



# **Roadmap to Risk Management for Transportation Planning**

## **Risk Tools Compilation and Standards Investigation as Related to Long Range Plans and Scenario Planning**

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<b>16. Abstract</b> This document provides broad guidance to help transportation agencies apply risk management methods and techniques to the planning process. Used widely in the corporate arena and increasingly by transportation agency managers, risk management provides a structured way to navigate the array of uncertainties, variabilities, and opportunities that may affect an entity's attempts to achieve its objectives. The ability to assess risk is a fundamental skill for transportation planners. Basic functions such as forecasting changes in population, employment, and travel demand depend upon constantly evolving economic, environmental, technological, and sociological factors that can change unpredictably. Risk management can help planners to identify, quantify, and communicate the types and levels of uncertainty and variability that could influence those forecasts. The roadmap is organized into five sections: a description of risk management and its relationship to the planning process; essential planning functions that are inherently uncertain or subject to variability; steps to begin integrating risk management into planning; methods for documenting uncertainty and variability in plans and programs; and guidelines and "off the shelf" tools for risk assessment.					
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## Introduction

### What is Risk Management?

*Risk* is the positive or negative effects of uncertainty or variability on agency objectives. *Risk management* encompasses the cultures, processes, and structures that are directed toward the effective management of potential opportunities and threats.<sup>1</sup> Risk management provides a structured way to navigate the array of uncertainties, variabilities, and opportunities that may affect an entity's attempts to achieve its objectives. In the corporate world, those objectives may be to earn a profit, launch a new product, or expand a line of business. Transportation agencies strive to meet objectives such as reducing crashes, enhancing mobility, sustaining assets, reducing emissions, and supporting economic development.

### Why is Risk Management Useful to Transportation Planners?

The ability to assess risk is a fundamental skill for transportation planners, whose work revolves around predicting, considering, and explaining emerging trends and future conditions that are often highly uncertain and subject to variability. Basic functions such as forecasting changes in population, employment, and travel demand depend upon constantly evolving economic, environmental, technological, and sociological factors that can change unpredictably. Risk management can help planners to identify, quantify, and communicate the types and levels of uncertainty and variability that could influence those forecasts.



*Opportunities are as important to consider as threats and hazards in a risk assessment. For example, the deployment of connected and automated vehicles could greatly improve safety and mobility, but much is unknown about the full range of their potential impacts. Risk management can help agencies to weigh both benefits and costs associated with investing in complex, rapidly evolving technologies.*

*Photo source: [Connected Vehicle Basics](#), USDOT Intelligent Transportation Systems Joint Program Office.*

### About This Roadmap

This document provides broad guidance to help transportation agencies apply risk management methods and techniques to the planning process. Rather than being an exhaustive “how-to” manual, it presents general approaches by which individual agencies and the transportation community as a whole could develop the information, tools, and resources necessary to identify and understand critical risks associated with transportation decisions. The roadmap is organized into five sections, as follows:

- A description of risk management and its relationship to the planning process.

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<sup>1</sup> Varma, S., G. Proctor. AASHTO Guide for Enterprise Risk Management. American Association of State Highway and Transportation Officials. Oct. 2016. [https://bookstore.transportation.org/Item\\_details.aspx?id=2706](https://bookstore.transportation.org/Item_details.aspx?id=2706)

- Essential planning functions that are inherently uncertain or subject to variability.
- Steps to begin integrating risk management into planning.
- Methods for documenting uncertainty and variability in plans and programs.
- Guidelines and “off the shelf” tools for risk assessment.

## Risk Management as a Transportation Agency Tool

### Enterprise Risk Management

The AASHTO *Guide for Enterprise Risk Management* describes a formal, systematic process to control uncertainty and variability associated with achieving strategic objectives by managing risks at all levels of the organization. The AASHTO guide builds from the international standard for risk management published by the International Organization for Standards, or ISO as it is known by its Swiss acronym. Both standards define risk as incorporating not only threats but also uncertainty, variability, and opportunities. This broad definition of risk applies to the planning process because by its very nature the planning process tries to forecast future events which are inherently uncertain and subject to variability.

The ISO and AASHTO definitions of risk build from the approach to risk often used in the corporate world, which acknowledges the uncertainty and variability that influence entities' attempts to achieve their objectives. In the corporate world, the objective may be to earn a profit or launch a new product. For transportation agencies, the objectives may be to reduce crashes, enhance mobility, sustain assets, reduce emissions, and complement land use patterns.

Explicit in the AASHTO guide, ISO, and corporate frameworks is the acknowledgement that risks are inevitable. As such, it is irresponsible not to acknowledge and manage them. In much of the corporate world, risk management is mandatory. To satisfy investors or regulators, large corporations are required to have high-level risk-management committees that advise executives on the uncertainties and threats to the corporation's profits, objectives, and to its shareholders. Major corporations' annual reports to stockholders include discussion of the risks and uncertainties that could affect the stockholders' investments.

Several state transportation agencies in Australia are required to have risk management committees, often with outside board members to provide objective assessments of risks to the agency's objectives. Similar to the way in which corporations inform stockholders of key risks to their investments, the Australian agencies provide stakeholders (i.e., taxpayers) with an objective assessment to be given an objective assessment of the uncertainties surrounding the agency's efforts to achieve its objectives.

### Participatory Risk Assessment Processes

Enterprise risk management is a participatory process in which risk assessments flow down and up through the agency to keep all levels of the organization aware of the interconnected risks faced by all involved. Enterprise risk management generally is “owned” by the agency's senior leadership, board, or commission, but it is an active and continuous process to manage risks from the top down and from the bottom up. For example, modeling is a routine function, but if the travel demand model is flawed, the risk of misinformed decisions or distrust of the forecasts can

escalate to an enterprise-wide concern. Or, at the enterprise level, risks to an agency's funding could translate into staff reductions that risk the effectiveness of planning activities.

The AASHTO guide describes a hierarchy of risk management processes across different levels and functions of an organization, including programs, projects, and activities. Risks can be managed by *program* owners responsible for collections of projects intended to achieve agency objectives such as safety, construction, pavement quality, or planning. *Project* risks are managed for temporary endeavors undertaken to create a unique product, service, or result. *Activity* risks apply to a coordinated set of ongoing actions that are taken to support projects or programs. In the planning process, an activity could be collecting traffic or land use data or operating the travel demand models.

## Risk Management and Performance Management

Risk management is directly correlated to performance management. If an organization faces no accountability for its performance, it risks few consequences for not achieving its objectives. As performance becomes more important and transparent, so does managing the risk to achieving it. For example, a program manager may face relatively little public scrutiny for failing to meet internal performance targets for construction schedules. But if an airline fails to land a plane safely, severe and highly public repercussions are felt across the entire corporation.

The advent of more publicly documented performance standards under MAP-21 and the FAST Act raises the risk of negative consequences for underperformance. Risk management is an essential element of setting and meeting Federally required performance targets for pavement and bridge conditions, multimodal safety, congestion, reliability, asset management.

Beyond only avoiding a penalty or a sanction, risk management can build agency credibility, and increase understanding of the planning process. For example, when setting a safety target such as achieving a fatality rate of 1 death per 100 million miles of travel, a State DOT can use risk assessment to identify, monitor, and explain an array of critical variables that influence its ability to achieve the target. If fuel prices fall below expectations, automobile travel could increase and raise the potential for crashes. Trends in hazardous behaviors such as texting while driving could continue to rise. Increases in pedestrian and bicycling activity could be accompanied by an uptick in nonmotorized crashes. Acknowledging risk factors up front in the target-setting process sets the stage for a more robust, transparent process of monitoring progress and adjusting tactics over subsequent years.

FHWA asset management regulations call for risk assessments to be included in transportation asset management plans. These assessments identify risks to achieving asset management objectives and targets and identify appropriate responses to managing those risks. The development of a 10-year transportation asset management plan depends upon complex forecasting of pavement and bridge conditions. Assumptions about future conditions are based on forecasts of investment levels, pavement and bridge performance and deterioration curves, the effectiveness of treatments, and upon the accuracy of bridge and pavement models. If any of those variables are incorrectly forecast, the future conditions of bridges and pavements can be inaccurate.

## Building Agency Capacity for Risk Management

Risk management encompasses a continuum of sophistication from mere acknowledgement of



uncertainty to the quantification of it. At a basic level of risk management, the agency would acknowledge and explain the assumptions upon which it has based its objectives and the variables that must be controlled to achieve the objective. At a more sophisticated level, the agency could conduct statistical analysis of its objective and demonstrate the confidence levels surrounding the numeric target.

Risk management methods are similar to those used by many transportation agencies for scenario planning or hazard assessments to gauge potential climatic or seismic impacts on transportation systems. All three methods attempt to evaluate rational responses to potential alternative future conditions. Risk management involves a somewhat broader view than other methods by enabling planners not only to identify and consider the impacts of potential threats and opportunities, but also to quantify the associated levels of uncertainty and variability.

Several guides and frameworks are available to transportation agencies in building their capacity to assess and manage risk. A bibliography is included at the end of this roadmap to resources such as the following:

- The AASHTO *Guide for Enterprise Risk Management* was developed specifically for transportation departments.
- National Cooperative Highway Research Program (NCHRP) Project 20-24 (105) *Launching U.S. Transportation Enterprise Risk Management Programs*, includes a 40-page summary for chief executive officers on how to start and sustain an Enterprise Risk Management (ERM) program.
- The ISO 31000 standards provide a generalized framework for managing risks.
- The Project Management Institute (PMI) produced detailed guides for managing project and program risks.
- For assessing threats to physical assets, the *Risk Analysis and Management for Critical Asset Protection* (RAMCAP) framework was developed for infrastructure owners.
- The Federal Highway Administration (FHWA) produced a five-part series of reports on applying risk management to asset management, and several tools for managing project risks.
- FHWA also has produced an extensive body of work on scenario planning and on risk assessment to improvement system resilience.

The AASHTO guide and ISO are most suited for managing risks to the entire organization. The PMI guides focus on risks at the project and program levels. RAMCAP focuses on threats to assets. The FHWA documents focus on risks and uncertainties to asset management or to the uncertain and variable scenarios faced in the planning process.

## Addressing Risk in the Transportation Planning Process

The planning process is fraught with risks in the form of uncertainty, variability, threats, and opportunities. Typical planning activities that involve uncertainty and variability include the development of forecasts and analyses about major influences on transportation supply and demand such as the following:

- Traffic volumes, mode split, land use, population growth, and economic activity;

- Threats such as extreme weather events or major economic downturns; and
- Trends and disruptions that could pose both threats and opportunities such as the market growth of connected and automated vehicles (CAV), shared mobility, alternative fueled vehicles, and increased urbanization.

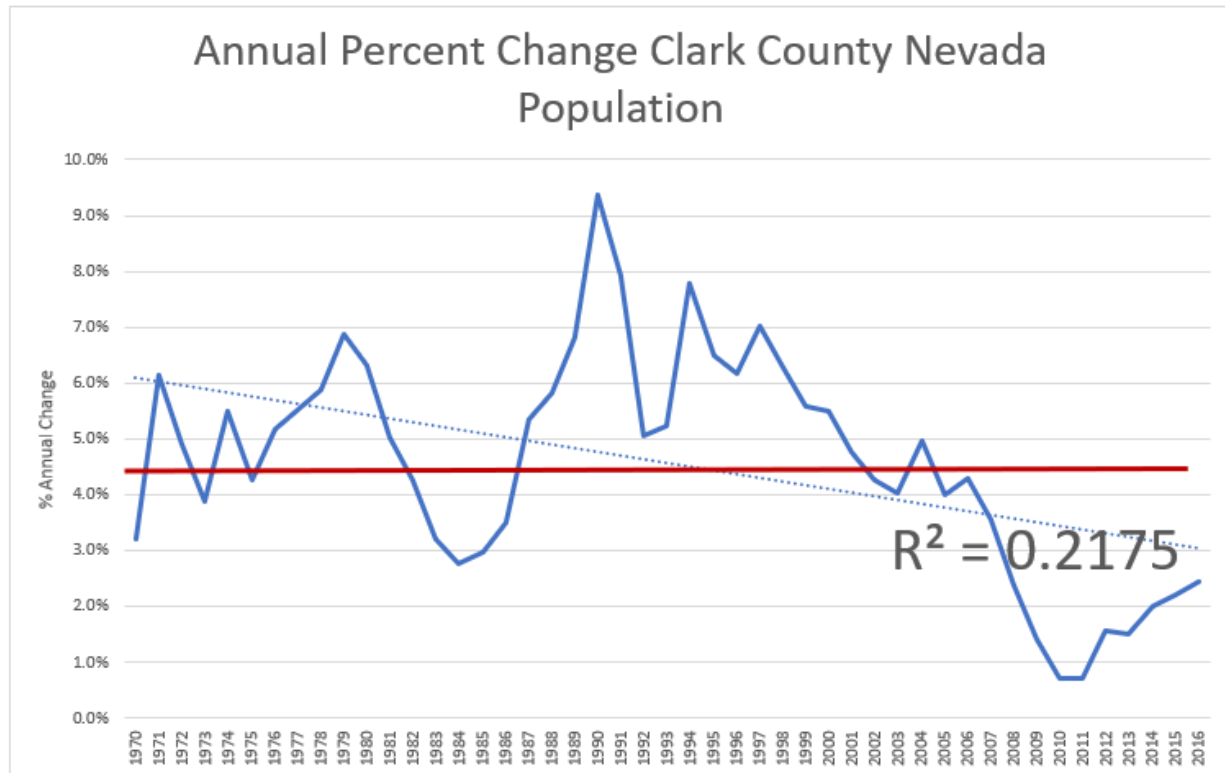
FHWA has produced many resources on resilience in the planning process with a vulnerability assessment framework, pilots, and development of a guidebook on incorporating resilience in the transportation planning process. Addressing climatic risks and other threats are an obviously beneficial form of risk management that can aid the planning process. Such risk assessments identify possible threats that can impede the objectives of a regional Metropolitan Transportation Plan (MTP) or a Statewide Long Range Transportation plan (SLRTP). Perhaps even more important, risk and vulnerability assessments can identify mitigation steps that could reduce possible impacts.

Although risk and resilience planning are one form of risk management, enterprise risk management could incorporate many other areas of uncertainty and variability in the planning process. Take, for example, an MPO that wants to adopt an enterprise risk management approach to developing its MTP. In addition to assessing climatic or seismic threats, it could identify the amount and type of uncertainty that underlies key assumptions such as for population growth by activities such as the following:

- Documenting the amount of variability in estimates and acknowledging the upper and lower limit of credible growth assumptions and how they vary when extrapolated over 20 years
- Discussing the uncontrollable external factors that could affect planning assumptions such as the effect of international events on fuel prices
- Explaining the variability surrounding mode split assumptions such as the effect of on-demand ride services, ride sharing, declining vehicle ownership, and land use patterns.

Figure 1 illustrates the degree of variability surrounding one key assumption, the annual rate of population growth. The chart illustrates the annual rate of change in population growth (not the absolute growth) between 1970 and 2016 for Clark County, Nevada, the area around Las Vegas. While the overall population grew steadily throughout this period, the rate of growth varied a great deal from year to year. The highest rate of growth was 9.36% from 1989-90, followed by a 7.92% growth rate the following year. In contrast, the rate of growth in 2011 was less than one percent.

Figure 1 Rate of population change in Clark County Nevada 1970-2016.



Forecasting often involves extrapolating from past trends. However, forecasting from such disparate past growth rates can be problematic. As seen in Figure 1, the thick horizontal line indicates an average rate of growth of 4.6 percent for the entire period. However, the average rate is not typical for any given year. Growth rates spiked upward frequently before 1995, dropped sharply in the early 2000s, and slowly rose after 2011. The R-squared value of .2175 shows there was little correlation year to year in the growth rate over the entire time horizon.

The lack of correlation in growth rates across the years indicates future forecasts based upon past trends should account for continued variability, rather than simply extrapolating the average growth rate. Will growth resume to past levels? Has the growth rate hit an inflection point? To consider these questions, planners must consider many factors. On the one hand, the casino industry responsible for huge influxes of residents and jobs in Las Vegas has been diluted by the introduction of legal gambling in other states. On the other hand, electric vehicle manufacturer Tesla chose nearby Sparks, Nevada, for a massive battery manufacturing site that could attract additional investments.

For planners facing such variability, risk management offers an option. Using a risk management approach, planners could take steps such as the following:

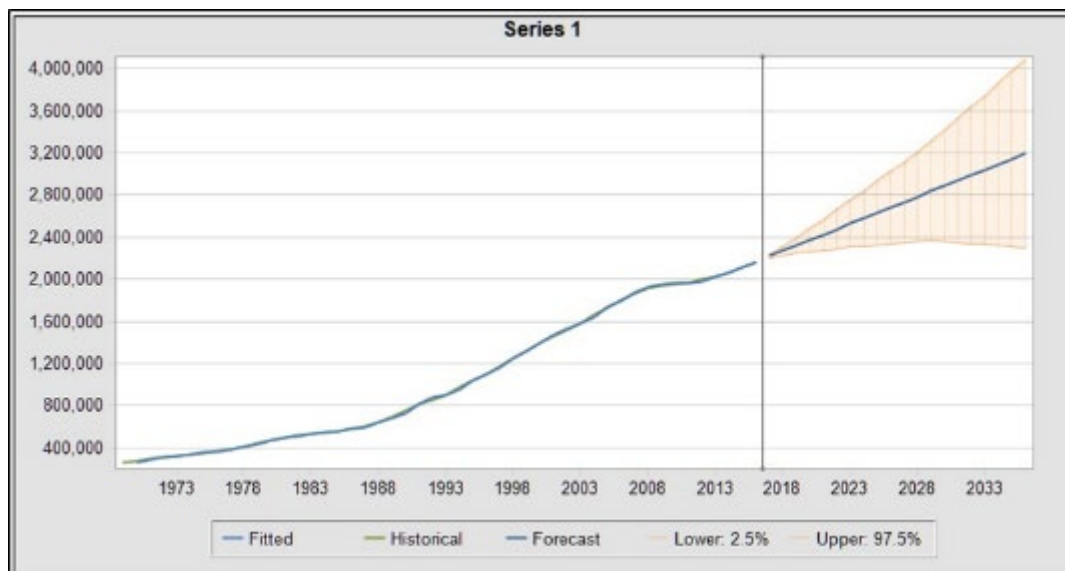
- They could organize panels of experts to identify the factors that could influence the growth rate and acknowledge that those factors could cause the agency's population forecast to vary.

- They could assess planning scenarios based upon low, medium, or high growth assumptions and illustrate how the different scenarios could result in very different outcomes for the region.
- It could conduct more complex analysis such as Monte Carlo simulation that allows increased quantification of the range of possible population growth impacts.
- The agency could identify and track leading indicators such as building permits, to anticipate and respond nimbly to fluctuations in population growth.

Figure 2 illustrates another way in which risk and uncertainty can be illustrated. The absolute population of Clark County, Nevada was plotted from 1970 to 2016. Then an off-the-shelf statistical tool (Crystal Ball, a privately vended add-on to Microsoft Excel) was used to generate 100 scenarios of growth for the next 20 years based upon the growth rates of the past. The tool randomly selects future growth rates based upon past growth rates. The line extended to 2036 illustrates a simple extrapolation of past average annual rates into the future.

The results of the analysis show that growth in 2036 could be as low as 2.4 million or as high as 3.9 million. Depending upon which past trends are assumed to carry into the future, the population could grow as little as 13 percent overall or it could double. The high and low forecasts on the upper and lower limits of the “cone” illustrate how high or how low the population could be. The variability arises from the random nature of selecting low-growth past years and assuming future growth will resemble the past years of slower growth. The higher estimate comes from random selection of higher growth based upon the higher growth rate of some past years.

Figure 2 A randomly generated simulation of possible future population.



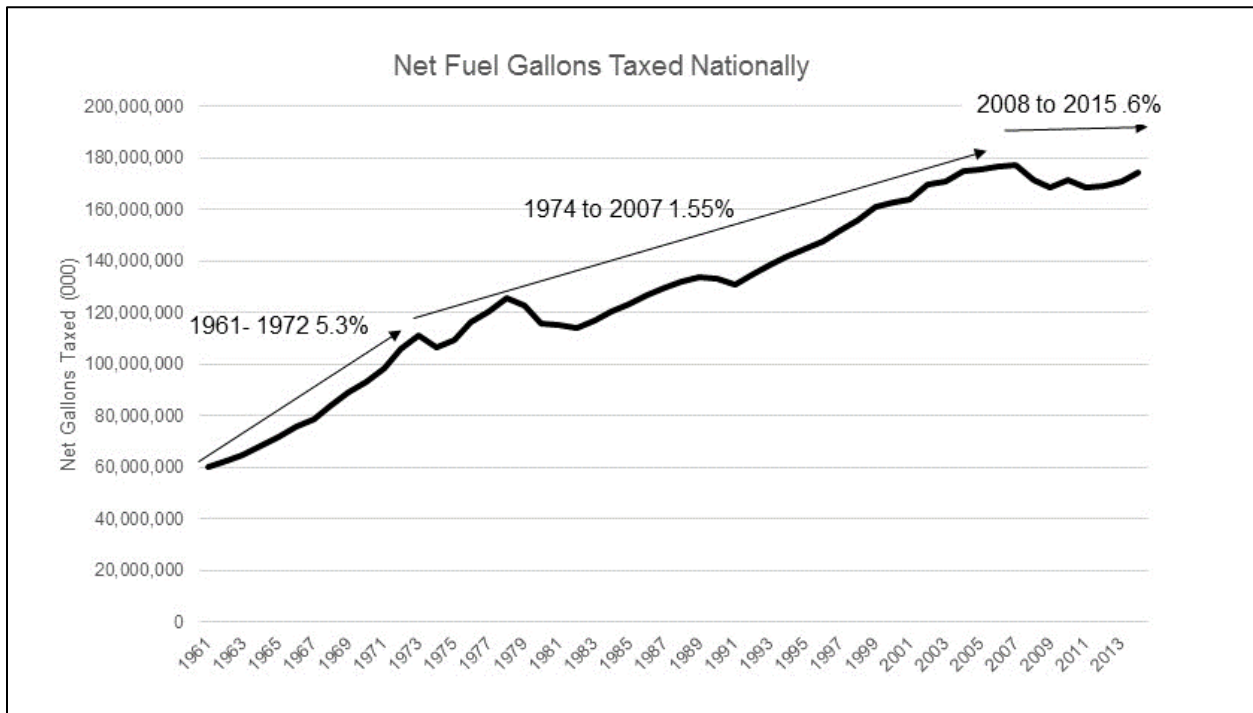
This example illustrates that risk assessment does not reduce uncertainty in and of itself. However, risk management allows an improved description of the uncertainty and its possible impacts, which in turn supports more informed discussions of possible future scenarios. For instance, the implications of different future population forecasts could be interpreted in several

ways depending on the context and priorities of the region. A possible spike in population could be viewed as an opportunity to a region that has experienced economic decline, so the conversation around the risk of growth could focus on making strategic transportation investments that would help to encourage desired new development. Alternatively, a community that has been struggling to improve infrastructure fast enough to serve a rapidly growing population may see a potential spike as a threat, and could use the data to help inform strategies for managing possible exponential impacts to congested networks. In either case, the risk analysis does not answer the question of which scenario is most likely, but can spur decisions to better prepare the region for uncertainty. Possible steps that either agency could take to further prepare for potential changes in future conditions include:

- Improve travel demand models to better understand the variable nature of growth on travel behaviors;
- If growth seems to be accelerating, prioritize capacity expansion and system optimization projects and services in the metropolitan or statewide Transportation Improvement Program (TIP or STIP);
- If growth continues to slow, focus more resources on system operations and maintenance and consider opportunities to optimize the effects of reduced travel demand;
- Use the alternative growth forecasts to support broader community planning discussion about guiding efficient, flexible land development patterns such as compact, transit-friendly communities that can support more growth within the existing networks.

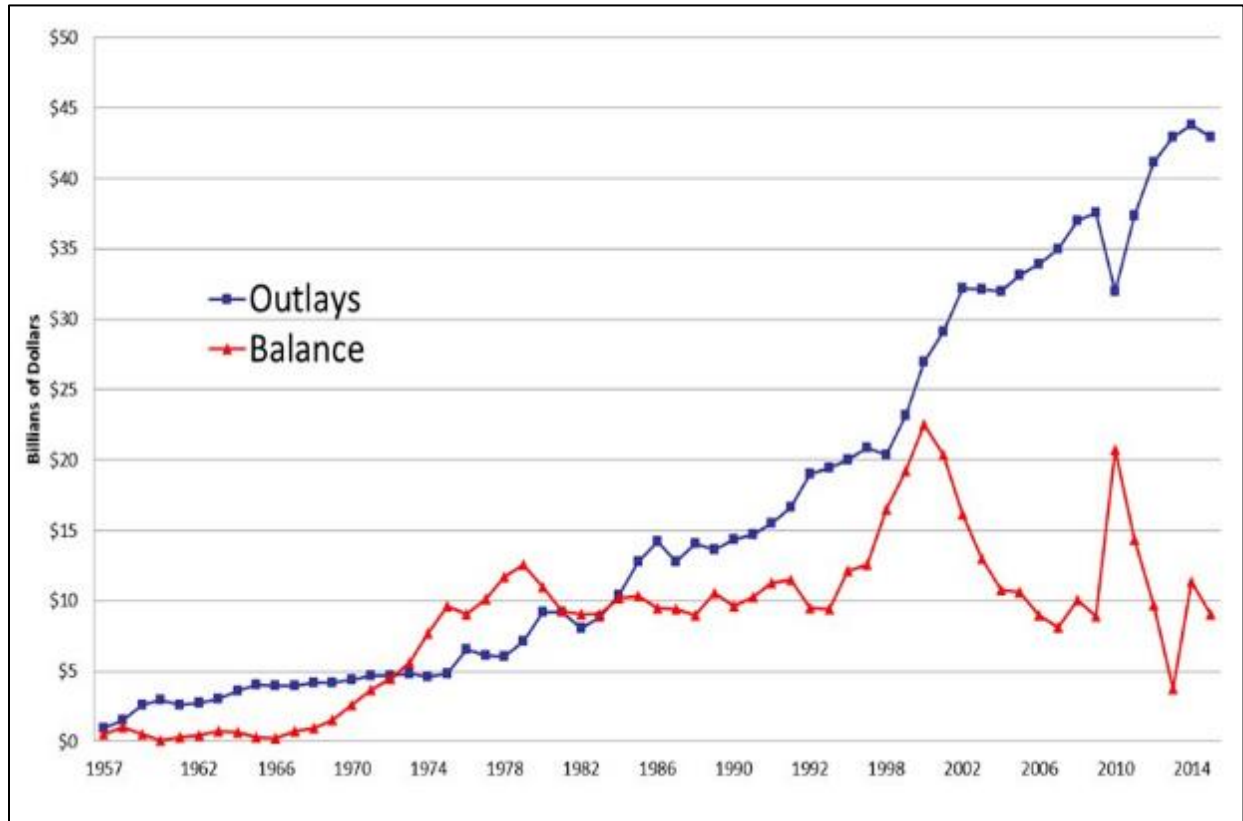
Another common planning step is to forecast available revenue. As seen in Figure 3, growth in Federal-aid revenue has changed greatly since the 1960s. From 1961 to 1972, annual gallons of fuel taxed rose 5.3%. That slowed to 1.55% annually from 1994-2007. It slowed further to less than one percent annually from 2008 to 2015.

Figure 3 Changes in net gallons of fuel taxed nationally.



Those trends of slowing revenue results in the trends shown in Figure 4, which tracks the growth in Highway Trust Fund receipts and outlays. Throughout the second half of the 20<sup>th</sup> century, receipts and outlays correlated closely before diverging sharply after 1998. The difference between receipts and outlays has been covered since then by periodic Congressional appropriations from other sources to highway and transit purposes. For planners who are trying to predict future Federal-aid resources for the next 20 years this presents a risk. Enriching the revenue forecast with information about critical risks does not reduce the uncertainty, but it helps decisionmakers to understand the tentative nature of the forecast, and to appreciate the need to frequently review and update planning assumptions.

Figure 4 Highway trust fund receipts and transportation outlays.



## Uncertainty Versus Variability

These examples help to illustrate the difference between uncertainty and variability. *Uncertain* risks are not easily quantified, while *variable* risks can be measured. For example, a forecast of the amounts of funding that Congress will appropriate for Federal-aid assistance over the next 20 years could be based on past rates of change in appropriations, but is subject to uncertain forces that are hard to quantify, such as political priorities. An example of variability, meanwhile, is the variation or “noise” in the charts of Clark County population growth rates. There are statistically valid methods to forecast future population based on past growth rates despite the variability, such as applying the deviation from the mean (a measure in the amount of variability) when extrapolating past rates onto future years. The variability in population growth rates lends itself to quantification, while the uncertainty of shifts in political power does not.

## Scenario Planning as a Tool for Risk Management

Transportation agencies that conduct scenario planning exercises are practicing a form of risk assessment. Scenario planning and risk management processes can help citizens and stakeholders in the public and private sector to better understand how a variety of external forces and policy drivers could impact transportation networks in a state, community, region, or study area. Risk management as a whole process tends to dive more deeply than scenario planning into tactical and operational decisionmaking, but the two methods have many characteristics in common.



FHWA describes scenario planning as follows in its 2016 guidebook *Supporting Performance-Based Planning and Programming Through Scenario Planning*:

Scenarios are stories about the future that planners develop to consider and prepare for possible challenges and opportunities. Scenario planning helps transportation agencies work with stakeholders and the public to establish a vision and implement a strategic plan for success in uncertain times. Well-crafted scenarios inspire critical thinking about issues and events that could significantly affect a region's economy, environment, and quality of life. provides a framework for developing a shared vision for the future by analyzing various forces (e.g., health, transportation, livability, economic, environmental, land use), that affect communities. The technique was originally used by private industry to anticipate future business conditions and to better manage risk.<sup>2</sup>

The 2016 guide defines different types of scenario planning as predictive, normative, and exploratory. Predictive scenario planning focuses on variations of probable trends that are considered fairly certain, such as ranges of population and job growth in a region where economic change is expected to be slow. Normative scenario planning involves depicting narratives of widely different future conditions in order to build consensus on a preferred outcome. Exploratory scenarios are used to examine the resilience of current conditions, plans, or goals to changes that are less predictable, such as global economic markets or environmental shifts.

A hallmark of scenario planning among transportation agencies since that late 20<sup>th</sup> century has been identifying land use patterns as variables rather than as static inputs to travel forecasts.<sup>3</sup> The variability in market forces, policy decisions, and environmental conditions that drive land development creates risk around the population and employment predictions that influence key outcomes such as travel demand, mode splits, and trip types. Scenario planning around land use variables has often been used to support visioning processes, which involve gathering input from diverse stakeholders to set priorities and identify policy goals for land use, economic development, and environmental preservation. This type of normative scenario planning is used to clarify community values (“norms”) and apply them systematically to evaluate and identify goals and objectives that support elements of a preferred future scenario.<sup>4</sup>

Over the first decades of the 21<sup>st</sup> century, transportation agencies have applied scenario planning to support not only normative planning processes, but also as an exploratory tool for considering implications of “rapid advancements in technology, changing climate conditions, evolving

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<sup>2</sup> Supporting Performance Based Planning and Programming Through Scenario Planning. FHWA. 2016. [https://www.fhwa.dot.gov/planning/scenario\\_and\\_visualization/scenario\\_planning/scenario\\_planning\\_guidebook/index.cfm](https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/scenario_planning_guidebook/index.cfm)

<sup>3</sup> FHWA Scenario Planning Guidebook. 2011. [https://www.fhwa.dot.gov/planning/scenario\\_and\\_visualization/scenario\\_planning/scenario\\_planning\\_guidebook\\_2011/](https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/scenario_planning_guidebook_2011/)

<sup>4</sup> Supporting Performance Based Planning and Programming Through Scenario Planning. FHWA. 2016. [https://www.fhwa.dot.gov/planning/scenario\\_and\\_visualization/scenario\\_planning/scenario\\_planning\\_guidebook/index.cfm](https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/scenario_planning_guidebook/index.cfm)



market preferences, major economic restructuring, and other transformational forces”<sup>5</sup> on transportation system performance. Exploratory scenario planning can be a useful tool for risk management, as it supports discussions around tactics that decisionmakers and agencies can use to avoid or mitigate potential challenges and to optimizing potential benefits posed by external forces.

Risk management and scenario planning techniques can be used to evaluate the uncertainty or variability surrounding planning assumptions, and identify a broad array of issues that could impede, or enhance, achievement of planning objectives. Scenario planning involves building and considering the implications of overarching narratives or sets of assumptions that describe plausible trajectories of change. Risk management can be used to illustrate the effects of different assumptions while also attempting to measure the uncertainty around each assumption.

Agencies use scenario planning to ask questions such as “What might the future look like given the continuation of current policies, programs, and development?” “What might the future look like given different environmental or technological conditions?” Scenario planning may or may not incorporate risk management, which focuses more specifically on identifying areas of uncertainty and quantifying levels of variability that could impact an agency’s ability to reach its objectives in positive or negative ways. A risk management process, supported by exploratory scenario planning and/ or other tools, enables stakeholders to answer questions about a proposed course of action, such as the following:

- What could go wrong?
- How might our data or assumptions be incorrect?
- What is the magnitude of the uncertainty or variability surrounding our assumptions?
- What operational or organizational weaknesses do we have that could undercut our objectives?
- What external factors create threats, uncertainty, or variability that are beyond our control?
- What opportunities might arise, where potential benefits outweigh potential costs?
- What threats can we mitigate and what opportunities should we seize?
- What contingencies should we have ready to execute if threats or opportunities arise?

Although the three types of scenario planning processes are not commonly discussed in risk management literature, they represent variations of risk analysis. The next section of this report describes deterministic and stochastic analysis techniques, which include elements of predictive, normative, and exploratory scenario planning.

## Deterministic and Stochastic Analyses

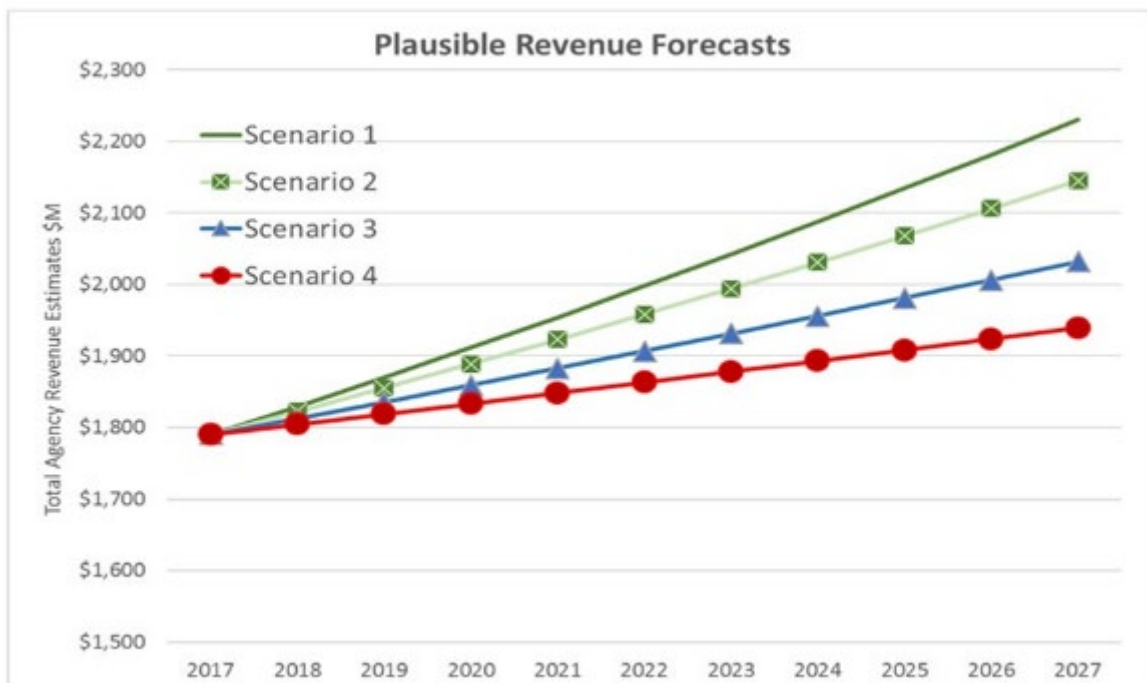
Predictive scenario planning has similarities to a *deterministic* risk analysis. In a deterministic analysis, single point trend lines may be used to illustrate the effects of different rates of change. Figure 5 illustrates an example of a deterministic analysis in which four different average annual

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<sup>5</sup> Next Generation Scenario Planning: a Transportation Practitioner's Guide. FHWA. 2017. [https://www.fhwa.dot.gov/planning/scenario\\_and\\_visualization/scenario\\_planning/publications/next\\_gen/chapter01.cfm#toc492644122](https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/publications/next_gen/chapter01.cfm#toc492644122)

growth rates are applied to a revenue forecast.

Figure 5 Deterministic growth rate scenarios.



Often, trends don't occur in steady linear patterns as shown in Figure 5. They often resemble Figure 1, the chart of historic population growth rates in Clark County, Nevada, which depicts frequent year-to-year variability, or "noise," when the data significantly deviated from the trend line average (mean) for the period as a whole. A *stochastic* analysis is a way to illustrate more uncertain future outcomes. Stochastic refers to randomness. Instead of extending the results of a steady growth rate, a stochastic analysis can incorporate the variability that could occur year-to-year or over a given period of time.

Figure 6 illustrates a stochastic forecast of the Clark County population using an off-the-shelf Monte Carlo simulation tool. Named after the famous gambling center in Monaco, a Monte Carlo simulation generates thousands or even millions of scenarios to depict the universe of possible outcomes given combinations of random variations within any forecast. Since the annual rates of population growth in Las Vegas have varied over the past 50 years from less than one percent to more than nine percent, it is reasonable to assume that future rates could vary widely from year to year. A Monte Carlo simulation, as shown in Figure 6, generates alternative scenarios that combine every possible variation in growth rates to every forecasted year.

Figure 6 A stochastic forecast of population.

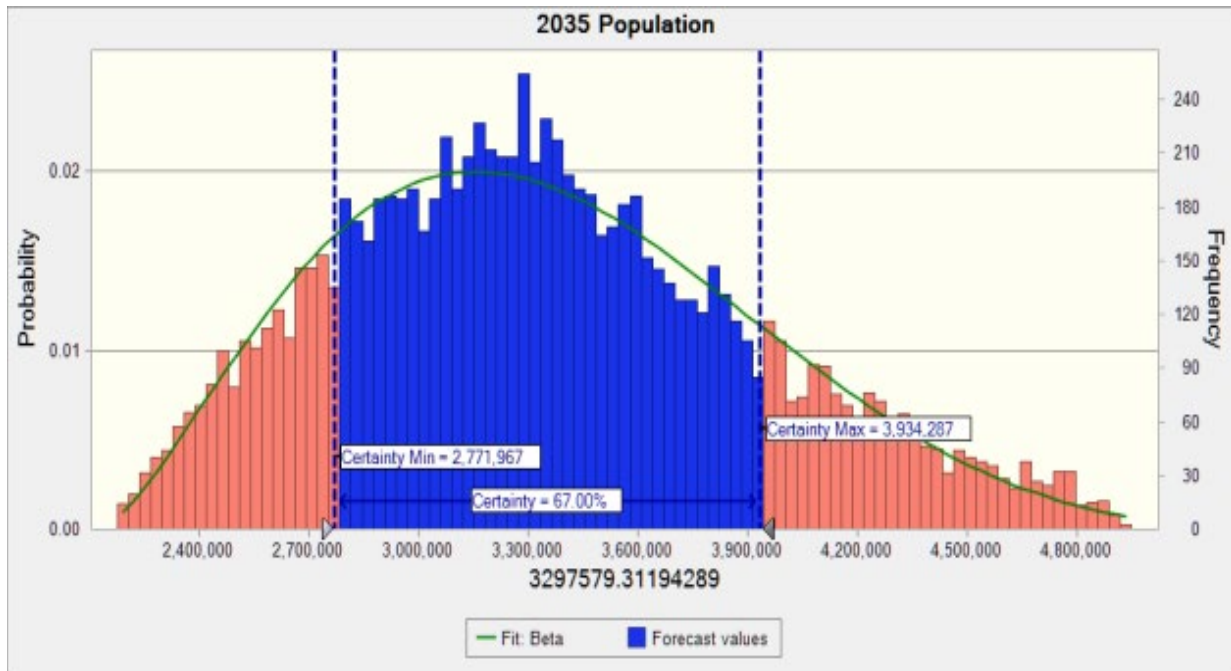


Figure 6 displays a Monte Carlo simulation of 100,000 scenarios for the Clark County, Nevada, population forecast from base year 2015 to horizon year 2035. Each scenario calculated a total population for the year 2035 by summing a unique combination of annual growth rates for each year in the 20-year period. The vertical bars indicate the number of times each of the possible year 2035 sum totals was reached during the scenario generation process. According to the simulation, the minimum year 2035 population is 2.169 million and the maximum is 5.013 million. The mean forecast is 3.347 million, and the median is 3.30 million. The forecast within one standard deviation of that mean is indicated by the two vertical dotted lines. The analysis forecasts a 67% probability that the year 2035 population will be in the range of 2.77 million to 3.959 million.

In a risk-based stochastic analysis, planners can illustrate how variability creates uncertainty surrounding future forecasts. The level of uncertainty grows with the range of possible outcomes. Figure 6 indicates a 67% likelihood that the total number of people living in Clark County in the year 2035 will be somewhere between 2.77 million and 3.959 million, which is a very wide range. Monte Carlo simulations do not nail down an answer to the question “What will our future population be?” Instead they address the question “How much variation could we anticipate, given an array of possible scenarios?”

In some fields such as investing, variability and risk are synonymous. If a pension fund manager needs to generate a certain rate of return in order to meet payment obligations, s/he will invest in a predictable portfolio. For this type of investment fund, variability from the desired rate of return is a major risk. A similar principle applies to the revenue forecast for a State DOT or Metropolitan Planning Organization (MPO). A significant change in the estimates of committed or available funds could have a major effect upon the agency’s ability to implement its program of projects and to achieve its targets.

Stochastic risk-based analyses illustrate that almost all forecasts are based on specific

assumptions and are subject to significant variability. By viewing the results of such an analysis, planners and stakeholders may better appreciate that all plans are subject to change and require constant monitoring. Perhaps more importantly, conducting a stochastic analysis within a full risk management process leads to a carefully structured identification of risk mitigation strategies. These strategies can help the stakeholders reduce the impacts of the negative influences on their plans and to sense and capture the positive ones.

The “management” in risk management refers to the intent to address, control, mitigate, or manage the issues that create the variability. Later in this document, the development of “risk registers” to identify risk management strategies will be discussed.

## Managing Risks for MPOs and DOTs

The processes for managing risks is similar for state DOTs and regional MPOs. Both are concerned with planning factors such as the accuracy of models, the comprehensiveness of data, and the tracking of internal and external threats. However, the span of control is different for DOTs and MPOs, and thus generates different threats and different opportunities. For example, DOTs are responsible for balancing a broad array of statewide urban and rural needs, while each MPO focuses upon a single region. In addition, MPOs (with some exceptions) tend to focus exclusively on planning and programming future transportation investments, while DOTs are responsible not only for planning and funding decisions, but also for implementing project design and delivery for the assets they own and operate. As implementing agencies, DOTs may be concerned about risks to their project delivery or system maintenance efforts. If a DOT does not deliver the projects called for in a transportation plan or program, it cannot achieve the plan or program objectives. If a DOT does not effectively execute transportation system management and operations (TSMO) strategies, it will not achieve its objectives to optimize performance of the transportation network.

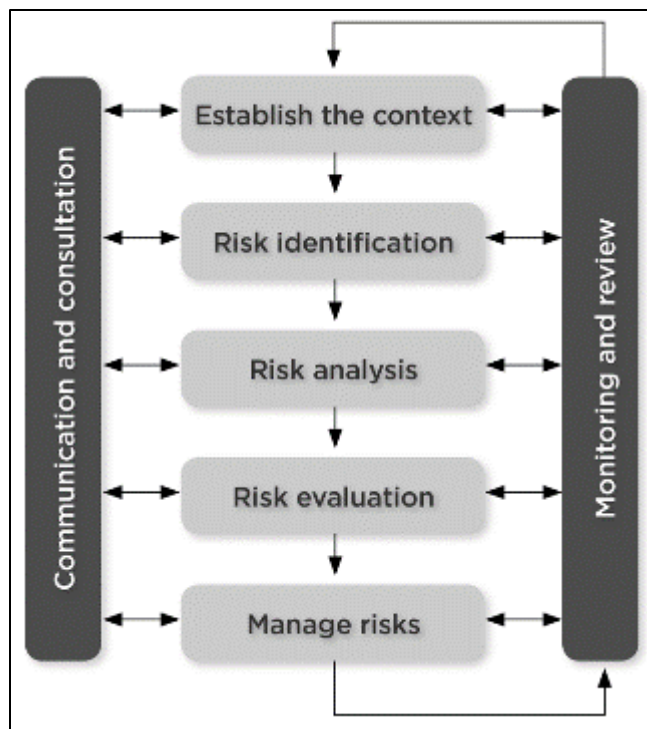
## Managing Versus Measuring Risks

The use of tools such as deterministic or stochastic forecasting assist with the measuring of risk and variability. However, risk management is about trying to control risks as well as measuring and predicting them. The AASHTO risk guide and other documents note that risk measurement can become complicated if an agency wants to rely on statistical models. Risk measurement and risk management do not have to be complex exercises, however. They can be as simple as asking, “What could go wrong? And what should we do about it.” As pointed out by the AASHTO risk guide, the greatest benefit from risk management comes from asking informed stakeholders their opinions about the uncertainty and variability surrounding objectives and then acting to control that uncertainty and variability.

Much of the risk management process complements the collaborative transportation planning process and the scenario planning process. All three – risk management, transportation planning, and scenario planning – rely on collaboration among stakeholders to share their vision of what a region wants to accomplish and what could impede that accomplishment. Related to this point, the next section discusses establishing a collaborative risk management program.

## Establishing a Risk Management Process for Planning

Figure 7 The ISO risk management process.



Two documents provide specific guidance on developing an Enterprise Risk Management (ERM) program for transportation agencies: Chapter 2 of the AASHTO Guide includes detailed guidance for establishing an enterprise risk management program, and NCHRP Project 20-24 (105) *Launching U.S. Transportation Enterprise Risk Management Programs*, includes a 40-page summary for chief executive officers on how to start and sustain an ERM program. Both documents reference the internationally recognized ISO risk management process illustrated in Figure 7.

The ISO risk management process, upon which the AASHTO and NCHRP guidance is based, bears many similarities to common performance management frameworks used by transportation agencies, such as performance-based planning, scenario planning, and the “plan, do, check, act” cycle. The risks to be managed in virtually any risk management approach are those that could impede performance. Hence, a sound risk management process resembles a performance-management process.

As shown in Figure 7, the risk management process involves five core steps, each of which is informed by continuous communication and consultation activities, and by iterative monitoring and review activities. Communication and consultation involve ongoing interaction with internal and external stakeholders to identify if internal or external events are raising or lowering the organization’s risk profile. Monitoring and review for risk management can be embedded into the agency’s routine performance based planning and programming process to ensure that risk-mitigation steps are occurring with the intended results.

### Step 1: Establish the Context

The risk management process starts by establishing the context. This involves identifying the objectives to be accomplished and the environment around the organization attempting to achieve them. The objectives could encompass broad initiatives such as the development of an MTP or SLRTP or the advancement of projects through the TIP or STIP. They could also be established for discrete activities that support the planning process, such as implementing a public involvement plan or developing a statewide pedestrian and bicycle data inventory. To support later steps in the risk management process, the context-setting process should also

include a description of the agency’s role and capacity to conduct the initiative or activity, as well that of relevant partners and stakeholders.

## Step 2: Identify Risks

Once the context is understood, the agency works with stakeholders to identify the risks that could affect its ability to achieve stated objectives. These risks could encompass threats and opportunities. This initial risk identification process can be done by gathering ideas through activities such as brainstorming sessions, surveys, focus group discussions, and interviews. The list will be more robust if the agency casts a fairly wide net during this step by involving staff and officials from various levels within the organization as well as partners and external stakeholders.

## Step 3: Analyze Risks

Once the list of risks is established, the agency assesses each risk in terms of likelihood, impact, uncertainty and variability. Agencies can document this analysis using a matrix like the one in Figure 8. It is a simple matrix in which participants are asked to assess how likely a risk could be and how great its impact could be. Some risks could have high impact but low likelihood. Others could have moderate impact and but a high likelihood. Some of the stakeholders involved in Step 2 can help to flesh out the matrix developed in Step 3.

Figure 8 A risk matrix.

Risk Matrix with Impact and Likelihood Definitions		Likelihood					
			Rare	Unlikely	Possible	Likely	Very Likely
		For Recurring Events	Less than once in 5 years	Once in 5 years	Once in 3 years	Once per year	More than once per year
For Single Events Probability over 5 years	< 10% (Less than 1 in 10)	10% to 25% (Avg. of about 1 in 6)	25% to 40% (Avg. of about 1 in 3)	40% to 60% (Avg. of about 1 in 2)	> 60% (Avg. of about 4 in 5)		
Impact	Very Significant	Multiple deaths & injuries, substantial public and private cost, foils agency objectives, and the agency fails in its basic mission.	Medium	Medium	High	Very High	Catastrophic
	Major	Multiple injuries, or a single death, substantial public or private cost and/or foils agency objectives.	Low	Medium	High	High	Very High
	Moderate	Injury, property damage, increased agency cost and/or impedes agency objectives.	Low	Medium	Medium	High	High
	Minor	Moderate agency cost and impact to agency objectives.	Low	Low	Low	Medium	Medium
	Insignificant	Impact low and manageable with normal agency practices.	Low	Low	Low	Low	Medium



## Step 4: Evaluate Risks

During the evaluation step, the agency considers the level to which it can influence the magnitude and likelihood of each risk. Risks that are directly tied to the agency's decisions, operations, and productivity, such as meeting internal performance targets, could be "owned" by the agency. In these cases, the evaluation would determine that the agency can influence the risk and should take steps to do so. Other risks could be significant but hinge upon key factors that are beyond an agency's control. In those cases, the agency could monitor the indicators associated with the risk, and coordinate risk management efforts (through Step 5) with partner agencies that have more influence. For example, an MPO and local transit agency could collaborate with a local economic development authority to coordinate investments and monitor progress toward desired station area development along a new Bus Rapid Transit (BRT) line.

## Step 5: Manage Risks

To complete the process, the agency develops and implements a strategic plan for risk management. The plan identifies the actions the agency will take in response to each risk, and assigns responsibility for each action to a specific person, work unit, or body. The management of the risk is assigned to the appropriate level either at the enterprise, program, project, or activity level. Corporate or enterprise-wide risks may be "owned" by the agency's board or chief executive. Program risks would be assigned to managers of divisions such as planning or programming. Activity risks would be the purview of activity owners, such as construction engineers.

Some risk management strategies can be shared. For example, a common risk for achieving safety targets is the problem of inaccurate or incomplete crash data created by multiple local police departments. Inaccurate crash data can impede development of proper countermeasures. To mitigate that risk, the chief executives could communicate and coordinate with the mayors and police chiefs while the safety program manager coordinates with the staff-level police department record keepers.

Assigning authority to each risk management strategy reinforces agency performance management processes. As process owners work to ensure the achievement of the objectives that have been assigned to them, they also track and manage the risks to those objectives. Then, as the agency reports through progress meetings and dashboards its progress toward achieving its objectives, it also can advise stakeholders if the risks to those objectives are influencing the agency's performance.

A *risk register* is a simple table used by many agencies that practice risk management. Shown in Figure 9 it includes "if/then" risk statements such as "If X risk occurs, then the impact will be Y." The risk register provides a snapshot of the likelihood and impact of the risk, and what steps, if any, are being taken to manage the risk. Figure 9 illustrates some risks and responses to an asset management objective. Risk registers often record many risks associated with each objective established by the agency, program manager, or project manager.

Figure 9 A sample risk register for the objective of maintaining assets in a state of good repair.

Objective	Maintain Assets in a State of Good Repair				Response
Risk Event	Risk Effect	Likelihood	Impact	L X I	
If funding decreases..	...then we may not be able to sustain its assets in a state of good repair.	Very Likely	Major	High	We will monitor Congressional actions on Federal-aid appropriations and remain in contact with the Congressional delegation to emphasize the importance of Federal-aid to the our program.
If Program selection priorities do not emphasize sustaining asset conditions...	..then we may not be able to invest appropriately to sustain a state of good repair.	Likely	Moderate	High	We will urge legislators to continue giving high priority to recommendations for bridge and pavement investments to ensure that programs to preserve asset conditions remain a top priority.
If Population growth and land uses increase creating high demand for congestion-relief projects...	..then we may not be able to invest enough to sustain a state of good repair.	Likely	Moderate	High	We will remain active in the metropolitan and statewide planning processes to monitor population and traffic growth and advise the Board if the demand for new capacity projects exceeds current amounts budgeted for them.

## Integrating Risk Management and Scenario Planning

As defined by FHWA, “scenario planning is an analytical tool that can help transportation professionals prepare for what lies ahead. Scenario planning provides a framework for developing a shared vision for the future by analyzing various forces (e.g., health, transportation, economic, environmental, land use, etc.) that affect growth. Scenario planning, which can be done at the statewide level or for metropolitan regions, tests various future alternatives that meet state and community needs. A defining characteristic of successful public sector scenario planning is that it actively involves the public, the business community, and elected officials on a broad scale, educating them about growth trends and trade-offs, and incorporating their values and feedback into future plans.”<sup>6</sup>

A comparison of FHWA’s scenario-planning steps (Figure 10) with the ISO-based risk management process (Figure 7) reveals many similarities. Both proceed with logical “plan, do, act, check” cycles, and incorporate stakeholders’ assessments of issues, opportunities, and strategies associated with achieving agency objectives.

Steps 1, 2, and 3 of the scenario planning process include scoping the effort, engaging partners, establishing baseline information, and identifying goals. These steps are analogous to the initial context-setting step of the risk management process. Step four in the scenario planning process involves creating baseline and alternative scenarios, akin to risk management process steps 2 and 3, identifying and analyzing risks. Step 5 of the scenario planning process is focused on assessing scenario impacts, influences, and effects, which is very similar to the risk management process step 4 (evaluating risks). The final scenario planning step 6 involves crafting the vision, strategic actions and performance measures which can help the region achieve its vision. This step also is analogous to the risk management step 5, to identify and assign risk mitigation strategies.

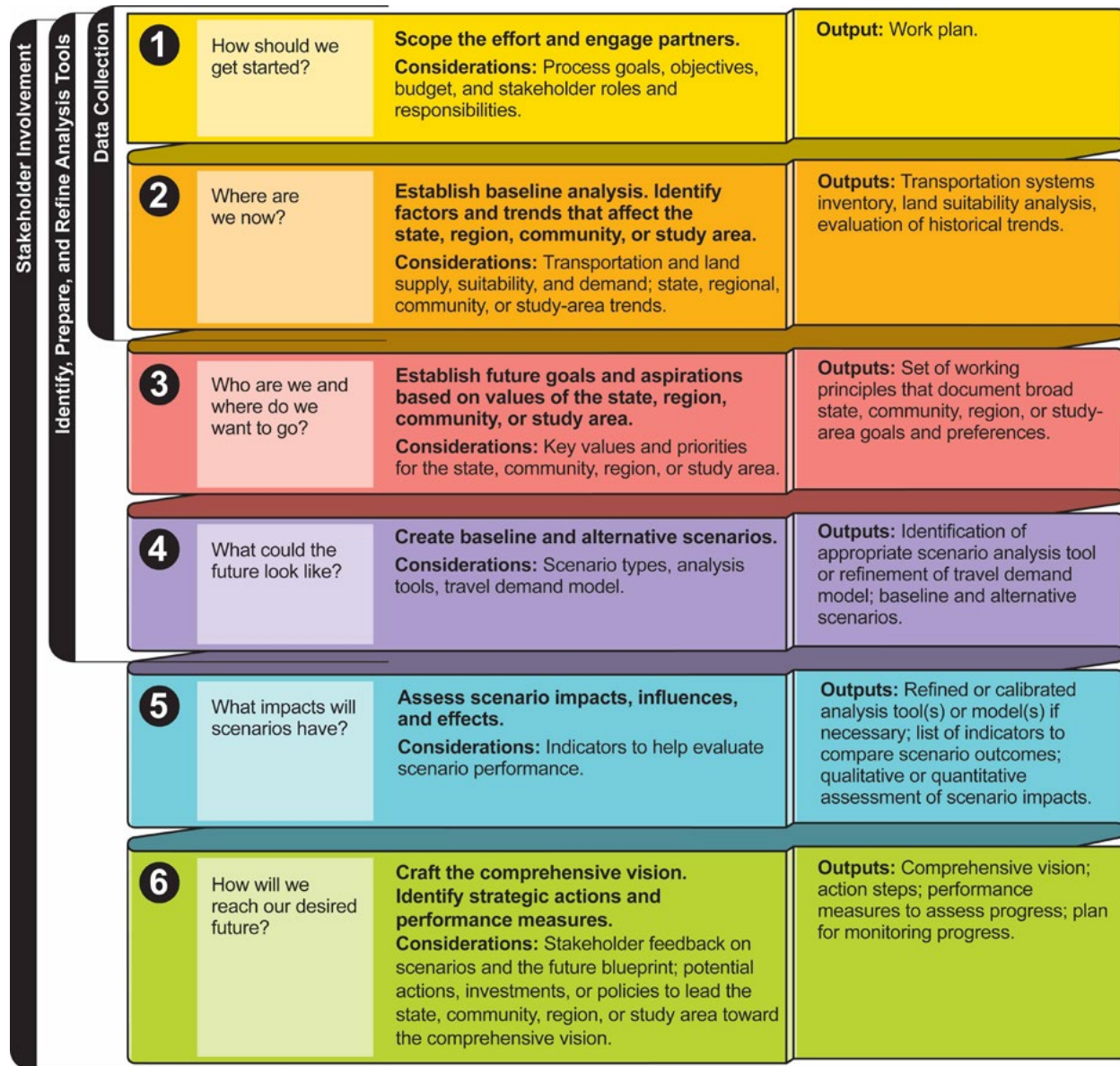
This comparison of the risk management process with the scenario planning process reveals the complementary nature of the two approaches. Each was developed to help planning stakeholders better understand how to shape and influence the steps an organization or community would take

<sup>6</sup> FHWA Scenario Planning and Visualization in Transportation Website [https://www.fhwa.dot.gov/planning/scenario\\_and\\_visualization/scenario\\_planning/](https://www.fhwa.dot.gov/planning/scenario_and_visualization/scenario_planning/)



to achieve its objectives. The two frameworks arose from different disciplines, but both evolved to help improve the decision-making process.

Figure 10 The scenario planning process.



### Stakeholders in Scenario Planning and Risk Management

Another similarity between scenario planning and risk management processes is the reliance on stakeholders. Risk guides are nearly universal in their recommendation to include stakeholders in the risk process. The many stakeholders involved in a continuing, comprehensive, and cooperative transportation planning process can offer valuable insights into risks and how to manage them. MPOs typically staff numerous stakeholder committees, all of which could contribute to scenario planning and risk management processes. Stakeholders who are not traditionally associated with regional or statewide transportation planning processes could be

valuable participants in identifying, assessing, and managing risks to the goals, objectives, and targets embedded in plans. For example, the inflation of construction costs is a major risk to programming, constructing, and maintaining infrastructure. Stakeholders such as bid estimators, construction staff, materials staff, outside economists, or contractors could provide insights into long-term construction cost trends to inform scenarios and risk assessments for achieving long-term plans and programs.

Stakeholders and experts can also lend valuable support to the forecasting exercises conducted for scenario planning and for risk management. For example, outputs from Monte Carlo analyses should be influenced by the qualitative opinion of experts and informed stakeholders. These tools accommodate Bayesian statistical analyses frameworks, in which the values of forecasting variables can be changed based upon observations or opinions about developing trends. In other words, a forecast can depend upon more input than simply a statistical extrapolation of past trends. For the population forecasting exercise in Clark County, Nevada, stakeholders and experts could advise the agency if they think future population growth will be influenced by factors that have not occurred and/ or been accounted for in historical trend analyses. Water management experts, for example, could weigh in on the potential impacts of sudden changes in environmental conditions upon the region's capacity to sustain the existing population or to support growth. The influence of those new factors can be used to adjust growth rates and levels of variability to improve the population forecast.

## Best Practices for Integrating Risk Assessment

### Establish a Risk Management Framework

A risk management framework can be incorporated into any planning process that involves evaluating alternatives and deciding upon strategies, from MTP/ SLRTP updates and corridor studies to bicycle plans, public involvement plans, and data management programs. It can also be a highly useful tool to support TIP or STIP decisions regarding project prioritization, selection, financing, and staging, as well as monitoring performance objectives and long term outcomes generated by completed projects.

It is critical to articulate the agency's commitment to incorporating risk management into its everyday functions. This sets the stage for building the agency's capacity and leadership for effective risk management. Key steps include the following:

- Adopt an agency policy to incorporate risk management into the planning process;
- Train key staff, such as planning program directors, in risk management methods;
- Appoint a risk manager or subject matter expert with a working knowledge of risk management to lead the effort.

### Conduct Periodic Risk Identification and Mitigation Cycles

These can be applied to agency-wide initiatives, such as periodic updates to the MPO Unified Planning Work Program (UPWP) or strategic plans for agency staffing and budgeting, or to specific planning functions and processes, such as updating a travel model, an MTP or SLRTP, or a TIP/ STIP. Use the step-by-step process described in the previous section of this roadmap to

engage stakeholders in completing the following activities:

**Establish the context and objectives for the risk management application.** For example, the risk management assessment could support decisionmaking and ongoing performance monitoring associated with investments and initiatives in the MTP or SLRTP. In this case, objectives could include using the risk assessment process to refine key data such as population forecasts, to broaden the understanding of key issues and opportunities the plan should consider, to inform the development evaluation of alternative solutions, and to increase the resilience of planned investments.

**Identify and analyze relevant risks, including threats and opportunities.** Develop a risk register that summarizes relevant risks and how they are to be managed. Document the supporting information and analyses conducted to identify the risk, to determine how it could affect the achievement of stated objectives, and to understand the levels of uncertainty and variability associated with the risk. For example, a Monte Carlo simulation and other analyses could help to establish a range of potential population forecasts that reflect the variable nature of historic growth trends and the potential for new events or outside forces to impact future growth. The agency can then articulate the “what-if” threats and opportunities associated with the range of growth trajectories.

**Decide upon mitigation strategies, monitor outcomes, and adjust as needed.** Use the risk registers and supporting information to help explain risks and assumptions to stakeholders (especially those who are essential for developing and implementing mitigation strategies), and to track the key indicators that are most closely associated with each risk. For example, the agency can identify and track key economic and environmental indicators that are associated with historic changes in population growth, as well as emerging indicators that might have critical impacts on future growth.

## Engage Stakeholders

The committees and community stakeholders commonly involved in developing planning products, such as MTP and SLRTP objectives, can also engage in risk identification and assessment efforts. In addition to identifying objectives the stakeholders could identify and assess the risks to those objectives. Additional stakeholders such as subject matter experts from partner agencies (e.g. economic development, environmental preservation, etc) could help to analyze risks associated with their realms, and to help identify and support mitigation strategies.

## Acknowledge Risks

Incorporating discussion of risks in key public documents such as an MTP, SLRTP, TIP, STIP, and an annual system performance report can promote consideration of risks across all elements of the planning process. The risk assessments developed for regularly updated transportation planning documents are somewhat analogous to a corporation’s annual reports to its shareholders. Corporate annual reports include detailed discussion of the risks facing the corporation and how the corporation tries to manage them. In the corporate world, acknowledgement of risk is required for transparency.

In the planning realm, acknowledging the uncertainty, variability, and threats to planning objectives also could increase transparency with the public. Some typical risks that can be acknowledged in planning documents include the following:

- Known weaknesses in travel demand models;
- Uncertainty about land use or population forecasts because of changing local circumstances;
- Risks surrounding revenue or construction costs;
- Uncertain technology impacts, such as the pace or scope of alternatively fueled or connected vehicles; and
- Changing demographic patterns such as in-migration to some major cities and out-migration from others.

## Assess Uncertainty and Variability

Assessing the variability and uncertainty around key planning assumptions is a fundamental element of incorporating risk management into the planning process. Planning tools and methods rely heavily upon long-range forecasts about land use, economic trends, mode choice, and development patterns. A single straight-line forecast of any variable can provide a false sense of certainty. Variability surrounds each of the assumptions upon which these forecasts are built.

By showing a range of possible future outcomes and explaining the rationale behind the assumptions, the agency can provide a more realistic picture of the uncertain environment in which transportation planning takes place. Acknowledging the assumptions and documenting associated variabilities and uncertainties prepares the agency to monitor key indicators and to adjust its strategies if trends do not unfold the way the forecasts assumed.

## Use Risk Management to Promote Resilience

FHWA defines resilience as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.<sup>7</sup> Transportation agencies can use risk management as foundation for increasing the resilience of the infrastructure, assets, and services they plan and operate. A risk-based planning effort, for example, is likely to identify environmental threats such as increasingly frequent floods and sea level rise in low-lying coastal areas. By assessing the magnitude and likelihood of these conditions, and documenting specific potential impacts on transportation networks, the transportation planning agency can work with its stakeholders to develop targeted strategies to make infrastructure more robust and to improve the community's capacity to recover rapidly from weather disasters. FHWA's *Vulnerability Assessment and Adaptation Framework* ([https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation\\_framework/index.cfm](https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/index.cfm)) provides a toolkit for identifying these types of system vulnerabilities and addressing them in plans and programs.

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<sup>7</sup> FHWA Order 5520, quoted in *Integrating Resilience into the Transportation Planning Process* white paper. FHWA. 2018.

[https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing\\_and\\_current\\_research/planning/integrating\\_resilience.cfm](https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/planning/integrating_resilience.cfm)

## Appendix A: Recommendations from Practitioners

In October 2017, FHWA conducted a peer exchange on the topic of incorporating risk into the planning process. The following suggestions came from participants in that peer exchange regarding activities and best practices for Federal agencies, State DOTs and MPOs to consider when building risk management programs.

### Provide Training

Participants discussed the need to train transportation planners on risk management processes and analysis techniques. Training could focus on areas such as the following:

- Defining the concept of risk, how is it managed, and how can it be applied to planning.
- Supporting enterprise risk management which is the practicing of risks across an agency. In the case of planning, the training could address how planners can identify and manage the major risks to the agency's planning process. Examples could include managing the major risks to the accuracy of socio-economic inputs to travel demand models or the assumptions that drive revenue and cost projections.
- Demonstrating the use of tools such as Monte Carlo simulation

### Move from Point Assumptions to Ranges

Participants discussed the benefits of demonstrating how ranges within forecasts could be incorporated into the planning process, instead of relying upon single-point assumptions. The planning process does not guarantee clarity about future trends. It usually generates information about the general direction of trends based on informed assumptions. It is important for decisionmakers and stakeholders to acknowledge that plans designed to address the current understanding of future needs may not be effective if major shifts occur down the road.

For example, instead of producing a single population forecast for an MTP or SLRTP, the agency can demonstrate the variability surrounding the forecast and the implications of that variability. Facilitating a thoughtful discussion of these ranges would help planners to illustrate the uncertainty about the future and the realities of the planning process.

### Share Information About Tools and Best Practices

Participants suggested a catalog of risk-based tools as a useful training and capacity building product. It would describe available tools and how each could support planning decisions. Another useful product could be a set of best practice case studies from Canada and Australia where risk management is more common in transportation agencies. A FHWA international scan report in 2012 described enterprise risk management practices in several countries. Examples of risk management applied to the planning process could expand upon the earlier report to specifically address risk-based planning.

### Start with Risk Assessments

Participants discussed the benefits of reports, guides, or case studies that demonstrate how risk management early in the planning process can strengthen planning decisions. A major planning effort, such as an MTP or SLRTP, could begin with an assessment of the risks to the



organization's planning objectives. Then, throughout the planning process, the effects of the risks could be considered to each planning element such as forecasting, prioritizing, or programming. The final plan could discuss the risks and how they will be addressed.

## Demonstrate Opportunity Costs

Participants also thought it would be helpful to convey the benefits that planners are missing by not addressing risks. Some of these "opportunity costs" could be the following:

- Stakeholder understanding of how planners must operate under uncertainty and base their decisions on highly variable assumptions;
- Credibility gained from acknowledging that "things may not turn out as planned" and that stakeholders should not be surprised if major assumptions need to change;
- Ability to identify major threats, or major opportunities, that lie in the future;
- Ability to do contingency planning for major threats, such as climatic or seismic impacts; and
- Better planning decisions based upon acknowledgement of future uncertainties.

## Promote DOT Engagement with MPOs

Another suggested benefit of incorporating risk management into planning is the opportunity to enhance state DOT discussions with MPOs about the degree of variability or uncertainty associated with critical planning data that are typically developed by the state, such as revenue forecasts. When planning or revenue forecasts are provided to the MPO, or from the MPO to the state DOT, analysis of the risks surrounding those assumptions could benefit both parties. Understanding the degree of confidence, or the lack of confidence, in the forecast could enhance understanding and better inform the planning process.

## Tailor Approaches to Agency Contexts

Another useful product could be guidance or advice on how risk management can be customized for MPO, State, and Federal agencies. Some common approaches would apply to all three, but each also has unique roles that could be enhanced with risk management. For example, MPOs may be best positioned to manage risks to key planning inputs such as regional population or land use changes. State DOTs may be best positioned to measure the risks surrounding asset management forecasts, such as future investments necessary to sustain bridge, and pavement conditions. FHWA may be best positioned to provide training, guidance, and support to state and regional agencies. Guidance on which tools and which approaches are best suited for each partner was identified as a useful product.

## Use Familiar Terminology

Some participants struggled with the terminology of "risk" but immediately identified with the concept of addressing "variability" or "uncertainty" in the planning process. Identifying and using terminology that resonates with planning agencies could benefit the advancement of risk-based planning.

## Integrate Risk Management Into PlanWorks

PlanWorks<sup>8</sup> is a decision support tool built from the experiences of transportation partners and stakeholders, which provides how-to information for planning and programming decisions. It was developed in the second Strategic Highway Research Program (SHRP2) and is now managed by FHWA. It would be an excellent framework for helping to build agency capacity conduct risk-based decision making.

## Appendix B: Resources

The following is a partial list of resources that can assist agencies to incorporate risk into the planning process and into their scenario planning efforts.

### Enterprise Risk Management

- Achieving Policy Objectives by Managing Risks. FHWA.  
<https://www.fhwa.dot.gov/asset/pubs/hif12054.pdf>
- Australian Government Better Practice Guide Risk Management, June 2008  
[https://www.finance.gov.au/sites/default/files/Better\\_Practice\\_Guide.pdf](https://www.finance.gov.au/sites/default/files/Better_Practice_Guide.pdf)
- Australian Government Common Wealth Risk Management Policy  
<https://www.finance.gov.au/comcover/risk-management/the-commonwealth-risk-management-policy/>
- CalTrans Project Risk Management Handbook: A Scalable Approach  
[http://www.dot.ca.gov/hq/projmgmt/documents/prmhb/PRM\\_Handbook.pdf](http://www.dot.ca.gov/hq/projmgmt/documents/prmhb/PRM_Handbook.pdf)
- Examining Risk-based Approaches to Transportation. FHWA.  
<https://www.fhwa.dot.gov/asset/pubs/hif12050.pdf>
- Executive Strategies for Risk Management by State Departments of Transportation, a 40-page summary within NCHRP Project 20-24 (105) *Launching U.S. Transportation Enterprise Risk Management Programs*. NCHRP.  
[http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24\(74\)\\_ExecutiveSummary.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(74)_ExecutiveSummary.pdf)
- Guide for Enterprise Risk Management. AASHTO. 2016. Book available for purchase; executive summary available as a free download.  
[https://bookstore.transportation.org/item\\_details.aspx?ID=2706](https://bookstore.transportation.org/item_details.aspx?ID=2706)
- Launching U.S. Transportation Enterprise Risk Management Programs. NCHRP Project 20-24 (105). [http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24\(105\)\\_FR.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(105)_FR.pdf)
- Managing Risk in Government: An Introduction to Enterprise Risk Management  
<https://www.rims.org/resources/ERM/Documents/Risk%20in%20Government.pdf>
- Managing Risks to Networks, Corridors, and Critical Structures. FHWA.  
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