondents to compare current performance relative to performance five years ago. This provides a baseline for the general trend of Arizona's freight transportation system, i.e. performance is getting better, declining, or staying the same. Furthermore, survey respondents had the option to cite specific issues to provide a context to their answers.

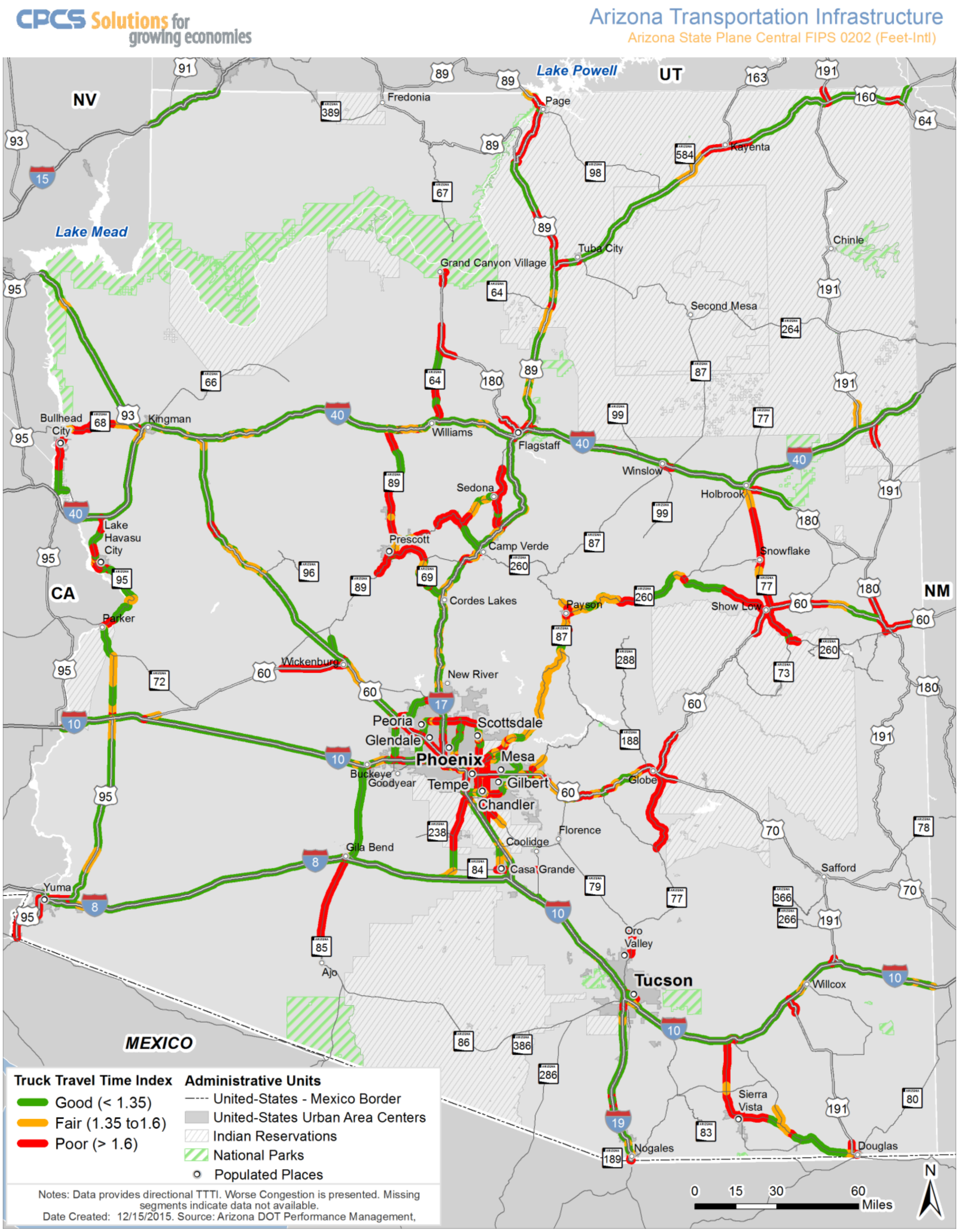
ES 1-2: Value Judgment Indicators Informing Quantitative Performance Measures

Freight Transportation System Objectives	Quantitative Performance Measure	Value Judgment Indicator Questions
Increasing Mobility and Multimodal Accessibility	**Mobility:** Truck Travel Time Index (TTTI)	**Mobility:** How have freight travel times changed in the last five years? **Multimodal Accessibility:** How have multimodal options (ability to ship by truck, rail, air) changed relative to five years ago?
Increase System Efficiency and Reliability	**Efficiency:** Annual Hours of Truck Delay **Reliability**: Truck Planning Time Index (TPTI)	**Efficiency:** How have logistics costs due to system inefficiencies changed in the last five years? **Reliability:** How has on-time delivery changed in the last five years?
Increase Safety And Security	**Safety:** Accident rate per 100 million vehicle miles of travel **Safety:** Total societal cost of accidents	**Safety:** How have incidents and close calls changed in the last five years? **Security:** How has freight security changed in Arizona relative to five years ago?
Minimize Negative Social and Environmental Impacts	**N/A**	**Environmental/Social:** Have negative environmental externalities relating to freight activity and transportation decreased relative to the previous period?

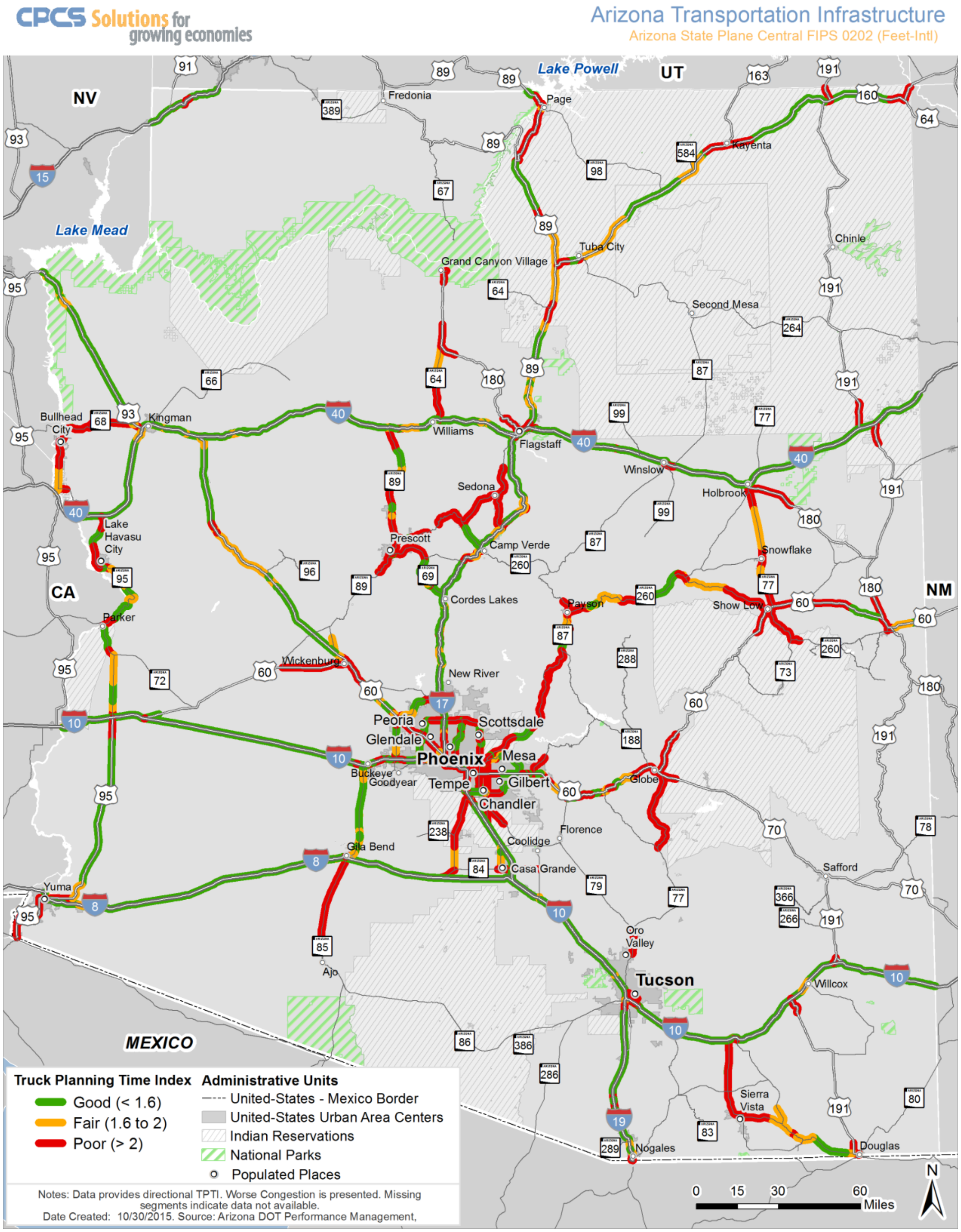
Mobility, Reliability and Multimodal Accessibility

ES 1-3 and ES 1-4 displays the performance of Arizona's freight transportation system based on measures representing truck mobility and travel times (Truck Travel Time Index or TTTI) and truck reliability (Truck Travel Planning Time Index or TPTI), respectively. Additionally, ES 1-5 and ES 1-6 summarize the performance of the Key Commerce Corridors (KCCs) on TTTI and TPTI measures. Overall, relatively few highway segments experience poor performance across TTTI and TPTI measures, with a few exceptions, and those poor TTTI and TPTI segments largely coincide. Overall, large portions of the Arizona's roadways and the overwhelming majority of the KCCs are performing well.

ES 1-3: Truck Travel Time Index



ES 1-4: Truck Planning Time Index



ES 1-5: Arizona Key Commerce Corridor TTTI Performance

Corridor	Length (miles)	Rural/Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)
Key Commerce Corridor	1,375	Rural	1210	87%	10%	3%
		Urban	165	80%	10%	10%
Overall Key Commerce Corridor (Urban and Rural Combined)				86%	10%	4%

ES 1-6: Arizona Key Commerce Corridor TPTI Performance

Corridor	Length (miles)	Rural/Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)
Key Commerce Corridor	1,375	Rural	1210	87%	10%	3%
		Urban	165	76%	8%	16%
Overall Key Commerce Corridor (Urban and Rural Combined)				85%	10%	5%

The transportation system is performing well with more than 85% of KCC's rated "good" for both travel time and reliability.

The freight plan uses value judgment indicators to assess multimodal accessibility and to supplement the quantitative assessment of mobility and reliability. When asked about multimodal accessibility, stakeholders most frequently suggested that multimodal options have increased or stayed the same compared to five years ago. While an increase in the number of options would be the best indicator, multimodal accessibility is leaning in the direction of a more competitive freight transportation system.

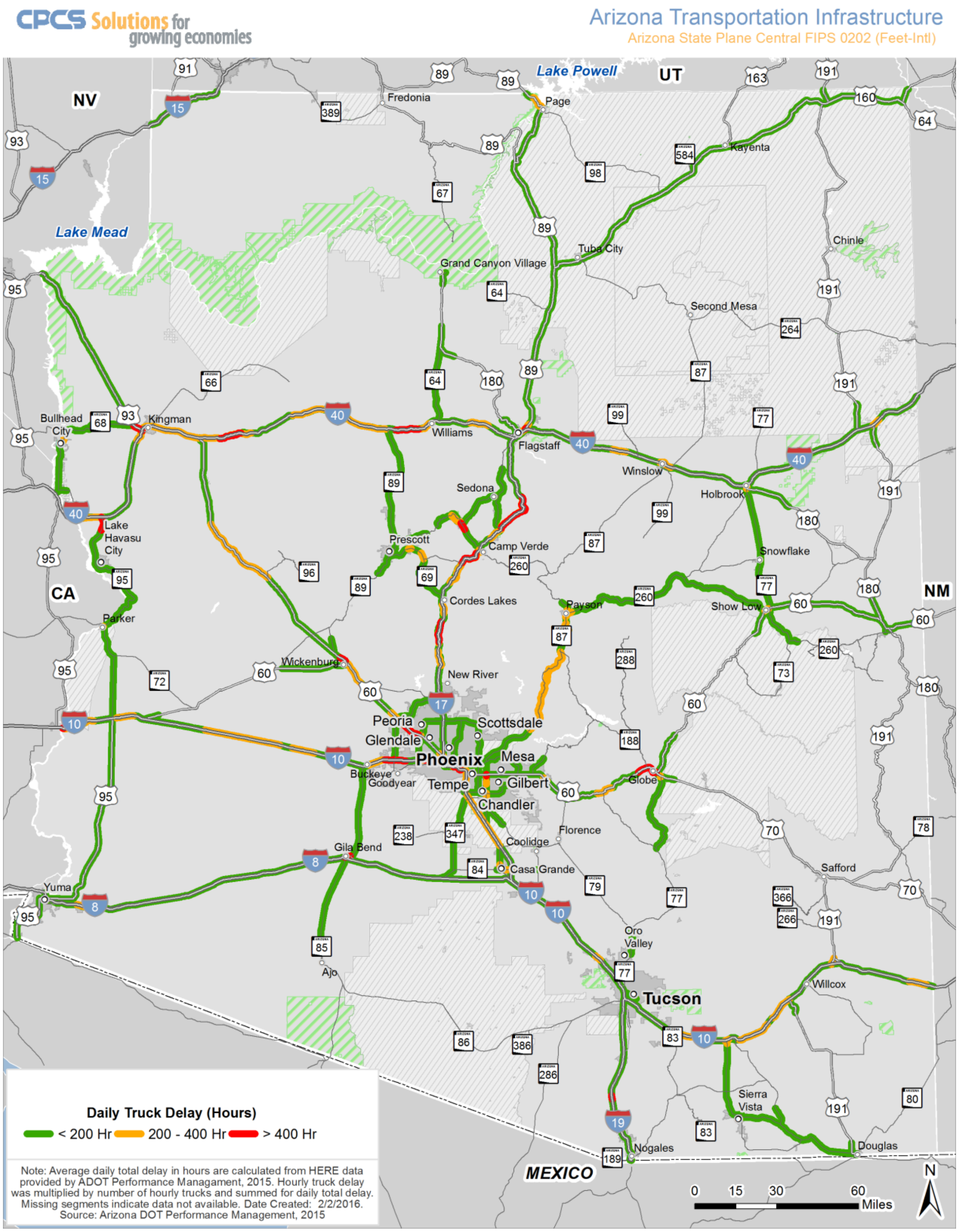
When surveyed, stakeholders suggested that mobility is getting worse relative to five years ago. Similarly, stakeholders suggested that the reliability of the transportation system is getting worse, but respondents provided a greater distribution of responses (across the different groups consulted) compared to the mobility measure. Adding the value judgment indicators suggests that there has been a generally negative trend in performance over time.

Value judgment indicators for mobility and reliability suggest the performance of the freight transportation system is getting worse relative to five years ago.

Efficiency

ES 1-7 displays the daily total hours of truck delay by roadway segment. Both truck volumes and operating delay are accounted for while calculating total hours of daily truck delay. Rural corridors experience truck delay during nighttime, which is largely a function of driving conditions (lack of lighting, grades, lack of passing and climbing lanes, adverse environmental and weather conditions), and not necessarily a function of congestion or traffic volume. In urban areas, delay is mostly due to peak period congestion when the overall traffic volume is high. When asked to assess how the efficiency of the transportation system has changed over time, nearly every stakeholder suggested that it is getting worse.

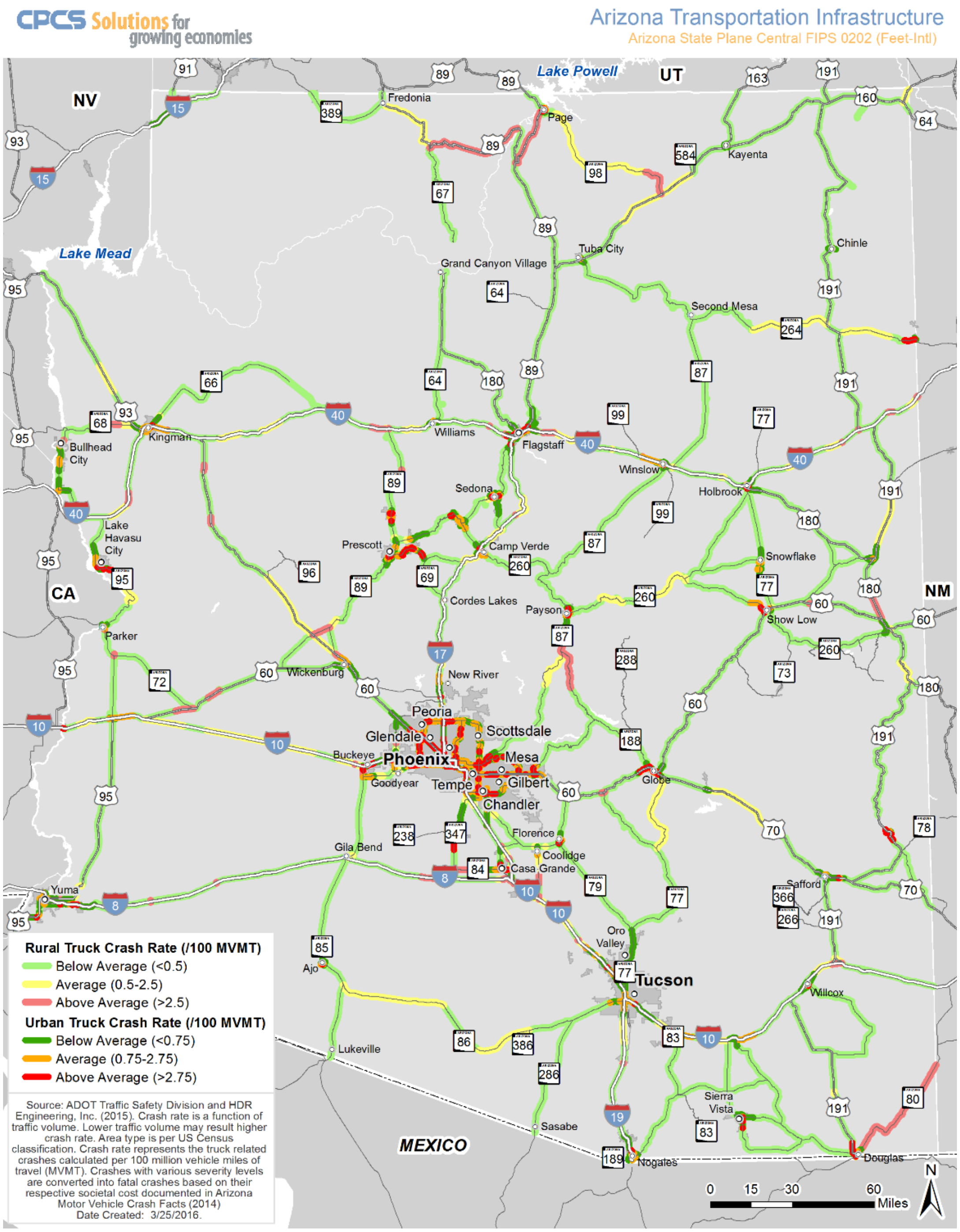
ES 1-7: Arizona Daily Hours of Truck Delay (2014)



Safety and Security

ES 1-8 displays crashes categorized into one of three categories, below average, average, or above average (based on rural or urban characteristics). The number, weighted by severity, of crashes involving trucks per 100 million VMT by all traffic is used to differentiate the predominant locations of truck-related accidents on Arizona's transportation system. While Arizona has a good safety record, truck safety remains a significant state, regional and local transportation system issue.

ES 1-8: Arizona Safety Performance Measure (Truck Crash Rate, 2014)



In response to the safety and security value judgment indicators, stakeholders suggested that these factors are largely unchanged, with some suggesting performance has gotten worse. The only reason provided for their answer on the safety and security questions was to suggest that traffic is causing safety to get worse.

Social and Environmental Impacts

Transportation officials found it difficult to comment on broad trends relating to social and environmental impacts, as these issues are addressed primarily through land use planning, or environmental processes. Additionally, none of the benchmarked state freight plans analyzed included social impacts performance measures and only a third of recently completed state freight plans included an environmental performance measure. Air quality nonattainment areas are used as a proxy for environmental impacts, but transportation may not be the sole cause of air quality nonattainment. Other sectors such as mining (for example, Hayden and Miami), agriculture and land development also impact air quality. Seven counties in Arizona are classified as nonattainment areas for various pollutants by the U.S. Environmental Protection Agency.

Overall Performance

Outreach suggested that most users are largely satisfied with the performance of the transportation system. Yet, the system faces some specific performance issues which are relevant to this working paper, as revealed through consultations with freight transportation system stakeholders:

- **Recurring congestion and bottlenecks in and around urban centers, particularly Phoenix:** Peak congestion and associated bottlenecks were identified by virtually all freight sectors as problematic, and as a barrier to transportation system performance and sector competitiveness.

  Relevant objectives: System Efficiency and Reliability; System Mobility and Multimodal Accessibility

- **Non-recurring congestion and bottlenecks:** Although less frequently cited as an issue, several stakeholders – across most sector groups – noted non-recurring congestion and road closures as hindering the reliability of their transportation operations. Cited causes included road construction-related lane closures, crashes, and weather events, amongst others.

  Relevant objectives: System Efficiency and Reliability; System Mobility and Multimodal Accessibility

The consultations echo the findings of both the quantitative and qualitative performance measures. The performance evaluation reveals that the freight system is performing well, but freight movement experiences some level of recurring delays and non-recurring delays in both the urban and rural areas of the state.

As evidenced by the TTTI evaluation, only a small percentage of the 1,370 miles of KCC routes have a poor rating. The TPTI evaluation indicates a larger percentage of the system has a poor rating, a result of the non-recurring delays impacting reliability. The segments experiencing the greatest planning time delays are in the rural areas of the state, where alternatives are limited, and detours are relatively long.

Coupling the value judgment indicators and performance measures, the overall freight system is performing well, but stakeholders suggest a generally decreasing trend in system performance relative to five years ago. Additionally, stakeholders often suggested issues on similar roadways throughout the value judgment indicators.

The results of the quantitative performance measures and the value judgment indicators will be used in subsequent phases of work to identify the locations where freight performance is poor, and help inform strategic solutions to address them.

This Working Paper focuses on the performance of the roadway system given ADOT's asset ownership over highways and its limited ability to invest in performance of other modes. Working Paper 2 contains additional information on non-highway modes.

Acronyms / Abbreviations

AADT	ANNUALIZED AVERAGE DAILY TRAFFIC
AADTT	ANNUALIZED AVERAGE DAILY TRUCK TRAFFIC
ADOT	ARIZONA DEPARTMENT OF TRANSPORTATION
ATR	AUTOMATIC TRAFFIC RECORDERS
ATRI	AMERICAN TRANSPORTATION RESEARCH INSTITUTE
CBRE	CB RICHARDS ELLIS
CMAQ	CONGESTION MITIGATION AND AIR QUALITY
COG	COUNCIL OF GOVERNMENTS
EPA	ENVIRONMENTAL PROTECTION AGENCY
FAC	FREIGHT ADVISORY COMMITTEE
FHWA	FEDERAL HIGHWAY ADMINISTRATION
GIS	GEOGRAPHIC INFORMATION SYSTEM
HPMS	HIGHWAY PERFORMANCE MONITORING SYSTEM
KCC	KEY COMMERCE CORRIDORS
LA/LB	LOS ANGELES/LONG BEACH
LRTP	LONG RANGE TRANSPORTATION PLAN
MAP-21	MOVING AHEAD FOR PROGRESS IN THE 21ST CENTURY ACT
MPD	MULTIMODAL PLANNING DIVISION
MPH	MILES PER HOUR
MPO	METROPOLITAN PLANNING ORGANIZATION
MVMT	100 MILLION VEHICLE MILES TRAVELED
TAC	TECHNICAL ADVISORY COMMITTEE
TPTI	TRUCK PLANNING TIME INDEX
TTTI	TRUCK TRAVEL TIME INDEX
U.S. DOT	UNITED STATES DEPARTMENT OF TRANSPORTATION
VMT	VEHICLE MILES OF TRAVEL

1 Introduction

Key Messages

The Arizona State Freight Plan will define immediate and long-range investment priorities for the state's freight transportation system.

This Working Paper is the output of Phase 5 of the Freight Plan. It provides an assessment of the conditions and performance of Arizona's freight transportation system and related implications for the competitiveness and growth of Arizona's key freight sectors.

Analysis conducted as part of Phase 5's intermediate steps is used as the basis for much of this Working Paper, including the identification of the performance measures used to assess the performance of Arizona's freight transportation system. Performance measures are defined to support the Plan's vision, goals, objectives, policies and strategies.

Performance measures, supporting data and analytical approaches were previously reviewed and approved for use in the Freight Plan by both ADOT and the Technical Advisory Committee (TAC).

1.1 Introduction: Context

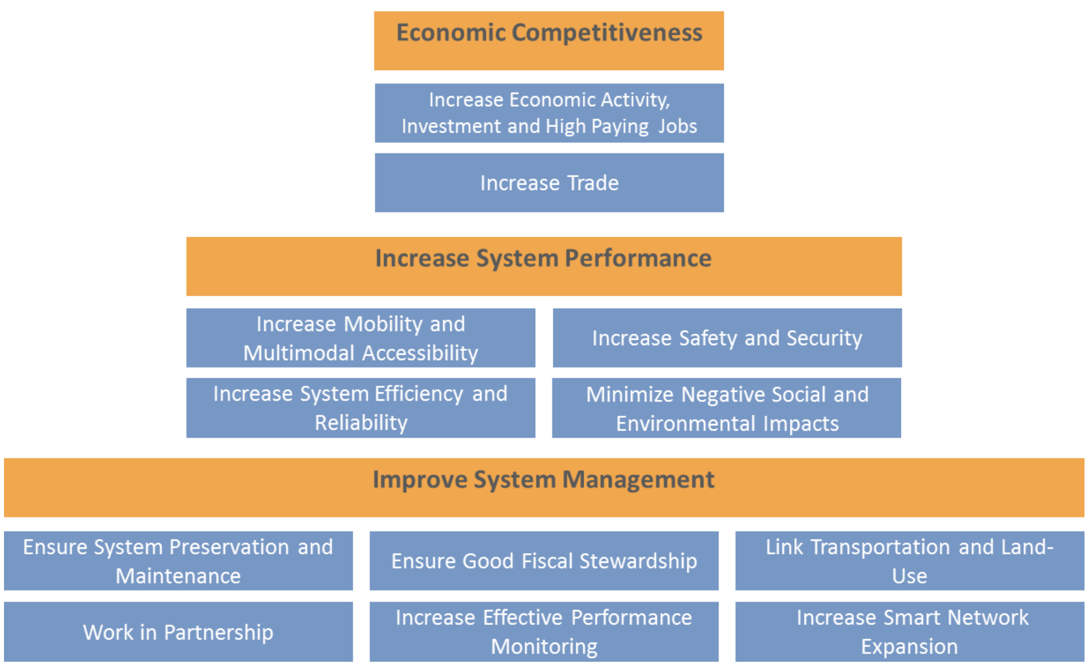
Arizona's economic potential is supported by the state's transportation infrastructure, which connects sources of production to markets. When transportation infrastructure and related services are efficiently designed and competitively positioned, businesses benefit from lower transport costs, faster and better transportation services and increased reliability. These transportation benefits in turn contribute to competitiveness and growth of businesses and the broader region.

Effective freight planning and programming can help achieve competitiveness and growth. Yet, fiscal realities are such that Arizona's Department of Transportation (ADOT) cannot address all transportation system needs and constraints. Rather, ADOT must be strategic in defining and prioritizing its investments and system improvements.

To this end, ADOT's Multimodal Planning Division (MPD), is developing Arizona's State Freight Plan (Freight Plan, or Plan) which will provide strategic guidance to achieve its vision, goals and objectives. The following vision, goals and objectives have been developed to guide the freight planning process (Figure 1-1).

Vision: Arizona's freight transportation system enhances economic competitiveness and quality growth through effective system performance and management.

Figure 1-1: Arizona State Freight Plan Goals and Objectives



Source: CPCS

1.2 Project Objectives

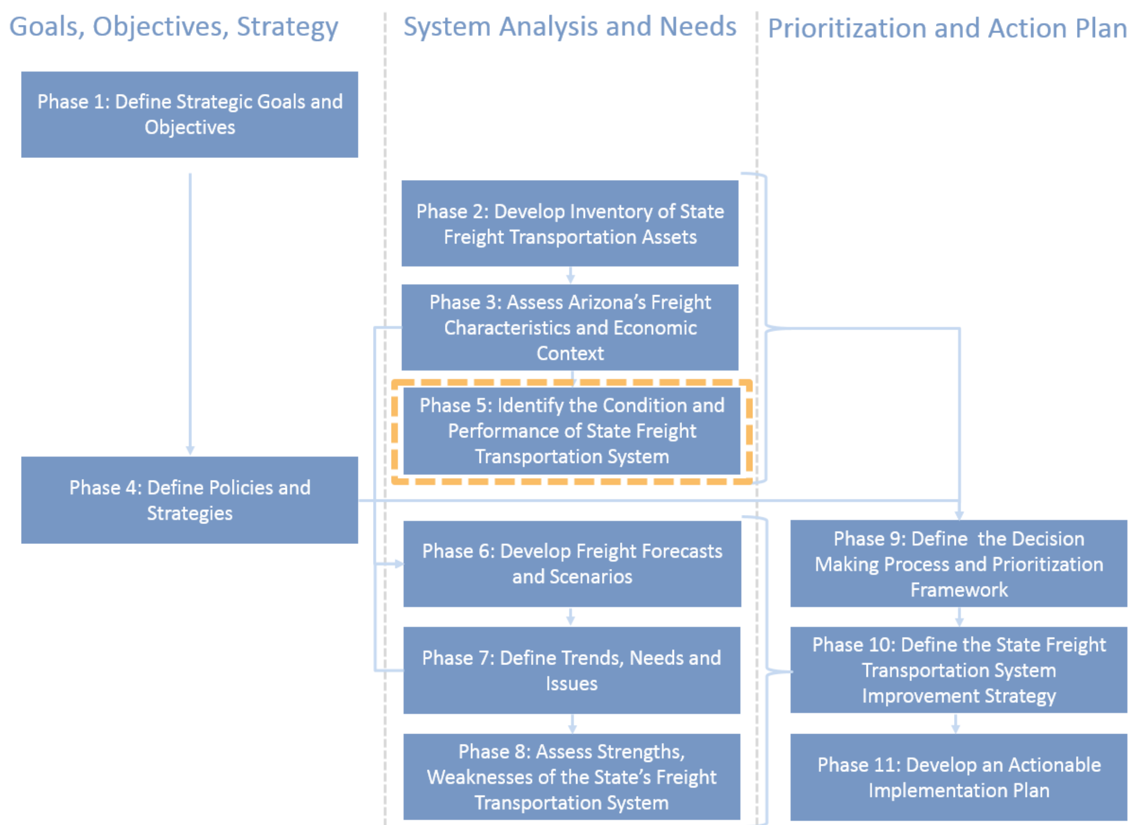
The Freight Plan will define immediate and long-range freight investment priorities and policies that will generate the greatest return for Arizona's economy, while also advancing other key transportation system goals, including national goals outlined in the Moving Ahead for Progress in the 21st Century Act (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 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 Freight Plan's vision, goals, and objectives, and notably, promote regional economic competitiveness and growth. The Freight Plan should also inform broader transportation system planning in Arizona, including future updates to the Long Range Transportation Plan (LRTP).

1.3 Freight Plan Development Phases

The State Freight Plan is being developed in 11 phases, organized under three overarching headings, as summarized in Figure 1-2. The present Working Paper is the output of Phase 5.

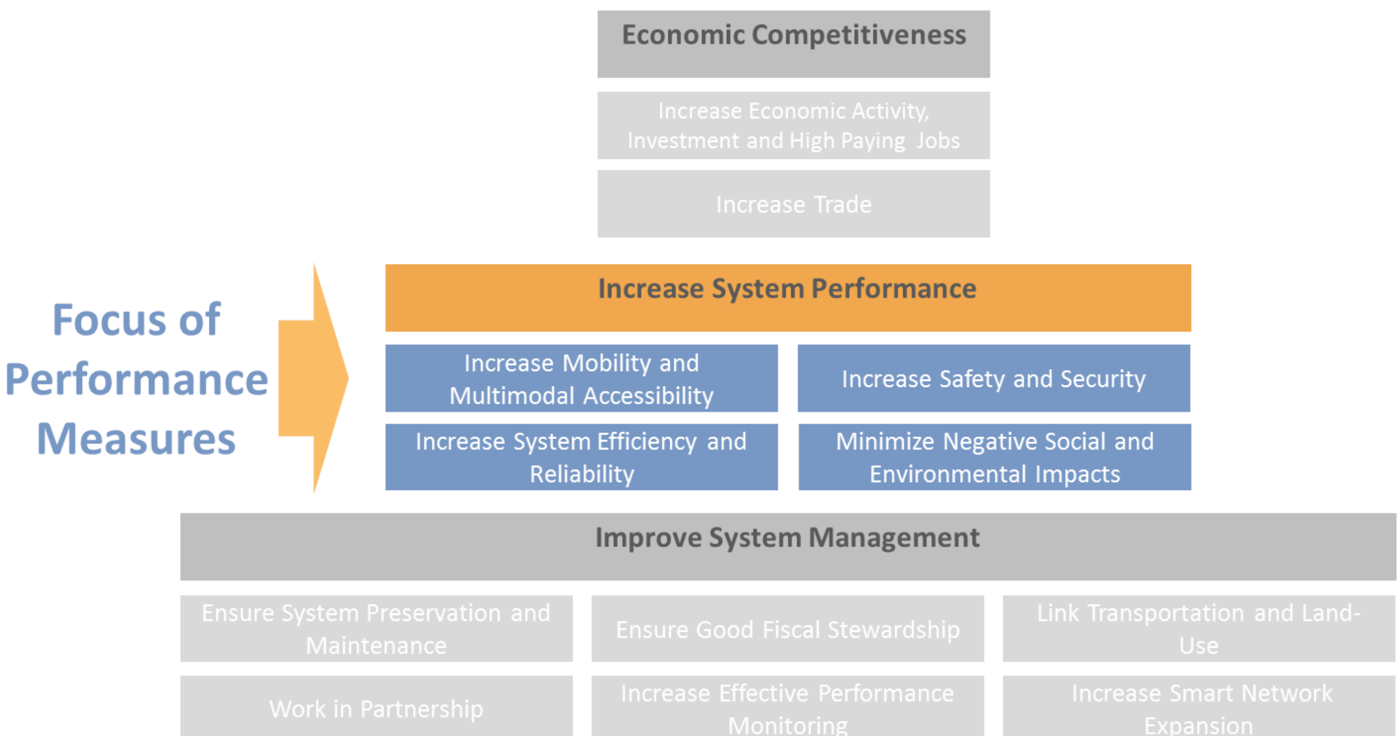
Figure 1-2: Phased Approach to the Development of Arizona's State Freight Plan



1.4 Purpose of this Working Paper

This Working Paper presents an assessment of the the overall condition and performance of Arizona’s freight transportation system, with respect to the system performance objectives of the Freight Plan: 1.) Increase mobility and multimodal accessibility, 2.) Increase safety and security, 3.) Increase system efficiency and reliability, and 4.) Minimize negative social and environmental impacts shown in Figure 1-3.

Figure 1-3: Improve System Performance Goal and Objectives



The assessment of performance presented in this Working Paper uses the performance measures previously proposed and subsequently approved by the ADOT Project Manager and Technical Advisory Committee (TAC). This includes a combination of quantifiable performance metrics where feasible, failing which, qualitative value judgment indicators are used. This Working Paper focuses on the performance of the roadway system, because Working Paper 2 on transportation system assets already outlined the condition of all freight modes. Additionally, the performance of all modes was also assessed in Working Paper 2.

This Working Paper highlights the implications of condition and performance issues on the competitiveness and growth of Arizona’s key freight sectors.

The assessment of condition and performance informs the identification and prioritization of freight transportation system improvements in the context of the Freight Plan. The condition and performance assessment also establishes a baseline to compare freight transportation system performance over time.

This Working Paper is presented for review and comments by the ADOT Project Manager, the TAC and the Freight Advisory Committee (FAC).

1.5 Methodology

This Working Paper is informed by a combination of data analysis and consultation with the operators and asset owners of Arizona's statewide multimodal freight system. Additionally, this Working Paper consolidates and builds upon the previous phases, especially the Phase 2 Inventory of State Freight Transportation Assets and the Phase 3 Economic Context Working Paper outlining Arizona's economy and key economic sectors.

The draft performance measures, data, and approaches for the freight transportation system evaluations were presented and submitted to ADOT and the TAC in an interim Phase 5 document.

1.6 Limitations

This Working Paper is in many cases informed by data and input provided by third parties. CPCS has verified this information to the extent possible through analysis and cross-checking with other sources but cannot guarantee the accuracy of data received from third parties.

2 Approach to Performance Measures

Key Messages

The quantitative performance measures approved for use in the Arizona State Freight Plan focus on increasing transportation system performance. Additionally, to supplement the quantitative performance measures, the Freight Plan uses qualitative measures to assess variables with limited data.

The Arizona State Freight Plan's approach to performance measures complies with the freight themes of MAP-21, but U.S. DOT has yet to provide specific guidance on freight performance measures. Therefore, there is uncertainty regarding whether the proposed performance measures will match future MAP-21 and FAST Act rulemakings.

These measures, data, and approaches are applied to assess the performance of Arizona's freight transportation system.

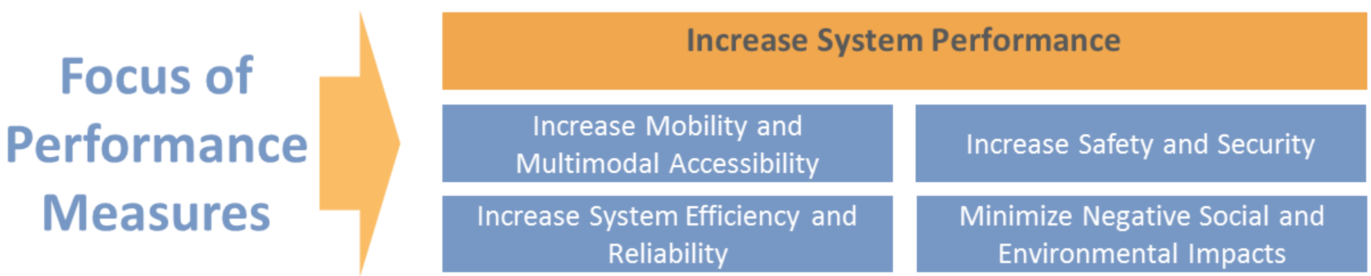
2.1 Simple and Practical Approach to Performance Measures

By leveraging ADOT's existing work on performance measures and recognizing that more performance measures do not necessarily produce better outcomes, this approach allows ADOT to measure and track fewer freight transportation system performance measures—with more focus. These performance measures are practical to measure and use, provide appropriate proxies for the performance parameters that freight transportation system users care about (for example, transit time, logistics cost, reliability), and provide meaningful insight into the conditions and performance of Arizona's freight transportation system.

2.1.1 Linking Performance Measures to Objectives

Increasing transportation system performance is one of the goals of the Arizona State Freight Plan, which ultimately enables economic competitiveness and quality growth. Freight performance measures are therefore directly tied to this goal and associated objectives. Accordingly, the performance measures flow from and measure progress toward the system performance objectives shown in Figure 2-1.

Figure 2-1: Improve System Performance Goal and Objectives



2.1.2 Building on ADOT Performance Monitoring and Evaluation

Much of the data needed to track and monitor progress toward the system performance objectives is already collected by ADOT and, in several instances, ADOT has implemented the related performance measures. Figure 2-2 displays the performance measures that are used to support the Arizona State Freight Plan.

Figure 2-2: Arizona State Freight Plan Performance Measures

Freight Transportation System Objective	ADOT Performance Measure
Increase Mobility	Truck Travel Time Index (TTTI)
Increase System Efficiency	Annual hours of truck delay
Increase System Reliability	Truck Planning Time Index (TPTI)
Increase Safety	Accident rate per 100 million miles of travel Total societal cost of accidents

2.1.3 Recognizing Quantitative Limitations

Inventing new, complex measures that are not yet supported by available data or are difficult to link to the freight sector causally is neither practical nor useful. Therefore, the following system performance objectives are qualitatively assessed in the Arizona State Freight Plan:

- Increase multimodal accessibility
- Increase security
- Minimize negative social impacts
- Minimize negative environmental impacts

These system performance objectives are either not currently tracked by ADOT, are difficult to measure and track empirically, and/or are difficult to relate specifically to freight activity. In these cases, progress toward these performance objectives are tracked qualitatively, using value judgment indicators and other, practical alternative means (discussed in Section 2.3 of this Working Paper).

2.2 Quantifiable Performance Measures to Assess System Performance

Leveraging the data and performance measures currently used by ADOT, the following sections outline the performance measures—including the data, approach, outcomes, and limitations of the measure or data. Because of the differing characteristics of rural and urban roadways, performance measures (TTTI, TTPI, and Safety) for urban and rural segments are evaluated separately. The U.S. Census area type classification is used to identify rural and urban roadway segments.

2.2.1 Overall Freight Activity Measure

Overall freight activity levels are used as a broad measure to add context to other performance measures. As a general measure, freight activity is not reported to the same degree as the other performance measures, but instead is used as a supplement to the other performance measures. The density of tonnage originating and destined for Arizona businesses, the density of warehouse and industrial square footage, average daily truck traffic (AADTT) counts and the proportion of trucks to the overall traffic stream are used to display overall freight activity. These measures indicate the location of freight activity (tonnage and warehousing and industrial density) and whether freight activity is increasing or decreasing on the whole network or on specific facilities over time (AADTT and truck percentage).

Link to Objective: Increase Economic Activity

The tonnage density, warehouse density, truck counts and the proportion of trucks utilize a variety of factors to show the location and intensity of freight focused economic activity.

Data

The density of tonnage utilizes the Freight Finder data set, which reports the inbound and outbound freight tonnage associated with businesses in Arizona. These data were analyzed in a Geographic Information System (GIS) to identify the areas with concentrated freight tonnage.

Warehouse and industrial density was identified for warehousing and industrial facilities based on the CB Richards Ellis (CBRE) dataset. The CBRE dataset is based on construction permit records from 1998 to 2015. The overall output is the density of freight facilities in Arizona by square footage.

Truck counts and the percent truck use ADOT data on average daily traffic and the truck percentages along state facilities each year. ADOT uses automatic traffic recorders (ATRs) along state facilities to conduct traffic counts measure speed, volumes and vehicle classification. ATR stations provide extensive traffic information that is used to make inferences about travel activity in accordance with FHWA guidelines. Various adjustments factors are applied on the raw daily traffic counts to calculate the annual average daily traffic (AADT). Based on the number of axles, ADOT uses FHWA's "Scheme F" vehicle classification to differentiate single- and multi-unit trucks. Both single[1] and multiunit[2] trucks are summed to calculate the truck percentages.

Approach

Warehouse and industrial square footage and tonnage density are calculated using the total tonnage or square footage within one mile of a point to create the density maps. This approach displays the clustering of large tonnage generators or locations of warehouses and industrial sites.

The percent of overall truck traffic is calculated by taking the annualized truck traffic divided by the annualized non-truck traffic. Annualized truck and non-truck traffic rates are calculated by the total volume of traffic on a highway segment for one year, divided by the number of days in the year.

Daily truck flows along state facilities are evaluated to identify the major freight corridors experiencing heavy truck activity (relative to the total number of vehicles). Routes with a high percentage of truck volumes represent the roadways carrying significant amounts of commercial and freight commodities throughout the state. Truck volumes also provide a

[1] Single units are light to medium weight straight-bodied trucks consisting of one motorized unit with six or fewer axles (as characterized by FHWA's "Scheme F" vehicle classification 4-7). Examples would include local delivery, dump, and garbage trucks. Buses of all kinds are included in these classes of vehicles.

[2] Multiunit or combination commercial vehicles are heavy weight trucks with two or more units—typically tractor-trailer combinations such as those used by over-the-road motor freight carriers (as characterized by FHWA's "Scheme F" vehicle classification 8-13).

measure of the amount of goods that are being moved through the freight system network. The percent truck at each segment is calculated as follows:

$$\text{Percent Truck} = \frac{\text{Single Unit Truck Traffic} + \text{Multi Unit Truck Traffic}}{\text{Annual Average Daily Traffic}}$$

Outcome

The overall freight activity measures are summarized on a statewide map in Section 3 of this Working Paper. For the Key Commerce Corridors (KCCs), average truck percentage is summarized for the base year; comparisons of future year volumes can be made to evaluate changes in system use over time.

Limitation

The CBRE data utilize historic building permits (1998-2015) to define facility use, but the facility may be used in a different way than originally permitted or could be empty. Additionally, the measure of square footage treats all facilities the same, regardless of employment, value added or tonnage.

While the use of ATRs on the state roadway network is extensive, there are areas without ATRs, or where there is limited coverage. Locations where field-truck data are not available are often estimated to other highway segments observed to exhibit similar traffic behavior patterns.

2.2.2 Truck Mobility Performance Measure

Link to Objective: Increase Mobility

Truck mobility and accessibility improvements are evaluated using the TTTI, which measures truck-related recurring delay primarily attributable to peak period congestion. TTTI is used to evaluate the difference in travel time between "free flow" and congested flow conditions.

Data

ADOT currently uses HERE data, which provides user travel speed information for cars and trucks. HERE is based on passenger vehicle probe data obtained from a number of sources including mobile phones, vehicles, and portable navigation devices. Freight probe data are obtained from the American Transportation Research Institute (ATRI), which leverages embedded fleet systems data. ADOT currently maintains an intranet web portal that summarizes TTTI on a limited number of state facilities, including all of the KCCs.

Approach

The speed-based TTTI is calculated using the following formula:

$$\text{Truck Travel Time Index} = \frac{\text{Free Flow Truck Speed}}{\text{Observed Average Peak Period Truck Speed}}$$

As part of ADOT's Corridor Profile Studies program, the agency defined an initial set of TTTI thresholds[3] to support the ongoing Corridor Studies currently under analysis. As documented in the *Phase 5: Performance Measures, Data, and Approaches Interim Working Paper*, these initial thresholds were defined to rank segments by good, fair, and poor mobility conditions.

After these TTTI thresholds were defined, ADOT refined the TTTI calculation methodology to use the posted speed limit as the proxy for free flow speeds. The thresholds initially defined in the corridor profile studies were updated based on a change in TTTI calculation methodology.[4] Even though trucks often operate at slower speeds than the posted speed limit (for example, in areas with posted truck speed restrictions), this approach maintains a consistent evaluation approach for the entire system.

Since the Arizona State Freight Plan evaluates freight performance throughout Arizona (as opposed to the Corridor Profile Studies, which evaluate specific corridors), establishing an overall statewide threshold is necessary. The statewide threshold derived for the Freight Plan accommodates differing roadway functional class, speeds, and operating environments to assess statewide freight performance.

A statistical approach to defining the Freight Plan performance thresholds using defined percentiles (according to the distribution of TTTI values) allows ADOT to evaluate freight performance over time. Since ADOT has not previously established statewide thresholds, the thresholds used for the State Freight Plan are assigned to closely mimic the results of the previous Corridor Profile Studies. Arranged in percentiles, with the lowest speeds equaling 0 and the highest speeds equaling 100, the revised TTTI thresholds used in this truck mobility performance evaluation are:

- Poor: >1.6 (15th percentile of speed)
- Fair: 1.35 to 1.6 (15th to 30th percentile of speed)
- Good: <1.35 (30th to 100th percentile of speed)

Using the statistically established thresholds (percentile based), ADOT will develop threshold values for each new data set to compare freight performance over time. When applied to the KCCs, the thresholds allow evaluation over time of the roadway segment miles operating at good, fair, or poor conditions. Improved performance will be indicated by greater miles of segments operating under improved conditions.

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[3] ADOT's TTTI dataset was initially mapped by the following thresholds to measure the freight travel time related to recurring delay: Good: <1.15; Fair: 1.15 to 1.33; Poor: >1.33.
[4] HDR consulted with ADOT on the change in thresholds prior to preparing the maps.

In addition to a segment-by-segment approach, an overall corridor rating was developed that provides a "weighted average" based on segment length. The segments-based TTTI is calculated using the following formula:

$$\text{Overall Corridor value} = \frac{\sum(\text{link length} \ * \ \text{link TTTI})}{\text{Entire segment length (mi)}}$$

Outcome

The TTTI results are summarized on a statewide map in Section 3 of this Working Paper, displaying roadway segments (where data are available) with poor freight mobility. Additionally, a single index specific to the KCCs was developed as a benchmark and overall indicator of performance (although the segment-level values provide a better measure of performance year-to-year).

Limitation

ADOT currently does not have access to historical TTTI data. In addition, data are not available for all state-owned facilities. In remote areas of the state where such data may not be available, congestion is not typically a significant issue. However, as data coverage improves, ADOT will be able to expand the coverage of the TTTI performance measure, encompassing more state facilities. Wider TTTI data coverage will help ADOT provide more reliable system-wide freight performance evaluations. In the short term, coverage of the KCCs is the primary focus.

2.2.3 Annual Hours of Truck Delay Performance Measure

Link to Objective: Increase System Efficiency

Annual hours of truck delay is designed as a measure of traffic congestion and delay on the overall transportation system, which directly affects truck efficiency and reliability. This delay results in slower speeds and longer trip times along specific locations on the transportation system. Annual hours of truck delay can be assessed at a system level as well as at individual bottlenecks. The impact of highway system bottlenecks is measured by total truck hours of delay, which also provides a relative ranking of bottlenecks throughout the state.

Annual hours of truck delay captures both characteristics of slower speed and longer trip times and is a primary indicator of freight performance.

Data

The following data, maintained by ADOT, are used to calculate annual hours of truck delay:

- Speed limits: HPMS data are used as the source of speed limits on statewide facilities
- Truck operating speeds: HERE data are used for actual peak period truck speed

- Annual vehicle classification traffic counts: ADOT's Traffic Division supplied the traffic counts used in this analysis

Approach

ADOT has yet to develop the GIS–based, interlinked dataset (conflation) between the speed and vehicle count datasets necessary to calculate annual hours of congestion-related truck delay. However, ADOT currently maintains multiple datasets encompassing real-time truck operating speeds and traffic counts. Annual hours of delay from these data sources are linked with roadway segments and conflated into a GIS to allow analysis and representation through GIS mapping.

ADOT derived the delay per truck at a segment level based on HERE speed data. Cumulative total daily hours of delay is calculated by multiplying segment delay with the number of trucks by segment. The ADOT Traffic Division maintains vehicle classification counts by hour at selected roadway segments. Representative hourly vehicle classification counts at key truck count locations are used to compute the daily distribution of truck operations.

Hourly cumulative truck delay is summed for daily total hours of truck delay. Yearly cumulative delay is based on information presented in the Highway Capacity Manual (Special Report 209, Transportation Research Board, 2000). [5]

Once the annual hours of truck delay are defined at a segment level, they can be compared to define the worst bottlenecks in Arizona. When delay over all of the segments are summed, they define total annual truck delay over the transportation system.

Outcome

The annual truck hours of delay is tabulated by the morning (6 a.m. to 9 a.m.), midday (9 a.m. to 3 p.m.), afternoon (3 p.m. to 6 p.m.) and nighttime (6 p.m. to 6 a.m.) periods. Since the cumulative truck delay is a function of truck volume and the total segment length, results are normalized by delay per thousand vehicle miles of truck travel. Truck VMT by KCC corridors is calculated from the ADOT Statewide Travel Demand model (AZTDM, September 2015) and corridor delay per thousand vehicle miles of truck travel is summarized. A statewide map shows the cumulative daily hours of truck delay by roadway segment (where data is available). KCCs and other roadway segments showing poor freight performance are identified.

[5] Total truck working days is based on information presented in the Highway Capacity Manual (Special Report 209, Transportation Research Board, 2000). To determine truck operating working days per year, an average truck working week of 5 weekdays at full capacity and 2 weekend days at 44 percent capacity is used; this equated to 306, which is included in the computations of this measure. Daily truck delays are multiplied by 306 to estimate annual total hours of truck delay.

Limitation

This measure typically underestimates the total truck hours of delay because it does not consider the impacts of intersecting arterial roadways. In addition, the analysis methods do not yet adequately account for the congestion effects of traffic weaving and merging at on- and off-ramps. ADOT currently has some historical (2014 and part of 2015) truck operating speed data for a limited number of major freight corridors. As data coverage improves, ADOT will be able to expand the coverage of annual truck delay and a more thorough analysis of the state transportation network can be completed.

2.2.4 Truck Reliability Performance Measure

Link to Objective: Increase System Reliability

Unreliable freight transportation requires added supply chain redundancy and costs for businesses, making reliability a key performance metric. Reliability of the freight transportation system influences logistics decisions, such as the number and location of manufacturing plants and distribution centers, affecting regional, state, and local economies. Reliability is measured through nonrecurring delay, which refers to unexpected delay caused by closures or restrictions resulting from crashes, inclement weather, and construction activities. System efficiency and reliability are measured using the TPTI. TPTI represents the amount of time over and above the expected travel time that should be planned to make an on-time delivery 95 percent of the time. It is a comparison between the 5th percentiles of the lowest mean speed to free flow conditions at a specific location of a corridor.

Data

ADOT currently develops and applies the TPTI for major freight corridors using the HERE dataset.

Approach

The speed-based TPTI is calculated using the following formula:

$$\text{Truck Planning Time Index} = \frac{\text{Free Flow Truck Speed}}{\text{Observed 5th Percentile Lowest Truck Speed}}$$

As part of ADOT's Corridor Profile Studies program, the agency defined an initial set of TPTI thresholds.[6] As documented in the *Phase 5: Performance Measures, Data, and Approaches Interim Working Paper*, these initial thresholds were defined to rank segments by good, fair, and poor mobility conditions. Arranged in percentiles, with the least reliable segments equaling

[6] ADOT defined an initial set of TPTI thresholds to support the ongoing Corridor Profiles. ADOT's TPTI dataset was initially mapped by the following thresholds: Good: <1.3; Fair: 1.3 to 1.5; Poor: >1.5.

0 and the most reliable segments equaling 100, the revised TPTI thresholds used in this truck reliability performance evaluation are:

- Poor: >2.0 (15^{th} percentile of planning time)
- Fair: 1.6 to 2.0 (15 to 30^{th} percentile of planning time)
- Good: <1.6 (30^{th} to 100^{th} percentile of planning time)

An overall roadway rating provides a "weighted average" based on segment length. The segment-based TPTI is calculated using the following formula:

$$\text{Overall Corridor value} = \frac{\sum(\text{link length} \ * \ \text{link TPTI})}{\text{Entire segment length (mi)}}$$

Outcome

The TPTI results are summarized on a statewide map. KCC and other roadway segments (where data are available) showing poor freight performance are also identified. A single index for the KCCs is developed as a benchmark and overall indicator of performance, although the segment-level values provide a better measure year-over-year of performance.

Limitation

Similar to the TTTI measure, ADOT currently has limited TPTI data that cover only major freight corridors in the state since 2014.

2.2.5 Truck Safety Performance Measure

Link to Objective: Increase Safety

Highway crashes involving trucks tend to be a disproportionately low percentage of all highway crashes. Despite a relatively good safety record in Arizona, concern over truck safety remains significant because of the size, weight, and reduced handling characteristics of trucks compared to automobiles. To measure the trucking industry's safety performance, the number of crashes involving trucks per 100 million vehicle miles of travel (VMT) is calculated, along with their total societal cost.

Data

ADOT's Traffic Safety Division maintains and updates a statewide crash database, including historical data consisting of location, severity, collision manner, harmful event, driver behavior, and environmental and weather condition. The crash database is compiled from Arizona Traffic Accident Reports submitted to ADOT by state, county, city, tribal, and other law enforcement agencies and is updated periodically. The safety performance measure focuses on crash data involving trucks within the most recent 3 years between January 1, 2011, and December 31, 2013.

Approach

ADOT's Annual Motor Vehicle Crash Facts (2014) is used to estimate the lifetime economic costs to society. These values are as follows:

Figure 2-3: Lifetime Economic Costs to Society by Crash Type

Crash Type	Lifetime Economic Costs to Society (per crash)
Fatal	$1.53 million
Incapacitating	$76,398
Non-incapacitating	$24,480
Possible injury	$13,872
Property damage only	$9,486

Truck-involved crashes with various injury levels are converted into equivalent fatal crashes using the societal cost (as a proportion) as shown in Figure 2-3. ADOT currently uses urban and rural area types to analyze the crashes because traffic volumes and number of crashes varies significantly by area type. ADOT has reported that urban crashes account for 81.6 percent of all crashes and 53.4 percent of fatal crashes.[7] A safety index—categorized by below average, average, and above average—is developed for urban and rural roadway segments throughout the state per 100 million VMT. The higher the safety index value, the higher the risk of truck-related crashes. The Safety of individual roadway segment indices is compared with the statewide average by urban and rural area types and is categorized as above average, average, and below average. The calculation of this measure is shown below:

$$\text{Truck Crash Rate} = \frac{\text{Total Number of Truck Involved Crashes } * 100 \text{ Million}}{\text{AADT } * \ 365 \ * \text{ Crash Analysis Period (yrs)} * \text{Segment Length (mi)}}$$

Statistics-based crash rate thresholds[8] are computed for urban and rural areas because of the differences in travel behavior characteristics and activities within each distinct area type. The crash rate measures for rural areas are:

- Below average: <0.5 crashes per 100 million VMT
- Average: 0.5 to 2.5 crashes per 100 million VMT
- Above average: >2.5 crashes per 100 million VMT

[7] ADOT Traffic Engineering Guidelines and Processes include definitions of urbanized areas from the decennial census by the U.S. Census Bureau (Section 300, June 2015).

[8] Crash thresholds are developed for both urban and rural roadway segments using the following criteria:

- Below average: crash rates of 50th percentile or less
- Average: crash rates of 50th to 85th percentile
- Above average: crash rates of 85th percentile or greater

Crash rate measures for urban areas are:

- Below average: <0.75 crashes per 100 million VMT
- Average: 0.75 to 2.75 crashes per 100 million VMT
- Above average: >2.75 crashes per 100 million VMT

Outcome

The safety performance measure informs recommendations on project improvements and solutions to improve freight safety along the KCCs and other truck corridors exhibiting above-average crash rates. In addition, hot spots of freight-involved crashes are identified and used to compile critical system improvements.

Limitation

ADOT's crash database is comprehensive, maintained, and periodically updated; however, limited crash information is available for tribal lands. These data are maintained by local law enforcement agencies and the ADOT database is not updated consistently with this information.

2.3 Beyond Quantifiable Performance Measures: Value Judgment Indicators

When the development of quantitative performance measures is not practical, feasible, or meaningful, qualitative measures are defined to provide useful proxies for performance. Qualitative assessments of performance, using value judgment measures, are applied in this process as needed.

Value judgments provide an assessment of system performance from the user's perspective and can be a useful complement to quantitative measures.

Value judgment indicators are measures of perception, informed by a combination of qualitative information, observation, local knowledge, and stakeholder consultations, which are both relevant and appropriate. Value judgment indicators are particularly useful as a basis for defining whether transportation performance is getting better, worse, or remaining relatively constant versus past performance. Value judgments are less useful for comparing performance across different geographies and freight transportation systems, given differing contexts.

Value judgment indicators rely on user input to determine how performance is changing over time.

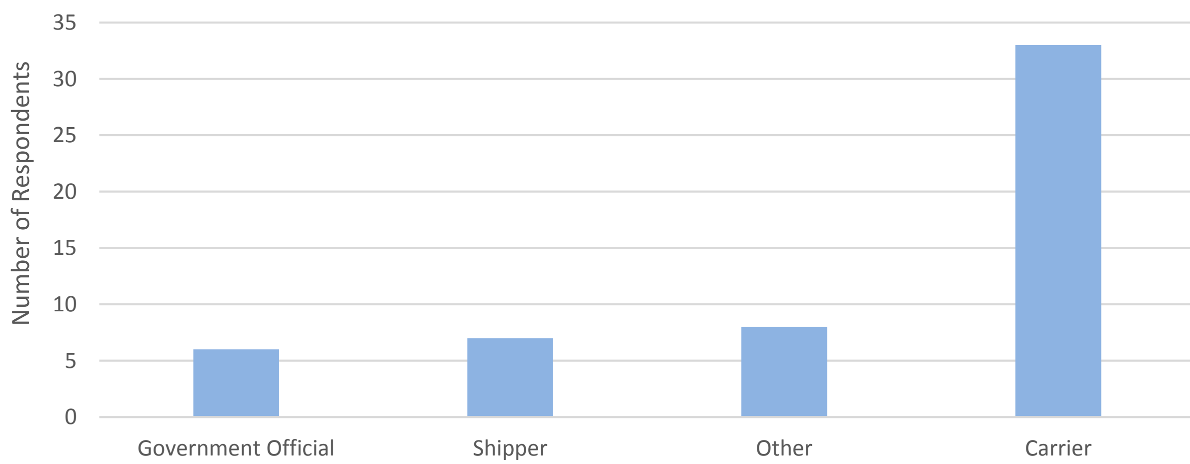
One of the advantages of using value judgment criteria is that they provide an opportunity for qualitative comments or details to support a performance assessment, which in turn can provide insights into issues or improvements for further analysis.

2.3.1 Collection of Value Judgment Indicators

To develop and use value judgment indicators, the measures must be clearly defined and assessed against benchmark criteria that are relatively objective and that can be ranked on a scale. Benchmark criteria do not need to be detailed or complex, but provide a reasonably clear basis for establishing value judgments. Put simply, value judgment indicators should be reasonably easy to use and replicate.

The value judgment indicators for the state freight plan were collected via an online survey presented to the FAC. In total, 61 responses were collected, 54 of which completed at least one value judgment indicator question. Figure 2-4 displays the distribution of the respondents to the value judgment indicators. Overall, carriers have the greatest total number of responses, with government officials, shippers and others having a nearly equal number of responses.[9]

Figure 2-4: Distribution of Value Judgment Indicators Respondents



2.3.2 Value Judgment Indicators for the Arizona State Freight Plan

The following outlines the value judgment criteria and associated benchmark criteria for the performance objectives that are difficult or impractical to measure quantitatively.

[9] "Other" includes third-party logistics providers, utilities, technology providers, equipment providers, towing companies and rail yards.

Objective: Increase Multimodal Accessibility

Value Judgment Indicator: Multimodal Accessibility	Benchmark Criteria
How have multimodal options (ability to ship by truck, rail, air) changed relative to five years ago?	1. Viable multimodal options have decreased 2. Viable multimodal options have not materially changed 3. Viable multimodal options have increased
Basis for informing value judgment indicator: Consultation with shippers (perception), review of new multimodal connections in Arizona (for example, new rail spurs or cargo air facilities), identification of increased use of non-road modes by shippers (mode share).	

Objective: Increase Security

Value Judgment Indicator: Freight Security	Benchmark Criteria
How has freight security changed in Arizona relative to five years ago?	1. Freight security incidents (or perception of security risks) have increased 2. Freight security incidents (or perception of security risks) have not materially changed 3. Freight security incidents (or perception of security risks) have decreased
Basis for informing value judgment indicator: Consultation with shippers (perception), consultation with border officials, consultation with police department or other first responders, review of security incident reports or statistics (for example, product theft, violent incidents, hijackings, or other freight-related illegal activity).	

Objective: Minimize Negative Social Impacts

Value Judgment Indicator: Freight Social Impacts	Benchmark Criteria
Have negative social externalities (noise, dust, night-lights, etc.) relating to freight activity and transportation decreased relative to the previous period?	1. Freight-related negative social externalities have increased 2. Freight-related negative social externalities are unchanged 3. Freight-related negative social externalities have decreased
Basis for informing value judgment indicator: Consultations with Metropolitan Planning Organizations (MPOs) and community associations near major freight clusters (for example, perception, reported complaints, anecdotes), number of freight-related municipal bylaw complaints, news stories about society concerns regarding freight activity, etc.	

Objective: Minimize Negative Environmental Impacts

Value Judgment Indicator: Freight Environmental Impacts	Benchmark Criteria
Have negative environmental externalities (dangerous goods spills, encroachment on wildlife, etc.) relating to freight activity and transportation decreased relative to the previous period? Different environmental externalities can be assessed separately, although the risk is in developing too many qualitative indicators.	1. Freight-related negative environmental externalities have increased 2. Freight-related negative environmental externalities are unchanged 3. Freight-related negative environmental externalities have decreased
Basis for informing value judgment indicator: Consultations with Arizona Department of Environmental Quality, MPOs, and affected environmental groups near major freight clusters (perception, reports of complaints, anecdotes); air quality reports near freight clusters; news stories, extent to which natural gas-powered engines are increasing in Arizona, Compressed Natural Gas (CNG) stations, etc.	

2.3.3 Other Uses for Value Judgment Indicators

Beyond the use of value judgments to gauge progress toward those Arizona State Freight Plan objectives that are difficult to measure quantitatively, value judgment indicators can serve as a useful basis for qualitatively validating or adding color to quantified performance metrics.

For example, value judgment indicators can complement the four quantifiable performance measures by focusing on elements of performance that may be implicit in those performance measures. Figure 2-5 displays the value judgment indicators questions used to validate other quantitative measures.

Figure 2-5: Value Judgment Indicators Informing Quantitative Performance Measures

Freight Transportation System Objectives	Value Judgment Indicator Questions	Benchmark Criteria
Increase Mobility	How have freight travel times changed in the last five years?	All other things being equal, are things: 1. Much worse 2. Getting worse 3. No material change 4. Getting better 5. Much better
Increase System Efficiency	How have logistics costs due to system inefficiencies changed in the last five years?	
Increase System Reliability	How has on-time delivery changed in the last five years?	
Increase Safety	How have incidents and close calls changed in the last five years?	

These and similar value judgment indicators can be developed on a regular basis (for example, annually) through simple surveys or, better, informal consultations with freight transportation system stakeholders (for example, FAC members).

Such value judgment assessments should also be complemented with open ended questions to obtain further insight about the value judgment assessment. Simple questions such as "Are there specific performance issues you would like to highlight?" and "Can you cite specific examples of improvements that would lead to an improved assessment next year?" can produce significant insights (where those consulted are open to providing responses).

Another benefit of this approach is that it institutionalizes regular interaction between ADOT and freight transportation system stakeholders. This promotes an ongoing collaborative dialogue that can improve future freight planning efforts.

2.4 Relationship to MAP-21

The development of freight performance measures is important not only on a statewide scale, but nationally. MAP-21 encourages states to develop a freight plan with performance measures that, in turn, guide freight-related transportation investments.[10] Additionally, MAP-21 calls for the Secretary of U.S. Department of Transportation to develop performance measures for the transportation system under four programs:

- **National Highway Performance Program:** U.S. DOT guidance released
- **Highway Safety Improvement Program:** U.S. DOT guidance released
- **Congestion Mitigation and Air Quality (CMAQ) Program:** U.S. DOT guidance forthcoming
- **Freight Movement:** U.S. DOT guidance forthcoming

Federal Highway Administration (FHWA) has released guidance on some of the programs, whereas other programs still require the U.S. DOT to promulgate a rulemaking.

U.S. DOT has yet to release the proposed performance measures for freight movement on the interstate system.

Additionally, states in coordination with MPOs will be required to set performance targets for the transportation system. MAP-21 also requires states to report on the system's performance every two years following an initial report by October 1, 2016, and to report on metropolitan system performance every four to five years.

2.5 Communication of Performance Measures

The communication of performance measures is highlighted by FHWA as a noteworthy practice and is included in best practices literature as a critical factor for success in state and regional

[10] Section 1118(b)(2)

planning. The following considerations are critical to effectively communicating performance measures:

- **Define the goal of communication:** identify the goal of communicating performance measures.
- **Know your audience:** match the communication of performance measures to the intended audience with the level of detail required by that audience.
- **Communicate strategically:** select timing, distribution channels, and method to match the audience and goals.

In addition to complying with federal legislation, ADOT's performance measures target three distinct audiences: Arizona transportation agencies, other Arizona government agencies, and the private sector. Figure 2-6 displays proposed goals and techniques for communicating freight performance measures to each audience.

Figure 2-6: Performance Measures Communication Strategy

Audience	Goal	Communication Method
Arizona transportation agencies (state, city, region)	• Expand knowledge of freight performance for planning • Use in project prioritization • Communicate needs to executives • Promote transparency	• Detailed communication • Supported by data, such as data portal • Display trends and benchmarking • Distribute through internal communication • Release public document and online data portal
Arizona government agencies (state and local)	• Expand knowledge of freight • Communicate needs to executives • Build support for ADOT initiatives • Improve perception and trust • Promote transparency	• Synthesize data to display trends • Display visually using maps and text detailing needs • Distribute through ADOT executives • Use common units (dollars, hours, etc.) for context • Focus on policy, if applicable • Release in hard and electronic mediums, matched to recipient
Private sector freight stakeholders	• Build support for ADOT initiatives • Improve perception and trust • Promote transparency • Facilitate communication of needs	• Display only most important information • Display visually and minimize text • Use common units (dollars, hours, etc.) for context • Release by press release

According to best practices, DOTs should use performance measures to inform decision making and to communicate and inform internal and external stakeholders of needs, DOT initiatives and historic performance. The value of performance measures—beyond measuring change over time—is their ability to tell a complex story through graphics or statistics. DOTs that effectively use performance measures to communicate with all three audiences are better able to convey needs and outcomes to critical constituencies. Additionally, effective communication of performance measures allows the DOT to frame conversations surrounding transportation decisions using data and trends.

3 Arizona Freight System Condition and Performance Assessment

Key Messages

The performance evaluation provides a baseline for comparing future system performance. Overall system performance is good, but specific locations have issues

- 86 percent of KCCs are rated good on TTTI
- 85 percent of KCCs are rated good on TPTI
- Urban areas experience worse performance relative to rural areas on TTTI and TPTI

Stakeholders indicated a generally decreasing trend in system performance relative to five years ago when polled using the value judgment indicators. Taken together with the quantitative and qualitative measures suggest the system is performing well, but performance is generally decreasing relative to five years ago.

3.1 Condition and Performance of Arizona's Freight Transportation System

The following four objectives are central to increasing the performance of the Arizona freight transportation system:

- Increase mobility and multimodal accessibility
- Increase safety and security
- Increase system efficiency and reliability
- Minimize negative social and environmental impacts

This section provides an assessment of the current condition and performance of Arizona's transportation system.

3.1.1 Overall Freight Activity

Truck Traffic

The percent of freight volume related to overall traffic is shown in Figure 3-1. As the figure illustrates, high truck percentages on freight corridors such as I-40 and I-10 indicate that these routes play a major role transporting interstate commercial products across Arizona, connecting California, New Mexico and points beyond. The fluctuation of truck percentages along the corridor is indicative of freight activities and/or major commercial activity centers.

Figure 3-2 shows the daily and percent truck volume ranges at key locations along the KCCs. The truck number on a low traffic volume corridor shows higher truck percentages. To better understand the high truck volume corridors, raw truck numbers are presented in Figure 3-3. Overall, KCC corridors have relatively high truck numbers. Within Phoenix metro-area, I-10 has more than 10,000 daily trucks (both single- and multi-units combined).

Figure 3-1: Freight Activity as a Percent Vehicle Volume

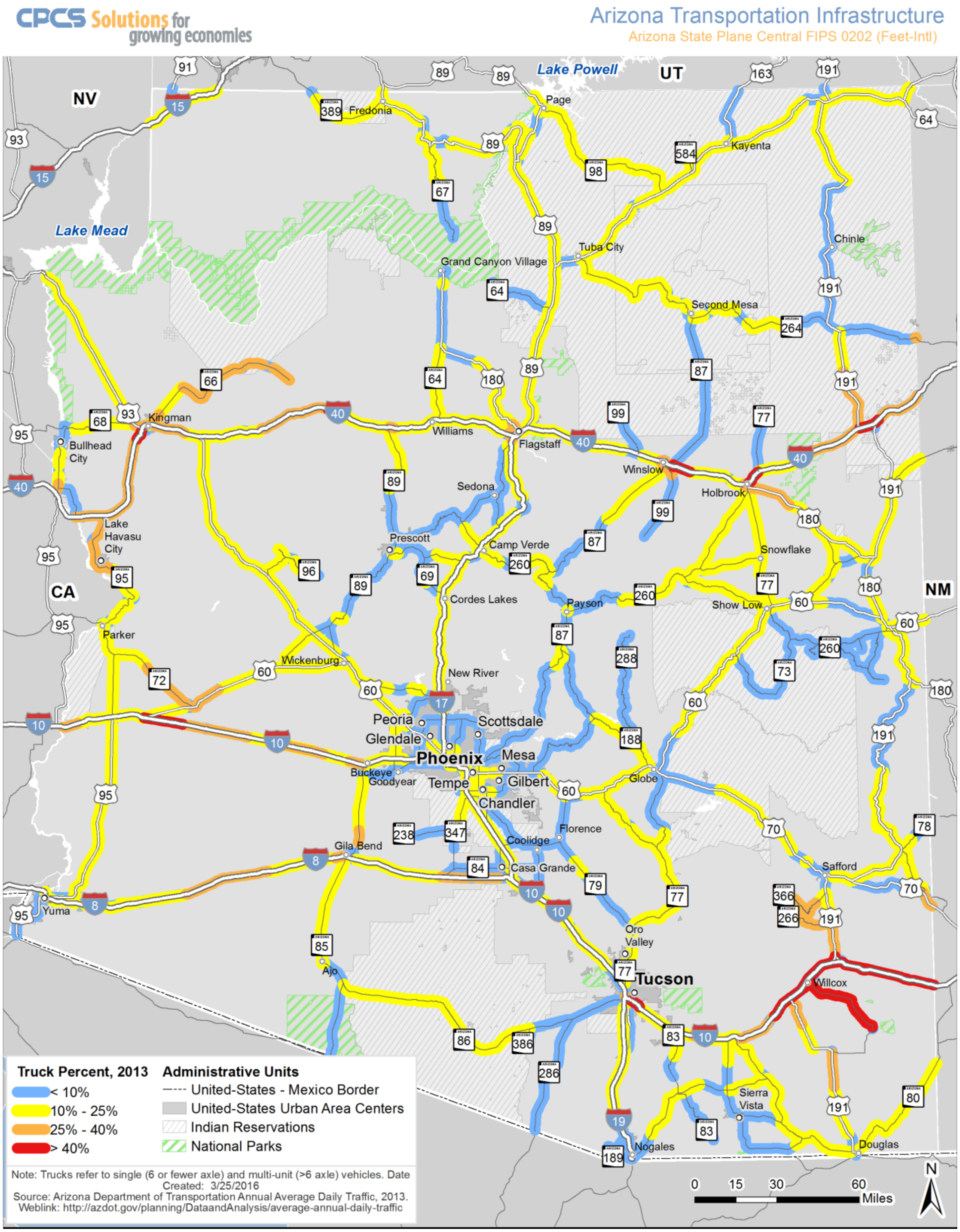


Figure 3-2: Freight Activity as Absolute Truck Volume

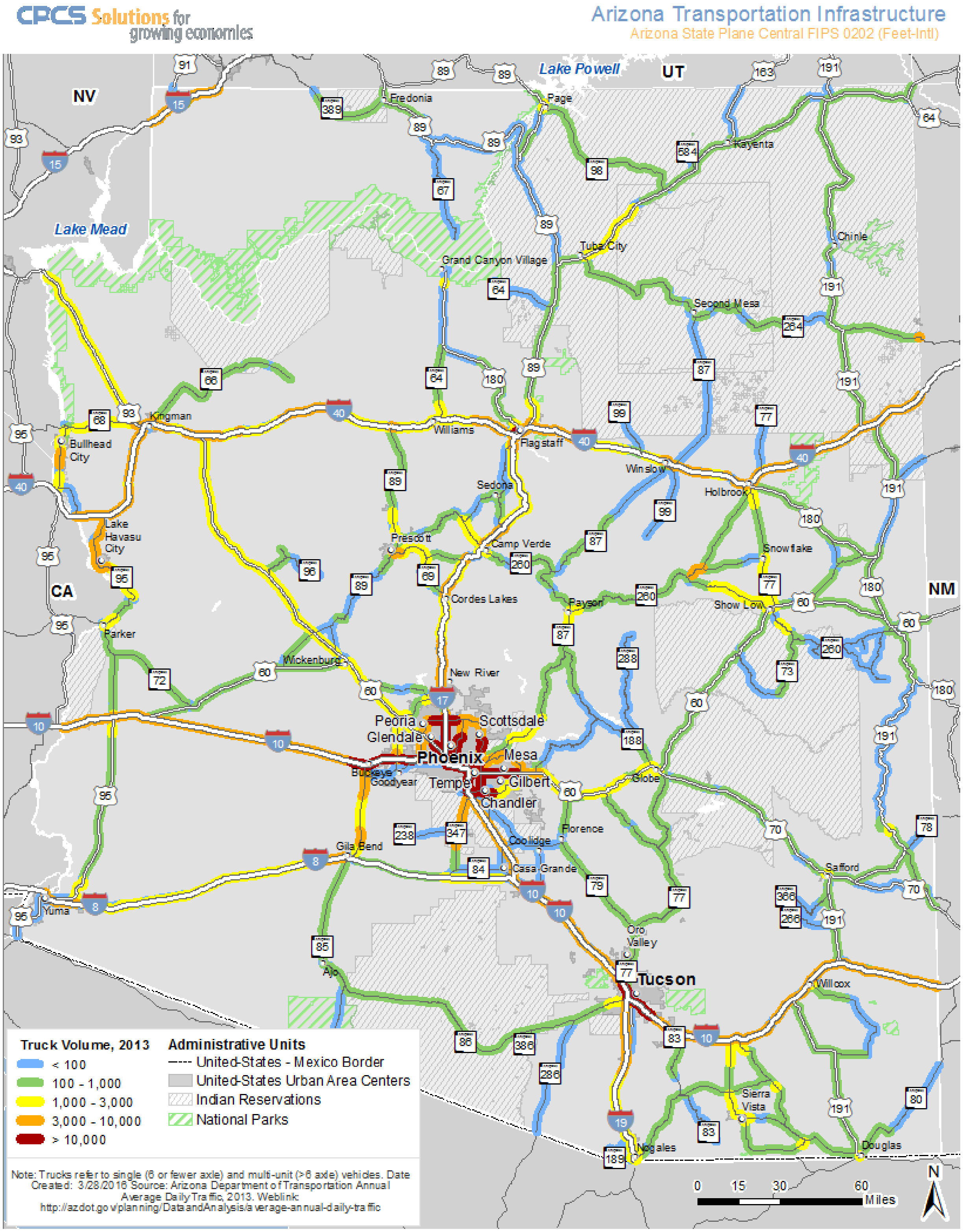


Figure 3-3: Arizona Key Commerce Freight Activity

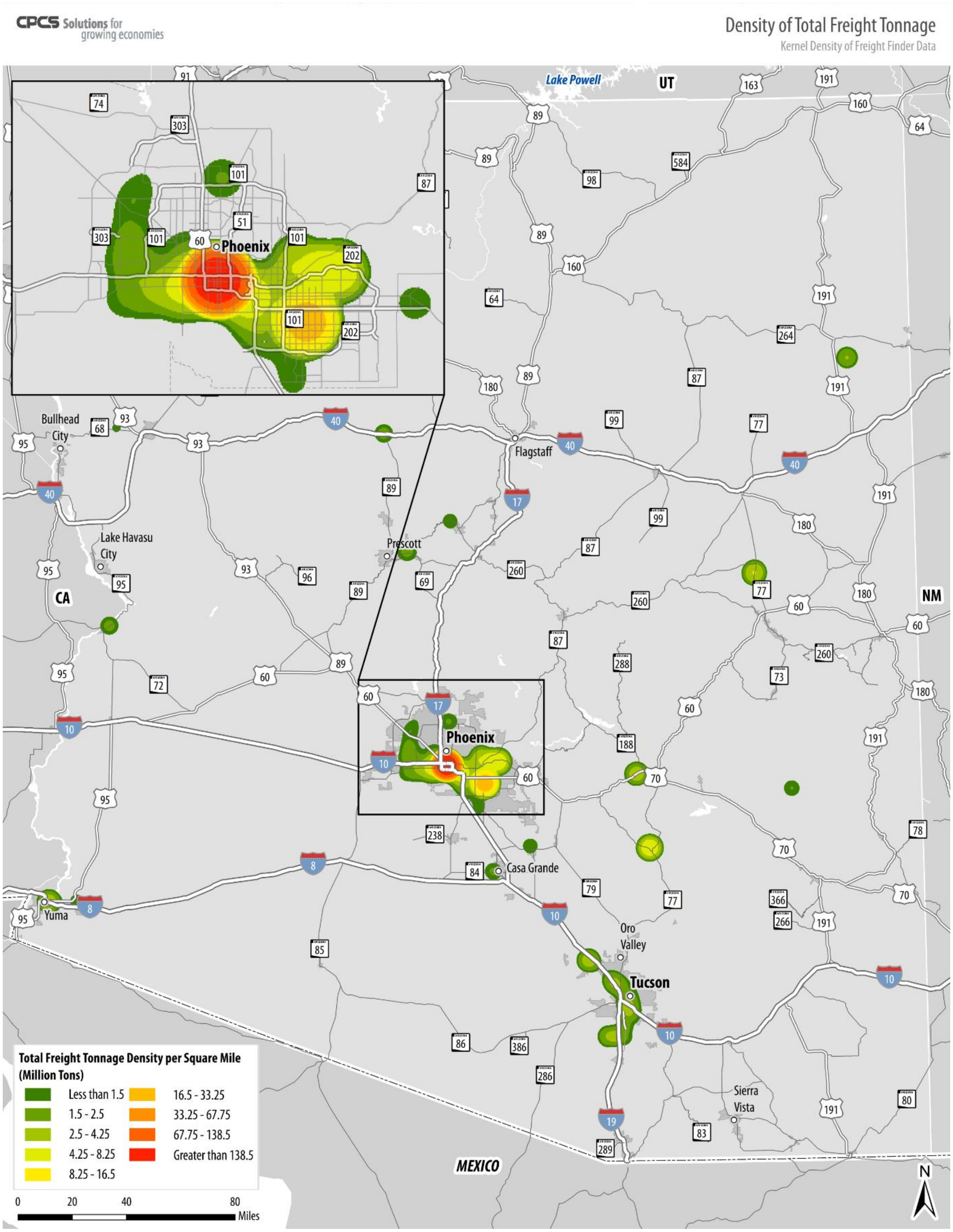
Corridor	Location	Daily Trucks	Percent Trucks
I-19 Nogales to Tucson	South of I-10	5,500	13%
	Within Nogales	1,500	9%
I-10 and SR 85	Near CA border	7,500	35%
	At Phoenix (L101 to I-17)	18,000	8%
	At Tucson (Ina Rd to I-19)	14,000	9%
	Near NM border	5,600	40%
	SR 85: South of I-10	3,000	23%
	SR 85: North of I-8	500	26%
I-8 Casa Grande to California Border	Near CA border	6,300	18%
	West of I-10	2,000	29%
I-11 (US 93) Phoenix to Nevada Border	Near NV border	2,000	19%
	Near Wickenburg	1,700	17%
	West of L303	1,800	12%
I-17 Phoenix to Flagstaff	Phoenix Downtown	10,000	9%
	Near SR 179	3,000	15%
	South of I-40	7,500	25%
I-40 New Mexico to California Border	Near CA border	5,300	32%
	Within Flagstaff	4,300	25%
	Near NM border	6,000	40%

Source: ADOT Traffic Counts, 2013

Tonnage Density

Figure 3-4 displays the density of freight tonnage inbound and outbound from Arizona business locations. The map displays clustering in urban areas such as Phoenix, Tucson, Yuma, Prescott, and Casa Grande among others. Rural clustering is often associated with mining operations or freight moving to and from small towns.

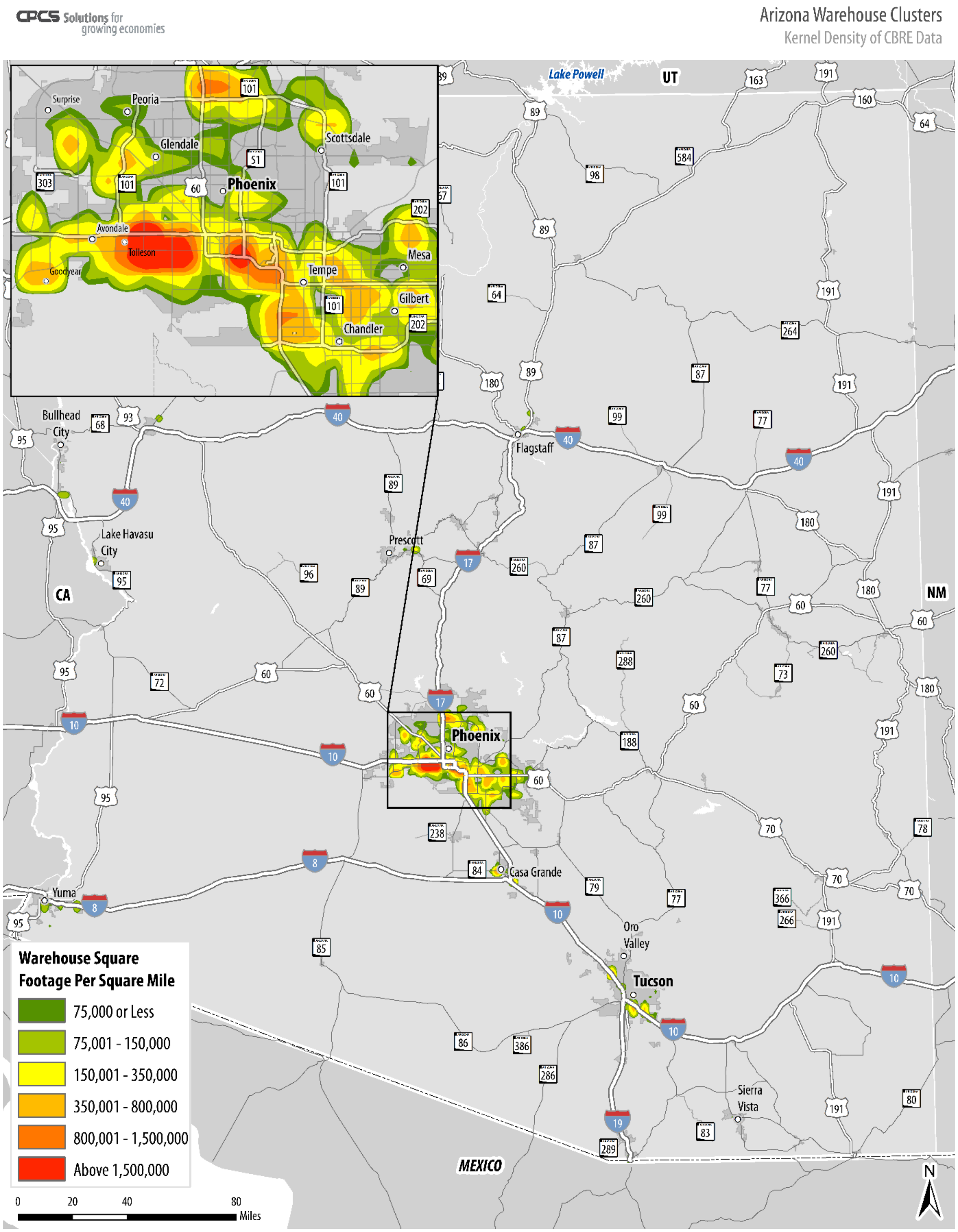
Figure 3-4: Density of Freight Tonnage for Arizona Businesses



Warehousing and Industrial Density

Figure 3-5 displays the clustering of warehousing and industrial space in Arizona. The greatest concentration of warehousing and industrial activities is located in the Phoenix metropolitan area, followed by the cluster in the Tucson metropolitan area. In Phoenix, the clusters are generally located in the southern portion of the metropolitan area concentrated along I-10 and US 60. The cluster in Tolleson and around the Sky Harbor Airport are the most concentrated locations in the state. Tucson has two major clusters – one in the south, near Tucson Airport and including the Port of Tucson, and one at the north close to I-10. Outside the Phoenix and Tucson metropolitan areas, clusters are notably located in Casa Grande, Yuma City, Prescott Valley, and Flagstaff.

Figure 3-5: Density of Warehousing and Industrial Square Footage



3.2 Increase Mobility and Multimodal Accessibility

3.2.1 Mobility

Figure 3-6 presents an overview of the TTTI mobility performance of Arizona's statewide transportation system (on routes for which data are available). Roadways and roadway segments shown include Arizona's KCCs, Corridor Profile segments, and other state system facilities. Figure 3-7 summarizes the mobility information shown in Figure 3-6 and identifies probable causes and critical issues affecting mobility by rural or urban area type.

In general, both the urban and rural segments of the KCCs are operating in 'good condition', with rural corridors performing slightly better than urban conditions (87 percent in good rating versus 80 percent in good rating, respectively).

Figure 3-6: Arizona Truck Mobility Performance (TTTI, 2014)

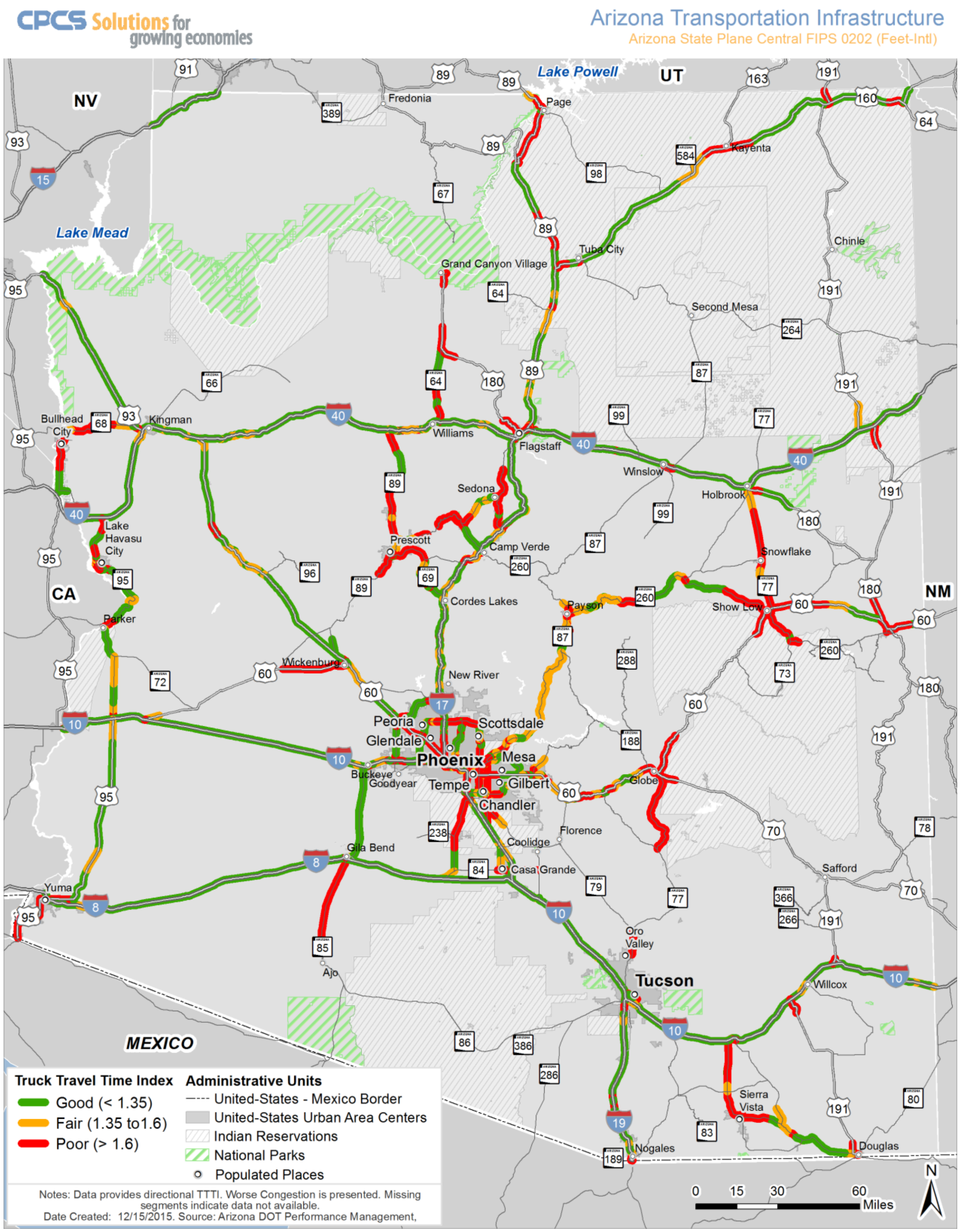


Figure 3-7: Arizona Truck Mobility Performance, by Key Commerce Corridors and Other Major Routes (TTTI, 2014)

Corridor	Length (miles)	Rural / Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)	Probable Causes/Key Issues
I-19 Nogales to Tucson	65	Rural	42	83%	11%	6%	Border inspection station in northbound direction at milepost 25; heavy truck traffic origin/destination by way of Mariposa traffic interchange and SR 189 contributes to congestion and delay
		Urban	23	72%	7%	21%	Heavy truck traffic due to U.S.-Mexico border activity at Nogales, congestion at system interchange at I-10
I-10 and SR 85 California Border to Gila Bend via I-10 and SR 85	150	Rural	145	95%	4%	1%	Congestion at key junctions (US 60, SR 95, SR 85)
		Urban	5	94%	6%	0%	Urban activity at Buckeye
I-10 I-10 at SR 202L to New Mexico Border	235	Rural	190	91%	8%	1%	Topography at Dragoon(near Texas Canyon Rest Area), Cochise County area; heavy truck volume
		Urban	45	92%	8%	0%	Urban activity and congestion at key junctions; areas of bottlenecks to reduced number of lanes
I-8 Casa Grande to California Border	180	Rural	165	99%	1%	0%	None
		Urban	15	77%	23%	0%	Urban activity within Yuma area
I-11 (US 93) Phoenix to Nevada Border	225	Rural	210	80%	13%	7%	One-lane directional travel within Wikieup area; inadequate passing/climbing lane; steep grades
		Urban	15	95%	5%	0%	Urban activity within Wickenburg, Kingman, and Wikieup
I-17 Phoenix to Flagstaff	145	Rural	110	68%	23%	9%	Uphill grade (northbound - mileposts 245 to 263 and 299 to 320; southbound 278 to 288); weather
		Urban	35	50%	18%	32%	Heavy truck volume; urban activity
I-40 Flagstaff to California Border	210	Rural	200	82%	16%	2%	Heavy truck volume; weather conditions; congestion at key junctions (SR 89, US 93); lack of passing/climbing lane
		Urban	10	99%	1%	0%	Urban activity at Flagstaff, Kingman, and Ash Fork

Overall segment ratings: Good <1.35 Fair 1.35 to 1.60 Poor >1.60

Figure 3-7 continued: Arizona Truck Mobility Performance by Key Commerce Corridors and Other Major Routes (TTTI, 2014)

Corridor	Length (miles)	Rural / Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)	Probable Causes/Key Issues
I-40 Flagstaff to New Mexico Border	165	Rural	150	97%	2%	1%	Heavy truck volumes; limited capacity along two-lane directional travel
		Urban	15	99%	1%	0%	Urban activity at Flagstaff, Winslow, and Holbrook
US/SR-95 Yuma to Needles	175	Rural	145	67%	18%	15%	Oversize trucks; inadequate shoulder widths; limited two-lane directional travel; low water crossing
		Urban	30	30%	65%	5%	Urban activity within Yuma, Quartzsite, Parker, and Lake Havasu City area
US-60 Phoenix to just east of Globe	100	Rural	55	31%	41%	28%	Uphill grade; sharp curves; limited directional capacity (combination of one-/two-lane)
		Urban	45	38%	14%	48%	Urban activity within Phoenix metropolitan area, Superior, Miami, and Globe
SR-87 Phoenix to Payson	75	Rural	63	11%	71%	18%	Uphill grade; limited directional capacity
		Urban	12	27%	0%	73%	Urban congestion within Phoenix metropolitan area and Payson; signalized intersections at Fort McDowell Yavapai Nation

Overall segment ratings: Good <1.35 Fair 1.35 to 1.60 Poor >1.60

Figure 3-8: Arizona Key Commerce Corridor TTTI Performance

Corridor	Length (miles)	Rural/Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)
Key Commerce Corridor	1,375	Rural	1210	87%	9%	3%
		Urban	165	80%	10%	10%
Overall Key Commerce Corridor (Urban and Rural Combined)				86%	10%	4%

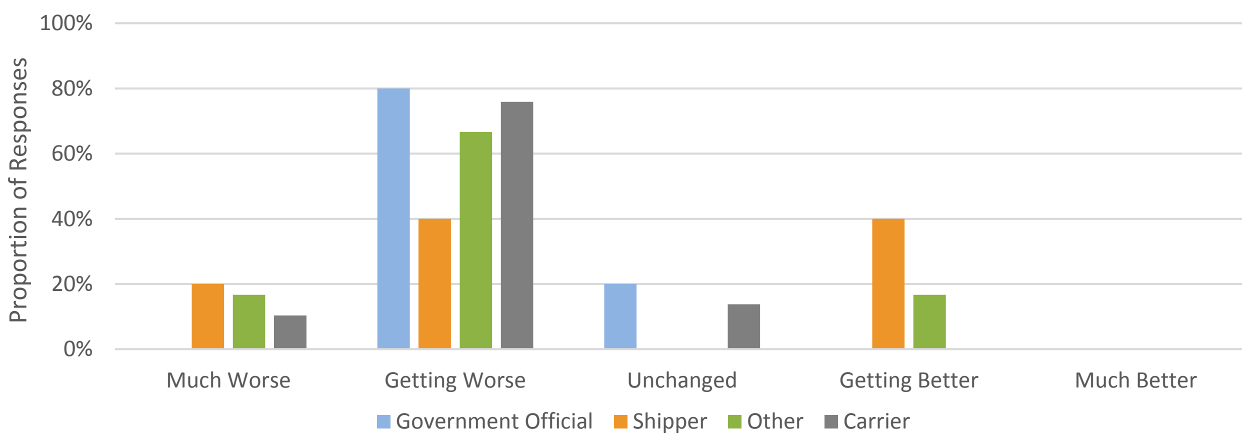
Mobility Value Judgment Indicator

In addition to calculating TTTI, system mobility is assessed as part of the value judgment indicators. FAC members were asked how travel times have changed in Arizona. Figure 3-9 and subsequent graphics on value judgment indicators display a percentage-based comparison of responses calculated within each user group (government official, shipper, other, carrier). We present the data as a percentage to display differences in each group and to not overstate carriers in the graph.

Respondents could respond that freight travel times are much worse, getting worse, unchanged, getting better or are much better. Additionally, respondents had the option to respond "not applicable" or "skip the question."

How have freight travel times changed in the last five years?

Figure 3-9: Mobility Value Judgment Indicator



The overwhelming majority (71 percent) of respondents suggested that mobility is getting worse. The cited reasons for mobility getting worse are as follows:

- **Infrastructure:** specifically cited infrastructure problems include road congestion, road condition, truck parking and accident-related congestion. I-17 following an accident and I-40's condition were specifically mentioned by respondents.

- **Regulatory:** specifically cited regulatory issues include inspections at border crossings and the corridors to and from ports of entry, electronic logging and driver hours of service regulation.

- **Other issues:** other issues included increased weight of tractors decreasing the volumes per load, driver shortage, unreliable service and unpredictable pricing.

Overall, respondents cited I-10 from SR 51 to SR 101 west, I-10 from Phoenix to Los Angeles, I-40's general condition and I-17 congestion following an accident as specific issues affecting mobility. Overall, the mobility value judgment indicator suggests that mobility has been getting worse over the past five years.

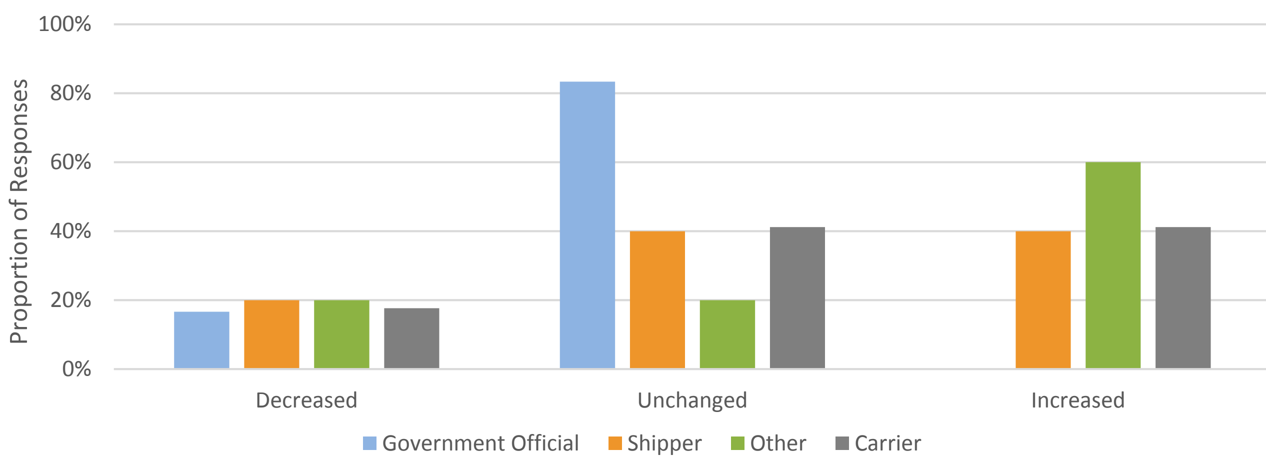
3.2.2 Multimodal Accessibility

Multimodal accessibility denotes the extent to which shippers have access to an increasing number of viable multimodal options to ship their goods. Multimodal accessibility is largely a measure of perception denoting whether multimodal accessibility is increasing, decreasing or staying the same over time.

Figure 3-10 displays the distribution of survey responses. Respondents could indicate viable multimodal options have increased, not materially changed or decreased. Additionally, respondents had the option to respond "not applicable" or "skip the question."

How have multimodal options (ability to ship by truck, rail, air) changed relative to five years ago?

Figure 3-10: Multimodal Accessibility Value Judgment Indicator



Of those who responded to the question, 46 percent suggested that multimodal accessibility remained the same and 35 percent suggested that viable multimodal options increased over the last five years.

Comments on the survey provide examples of both increasing and decreasing access. For example one respondent cites ocean containers at Tucson as an example of increasing access. Conversely, another respondent cited trailer on flat car from Phoenix and Los Angeles/Long Beach (LA/LB) as an example of decreasing accessibility. Similarly another respondent expressed the desire to use rail, but is limited by the short shelf life of goods and the need for reliable transportation.

Overall, the distribution of responses is skewed towards multimodal accessibility staying the same to increasing slightly over the past five years. Other stakeholder outreach suggested that Arizona had not implemented any significant infrastructure improvements during the past five years to improve multimodal accessibility for their operations.[11] Over time, this qualitative measure will likely change as new freight-oriented infrastructure (roadway, rail, air) is developed and implemented.

3.3 Increase Safety and Security

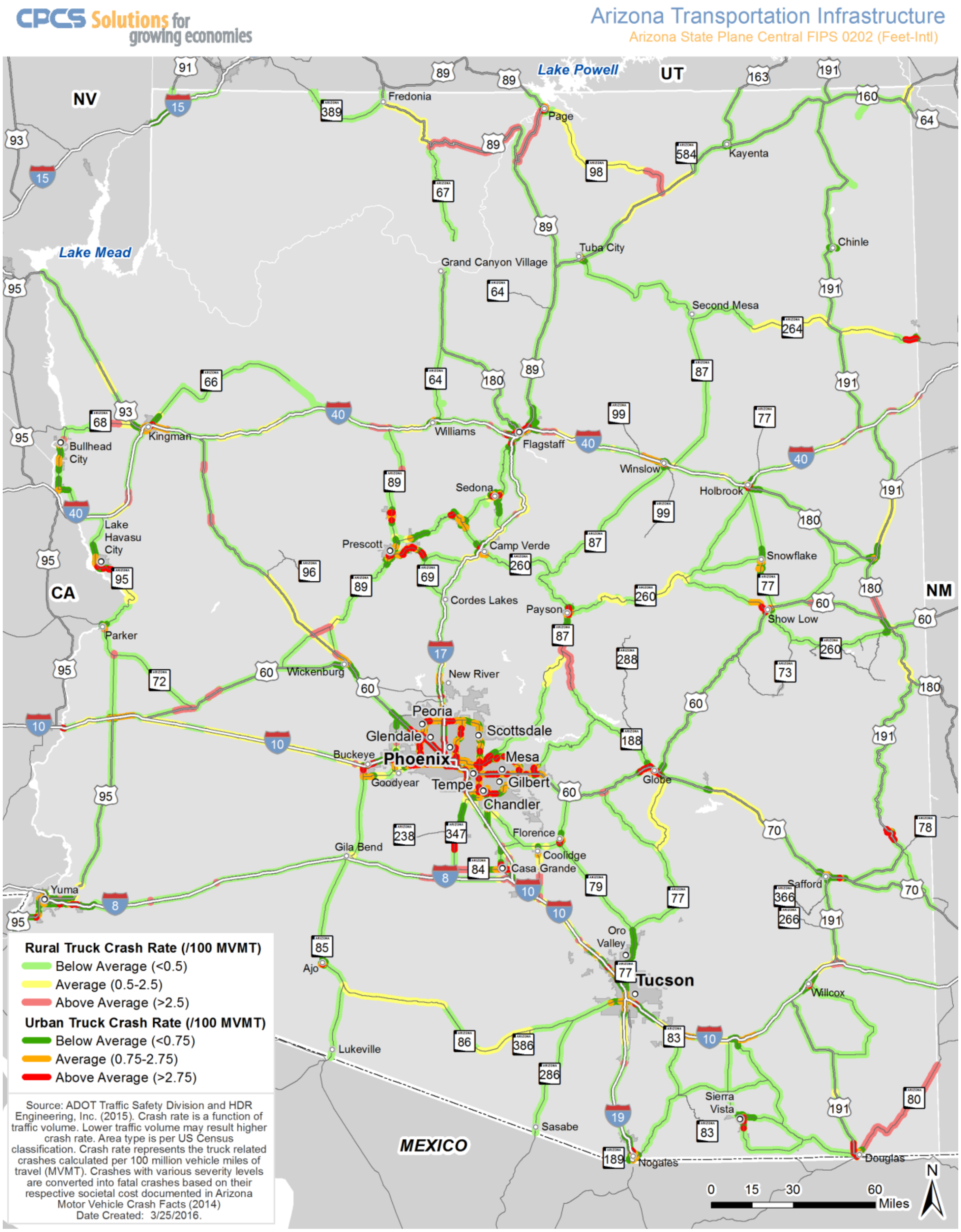
3.3.1 Safety

While Arizona has a good safety record, truck safety remains a significant state, regional and local transportation system issue. The ADOT Traffic Safety Division's statewide crash database is used to identify the number of crashes involving trucks per 100 million VMT by all traffic.

Crashes are reported by urban and rural area types, as shown in Figure 3-11. The truck crash rates shown in Figure 3-11 are used to show the predominant locations of truck-related accidents on Arizona's transportation system.

[11] Stakeholder information was gathered in combination with input from the FAC, interviews with the Class I (Union Pacific Railroad [UP] and BNSF) and Class III (short line) railroads, and the Phase 2 modal inventory and assessment of new multimodal infrastructure implemented in Arizona over the past 5 years.

Figure 3-11: Arizona Safety Performance Measure (Truck Crash Rate, 2014)



Performance of Key Commerce Corridors

Figure 3-12 displays KCC segments with above-average truck crash rates.

Figure 3-12: Arizona Urban and Rural Truck Crash Rate Performance by Key Commerce Corridor (2014)

Key Commerce Corridor	Rural / Urban	Highest Truck Crash Rate Segments
I-19 Nogales to Tucson	Rural	• No high crash rates reported on rural segments
	Urban	• Just north of the U.S.-Mexico border at Nogales • South of Sahuarita
I-10 and SR 85 California Border to Gila Bend via I-10 and SR 85	Rural	• West of Buckeye in area of SR 85 junction • I-10 at SR 95
	Urban	• Phoenix metropolitan area • Within Ehrenberg area
I-10 I-10 at SR 202L to New Mexico Border	Rural	• Near Marana • South and north of SR 87 • South of I-8/Casa Grande • South of Coolidge • East at US 191 (north) • East of Benson • East of SR 83
	Urban	• North of I-8/Casa Grande • Various inner loop segments in Phoenix • West of Tucson • East of Flowing Wells • East of Tucson • At Wilcox
I-8 Casa Grande to California Border	Rural	• West of junction with I-10 • West of junction with SR 238
	Urban	• East of Yuma
I-11 (US 93) Phoenix to Nevada Border	Rural	• US 93 south and north of Wickenburg Bypass • US 93 south of SR 89 • US 93 near SR 129 • US 93 south of I-40 • US 93 south of Kingman
	Urban	• US 60 in Phoenix metropolitan area
I-17 Phoenix to Flagstaff	Rural	• South of SR 179 • In the area of New River
	Urban	• Phoenix metropolitan area • Within Flagstaff near junction with I-40

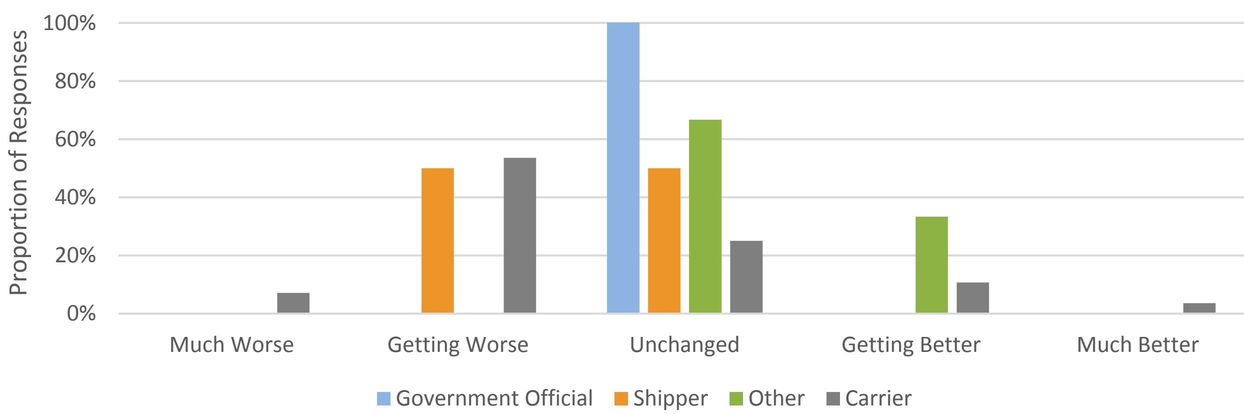
Safety Value Judgment Indicator

The safety value judgment indicator is targeted at determining whether safety has changed in terms of both truck crashes as well as close calls experienced by drivers. "Close calls" is a subjective measure that will likely be based on perception, but it may suggest a future increase in crashes if trends persist.

Figure 3-13 displays the distribution of survey responses. Respondents could indicate that the number of safety incidents and close calls has gotten much worse, worse, unchanged, better or much better over the past five years. Additionally, respondents had the option to respond not applicable or skip the question. Data are presented as a percentage to display differences in each group and to not overstate carriers in the graph.

How have incidents and close calls changed in the last five years?

Figure 3-13: Safety Value Judgment Indicator



In absolute numbers, a total of 17 (36 percent) of respondents selected that the safety of the Arizona transportation system is unchanged and another 17 responded that it is getting worse. The only comment received suggested that traffic is the issue driving the decrease in safety. Overall, shippers and carriers generally view safety as unchanged to getting worse, whereas government officials and those in the other category viewed safety remaining unchanged to getting better.

3.3.2 Freight Security

Freight security encompasses incidents or the perception that freight movements are unsafe while using the Arizona transportation system. Examples of incidents covers a wide range of events, including product theft, violent incidents, hijackings or other illegal activity related to freight. Quantifiable performance measures are not readily available regarding security and, in some cases, the perception of security may not be reflected in the data. Therefore, a value judgment indicator is used, informed by consultations with shippers and available information.

Figure 3-14 displays survey responses to the freight security value judgment indictor. Respondents could respond that freight incidents have decreased, remain unchanged or increased. An increase in freight security incidents is worse compared to a decrease in incidents.

How has freight security changed in Arizona relative to five years ago?

Figure 3-14: Freight Security Value Judgment Indicator

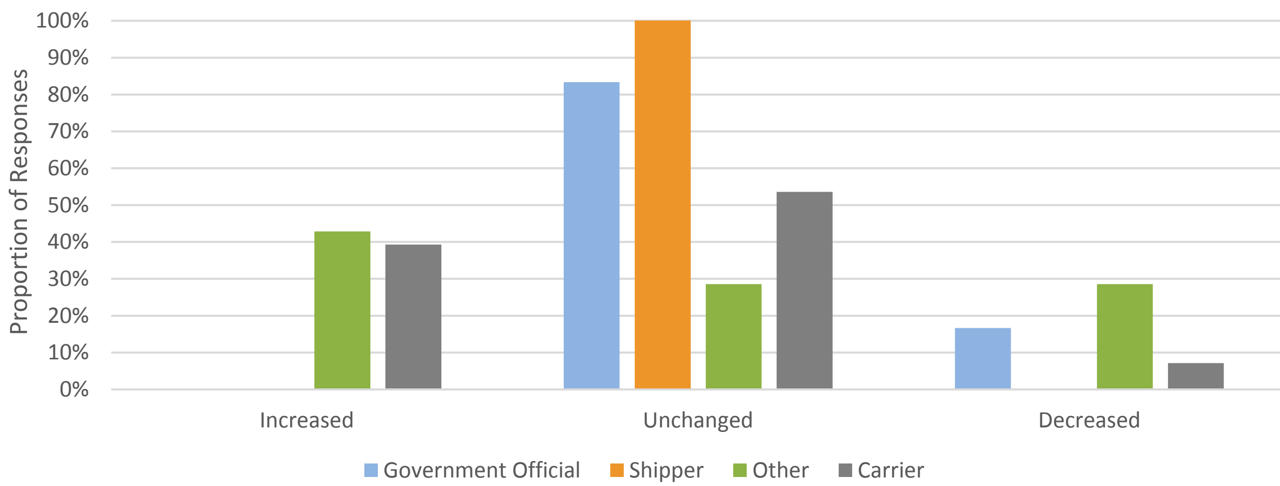


Figure 3-14 suggests that freight security has remained largely unchanged. Over 57 percent of respondents suggested that no change has occurred concerning freight security compared to 32 percent that suggested the security incidents are increasing (security is getting worse) and 11 percent that suggested that security incidents have decreased (security is getting better).

Within user groups, carriers are fairly split between security remaining unchanged and getting worse. Whereas, all shippers suggested that security is unchanged. Overall, the freight security value judgment indicator suggests that freight security is largely unchanged, with some suggesting that the incidents are increasing and therefore security is getting worse.

3.4 Increase System Efficiency and Reliability

3.4.1 Efficiency

The efficiency of the freight transportation system is a function of a number of factors, including the congestion trucks experience when traveling from origin to destination. As a measure of not only the location and duration of congestion, but also a measure of the number of trucks affected over the year, annual hours of delay is used to measure the efficiency of Arizona's freight transportation system. Figure 3-15 shows the cumulative hours of daily truck delay throughout the state roadway system (subject to the availability of data).

Figure 3-15: Arizona Hours of Daily Truck Delay (2015)

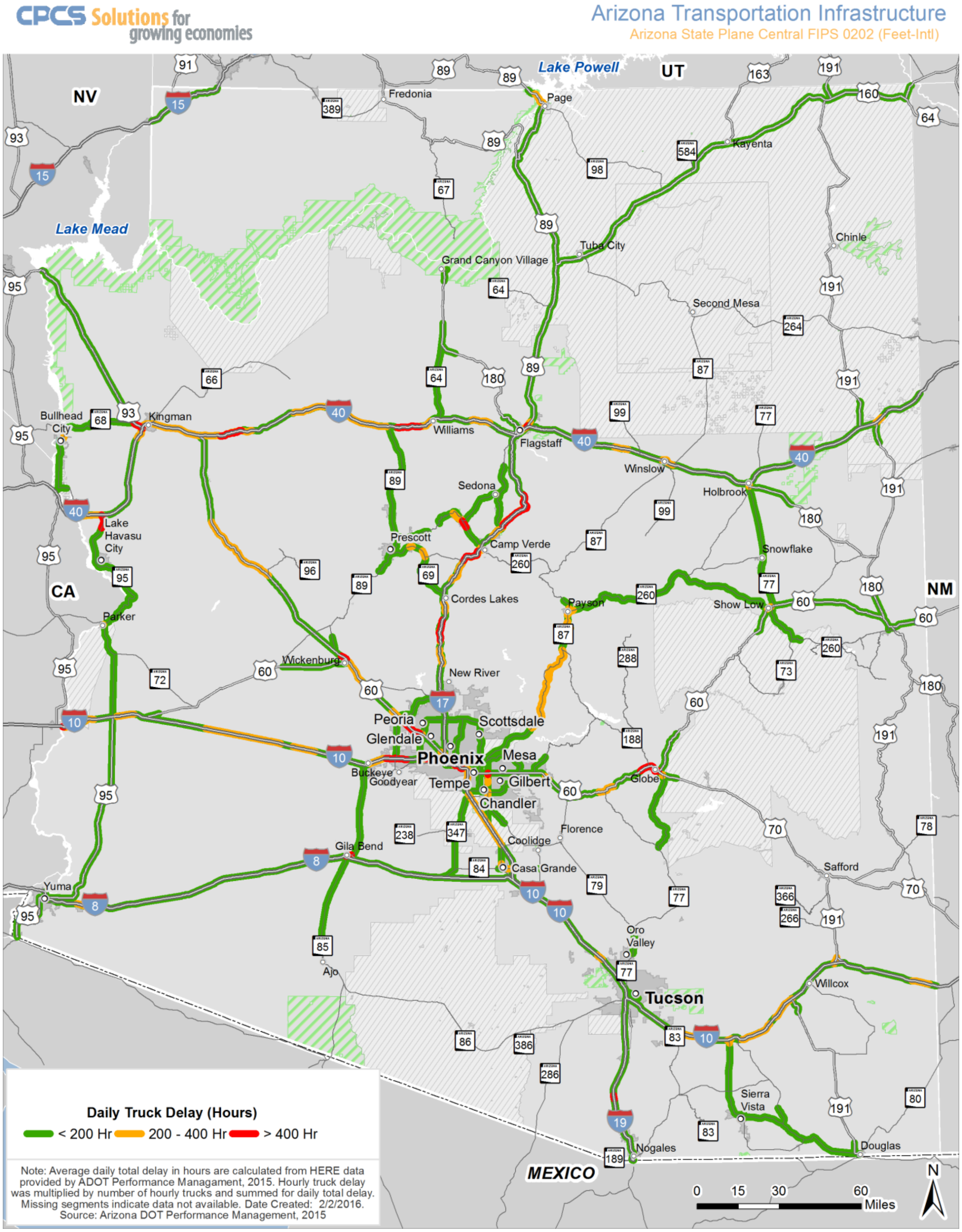


Figure 3-15 illustrates that steep grades are a major contributing factor to truck delays. This can be observed on I-17 between Phoenix and Flagstaff, I-10 east of Benson, and SR 87 between Phoenix and Payson. Other areas experiencing delay include multiple segments along I-10 and I-40, where percent truck traffic is relatively high and roadway segments are typically 2-lanes.

Nighttime driving conditions are also a contributing factor the total daily hours of truck delay which is largely a function of lack of lighting, grades, lack of passing and climbing lanes, and adverse environmental and weather conditions and not necessarily a function of congestion or traffic volume. Many of the rural segments showed longer truck delay, which is a combination of roadway characteristics, driving conditions and traffic volumes.

Performance of Key Commerce Corridors

Figure 3-16 shows the annual cumulative truck delay in hours. Cumulative truck delay in hours is a function of truck volume and the time of delay. Since the duration of the peak periods for midday (6 hours) and nighttime (12 hours) are longer, they yield higher overall delay than the AM and PM peak period (each having 3 hours of duration). Also, the longer the congested segment, the higher the cumulative hours of delay. To normalize the results, a (daily) delay index was developed. The Delay Index is the product of daily hours of truck delay and 1,000/Vehicle miles of truck travel.

Figure 3-17 shows truck travel time delay between major originations and destinations, where the KCCs are the primary route.

Figure 3-16 : Annual Cumulative Truck Delay

Corridor	Length (miles)	Rural / Urban	Length (miles)	Delay (hours)						Daily VMTT[1]	Delay Index
				AM	Midday	PM	Nighttime	Daily	Annual		
I-19 Nogales to Tucson	65	Rural	42	48	143	96	148	435	133,000	220,905	2.0
		Urban	23	46	83	63	65	257	79,000	124,562	2.1
I-10 and **SR 85** CA Border to Gila Bend	150	Rural	145	275	745	455	690	2,165	662,000	1,181,040	1.8
		Urban	5	5	14	9	13	41	13,000	17,370	2.4
I-10 I-10 at SR 202L to NM Border	235	Rural	190	512	1,340	856	1,213	3,921	1,200,000	2,021,341	1.9
		Urban	45	128	290	226	265	909	278,000	485,950	1.9
I-8 Casa Grande to CA Border	180	Rural	165	125	339	204	317	985	301,000	423,831	2.3
		Urban	15	22	57	35	51	165	50,000	61,070	2.7
I-11 (US 93) Phoenix to NV Border	225	Rural	210	330	787	391	801	2,309	707,000	223,503	10.3
		Urban	15	24	74	26	44	168	10,000	16,104	10.4
I-17 Phoenix to Flagstaff	145	Rural	110	164	439	275	424	1,302	398,000	419,523	3.1
		Urban	35	302	152	631	55	1,140	349,000	287,343	4.0
I-40 Flagstaff to CA Border	210	Rural	200	244	673	398	609	1,924	589,000	1,804,646	1.1
		Urban	10	21	53	32	50	156	48,000	52,772	3.0
I-40 Flagstaff to NM Border	165	Rural	150	223	598	356	553	1,730	529,000	1,654,498	1.0
		Urban	15	21	60	36	56	173	53,000	148,593	1.2
US/SR-95 Yuma to Needles	175	Rural	145	333	832	498	840	2,503	766,000	67,649	37.0
		Urban	30	315	1,095	611	527	2,548	780,000	58,009	43.9
US 60 Phoenix to Globe	100	Rural	55	51	141	88	90	370	113,000	79,850	4.6
		Urban	45	566	512	558	376	2,012	616,000	236,398	8.5
SR-87 Phoenix to Payson	75	Rural	63	50	130	81	129	390	119,000	66,757	5.8
		Urban	12	23	66	45	61	195	60,000	31,609	6.2

Notes: AM peak – 6 a.m. to 9 a.m., midday peak – 9 a.m. to 3 p.m., PM peak – 3 p.m. to 6 p.m., nighttime peak – 6 p.m. to 6 a.m.

1 Vehicle miles of truck travel was calculated from AZTDM2 model and rounded to nearest thousands.

Truck volume is the sum of single and multi-unit trucks as estimated in the model.

Delay Index = Daily hours of delay x 1,000/(Vehicle miles of truck travel)s

Figure 3-17 : Truck Travel Delay between Major Origin and Destinations

Origin-Destination	Primary Route	Length (miles)	No Congestion Travel Time (minutes)	To Destination (minutes)		From Destination (minutes)	
				Worst Truck Travel Time	Delay / Truck	Worst Truck Travel Time	Delay / Truck
Phoenix to Tucson	I-10	115	98	123	25	126	28
Phoenix to Flagstaff	I-17	145	126	181	55	178	52
Phoenix to Nevada border	I-11 (US 93)	225	205	270	65	287	62
Phoenix to Payson	SR 87	75	70	108	38	103	33
Phoenix to California border	I-10	145	120	150	30	165	45
Casa Grande to California border	I-8	180	150	175	25	178	28
Tucson to Nogales	I-19	65	60	75	15	86	26
Tucson to New Mexico border	I-10	135	115	130	15	130	15
Flagstaff to New Mexico border	I-40	165	140	160	20	158	18
Flagstaff to California border	I-40	195	155	198	43	195	40
Flagstaff to Utah border	US 89	130	125	220	95	210	85

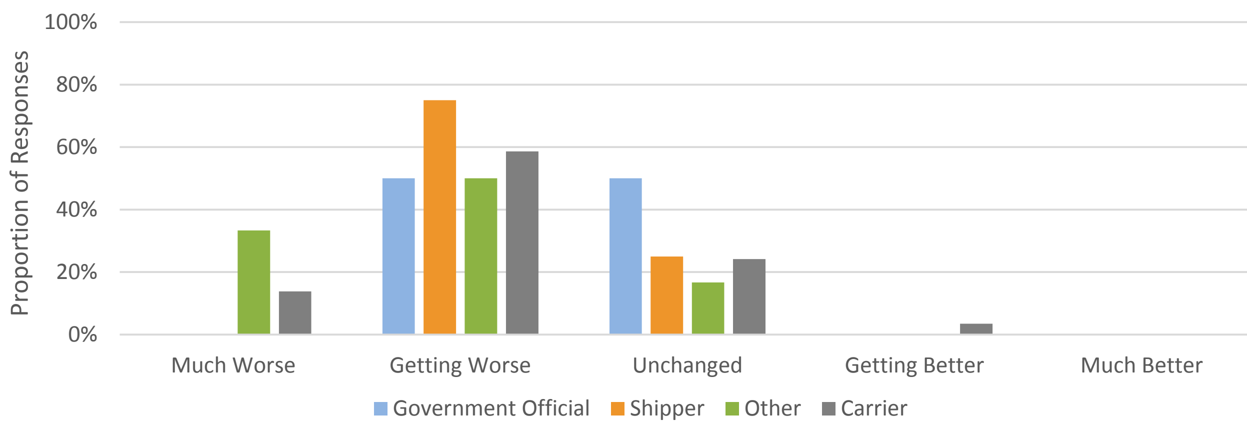
Note: Travel time between major origin-destination locations are calculated using the HERE data received from ADOT. KCC corridors re used as a primary route to compute the travel delay.

System Efficiency Value Judgment Indicator

In addition to calculating delay, system efficiency is assessed as part of the value judgment indicators survey. FAC members were asked how costs due to inefficiency have changed, namely have costs gotten much worse, getting worse, unchanged, getting better or are much better. Figure 3-18 displays the output of the system reliability value judgment indicator.

How have logistics costs due to system inefficiencies changed in the last five years?

Figure 3-18: System Efficiency Value Judgment Indicator



With the exception of government officials, the most frequent response was that the efficiency of the transportation system has gotten worse over the past five years. In total, 57 percent of respondents thought system efficiency is getting worse, 25 percent thought it is unchanged and 14 percent thought it is much worse. The following comments on system efficiency were submitted by respondents:

- **Infrastructure:** the only specific infrastructure issue cited by respondents was congestion.
- **Regulatory:** specific regulatory issues include a decrease in the number of miles per day carriers are able to travel, punitive behaviors from state agencies leading to increased insurance rates and alternative routings which adds mileage, longer rest times and generally more regulations.
- **Other issues:** other issues noted on the survey include heavier trucks decreasing carrying capacity, time lost at shipper or consignees facilities and a reduction in the number of carriers increasing costs.

The only specific infrastructure cited was I-10 from Phoenix to Los Angeles. Overall, the value judgment indicator on efficiency, as measured by logistics costs, suggests efficiency has gotten worse in Arizona.

3.4.2 Reliability

Figure 3-19 presents an overview of the TPTI reliability performance measure of Arizona's transportation system. Roadways and roadway segments shown in Figure 3-19 include Arizona's KCCs, Corridor Profile segments, and other state system facilities. Figure 3-20 and Figure 3-21 summarizes the reliability information shown in Figure 3-19 and identifies probable causes and critical issues affecting mobility by rural or urban area type.

Figure 3-19: Arizona Truck Reliability Performance (TPTI, 2014)

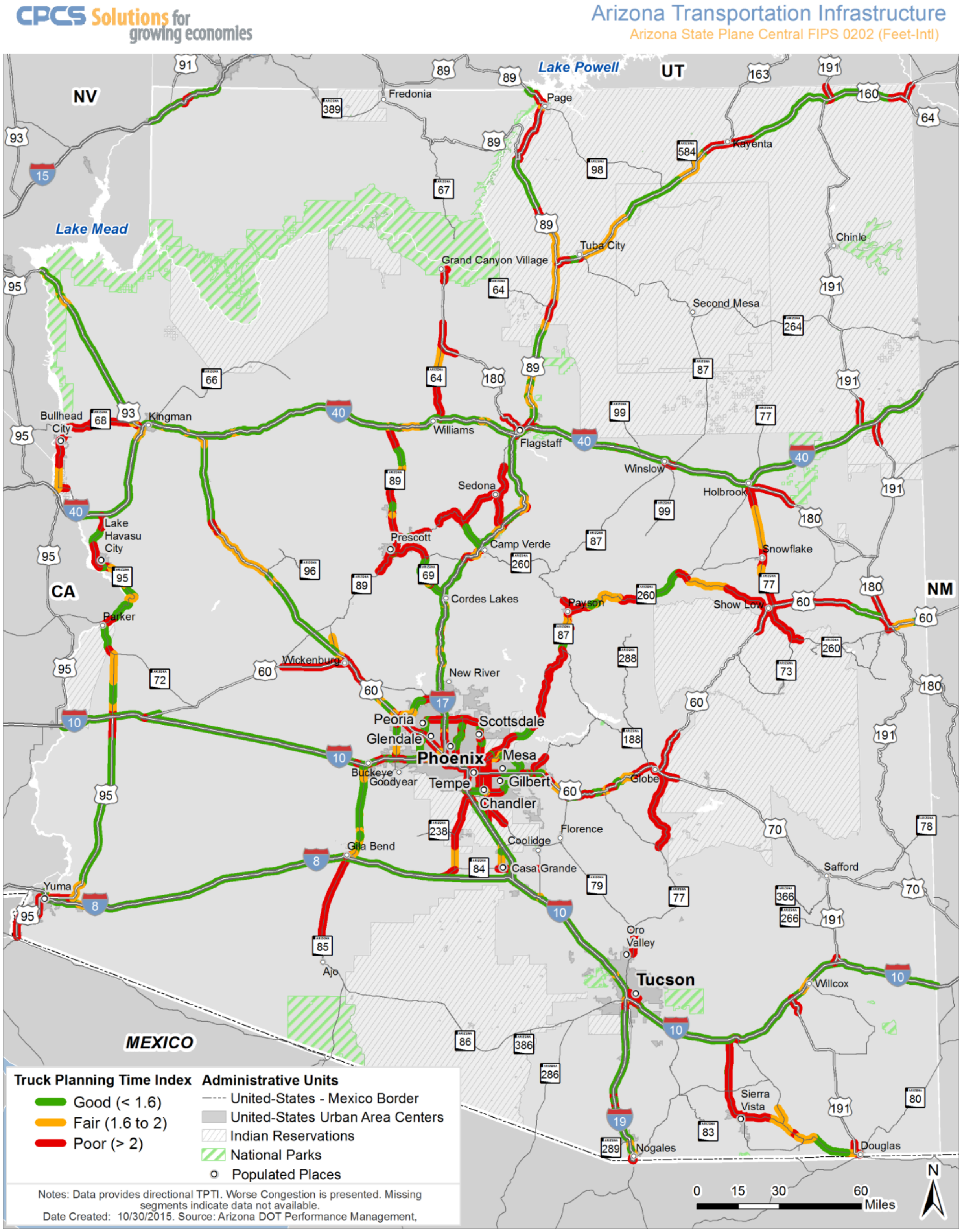


Figure 3-20 : Arizona Truck Reliability Performance by Key Commerce Corridors and Other Major Routes (TPTI, 2014)

Corridor	Length (miles)	Rural/ Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)	Probable Causes
I-19 Nogales to Tucson	65	Rural	42	88%	6%	6%	All traffic is stopped at milepost 25 due to border inspection activity
		Urban	23	71%	6%	23%	Heavy truck traffic due to U.S.-Mexico border activity
I-10 and SR 85 California Border to Gila Bend via I-10 and SR 85	150	Rural	145	89%	8%	3%	Overall good; however, two-lane limited directional capacity affects truck planning time
		Urban	5	94%	6%	0%	Urban congestion at major junctions at US 60, SR 95, SR 85
I-10 I-10 at SR 202L to New Mexico Border	235	Rural	190	95%	3%	2%	Overall good; however, two-lane limited directional capacity through mountainous region (Dragoon) affects truck planning time
		Urban	45	88%	5%	7%	Urban congestion at Phoenix and Tucson areas; limited capacity within Gila River tribal area
I-8 Casa Grande to California Border	180	Rural	165	100%	0%	0%	Overall good
		Urban	15	73%	27%	0%	Overall good
I-11 (US 93) Phoenix to Nevada Border	225	Rural	210	67%	25%	9%	Limited directional capacity; uphill slope; inadequate passing/climbing lane
		Urban	15	78%	12%	10%	Urban activity within Wickenburg, Kingman, and Wikieup
I-17 Phoenix to Flagstaff	145	Rural	110	70%	17%	13%	Overall good; however, mountainous terrain at Black Canyon City, Camp Verde, and south of Flagstaff area affects travel; winter weather affects travel time
		Urban	35	46%	5%	49%	Urban activity in Phoenix and Flagstaff area

Overall segment ratings: Good: <1.6 Fair: 1.6 to 2.0 Poor: >2.0

Figure 3-21 : Arizona Truck Reliability Performance by Key Commerce Corridors and Other Major Routes (TPTI, 2014)

Corridor	Length (miles)	Rural/Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)	Probable Causes
I-40 Flagstaff to California Border	210	Rural	200	87%	12%	1%	Weather conditions; limited roadway capacity and lack of passing/climbing lane with heavy truck activity
		Urban	10	99%	1%	0%	Urban activity in Flagstaff area
I-40 Flagstaff to New Mexico Border	165	Rural	150	97%	2%	1%	Weather conditions; limited roadway capacity with heavy truck activity
		Urban	15	99%	1%	0%	Urban activity in Flagstaff area
US/SR-95 Yuma to Needles	175	Rural	145	64%	14%	22%	Oversize trucks; inadequate shoulder width; limited roadway capacity
		Urban	30	3%	20%	77%	Urban activity at Yuma, Lake Havasu City, and Parker
US-60 Phoenix to Globe	100	Rural	55	41%	21%	48%	Mountainous terrain; sharp curves; limited roadway capacity (one/two directional lane)
		Urban	45	36%	6%	58%	Urban activity at Phoenix, Superior, Miami, and Globe
SR-87 Phoenix to Payson	75	Rural	63	17%	8%	75%	Mountainous terrain; inadequate passing / climbing lane
		Urban	12	26%	0%	74%	Urban activity within Phoenix and Payson areas

Overall segment ratings: Good: <1.6 Fair: 1.6 to 2.0 Poor: >2.0

Figure 3-22: Arizona Key Commerce Corridor TPTI Performance

Corridor	Length (miles)	Rural/Urban and Performance	Miles by Area Type	Good Rating (% miles)	Fair Rating (% miles)	Poor Rating (% miles)
Key Commerce Corridor	1,375	Rural	1210	87%	10%	3%
		Urban	165	76%	8%	16%
Overall Key Commerce Corridor (Urban and Rural Combined)				85%	10%%	5%

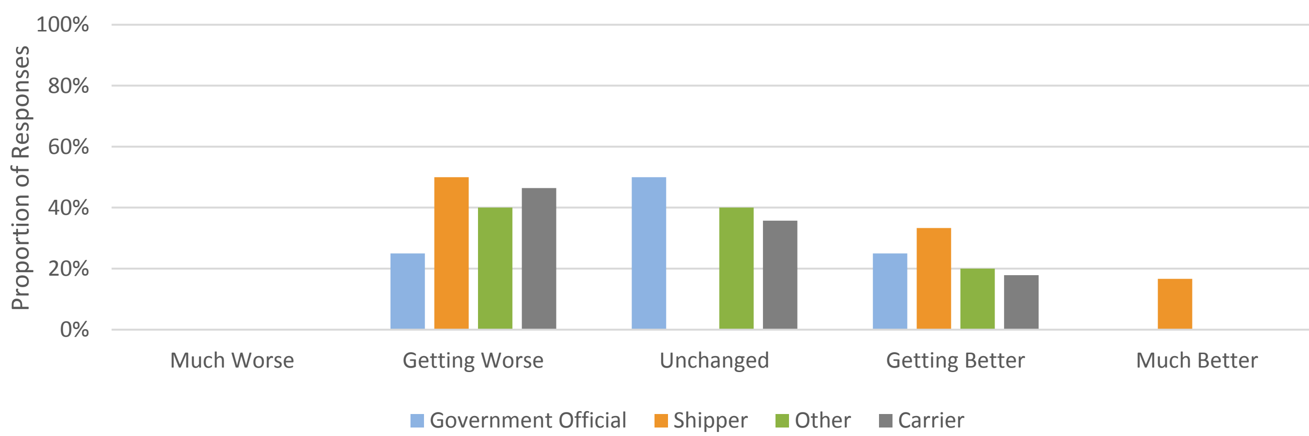
Data indicate that both the urban and rural segments of the KCCs are performing well. Overall, 16 percent of urban corridors have a poor rating, while three percent of the rural areas have a poor rating.

Reliability Value Judgment Indicator

In addition to calculating TPTI, system reliability is assessed as part of the value judgment indicators. Reliability is assessed by asking FAC members about changes in the on-time delivery of goods. Figure 3-23 displays the output of the system reliability value judgment indicator.

How has on-time delivery changed in the last five years?

Figure 3-23: System Reliability Value Judgment Indicator



The most frequent response for shippers, carriers and other system users (44 percent) was that system reliability is getting worse. The other frequently selected category for carriers and other system users was that system reliability is unchanged (33 percent).

The only reason provided to explain the decrease in reliability was regarding inspections by state agencies at border crossings and on corridors to and from ports of entry. Respondents who indicated reliability is unchanged suggested that rail is becoming a more reliable option through high tech visibility/traceability and that shippers and carriers must adjust work schedules or pay overtime to change reliability.

The distribution of responses for system reliability leans towards getting slightly worse, but there is still a significant number of respondents that indicated things are unchanged and 21 percent suggested things are getting better.

3.5 Minimize Negative Social and Environmental Impacts

3.5.1 Social Impacts

Negative social impacts of the freight system are related to safety, noise, undesirable nighttime lighting, vibrations and traffic congestion. These impacts affect the quality of life in communities surrounding freight facilities. In many ways these issues can and are mitigated through local land use decisions which accommodate these activities in areas of like activities, and away from the communities and uses which may be negatively impacted. A survey of over a dozen recently completed state freight plans found that none had specific performance measures related to social impacts. Several did, however, suggest policy guidance addressing a number of factors relating to quality of life (clean vehicle technology; engine idling at rest stops; land use planning as examples).

Those consulted for the social impacts performance measure found it difficult to comment on broad trends relating to social impacts, as these issues are addressed primarily through land use planning, or environmental processes. Transportation agencies consulted are not typically made aware of these concerns, as these are generally seen as either a local land use issue or an issue arising from a proposed project. For example, ADOT has a noise abatement policy to address highway traffic noise and construction noise for projects where there is a new alignment, a significant change in the horizontal or vertical alignment of an existing highway or the addition of new through lanes.

ADOT should continue their policy of addressing negative social impacts through the environmental planning process, as well as monitor the concerns raised by affected agencies and stakeholders.

3.5.2 Environmental Impacts

A qualitative assessment of environmental impacts is implemented in response to the very specialized and costly nature of producing freight specific emissions estimates. These estimates can miss broader trends driving increases in freight-related emissions (for example changing economic activity or weather events). A survey of over a dozen recently completed state freight plans found that about one-third of them contain specific performance measures related to environmental impacts (see Appendix A for a summary of findings). Additionally, ADOT will be required to report performance measures for mobile source emissions as part of the CMAQ program.

During consultations, agencies found it difficult to comment on broad trends relating to environmental impacts. Air quality is monitored in urbanized areas or point sources (such as mining or industrial sites), and transportation agencies routinely model the transportation system to ensure continued conformity with national standards for air pollutants. While transportation is a contributing factor in regional air quality, monitoring the annual status of Arizona Nonattainment Areas provides one measure of the environmental impact of freight.

The U.S. Environmental Protection Agency (EPA) has identified nonattainment areas in seven Arizona counties. Nonattainment areas are established when National Ambient Air Quality Standards for criteria pollutants are exceeded. Nonattainment has causes in addition to transportation, such as mining (for example, Hayden and Miami), agriculture and land development.

Figure 3-24: Arizona Nonattainment Areas

Pollutant	Nonattainment Area	Classification
Cochise County		
PM-10 (1987)	Paul Spur/Douglas, AZ	Moderate
Gila County		
Lead (2008)	Hayden, AZ	—
PM-10 (1987)	Hayden, AZ	Moderate
PM-10 (1987)	Miami, AZ	Moderate
Sulfur Dioxide (2010)	Hayden, AZ	—
Sulfur Dioxide (2010)	Miami, AZ	—
Maricopa County		
PM-10 (1987)	Phoenix, AZ	Serious
8-Hr Ozone (2008)	Phoenix-Mesa, AZ	Marginal
Pima County		
PM-10 (1987)	Ajo, AZ	Moderate
PM-10 (1987)	Rillito, AZ	Moderate
Pinal County		
Lead (2008)	Hayden, AZ	—
PM-10 (1987)	Hayden, AZ	Moderate
PM-10 (1987)	Phoenix, AZ	Serious
PM-10 (1987)	West Pinal, AZ	Moderate
PM-2.5 (2006)	West Central Pinal, AZ	Moderate
Sulfur Dioxide (1971)	Hayden, AZ	—
Sulfur Dioxide (2010)	Hayden, AZ	—
8-Hr Ozone (2008)	Phoenix-Mesa, AZ	Marginal
Santa Cruz County		
PM-10 (1987)	Nogales, AZ	Moderate
PM-2.5 (2006)	Nogales, AZ	Moderate
Yuma County		
PM-10 (1987)	Yuma, AZ	Moderate

Source: U.S. EPA, Current Nonattainment Counties for All Criteria Pollutants, http://www3.epa.gov/airquality/greenbook/ancl.html

MPOs in the state have developed plans to address nonattainment areas. In addition, projects in the MPOs Transportation Improvement Plans and Regional Transportation Programs undergo air quality conformity.[12]

3.6 Top Freight Transportation System Performance Issues

The performance evaluation provides a snapshot in time of the state's freight system, providing a baseline for comparing future system performance. The performance evaluation reveals that the freight system is performing well, but freight movement experiences some level of recurring delays and non-recurring delays in both the urban and rural areas of the state.

As evidenced by the TTTI evaluation (refer to section 3.2.1 Mobility), only a small percentage of the 1,370 miles of KCC routes have a poor rating (three percent of rural segments and ten percent of urban segments). Delay experienced on routes throughout rural areas can often be attributed to one travel lane, and where these routes travel through developed areas or areas of grades and curves, delays are greater.

The TPTI evaluation (refer to section 3.4.2 Reliability) indicates a larger percentage of the system is experiences a poor rating, a result of the non-recurring delays impacting reliability (three percent of rural segments, and 16 percent of urban segments). The segments experiencing the greatest planning time delays are in the rural areas of the state, where alternatives are limited, and detours are relatively long.

Figure 3-25 and Figure 3-26 synthesize performance measures on the KCCs and other key freight infrastructure. Generally, the segments shown have consistently poor performance on mobility and safety, but are fairly reliable. Good reliability and poor mobility suggests a large difference between free flow and peak traffic speeds that occurs with little variation. Those segments that have both poor reliability and mobility have large differences between free flow and peak traffic speeds and experience greater variation in speeds.

Coupling the value judgment indicators and performance measures, the overall freight system is performing well, but stakeholders suggest a generally decreasing trend in system performance relative to five years ago. Additionally, stakeholders often suggested issue on similar roadways throughout the value judgment indicators.

[12] Transportation conformity ("conformity") ensures that transportation activities are consistent with (federal) air quality goals. Conformity applies to transportation plans, transportation improvement programs (TIPs), and projects funded or approved by FHWA or the FTA in areas that do not meet or previously have not met air quality standards for ozone, carbon monoxide, particulate matter, or nitrogen dioxide (these areas are known as "nonattainment areas" or "maintenance areas").

The results of the quantitative performance measures and the value judgment indicators will be used in subsequent phases of work to identify the locations where freight performance is poor, and help inform strategic solutions to address them.

Figure 3-25: Key Commerce Corridor Performance Evaluation Summary (Ranked by Truck Volume)

Route	Segment	Observation	Daily Trucks	Mobility	Reliability	Safety	Worst Peak
I-10	At I-19 Traffic interchange	Trucks experience delay on I-19 system ramps merging onto I-10	12,600	🟡	🟢	Above	PM
I-10	East of I-19 (Milepost 260 to 263)	Westbound trucks experience delay. Traffic volume is about 102k with 13% trucks	12,100	🟢	🟢	Above	PM
I-19	South of I-10 junction (Valencia Rd to I-10)	Urban activity	11,700	🟡	🟢	Above	PM
I-10	SR 85 to L303	Urban activity within Buckeye- 2 lane in each direction. Approximately 70k daily traffic volumes with 17% trucks	11,000	🟢	🟢	Above	PM
I-10	On ramps at I-8 system traffic interchange	Heavy traffic and truck volume	7,900	🟡	🟢	Above	NT
I-40	EB to NB system ramp at I-40/I-17/SR 89 interchange	Heavy traffic and truck volume	7,650	🔴	🟢	Above	NT
I-40	US 93 Junction	Trucks exiting to US 93 experience delay	6,100	🟢	🟢	Above	MD
I-40	Eastbound at Meteor Crater Rd Exit 233	Heavy truck activities	5,650	🟢	🟢	Below	NT
I-10	At US 60 Brenda TI	Eastbound off ramp traffic to US 60 experiences delay	5,306	🔴	🔴	Average	NT
I-10	Colorado River Crossing at AZ/CA Border	ADOT Port of Entry	5,191	🔴	🟢	Below	AM

Source: ADOT HERE data, 2015; ADOT Traffic Counts, 2014; ADOT Crash data (2010-2014); HDR Engineering, Inc., 2016

Legend

Mobility		Reliability	
🟢	Worst peak operating speed could be 60% of posted speed	🟢	Non-recurring delay could be as much as 2x the average travel time during worst peak
🟡	Worst peak operating speed could be 50%-60% of posted speed	🟡	Non-recurring delay could be as much as 3x the average travel time during worst peak
🔴	Worst peak operating speed could be 50% or less of posted speed	🔴	Non-recurring delay could be as much as 4x or longer the average travel time during worst peak

Notes:
Non-recurring delay refers to unexpected delay due to closures or restrictions resulting from circumstances such as crashes, inclement weather, and construction activities.
Daily trucks represents the sum of single (FHWA Class 4-7) and multi-unit FHWA Class 8-13) trucks in both direction of travel
Mobility data is based on the truck travel time index calculated as the ratio of posted speed limit to operating speed limit
Reliability data is based on the truck planning time calculated as the ratio of total travel time needed for 95% on-time arrival to free-flow travel time.
Safety is calculated based on the ADOT 5-year crash dataset between 2010 and 2014
Worst peak refers to the time period having highest duration of delay during an average weekday: AM (6am-9am); Midday (9am-3pm); PM (3pm-6pm) and nighttime (6pm-6am)
Data is sorted by decreasing daily truck volumes
All segments along the KCC corridors showing poor truck travel time index are summarized

Figure 3-25 (continued): Key Commerce Corridor Performance Evaluation Summary

Route	Segment	Observation	Daily Trucks	Mobility	Reliability	Safety	Worst Peak
I-40	Between SR 89 and SR 64 (Eastbound, Milepost 149-157)	Grade, heavy truck volumes	3,900	🟢	🟢	Above	MD
I-17	Within Black Canyon City (Northbound Milepost 244 to 248)	Grade, heavy truck volumes	3,800	🟢	🟢	Above	PM
I-17	South of Camp Verde (Southbound Milepost 278 to 285)	Grade, heavy truck volumes	2,900	🟡	🟢	Above	NT
I-17	North of SR 179 (Northbound Milepost 298 to 307)	Grade, heavy truck volumes	2,600	🟡	🟢	Above	NT
I-19	Within Tubac (Northbound Milepost 22 to 27)	Grade, border check post	2,500	🟡	🟢	Average	MD
I-11	North of I-40 junction at US 93 (Milepost 67-71)	Grade, urban activity	1,850	🔴	🟢	Average	NT
I-19	Nogales to SR 189 (Northbound Milepost 0 to 4)	Heavy truck activity in near proximity of US/MX Port of Entry	1,850	🔴	🟡	Above	MD
I-19	Nogales to Target Range Rd (Southbound Milepost 0 to 1)	Heavy truck activity in near proximity of US/MX Port of Entry	1,050	🔴	🟡	Above	MD
I-19	Nogales area	Heavy truck activities, northbound grade	800	🔴	🟡	Above	MD
I-11	South of I-40 junction at US 93 (Milepost 91-95)	Urban activity	500	🟢	🟢	Average	AM

Source: ADOT HERE data, 2015; ADOT Traffic Counts, 2014; ADOT Crash data (2010-2014); HDR Engineering, Inc., 2016

Legend

Mobility			Reliability		
	🟢	Worst peak operating speed could be 60% of posted speed		🟢	Non-recurring delay could be as much as 2x the average travel time during worst peak
	🟡	Worst peak operating speed could be 50%-60% of posted speed		🟡	Non-recurring delay could be as much as 3x the average travel time during worst peak
	🔴	Worst peak operating speed could be 50% or less of posted speed		🔴	Non-recurring delay could be as much as 4x or longer the average travel time during worst peak

Notes: Non-recurring delay refers to unexpected delay due to closures or restrictions resulting from circumstances such as crashes, inclement weather, and construction activities.

Daily trucks represents the sum of single (FHWA Class 4-7) and multi-unit FHWA Class 8-13) trucks in both direction of travel

Mobility data is based on the truck travel time index calculated as the ratio of posted speed limit to operating speed limit

Reliability data is based on the truck planning time calculated as the ratio of total travel time needed for 95% on-time arrival to free-flow travel time.

Safety is calculated based on the ADOT 5-year crash dataset between 2010 and 2014

Worst peak refers to the time period having highest duration of delay during an average weekday: AM (6am-9am); Midday (9am-3pm); PM (3pm-6pm) and nighttime (6pm-6am)

Data is sorted by decreasing daily truck volumes

All segments along the KCC corridors showing poor truck travel time index are summarized

Figure 3-26: Other Key Freight Corridors Performance Evaluation Summary

Route	Segment	Observation	Daily Trucks	Mobility	Reliability	Safety	Worst Peak
SR 347	I-10 to Maricopa City (Milepost 169-188)	Urban activity, heavy traffic volume, traffic signal	3,500	🔴	🟢	Above	PM
US 89	Within Flagstaff, north of I-40 (Milepost 418-421)	Urban activity, traffic volume	3,400	🔴	🟡	Above	PM
US 60	SR 88 to SR 79 (Milepost 200 to 204)	Grade, curves	3,200	🔴	🟢	Above	PM
US 60	Within Globe area, (Milepost 243 to 268)	Grade, traffic volume	2,400	🔴	🟢	Above	MD
SR 69	East of Prescott (SR 89 to Milepost 281)	Urban activity, heavy traffic volume	1,850	🔴	🟢	Above	MD
SR 260	West of Show Low to East of SR 73 (Milepost 322 to 360)	Urban activity	1,800	🟡	🟢	Above	PM
SR 95	Within Bullhead City (Milepost 234 to 249)	Urban activity, heavy traffic volume, traffic signal	1,600	🔴	🟡	Above	MD
SR 89	Prescott area (Milepost 319-337)	Urban activity, grade, curve	1,450	🔴	🟡	Above	PM
SR 68	East of Laughlin (Milepost 2 to 20)	Urban activity	1,400	🔴	🟢	Above	MD
SR 77	Between Show Low and Holbrook (Milepost 358-389)		1,400	🟡	🟢	Above	MD

Source: ADOT HERE data, 2015; ADOT Traffic Counts, 2014; ADOT Crash data (2010-2014); HDR Engineering, Inc., 2016

Legend					
Mobility	🟢	Worst peak operating speed could be 60% of posted speed	Reliability	🟢	Non-recurring delay could be as much as 2x the average travel time during worst peak
	🟡	Worst peak operating speed could be 50%-60% of posted speed		🟡	Non-recurring delay could be as much as 3x the average travel time during worst peak
	🔴	Worst peak operating speed could be 50% or less of posted speed		🔴	Non-recurring delay could be as much as 4x or longer the average travel time during worst peak

Notes: Non-recurring delay refers to unexpected delay due to closures or restrictions resulting from circumstances such as crashes, inclement weather, and construction activities.

Daily trucks represents the sum of single (FHWA Class 4-7) and multi-unit FHWA Class 8-13) trucks in both direction of travel

Mobility data is based on the truck travel time index calculated as the ratio of posted speed limit to operating speed limit

Reliability data is based on the truck planning time calculated as the ratio of total travel time needed for 95% on-time arrival to free-flow travel time.

Safety is calculated based on the ADOT 5-year crash dataset between 2010 and 2014

Worst peak refers to the time period having highest duration of delay during an average weekday: AM (6am-9am); Midday (9am-3pm); PM (3pm-6pm) and nighttime (6pm-6am)

Data is sorted by decreasing daily truck volumes

Figure 3-26: (continued) Other Key Freight Corridors Performance Evaluation Summary

Route	Segment	Observation	Daily Trucks	Mobility	Reliability	Safety	Worst Peak
SR 189	US/Mexico Port of Entry to I-19 *(Note: for SR 189, the mobility and reliability ratings are inferred from available data)*	Heavy truck activity within the land port of entry area	1,400	🔴	🟡	Above	MD
SR 87	South of Payson (Northbound, Milepost 239 to 254)	Urban activity, heavy traffic volume, traffic signal	1,350	🟡	🟢	Above	PM
US 95	San Luis POE to Yuma (Milepost 0-33)	Truck activity in near proximity of US/MX Port of Entry, urban activity	1,300	🔴	🟢	Above	MD
SR 95	South of I-40 (Milepost 197 to 201)	Junction related	1,200	🔴	🟢	Above	NT
SR 95	Within Lake Havasu City (Milepost 177 to 189)	Urban activity, heavy traffic volume, traffic signal	1,200	🟡	🟢	Above	MD
US 60	SR 79 to east of SR 177 (Milepost 231 to 241)	Grade, curves	1,100	🟢	🟢	Average	PM

Source: ADOT HERE data, 2015; ADOT Traffic Counts, 2014; ADOT Crash data (2010-2014); HDR Engineering, Inc., 2016

Legend	Mobility			Reliability		
		🟢	Worst peak operating speed could be 60% of posted speed		🟢	Non-recurring delay could be as much as 2x the average travel time during worst peak
		🟡	Worst peak operating speed could be 50%-60% of posted speed		🟡	Non-recurring delay could be as much as 3x the average travel time during worst peak
		🔴	Worst peak operating speed could be 50% or less of posted speed		🔴	Non-recurring delay could be as much as 4x or longer the average travel time during worst peak

Notes: Non-recurring delay refers to unexpected delay due to closures or restrictions resulting from circumstances such as crashes, inclement weather, and construction activities.

Daily trucks represents the sum of single (FHWA Class 4-7) and multi-unit FHWA Class 8-13) trucks in both direction of travel

Mobility data is based on the truck travel time index calculated as the ratio of posted speed limit to operating speed limit

Reliability data is based on the truck planning time calculated as the ratio of total travel time needed for 95% on-time arrival to free-flow travel time.

Safety is calculated based on the ADOT 5-year crash dataset between 2010 and 2014

Worst peak refers to the time period having highest duration of delay during an average weekday: AM (6am-9am); Midday (9am-3pm); PM (3pm-6pm) and nighttime (6pm-6am)

Data is sorted by decreasing daily truck volumes

All segments along the KCC corridors showing poor truck travel time index are summarized

Appendix A: Summary of Performance Measures in Other State Plans

Summary of Freight-related Social and Environmental Performance Measures in Other State Freight Plans

24 states' freight plans were identified (see list with website links at end of Appendix). Of these, 8 of the plans were in progress or recently completed and were not available for review; another 3 freight plans were published prior to 2010 and were not reviewed. The remaining 13 plans were reviewed, and pertinent points are summarized in the table below.

None of the plans included qualitative performance measures for environmental and social impacts. Some included quantitative measures for such impacts. Goals, strategies, objectives, etc. that pertain to environmental and social impacts are summarized in the table to provide context and assess the current practice of qualitative performance measures.

Figure A-1: Summary of Freight-related Social and Environmental Performance Measures in Other State Freight Plans

State Plan	Environmental Impacts
California Freight Mobility Plan	The performance measures for the "Environmental Stewardship" goal are quantitative. The following criteria pollutants are included: • Ozone (O3), Respirable particulate matter (PM10), Fine particulate matter (PM2.5), Carbon monoxide (CO), Nitrogen dioxide (NO2), Sulfur dioxide (SO2), and Lead The following greenhouse gases are included: • Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), and Fluorinated gases including sulfur hexaflouride (SF_6), nitrogen triflouride (NF_3), hydrocarbons (HFC), and perfluorocarbons (PFC)
Florida Freight Mobility and Trade Plan (2014)	No specific performance measures are identified.
Indiana 2014 Multimodal Freight and Mobility Plan	The performance measure for environmental impacts is quantitative: • Annual truck emissions (tons CO_2)
Massachusetts Freight Plan (2010)	No specific performance measures are identified.
Michigan Freight Plan (2013)	No specific performance measures are identified.
Mississippi Statewide Freight Plan (2015)	The performance measures for environmental stewardship are quantitative: • Statewide annual number of hazardous materials spills across the freight network • Designated nonattainment areas for all criteria pollutants (future measure) • The plan discusses two potential strategies to address hazardous materials spills: • Improve primary corridor highway facility geometrics or operating conditions in high-crash corridors to reduce spills resulting from crashes • Upgrade primary rail lines to provide target Federal Railroad Administration class to reduce spills resulting from derailments
Missouri State Freight Plan (2014)	No specific performance measures are identified.
North Dakota State Freight Plan (2015)	No specific performance measures are identified.
Ohio Statewide Freight Study (2013)	No specific performance measures are identified.

Identified State Freight Plans

- California Freight Mobility Plan – Reviewed
- Florida Freight Mobility and Trade Plan – Reviewed
- Indiana Freight Mobility – Reviewed
- Iowa State Freight Plan – In progress
- Kansas 2009 Statewide Freight Study – Published 2009 not reviewed
- Maryland Statewide Freight Plan – Published 2009 not reviewed
- Massachusetts State Freight Plan – Reviewed
- Michigan Freight Plan – Reviewed
- Minnesota Statewide Freight System Plan – In progress
- Mississippi Statewide Freight Plan – Reviewed
- Missouri's Freight Plan – Reviewed
- Nevada State Freight Plan – In progress
- New Jersey Comprehensive Statewide Freight Plan – Published 2007 not reviewed
- North Dakota State Freight Plan – Reviewed
- Ohio Statewide Freight Study – Reviewed
- Oregon Freight Plan – Reviewed
- Rhode Island Statewide Freight & Goods Movement Plan – In progress
- South Carolina State Freight Plan – Reviewed
- Tennessee State Freight Plan – In progress
- Texas Freight Mobility Plan – Recently completed not reviewed
- Utah Freight Plan – Reviewed
- Washington State Freight Mobility Plan – Reviewed
- Wisconsin State Freight Plan – In progress
- Wyoming Statewide Freight Plan – In progress