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Working Paper

Arizona State Freight Plan

(ADOT MPD 085-14)

Proposed Performance Measures, Data and Approaches

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CPCS Ref: 14325
September 25, 2015

Working Paper

This Working Paper proposes performance measures to be used to assess the condition and performance of Arizona's freight transportation system. It is provided for comment and discussion.

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

This Working Paper proposes a set of performance measures, data, and approaches for measuring, monitoring and reporting the condition and performance of Arizona's freight transportation system.

The recommended approach for the Arizona State Freight Plan is to focus on a select number of performance measures, while leveraging the measures that Arizona already uses. It is suggested that ADOT focus on freight transportation system performance measures, that:

1. Are tied directly to the goals and objectives of the Arizona State Freight Plan, specifically the system performance objectives;
2. Can practically be measured, updated and tracked on a rolling basis;
3. Provide insights about the performance of the freight system, in line with the performance needs of its users (e.g. shippers, carriers); and
4. Build on existing ADOT data collection and performance monitoring and evaluation.

To these ends, beyond generic freight activity measures (i.e. Annualized Average Daily Truck Traffic), the following performance measures are proposed for the Arizona State Freight Plan.

Figure 1: Proposed 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	*Truck accident rate per 100 million vehicle miles of travel* *Total societal cost of accidents*

With the exception of Annual Hours of Truck Delay, these measures are already used by ADOT and are described in more detail in this working paper, along with a proposed approach for using Annual Hours of Truck Delay. It is proposed that these performance measures be communicated using maps, along with system wide indices, as well as indices specific to each Key Commerce Corridor.

Other system performance objectives, notably those below, are either not currently tracked by ADOT, are difficult to measure and track empirically, and/or difficult to relate specifically to freight activity. For these reasons, it is proposed that progress toward these performance objectives be tracked qualitatively, using value judgement indicators and other, practical alternative means, in a manner outlined in this report.

- Increase multimodal accessibility
- Increase security

- Minimize negative social impacts
- Minimize negative environmental impacts to the extent required by Federal mandate

The use of value judgements has proven to be an effective method to gauge progress in the absence of empirical data. This working paper describes a means of utilizing value judgements to support ADOT's freight performance measurement activities, including as a method for qualitatively validating or adding color to quantified performance metrics.

Combined with other performance measures already developed and monitored by ADOT, the freight transportation performance measures outlined in this working paper are expected to meet MAP-21 requirements and provide a practical and meaningful approach to informing Arizona State Freight transportation system investments over time.

Acronyms / Abbreviations

ADOT	Arizona Department of Transportation
ATRI	American Transportation Research Institute
AZ-TAMS	ADOT Asset Management System
AZTDM	Arizona Statewide Travel Demand Model
BPR	Biennial Performance Reports
CMAQ	Congestion Mitigation and Air Quality Program
CR	Crashing Rate
DOT	Departments of Transportation
HSIP	Highway Safety Improvement Plan
HPMS	Highway Performance Monitoring System
IRI	International Roughness Index
KCC	Key Commerce Corridors
LOS	Level of Service
LRTP	Long Range Transportation Plan
MAP-21	Moving Ahead For Progress In The 21st Century Act
MOVES	Motor Vehicle Emission Simulator
MPD	Multimodal Planning Division
P2P	Planning to Programming
RIC	Recommended Investment Choice
STIP	State Transportation Improvement Plan
TAC	Technical Advisory Committee
TRB	Transportation Research Board
TPTI	Truck Planning Time Index
TTTI	Truck Travel Time Index
VMT	Vehicle Miles of Travel
VOC	Volume Over Capacity

1 Introduction

Key Messages

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

The work to date has established the vision, goals, objectives as well as the policy and strategies for the Freight Plan. This working paper proposes strategic performance measures to assess the performance of Arizona's freight transportation system toward the goals and objectives of the Freight Plan.

This Working Paper is an intermediate step of Phase 5 and is provided for comment and discussion. Once validated by ADOT and the Technical Advisory Committee (TAC), the team will proceed with the assessment of the performance of Arizona's freight transportation system using the proposed performance measures.

1.1 Introduction: Context

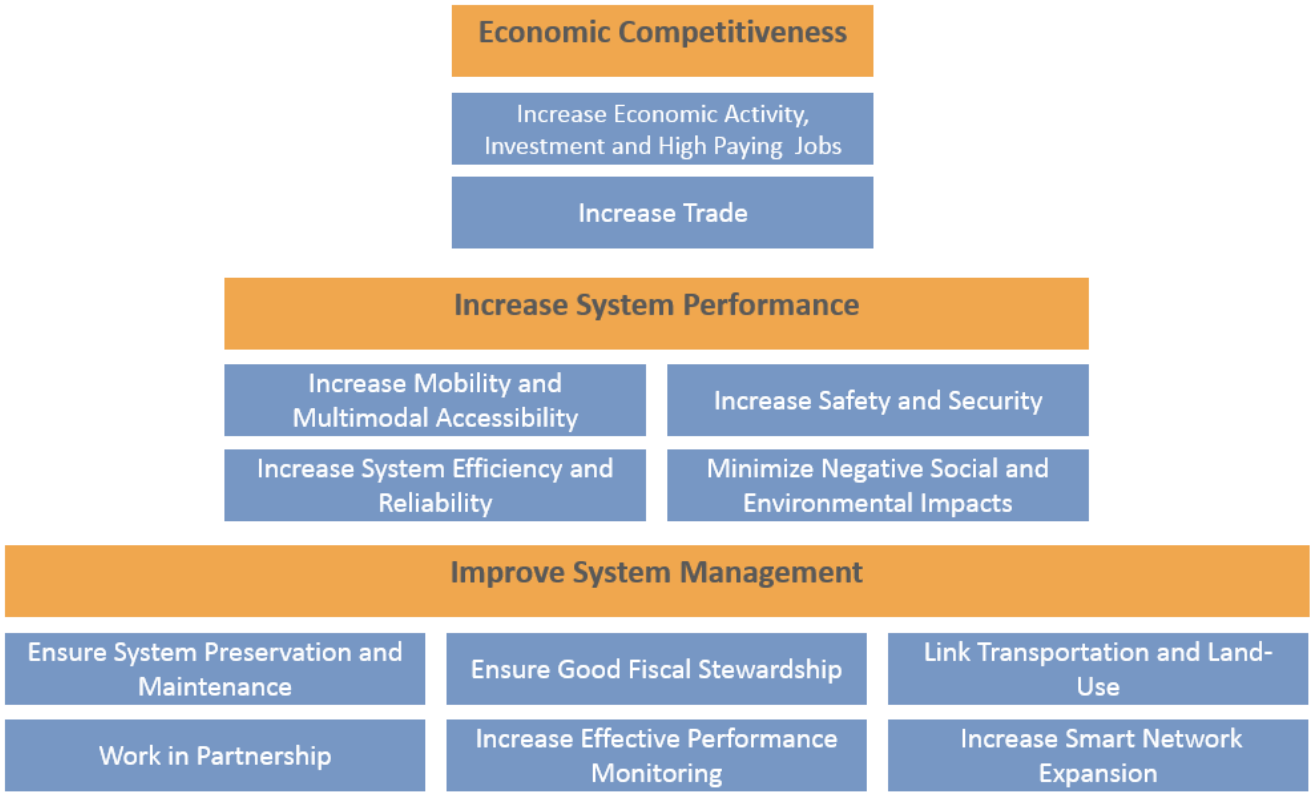
Arizona's economic potential is supported by the state's transportation infrastructure, which connects sources of production to markets. When transportation infrastructure and related services are efficiently designed and competitively positioned, businesses benefit from lower transport costs, faster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

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 Purpose of this Working Paper

This Working Paper aims to identify a set of performance measures, data and approaches for monitoring, measurement and reporting of the condition and performance of Arizona's freight transportation system.

Specifically, this Working Paper addresses the following key questions.

Which performance measures should guide investment decisions in Arizona's freight transportation system?

- Which performance measures and supporting data will reflect national and state Freight Plan goals and allow Arizona to establish baseline conditions and to monitor progress over time, and be feasible to develop and monitor?

This Working Paper is the interim output of Phase 5 in the development of the Arizona State Freight Plan and is provided for comment and discussion.

Once validated by ADOT and the Technical Advisory Committee (TAC), the team will proceed with the assessment of the performance of Arizona's freight transportation system using the proposed performance measures.

2 Background

Key Messages

The recommended approach for the Arizona State Freight Plan is to focus on a select number of performance measures, while leveraging the measures that Arizona already uses.

Performance measures are selected based on the goals and objectives of the Freight Plan, are practical for ADOT to measure and update, provide valuable insights into freight system performance and use data already collected by ADOT.

Additionally, a qualitative approach is proposed that addresses the issues and challenges related to difficult to measure performance categories such as emissions, security and connectivity.

2.1 Background on Performance Measures

State Departments of Transportation (DOTs) throughout the U.S. have developed performance measures to assess changes in the performance of their transportation systems. This broad adoption of performance measurement techniques includes freight-specific performance measures to track progress toward goals and to improve freight planning and capital investment focused on improving goods movement. A number of factors have catalyzed the increased focus on performance measures, including Congress and USDOT, which have encouraged or in some cases required transportation agencies to increase their use to monitor the freight transportation system.

One of the most challenging aspects of developing a freight performance measurement approach is determining which measures to formally integrate. This choice is complicated by the availability of many potential measures, including those identified in recent state and national studies.[1,2,3] The sheer variety of measures used throughout the U.S., in addition to the differences in available data, freight system condition, future outlook and forecasted needs suggests there is no ideal approach.

Types of Performance Measures

Freight specific – performance measures are those that only measure the performance of the transportation system for freight vehicles. Examples include: average annual daily truck traffic, truck accident rates, truck speeds, etc.

Freight applicable – performance measures that indicate the performance of the transportation system for all users, but provide insight for freight transportation. Examples include: planning time index, average speed (all vehicles), international roughness index, etc.

Yet there is often a tendency to try to measure too much.

This can be costly, time-consuming, confusing, and may require significant DOT resources, especially to collect data and maintain the measures in the long run. As importantly, more measures do not necessarily lead to better insights or decision making.

For these reasons, it is suggested that Arizona focus on a smaller number of freight transportation system performance measures, that:

- Are tied directly to the goals and objectives of the Arizona State Freight Plan;
- Can practically be measured, updated and tracked on a rolling basis;

[1] *NCFRP 10: Performance Measures for Freight Transportation.* Washington, D.C: Transportation Research Board, 2011.
[2] McMullen, B. S. and C. Monsere. Freight Performance Measures: Approach Analysis. SPR 664 OTREC-RR-10-04 Oregon Department of Transportation: Research Section, 2010.
[3] Varma, A. *Measurement Sources for Freight Performance Measures and Indicators.* MN/RC 2008-12. Minnesota Department of Transportation, 2008.

- Provide insights about the performance of the freight system, in line with the performance needs of its users (e.g. shippers, carriers); and
- Build on existing ADOT data collection and performance monitoring and evaluation.

To complement these performance measures, it is proposed that ADOT also use qualitative value judgement indicators, informed through regular and ongoing outreach with freight transportation system stakeholders, including (but not necessarily limited to) members of the FAC. The use of value judgement indicators is described in section 3.3.

This approach will provide a practical and meaningful basis for informing freight transportation system investment decisions. The qualitative approach will also promote an ongoing collaborative dialogue between ADOT and the freight community to improve the performance of Arizona's freight transportation system.

2.2 Arizona Freight Performance Measures

ADOT is continually building and improving its performance monitoring and evaluation systems, and underlying data collection and management processes. Arizona's Transportation Highway Performance Monitoring System (HPMS), Transportation Data Management System, and prototype Asset Management System (see box below), are examples of Arizona's performance monitoring capabilities. These ADOT resources and capabilities provide a solid foundation for developing and monitoring freight specific and freight applicable performance measures to support the implementation of the Arizona State Freight Plan.

ADOT Asset Management System (AZ-TAMS)

ADOT's Performance Management Group is developing a prototype performance management data portal - Asset Management System or AZ-TAMS - to provide performance-based information for the Department and others. AZ-TAMS uses data from various sections of ADOT to improve transportation safety, efficiency, and foster economic development. The AZ-TAMS tool is capable of displaying system performance at statewide and district levels through maps, charts, dashboard graphics, and text.

2.2.1 Use of Performance Measures at ADOT

ADOT's most recent Long-Range Transportation Plan (LRTP), *What Moves You Arizona*, defines transportation system goals, objectives and performance measures for the State's multimodal transportation network. Figure 2-1, identifies the LRTP's goals and associated performance measures. These performance measures are currently being monitored at the statewide level.

Figure 2-1: LRTP Goals and Performance Measures

LRTP Goals	Performance Measures
Improve Mobility and Accessibility	Congestion, speed, and travel delay
Preserve and Maintain the State Transportation System	Pavement and bridge deficiencies; maintenance spending
Support Economic Growth	Congestion, speed, travel delay, and resources available for economic initiatives and Job growth/job retention
Link Transportation and Land Use	Congestion, speed, travel delay, and improved access management
Consider Natural, Cultural, and Environmental Resources	Change in vehicle-related emissions, level of environmental certification
Enhance Safety and Security	Fatalities and serious injuries
Strengthen Partnerships	N/A – Focus on implementation policies
Promote Fiscal Stewardship	N/A – Focus on implementation policies

Source: LRTP

As noted in the 2011 LRTP, "This performance-based planning framework is the foundation for ADOT's accountability to its partners, stakeholders, and the public".[4] ADOT also plans to use performance measures as an input to Planning to Programming (P2P), to help prioritize projects consistent with the LRTP goals. This process is currently being piloted for the first time.

Figure 2-2 identifies some of the key metrics associated with the LRTP performance measures. The measures identified here are not freight specific; however, most are general indicators of the performance of the transportation system and indicate whether things are improving for all transportation system users.

[4] (LRTP, P27)

Figure 2-2: ADOT Performance Measures

Performance Measure	Comments	Performance Application	Freight Applicable
Congestion	Level of Service (LOS) can be derived from the Arizona Statewide Travel Demand Model (AZTDM) model using 'Volume over Capacity' (VOC) ratio. ADOT updates this model periodically with current socioeconomic data and updates to the state roadway network. The model includes base condition data for year 2040 planning horizon.	Based on the LOS, congested roadway segments and bottlenecks are identified for existing (2015) and future base conditions (2040). Mitigation measures are evaluated and prioritized based on modeling results at congested segment locations.	✓
Speed/ Travel delay	Real time vehicular operating speed is collected using passenger probe data. ADOT uses HERE data to compute actual operating speed during AM and PM peak periods. Currently, HERE data has limited roadway system coverage and the data is available from the beginning of 2014. Travel and planning time travel time index are used to measure the performance. Planning time index reflects the extra buffer time needed for on-time delivery while accounting for non-recurring delay such as crashes, inclement weather, and construction activities.	Travel and planning time travel time index is used to measure system performance. Duration and extent of recurring delay may be measured comparing the free flow and actual travel speed. Performance is evaluated based on the level of delay. Real time travel time is also used by ADOT in 80 variable message boards in urbanized areas of the state to assist motorists in avoiding congestion and delay.	✓
Pavement	The ADOT Materials Group maintains a statewide database comprising pavement condition ratings. The most commonly used ratings are the International Roughness Index (IRI) and the Crashing Rating (CR). ADOT incorporates pavement condition data into the Highway Performance Monitoring System (HPMS) GIS based roadway network. ADOT HPMS Pavement dataset is current as of 2014.	Based on the thresholds, pavement conditions are ranked as 'poor', 'medium' and 'good' using established pavement index values.	✓
Bridge deficiencies	Bridge conditions are presented by their sufficiency ratings and deficiency type. The ADOT Bridge Group maintains a statewide database containing bridge locations, and their sufficiency rating and deficiency status.	Based on the sufficiency rating, deficient bridges are identified and their eligibility for rehabilitation or replacement is determined. Based on the condition assessment, bridges may also be classified as "functionally obsolete" or "structurally deficient."	✓
Maintenance spending	The LRTP 'Recommended Investment Choice' (RIC) identified a target for 34 percent of the state's funding be assigned to "Highway Preservation".	Annual spending, as identified in the State Transportation Improvement Plan (STIP), may be compared to the "target" levels identified in the LRTP.	✓

Performance Measure	Comments	Performance Application	Freight Applicable
Improved access management	ADOT's Access Management Plan (June 2009) strives to maintain the integrity of ADOT's right-of-way and transportation facilities and reduces potential liability while achieving a reasonable balance with the needs of public safety, abutting land development, local road networks and regional mobility.	Access management is currently controlled through Department guidelines. Traffic impact analyses reports are required and evaluated by ADOT to approve developments requesting access to State highways.	✓
Fatalities and serious injuries	ADOT Traffic Safety Division maintains traffic crash data which include date, time, location and crash characteristics such as severity, collision manner, harmful events, weather, lighting condition and driver behavior. The crash database is compiled from Arizona Traffic Accident Reports submitted to ADOT by state, county, city, tribal, and other law enforcement agencies and updated periodically.	Safety index is calculated based on fatal and incapacitating injury (K-A) crashes. Hot spots with higher crash frequency and rates are identified and mitigation countermeasures are recommended.	✓
Change in vehicle-related emissions, level of environmental certification	ADOT uses the Motor Vehicle Emission Simulator (MOVES) model to evaluate emission related impacts on air quality. MOVES model uses inputs including vehicle miles of travel, speed, vehicle and fuel characteristics, and pavement conditions into consideration.	Outputs from the MOVES file are used to create an emission summary table to evaluate performance.	✓
Emissions	ADOT's Air and Noise Program office confirms that projects and operations comply with federal, state and local air quality laws and regulations. The State of Arizona has implemented federal air quality control standards and enacted control measures that are specific to Arizona.	MOVES is the official model for estimating emissions from highway vehicles. ADOT currently uses output from the AZTDM2 model with MOVES for conformity modeling outside the MPO regions.	✓

Freight Specific Performance Measures

Beyond the performance measures above, ADOT collects a number of other data sets that provide important information on the system's overall performance and relate directly to the efficiency and reliability of freight transportation in Arizona. These include data on physical elements (examples include, structures with low height clearance; roadway segments in need of climbing or passing lanes; railroad at-grade crossings; and truck parking); the incidence of non-recurring delays on the system (location, cause, duration); and operational data (border crossings, overweight/oversize vehicles, etc.).

ADOT is currently in the process of evaluating the condition and needs of the Key Commerce Corridors (KCC) through a series of corridor profile studies.

This effort is the Department's most comprehensive use of performance metrics to date in assessing the condition and needs of the freight transportation system. The performance measures in the profile studies are separated into primary and secondary measures and presented in the figure below. Two of the primary measures, truck planning time index and truck travel time index, relate directly to truck freight travel time reliability. Whereas, the secondary measures, displayed in Figure 2-3, relate to the roadway network efficiency. Appendix A shows the status of the corridor studies, which are anticipated to be complete by 2016.

Figure 2-3: Key Commerce Corridors Performance Measures

Performance Area	Primary Measure	Secondary Measures
Pavement	Pavement Index (based on a combination of International Roughness Index and Cracking)	Pavement Serviceability Pavement Failure Pavement Hot Spots
Bridge	Bridge Index (based on Deck Rating, Substructure Rating, or Superstructure Rating)	Sufficiency Rating Functionally Obsolete Bridge Hot Spots
Mobility	Mobility Index (based on combination of Current V/C and Future V/C)	Current Volume/Capacity Future Volume/Capacity Travel Time Index (TTI) Planning Time Index (PTI) Road Closure Frequency Multimodal Opportunities
Safety	Safety Index (based on frequency of fatal and incapacitating injury crashes)	Frequency of Strategic Highway Safety Plan Emphasis Areas Frequency of Truck Crashes Frequency of Motorcycle Crashes Safety Hot Spots
Freight	Freight Index (based on Truck Planning Time Index)	Truck Travel Time Index (TTTI) Truck Planning Time Index (TPTI) Road Closure Duration Clearance Restrictions

Source: Arizona Department of Transportation (2015).

2.3 Issues and Challenges

While ADOT has made major progress integrating performance measures into its operations and planning practices, the department may face several issues and challenges as it implements and monitors freight performance measures. Some of these challenges may emerge during initial implementation of freight performance measures and can be anticipated and overcome through careful planning. By strategically targeting a limited set of performance measures, the proposed approach recognizes the challenges faced by ADOT and presents a methodology that both promotes performance measurement and advances the resolution of the following challenges:

- **Proliferation of data.** Due to a variety of factors including legislative requirements and technological advancements, ADOT has access to more and better data. This includes field-collected data, such as pavement and bridge conditions; ADOT's photo log; real-time data, such as automatic traffic counts, real-time speed monitoring, and weigh in motion monitors. The expansion in the amount and variety of data presents opportunities to empirically enhance the tracking of specific measures, for example with automated sensor data. At the same time, data proliferation means that with limited resources to collect, analyze, and apply the data, ADOT may have to be increasingly selective in the measures and data it harnesses.
- **Data conflation**[5]**.** Data from different sources may not link to the network (e.g., different datasets that don't have matching roadway networks, data that is identified by coordinates not routes, manually entered data).
- **Commercial data availability and cost.** Commercial organizations provide products and services to state DOTs by researching, gathering, promoting, and selling freight data for use in planning. ADOT works with some of these data providers (see text box), but this data can be costly.
- **Federal policy.** The federal policy on freight performance measures required by MAP-21 has yet to be issued, resulting in uncertainty when state DOTs select freight performance measures.

Freight Plan's use of Data

To support the State Freight Plan, ADOT contracted with two commercial data providers, American Transportation Research Institute (ATRI) and IHS Global Insight. The information collected by entities such as these are helping to expand the Department's ability to understand freight movement.

- **Resource availability.** Data today has greater detail, precision, and timeliness than ever before. This expansion of meaningful data presents a challenge to all agencies. The effort of collecting, processing, validating and presenting data are significant. Resource

[5] Conflation is defined as the process of combining geographic information from overlapping sources so as to retain accurate data, minimize redundancy, and reconcile data conflicts (wiki.gis.com)

availability problems stem from data coming from many different sources and come in many formats. For example, validation often requires continued discussions and refinements with the entity responsible for compiling and distributing the data.

- **Prototype performance management site, AZ-TAMS.** ADOT's performance management site (AZ-TAMS) is in beta-testing. Through the development of the site, the Performance Management Group continues to identify and resolve gaps in datasets. Getting the site operating has resulted in addressing many of the data discrepancy issues previously noted. The portal's searchable and filterable interface will facilitate and emphasize data evaluation.
- **Areas of limited data availability.** Data coverage may not cover the entire state and could be non-existent in some areas or on some roadways. Throughout the state highway system there are routes with limited real-time vehicle data (for example, rural routes may be remote, infrequently traveled, through areas of rugged terrain).

3 Proposed Approach to Performance Measures

Key Messages

The quantitative measures proposed for the Arizona State Freight Plan are focused on increasing transportation system performance. To this end, the proposed measures are: truck travel time index, annual hours of truck delay, truck planning time index, truck accident rate per 100 million vehicle miles of travel and total societal cost of accidents.

Additionally, to supplement the quantitative performance measures the following qualitative measures are proposed: increase multimodal accessibility, increase security, minimize negative social impacts, and minimize negative environmental impacts.

The Freight Plan's approach to performance measures is compliant with the freight themes of MAP-21, but US DOT has yet to provide specific guidance on freight performance measures. Therefore, there is uncertainty whether the proposed performance measures will match future MAP-21 rulemakings.

3.1 Simple and Practical Approach to Performance Measures

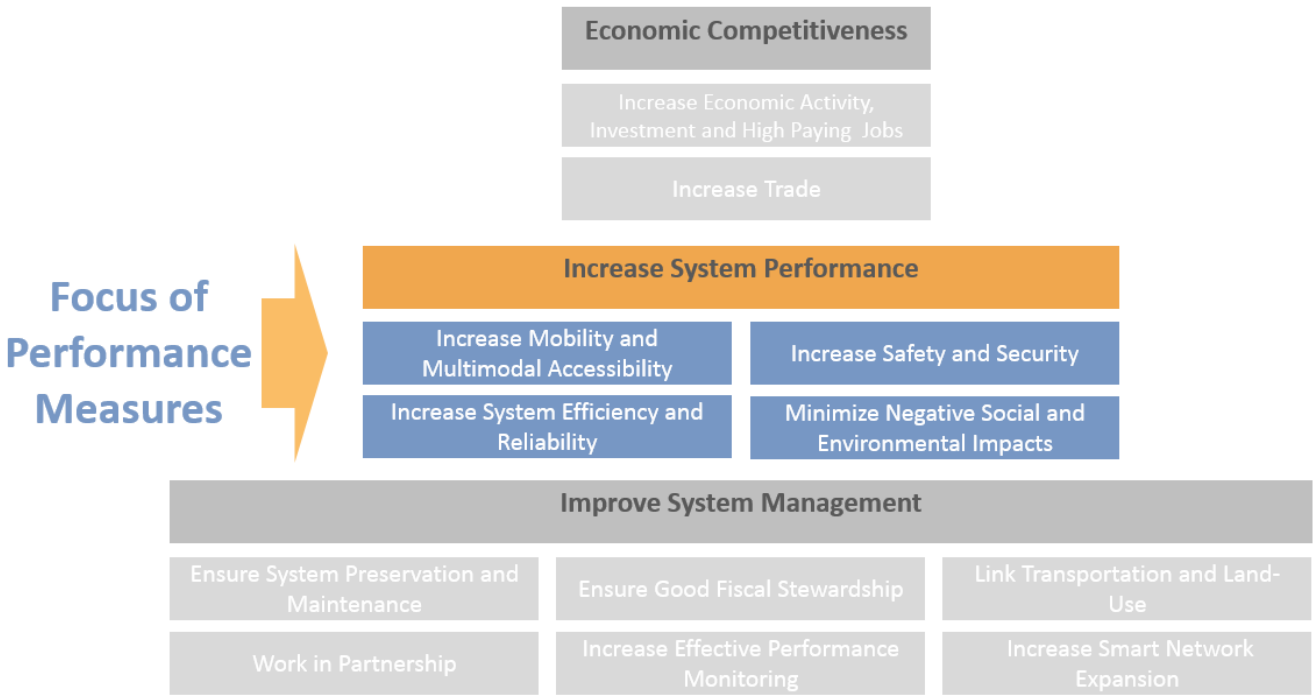
By leveraging ADOT's existing work on performance measures and recognizing that more performance measures do not necessarily equate to better outcomes, the proposed approach is for ADOT to measure and track fewer rather than more freight transportation system performance measures. These performance measures should be practical to measure and use, provide appropriate proxies for the performance parameters that freight transportation system users care about (e.g. travel time, logistics cost, reliability) and provide meaningful insight into the conditions and performance of Arizona's freight transportation system.

3.1.1 Linking Performance Measures to Objectives

Since increasing transportation system performance is the goal that the Arizona State Freight Plan will ultimately enable economic competitiveness and quality growth, freight performance measures should be directly tied to this goal and associated objectives.

Accordingly, it is proposed that performance measures informing and flowing from the Arizona State Freight Plan provide insight into progress with respect to the following *system performance* objectives: 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.

Figure 3-1: Improve System Performance Goal and Objectives



3.1.2 Building on ADOT Performance Monitoring and Evaluation

For practical reasons, it is proposed that the performance measures informing and flowing from the Arizona State Freight Plan leverage and build upon the performance measures ADOT already tracks.

Much of the data required 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.

With respect to the freight system performance objectives noted above, the project team proposes the following performance measures for the Arizona State Freight Plan:

Figure 3-2: Proposed 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	*Truck accident rate per 100 million vehicle miles of travel* *Total societal cost of accidents*

A more detailed discussion of these performance measures, underlying data, and how they can most meaningfully be used is provided in section 3.2.

3.1.3 Recognizing Quantitative Limitations

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

- 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 difficult to relate specifically to freight activity. In these cases, it is proposed that progress toward these performance objectives be tracked qualitatively, using value judgement indicators and other, practical alternative means (discussed in section 3.3).

3.2 Quantifiable Performance Measures to Assess System Performance

Leveraging the data and performance measures currently in use at ADOT, the following section outlines the proposed measures, including the data, approach, outcomes and the limitations of the measure or data.

3.2.1 Overall Freight Activity Measure

Overall freight activity levels will be used as a broad measure that adds context to the other performance measures. As a general measure, freight activity won't be reported to the same degree as the other performance measures, but instead used as a supplement to enhance the value of the other measures. Annualized Average Daily Truck Traffic (AADTT) provides the simplest measure of freight activity and will indicate whether freight activity is increasing or decreasing over time on the whole network as well as on specific facilities as needed.

3.2.2 Truck Mobility Performance Measure

Link to Objective: Increase Mobility

Truck mobility and accessibility improvements will be evaluated using *Truck Travel Time Index* (TTTI) which measures truck related recurring delay primarily due to peak period congestion. TTTI evaluates 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 probe data obtained from a number of sources including mobile phones, vehicles, and portable navigation devices. Freight probe data is obtained from ATRI which leverages embedded fleet systems data. ADOT currently maintains an intranet web portal that summarizes TTTI on a limited number of state facilities (which includes all of the KCC). The data was available for use at the beginning of 2014.

Approach

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

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

ADOT's TTTI dataset will be mapped using the following thresholds to measure the freight travel time related to recurring delay (thresholds established using information from ADOT's corridor profile studies are proposed here for consistency).

- Good < 1.15
- Fair 1.15 to 1.33
- Poor > 1.33

Data collected statewide will be evaluated.

Outcome

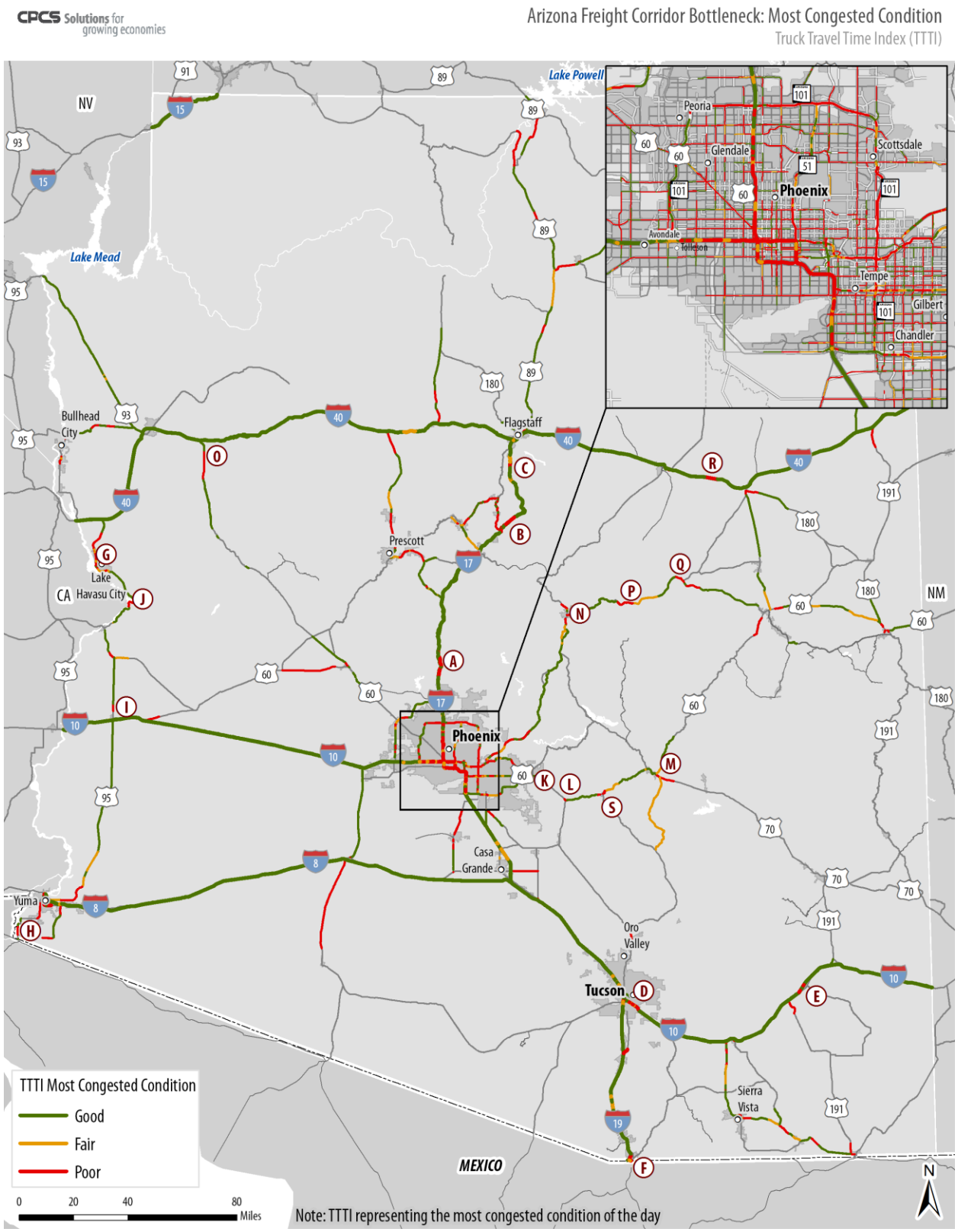
The results will be summarized on a statewide map (Figure 3-3). KCC and other roadway segments (where data is available) showing poor freight performance will be identified. In addition to the statewide map, a single index specific to the KCCs will be developed as a benchmark and overall indicator of performance (although the segment-level values will

provide a better measure of year-over-year of performance). ADOT currently evaluates freight performance using the TTTI, which is collected throughout the year.

Limitation

ADOT currently does not have access to historical TTTI data. In addition, data is not available for all state owned facilities. In remote areas of the state in which this data is unavailable, congestion is not typically a significant issue. However, as data coverage improves, ADOT will expand the coverage of TTTI data to encompass more state facilities. TTTI data coverage of larger areas will help ADOT provide more reliable system wide freight performance evaluations. In the short term, it is proposed that coverage of the KCCs be a primary focus.

Figure 3-3: Statewide Truck Travel Time Index



3.2.3 Annual Hours of Truck Delay Performance Measure

Link to Objective: Increase System Efficiency

Annual hours of truck delay measures the economic cost of congestion on the freight industry.

The impact of the highway system bottlenecks will be measured by total truck hours of delay, which also provides a relative ranking of individual bottlenecks. However, this measure typically underestimates the total truck hours because it doesn't consider the intersecting arterial roadways and the analysis methods do not yet adequately account for the congestion effects of traffic weaving and merging at on- and off-ramps.

Traffic congestion and delay are characterized by slower speeds, longer trip times, and increased queuing, and impact truck mobility significantly. Annual hours of truck delay captures all of these characteristics and is a primary indicator of freight performance. Annual hours of truck delay measures the economic cost of congestion on the freight industry

Data

The following data will be used to calculate annual hours of truck delay.

- Speed limits using the Highway Performance Monitoring System (HPMS) data
- Real-time truck operating speeds by peak period
- Annual vehicle classification traffic counts, provided by the ADOT traffic division

Approach

Delay is defined by the difference of time between free flow speed (e.g., posted speed) and actual operating speed along a defined roadway segment. Delay is higher during congested peak periods compared to off-peak periods. Delay per truck is multiplied by peak period truck traffic volumes, and summed to identify total daily hours of truck delay. Peak hour factors will be used to estimate peak period truck traffic using ADOT's daily truck counts.[6]

$$\text{Annual Hours of Delay} = (\text{Congested Travel Time} - \text{Free flow Travel time}) * Daily\ Truck\ Volume * 306$$

ADOT has yet to develop the GIS based inter-linked dataset (conflation) between speed and vehicle count data sets needed to calculate annual hours of congestion truck delay. However, ADOT currently maintains multiple datasets comprising real-time truck operating speeds and traffic counts. Data from these sources will be conflated into a GIS System to compute this measure. Data collected statewide will be evaluated and mapped.

[6] The Highway Capacity Manual (Special Report 209, Transportation Research Board, 2000) suggests an average truck working week of five (5) weekdays at full capacity and two weekend days at 44% capacity. This equates to 306 truck operating working days per year. Daily truck delays will be multiplied by 306 to estimate annual total hours of truck delay.

Outcome

The annual truck hours of delay will be summarized by the morning and afternoon peak periods on a statewide map. KCC and other roadway segments (where data is available) showing poor freight performance will be identified, and the economic impacts on specific sectors using and accessing the state's KCCs will also be evaluated.

Limitation

ADOT currently has limited historical (2014 and part of 2015) truck operating speed data for a limited number of major freight corridors. However, 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 evaluated. In addition, data to determine this metric does not link to the network, and considerable effort is necessary to conflate the data.

3.2.4 Truck Reliability Performance Measure

Link to Objective: Increase System Reliability

Unreliable freight transportation requires added supply chain redundancy and cost 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 that affect regional, state, and local economies. Reliability is measured through non-recurring delay which refers to unexpected delay caused by closures or restrictions resulting from crashes, inclement weather, and construction activities. Non-recurring delay is measured using the *Truck Planning Time Index* (TPTI).

Data

ADOT currently develops the TPTI for major freight corridors using the HERE dataset. The TPTI reflects the extra buffer time needed for on-time delivery while accounting for non-recurring delay. The data is available for 2014 and part of 2015. The speed based TPTI is calculated using the following formula:

- TPTI = Free-Flow Truck Speed / Observed 5th Percentile Lowest Truck Speed

Approach

The speed based TPTI is calculated using the following formula:

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

ADOT's TPTI dataset will be used and mapped using the following thresholds to measure the freight travel time performance related to recurring delay (as with the TTTI Index identified above, thresholds were established using information from the ADOT Corridor Profile studies currently underway, and are proposed for consistency).

- Good < 1.3

- Fair 1.3 to 1.5
- Poor > 1.5

Data collected statewide will be evaluated.

Outcome

The TPTI results will be summarized on a statewide map. KCC and other roadway segments (where data is available) showing poor freight performance will be identified. A single index for the KCCs will be developed as a benchmark and overall indicator of performance (although the segment-level values will provide a better measure year-over-year of performance). Freight routes with poor reliability will be identified and mitigation countermeasures may be recommended to improve system reliability and economic activities.

Limitation

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

3.2.5 Truck Safety Performance Measure

Link to Objective: Increase Safety

Highway crashes involving trucks tend to be a disproportionately low percentage of all highway crashes, especially considering the generally lower number of miles traveled by these vehicles each year. 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 primary measure proposed is the number of crashes involving trucks per 100 million vehicle miles of travel (VMT)[7] and their total societal cost.

Data

ADOT Traffic Safety Division maintains and updates a statewide crash database, including historical data comprised 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 updated periodically. The safety performance measure will focus on crashes data involving trucks within the most recent three years between January 1, 2011 and December 31, 2013.

Approach

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

- Fatal: $1.53 million per crash

[7] The truck safety performance measure uses the VMT from all vehicles in its calculation.

- Incapacitating: $76,398 per crash
- Non incapacitating: $24,480 per crash
- Property Damage Only (PDO): $9,486 per crash

Truck involved crashes with various injury levels will be converted into equivalent fatal crashes using the societal cost (as a proportion). ADOT currently uses urban and rural area types to analyze the crashes as traffic volumes and number of crashes varies significantly by area type. ADOT has reported that urban crashes comprise 81.6 percent of all crashes and 53.4 percent of fatal crashes. [8] Safety Index categorized by low, medium and high will be developed by 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. Individual roadway segment safety indices will be compared with the statewide average by urban and rural area types and categorized into high, medium or low.

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

Outcome

The safety performance measure will inform recommendations on project improvements and solutions to improve freight safety along the KCCs exhibiting high safety index values. In addition, hot spots of truck accidents will be identified and used to identify opportunities for critical system improvements.

Limitation

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

3.3 Beyond Quantifiable Performance Measures: Value Judgement Indicators

FHWA defines a performance measure as a qualitative or quantitative measure of outcomes, outputs, efficiency, or cost-effectiveness.

When the development of quantitative performance measures is not practical, feasible, or meaningful (e.g. when underlying data is not readily available, when a causal link to freight is not easy to define, or where there is insufficient capacity or resources to develop them), qualitative indicators can provide a useful proxy. We propose that qualitative assessments of performance, using value judgement indicators, be used in such instances.

[8] ADOT Traffic Engineering Guidelines and Processes includes definitions of urbanized areas from the decennial census by the United States Bureau of the Census. (Section 300, June 2015)

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

Value judgement indicators are measures of perception, informed by a combination of qualitative information, observation, local knowledge and stakeholder consultations, as available, relevant and appropriate. By their nature, these sources of information must be interpreted.

Value judgement indicators are particularly useful as a basis for defining if transportation performance – on one dimension or another – is getting better, getting worse, or relatively constant versus past performance. Value judgements are less useful for comparing performance across different geographies and freight transportation systems, given differing contexts.

To develop and use value judgement indicators, the indicators themselves must be clearly defined – often in the form of a simple question – and they must be assessed against benchmark criteria that are relatively objective and that can be ranked on a scale – say, one to three (the consultant team prefers smaller scales to minimize risks associated with different interpretations of the criteria). Benchmark criteria do not need to be detailed or complex, but they should provide a reasonably clear basis establishing value judgements. Put simply, value judgement indicators should be reasonably easy to use and replicate.

Of note, value judgment indicators are not meant to be perfect measures of reality, instead they are a reasonable reflection of performance over time.

The key benefit of value judgement indicators is in getting user input to determine if performance is improving or getting worse over time, and the related reasons.

One of the advantages of using value judgment criteria is that they also provide an opportunity for qualitative comments or details to support the value judgement assessment, which in turn can provide great insight into issues or improvements that can move the dial on future value judgment assessments.

System users are surveyed on value judgment indicators, providing a routine opportunity for ADOT to gain insight into specific transportation issues.

The following provides proposed value judgement criteria and associated benchmark criteria for the Arizona State Freight Plan performance objectives which are difficult or impractical to measure quantitatively.

Objective: Increase multimodal accessibility

Value Judgement Indicator: Multimodal Accessibility	Benchmark Criteria
Do shippers have increased multimodal options relative to the previous period?	1. Viable multimodal options less than in the previous period 2. Viable multimodal options unchanged from previous period 3. Viable multimodal options greater than in the previous period
Basis for informing value judgement indicator: Consultation with shippers (perception), review of new multimodal connections in Arizona (e.g. new rail spurs or cargo air facilities), increasing use of non-road modes by shippers (mode share).	

Objective: Increase security

Value Judgement Indicator: Freight Security	Benchmark Criteria
Has freight security improved in Arizona relative to the previous period?	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 judgement indicator: Consultation with shippers (perception), consultation with border officials, consultation with police department or other first responders, review of security incident reports or statistics (e.g. product theft, violent incidents, hijackings, or other freight-related illegal activity).	

Objective: Minimize negative social impacts

Value Judgement 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 judgement indicator: Consultations with MPOs, community associations (near major freight clusters (perception, reports of complaints and anecdotes), number of freight-related municipal by-law complaints, news stories about society concerns about freight activity, etc.	

Objective: Minimize negative environmental impacts

Note: the Transportation Research Board (TRB), among others, has conducted a considerable amount of research by about quantifying freight related emissions. This work is however very specialized and costly to reproduce and can miss broader trends driving increases in freight-related emissions (e.g. increased economic activity, weather events, etc.).

Additionally, as part of the Congestion Mitigation and Air Quality Program (CMAQ) and as required by MAP-21, ADOT will be required to report performance measures for mobile source

emissions. MAP-21 also requires states to set targets for on-road mobile source emissions, measure those emissions and produce and update a Congestion Mitigation and Air Quality Improvement Plan every two years. Therefore, a freight-specific emissions or environmental performance indicator is not proposed for Arizona's Freight Plan.

Value Judgement 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, though 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 judgement indicator: Consultations with Arizona environmental department, MPOs, affected environmental groups (near major freight clusters (perception, reports of complaints and anecdotes), air quality reports near freight clusters, news stories, etc., extent to which there are increasing natural gas-powered engines in Arizona, CNG stations, etc.	

3.3.1 Other Uses for Value Judgement Indicators

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

For example, value judgement indicators can complement the four quantifiable performance measures proposed in section 3.2 by focusing on elements of performance which may be implicit in those performance measures. The table below provides an example.

Figure 3-4: Value Judgement Indicators Informing Quantitative Performance Measures

Freight Transportation System Objectives	Value Judgement Indicator Questions (to complement quantitative measures)	Benchmark Criteria
Increase Mobility	Is freight travel time, on the whole, improving (since the last period)?	*All other things being equal, are things:* *1. Getting worse?* *2. No material change?* *3. Getting better?*
Increase System Efficiency	Are logistics costs associated with transportation system inefficiencies, decreasing, on the whole (since the last period)?	
Increase System Reliability	Is on-time delivery improving (since the last period)	
Increase Safety	Are incidents and close calls decreasing (since the last period)?	

These, and similar value judgement indicators can be developed on a regular basis (e.g. annually), through the use of simple surveys or, better, informal consultations with freight transportation system stakeholders (e.g. Freight Advisory Committee members).

Such value judgement assessments should also be complemented with open questions to obtain further insight about the value judgement assessment. Simple questions such as "what informed your assessment" and "can you cite specific examples of improvements that would lead to an improved assessment next year" can also lead to 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 which can improve future freight planning efforts.

3.4 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 that includes performance measures which in turn guide freight-related transportation investments.[9] Additionally, MAP-21 calls for the Secretary of USDOT to develop performance measures for the transportation system, under four programs:

- National Highway Performance Program (NHPP) – USDOT guidance released
- Highway Safety Improvement Program (HSIP) – USDOT guidance released
- Congestion Mitigation and Air Quality Program (CMAQ) - USDOT guidance forthcoming
- Freight Movement – USDOT guidance forthcoming

Note that FHWA has released guidance on some of the programs, whereas other programs still require the USDOT to promulgate a rulemaking. Figure 3-5 displays USDOT's proposed performance measures for MAP-21 programs when guidance is available and otherwise lists the category required in MAP-21. Additionally, Figure 3-5 includes whether ADOT currently collects this measure, if it is applicability to freight and whether the performance measures proposed in this plan are applicable. Overall, the required performance measures are generally applicable to freight, but none of those that have guidance are freight specific. For example, safety performance measures do no separate truck fatalities and serious injuries from the total occurrences.

[9] 1118(b)(2)

Figure 3-5: MAP-21 and ADOT Performance Measures Crosswalk

MAP-21 Programs and Performance Measures	ADOT Measurement	Applicable to Freight	Freight Plan Performance Measure
National Highway Performance Program (NHPP)			
Percentage of pavements on the Interstate System in good condition	✓	✓	BPR*
Percentage of pavements on the Interstate System in poor condition	✓	✓	BPR*
Percentage of pavements on the NHS (excluding the Interstate System) in good condition	✓	✓	BPR*
Percentage of pavements on the NHS (excluding the Interstate System) in poor condition	✓	✓	BPR*
Percentage of NHS bridges classified as in good condition	✓	✓	BPR*
Percentage of NHS bridges classified as in poor condition	✓	✓	BPR*
Performance of the Interstate system	Not-released	✓	✓
Performance of the non-Interstate NHS	Not-released	✓	✓
Highway Safety Improvement Program			
5-year rolling average of the total number of fatalities	✓	✓	HSIP**
5-year rolling average of the State's fatality rate per VMT	✓	✓	HSIP**
5-year rolling average of the total number of serious injuries	✓	✓	HSIP**
5-year rolling average of the total number of serious injuries per VMT	✓	✓	HSIP**
Congestion Mitigation and Air Quality Program			
Traffic congestion	Not-released	✓	✓
On-road mobile source emissions	Not-released	✓	✘
Freight Movement			
Freight movement on the Interstate system	Not-released	✓	✓

*ADOT collects and measures pavement and bridge data in compliance with MAP-21 and will be required to report progress on these measures in Biennial Performance Reports (BPR) to US DOT.
**A Highway Safety Improvement Plan (HSIP) is required by MAP-21. ADOT has developed and reported on MAP-21 performance measures related to safety.

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

3.5 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. The following considerations are critical to effectively communicating performance measures.

- **Know the audience.** The communication of performance measures must match the intended audience with the level of detail appreciated by that audience.
- **Define the goal of communication.** Identify the goal of communicating performance measures.
- **Strategically communicate.** Select timing, distribution channels and method to match audience and goals.

Generally speaking, three distinct groups comprise ADOT's audience: Arizona transportation agencies, other Arizona government agencies, and the private sector. Figure 3-6 displays proposed goals and techniques to communicating freight performance measures to each audience.

Figure 3-6: Performance Meausres Communication Strategy

Audience	Goal	Communication Method
Arizona Transportation Agencies (ADOT, MPOs, COG)	• Expand knowledge of freight performance for planning and programming • Use in project prioritization • Communicate needs to executives • Transparency	• Most detailed communication • Supported by data such as data portal • Display trends and benchmarking • Distribution through internal communication • Document and portal
Arizona Government (state and local governments)	• Expand knowledge of freight • Communicate needs to executives • Support for ADOT initiatives • Improve perception and trust • Transparency	• High level overview of trends and maps • Minimal text explaining needs • Distributed through ADOT executives • Use common units(dollars, hours, etc.) for context • Policy focus if applicable • Hard and soft copy distribution matched to recipient
Private Sector Freight Stakeholders	• Support for ADOT initiatives • Improve perception and trust • Transparency	• High level overview of trends and maps • Minimal text explaining needs • Use common units(dollars, hours, etc.) for context • Press release

According to best practices, DOTs should not only use performance measures to inform decision making but also to inform internal and external stakeholders. The value of performance measures—beyond measuring change over time—are in their ability to tell a complex story in a graphic or statistic. 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 with data and trends.

4 Next Steps

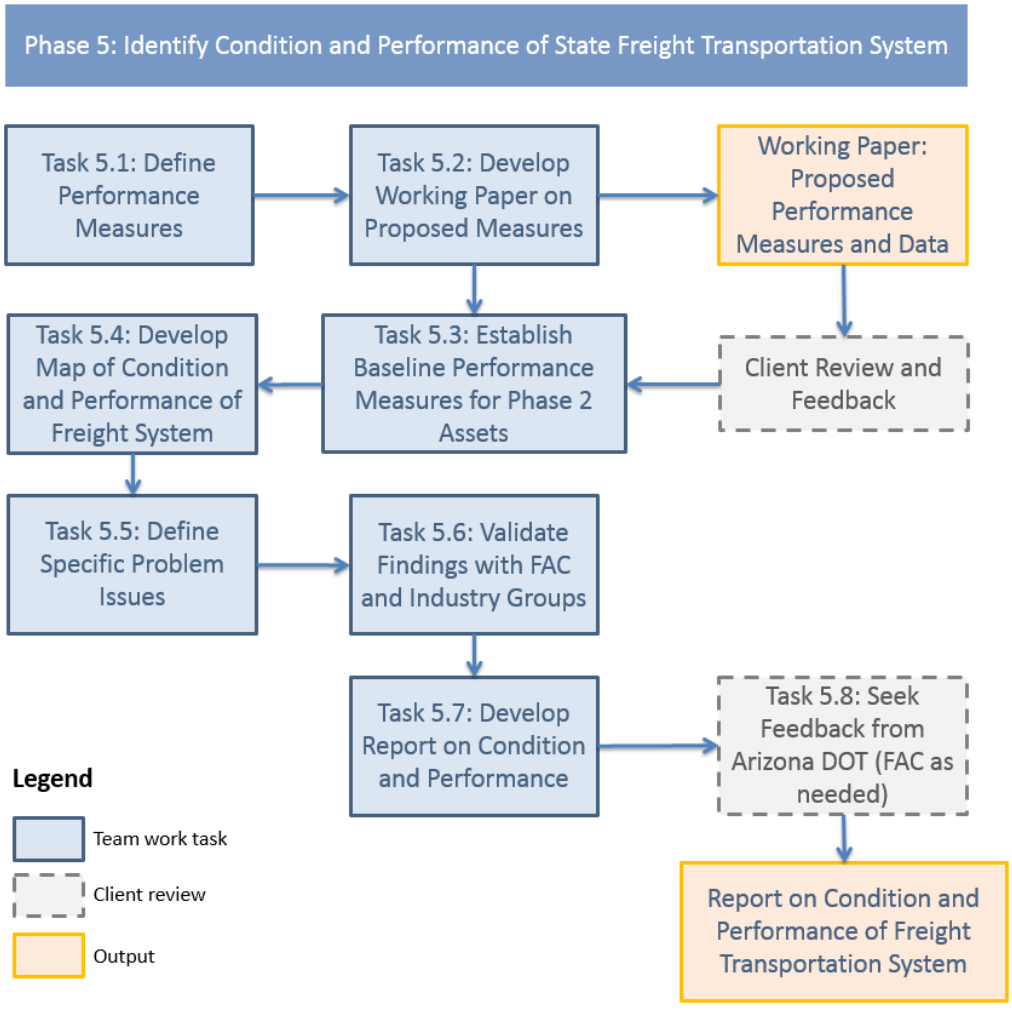
4.1 Key Considerations in Moving Forward

The key consideration moving forward is whether the performance measures outlined in this interim report match the needs of ADOT and the goals and objectives of the Freight Plan. Following approval from the ADOT Project Manager and the TAC, the consultant will prepare a condition and performance report using the approved freight performance measures.

4.2 Immediate Next Steps

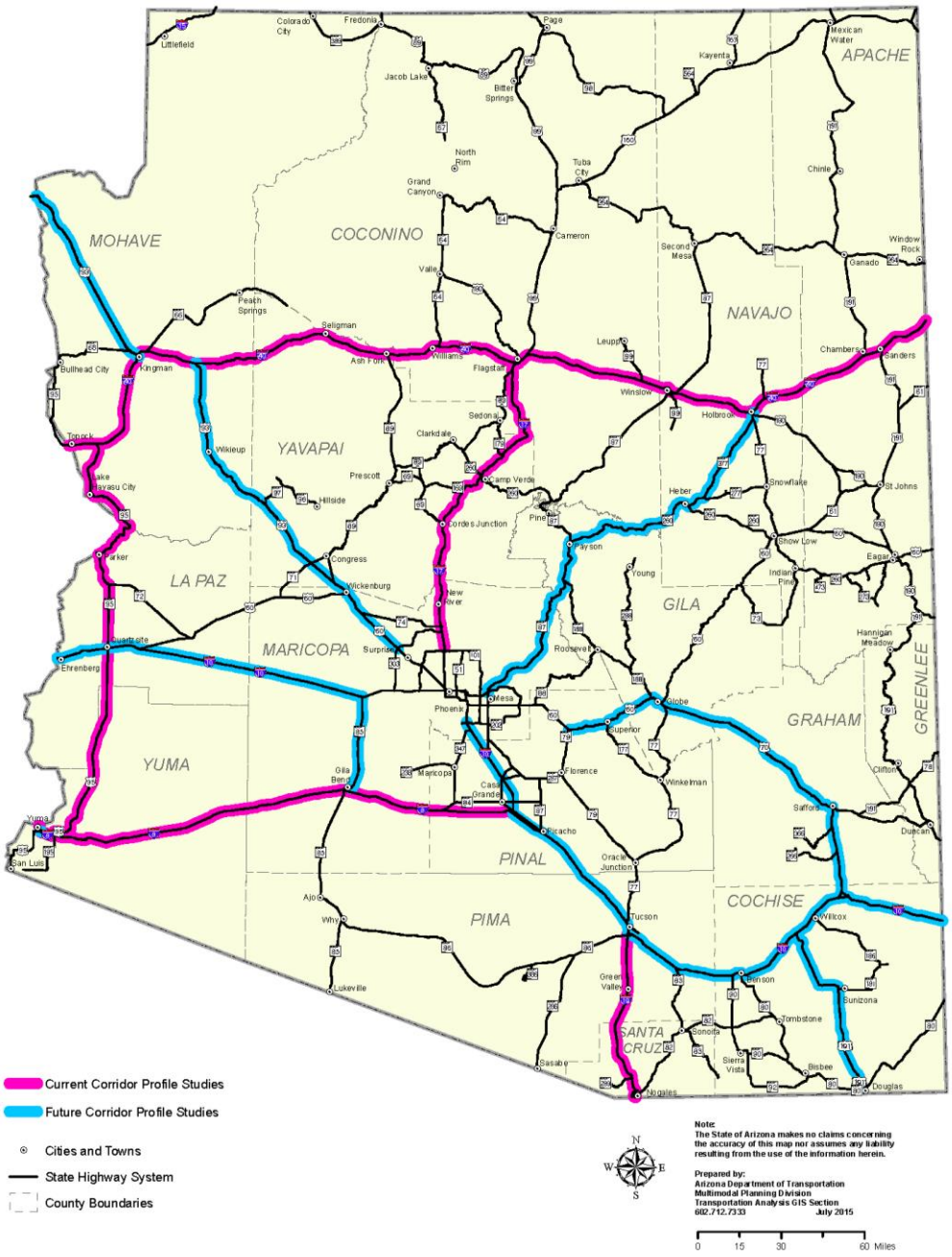
The present Working Paper, which is the output of task 5.1, is provided for discussion, feedback and input from ADOT and the TAC. It will be revised based on this input, as appropriate.

Figure 4-1: Phase 5 Process and Next Steps



Appendix A: Status of Corridor Studies

Figure 4-2: Status of Key Commerce Corridors Studies (2015)



Source: ADOT Multimodal Planning Division, 2015