

# Guidebook for Risk Assessment in Public Private Partnerships

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# 1 Introduction

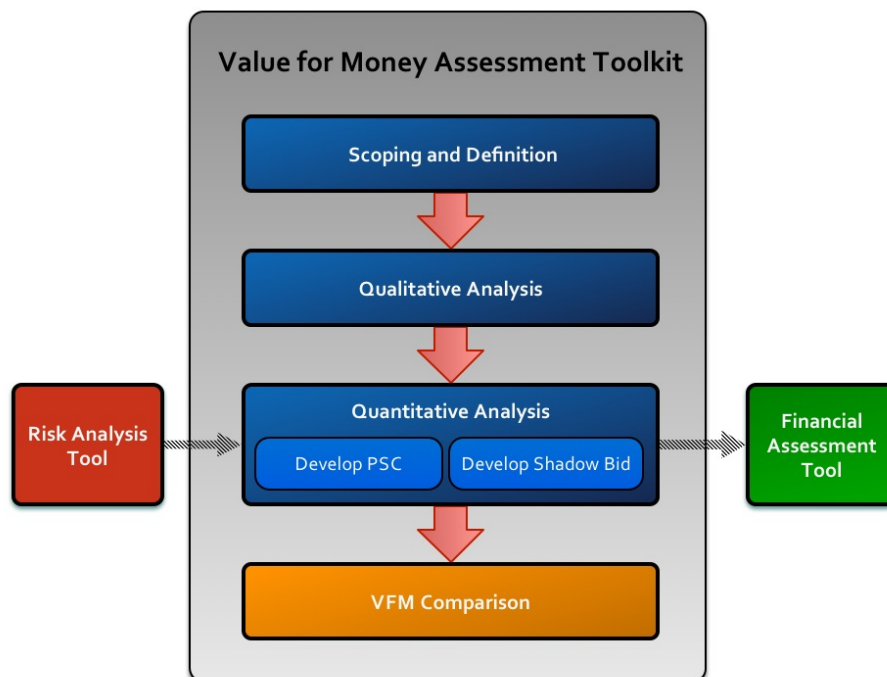
## 1.1 This guidebook is part of the FHWA P3 Toolkit

The Federal Highway Administration's (FHWA) Office of Innovative Program Delivery (OIPD) has developed a P3 Toolkit comprising tools and guidance documents to assist in educating public sector policymakers, legislative and executive staff, and transportation professionals. The P3 Toolkit forms the basis of a broader P3 capacity-building program that includes a curriculum of P3 courses and webinars. The P3 Toolkit addresses both Federal requirements related to P3s and four key phases in P3 implementation: (1) Legislation and Policy Development; (2) Planning and Evaluation; (3) Procurement; and (4) Monitoring and Oversight.

## 1.2 The purpose of this guidebook is to provide an advanced understanding of risk assessment

The FHWA's P3 Toolkit includes the *Guidebook for Value for Money Assessment for Public-Private Partnerships*. Risk assessment is one of the inputs for the quantitative analysis in the Value for Money assessment as seen in Figure 1-1. This guidebook is therefore best read in succession to the Value for Money Assessment guidebook.

Figure 1-1. Value for Money Assessment Tool





FHWA's P3 Toolkit includes both the *Risk Assessment for Public-Private Partnerships: A Primer*, and the *Risk Assessment Tool and User Manual*<sup>1</sup>. The primer provides an introduction to risk assessment and risk allocation in the context of Public-Private Partnerships (P3) and Value for Money analysis (VfM). The Risk Assessment Tool is a Microsoft Excel tool that demonstrates how a risk assessment can be conducted. These tools are intended for educational purposes. The evaluation of a specific project requires setting up a project-specific risk assessment.

This guidebook is intended to be a detailed follow-on to the primer, and as such covers more challenging and advanced risk assessment topics. It is designed to enhance the overall understanding of the relationship between risk assessment and Value for Money analysis and to provide hands on guidance for practitioners in the field. In addition to this guidebook for Risk Assessment, a guidebook on Value for Money analysis, which is a follow-on to the FHWA primer on VfM assessment, has been developed. The VfM guidebook offers guidance on how to conduct an assessment of conventional versus P3-delivery options. The risk assessment described in this guidebook is an input to the VfM assessment.

To make this guidebook as useful as possible to practitioners, it provides an advanced understanding of the practical applications for assessing and allocating project life cycle risks, and addresses the numerous challenges faced when doing so.

### **1.3 Risk assessment is crucial in preparing, procuring, and implementing P3 projects**

Well-performed risk assessment is absolutely essential to the successful implementation of P3 projects. A thorough understanding of risk allocation and risk valuation leads to a more accurate VfM analysis, providing decision makers with better information to determine and optimize project delivery alternatives. Proper risk assessment also improves the structuring of innovative P3 contracts because risk allocation can be optimized, allowing those risks to be transferred to (or retained by) the party best suited to handle the risks.

The fact that risk assessment is crucial in all project phases does not mean that the assessment should be equally detailed throughout all project phases. In the early phases a high-level risk assessment will suffice, whereas in latter phases—for example when a P3 transaction is being structured or when doing a VfM assessment on the basis of real P3 bids—a much more detailed analysis may be performed.

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<sup>1</sup> All tools can be found at <http://www.fhwa.dot.gov/ipd/p3/toolkit/index.htm>.

Professional risk assessment has the additional benefit of improving communication and public outreach, since P3 projects may involve public relations challenges. A proper risk allocation and valuation improves the credibility of the P3 analysis and enhances the ability of stakeholders to communicate the pros and cons of a chosen solution to the public at large.

#### **1.4 This guidebook focuses on the financial perspective, not the social perspective**

The scope of this guidebook is from the financial perspective of a government entity and not the perspective of the entire economy. This perspective mainly affects the valuation section, because the valuation is not based on benefit-cost methods from the perspective of society, but on financial pricing techniques from the perspective of the public agency or taxpayer.

The reason for this approach is that the primary application of risk assessment in the context of the P3 toolkit is in financial feasibility assessment and VfM assessment. As with most VfM assessment methodologies, the starting point is the financial calculation. A government agency may decide to separately assess socio-economic factors. The financial VfM calculation may be complemented by relevant non-financial and socioeconomic considerations such as those considered in a benefit–cost analysis (BCA).

#### **1.5 This guidebook is developed for transportation staff involved in P3 projects**

The intended audience for this material includes the staff at FHWA, individual state departments of transportation, executive branch departments and agencies considering P3s, metropolitan planning organizations, and other transportation management agencies that are considering a P3 approach or are preparing, procuring, and implementing a P3 project. With this guidebook in hand, the user will gain the ability to:

- ▶ Better explain the concepts of risk assessment and allocation
- ▶ Coordinate and monitor a team of specialized advisors
- ▶ Perform state-of-the-art risk assessment

#### **1.6 The structure of this guidebook mirrors the steps performed in an actual risk assessment**

The guidebook is organized to take the user through the different stages of a risk assessment in the same manner that any practitioner would expect to perform it from start to finish. While the ultimate goal of this assessment is to incorporate the results in the VfM assessment, this guidebook



guides the reader in performing a full risk assessment. Some of the risks identified and valued will not result in a marked difference in the VfM assessment between different delivery methods. However, performing a full risk assessment can ensure that no risks are forgotten.

To improve the understanding of the concepts introduced in this guidebook, a hypothetical example is provided that highlights some of the unique challenges facing practitioners in real life. This example is featured throughout the guidebook and is introduced below.

## **A hypothetical example: Introduction to the I-13 Project**

The State of Pennorado has decided to expand a highway, Interstate 13 (the Project). The Project is in the early stages in which its feasibility is being assessed, and different delivery methods are being compared in a Value for Money (VfM) assessment. Ms. Brown (the Project manager) and Mr. Regan (the risk manager) work with the Pennorado Department of Transportation (PDOT) on the Project team that is responsible for the planning, contracting, and implementation of this project. Currently the team is performing a risk assessment as part of the VfM assessment. The question is whether the Project should be contracted in the conventional way—design, bid, build (DBB)—or if it should be contracted in a P3 arrangement. The P3 contract may include either a toll concession, or exclude toll revenues and utilize availability payments only.

### Project history

The search for a regional transportation solution to the increased traffic congestion and accidents on I-13 started in 2003. In addition to the congestion and accidents, increased freight traffic and transportation to and from the regional airport need to be addressed. An investment study conducted in 2004 concluded that even with the large planned investments in transit in the region, the expansion of the I-13 corridor was the only alternative that can address the transportation needs outlined above. A Final Environmental Impact Statement (FEIS) was issued in January 2009.

### Project description

The Project is located on I-13, an existing four-lane highway connecting two metropolitan areas. The highway corridor is 78 miles long, with major arterials intersecting the roadway. Within the Project area, the I-13 corridor consists of a number of communities, including eight cities and five counties. Upon completion, I-13 will be eight lanes wide (four in each direction), four of which will be managed lanes (two in each direction). Carpools, buses, hybrid vehicles with permits, and motorcycles will use the lanes toll-free. The Project also includes bus rapid transit (BRT) service improvements.

### Project objectives

The objectives of the proposed I-13 corridor improvements are:

- Support local and regional comprehensive planning and development
- Maintain the efficiency of existing roadways in the immediate vicinity of the airport terminals
- Relieve local congestion
- Serve airport freight operations, reduce travel times between airport and freight destinations
- Improve regional mobility and safety
- Design Project in an environmentally responsible manner
- Complete the expansion on time to prevent relocation of an airline due to congestion issues
- Provide cost-effective alternatives and solutions.

### Project status

- Design: The preliminary design is 80% complete.
- Planning and Environmental Approvals: The environmental impact statement (EIS) and record of decision (ROD) were issued in 2009. Tolling was not included in the original I-13 National Environmental Policy Act (NEPA) documentation; additional analysis would be required to reflect the impacts from managed lanes.
- Right of Way Acquisition: 95 of the 223 parcels needed for the Project have been purchased. The Project assumes that the full right-of-way corridor will be purchased, though construction may be phased.
- Toll authorization: Legislative toll authorization would be required and is not available yet.
- Support: Most cities and all counties, the Port Authority, and the freight community support the Project.
- Investment cost estimates: Recent estimates for overall design and construction costs are \$865 M (1/1/2014).

## 2 Framework for Risk Assessment

### 2.1 Risk assessment is used throughout the project life cycle

Risk assessment is an essential discipline within professional project management. The essence of project management is maximizing achievement of the project's objectives in the most efficient manner possible. The project objectives are typically related to the schedule, quality, and budget. Major risks can and do affect each of these objectives.

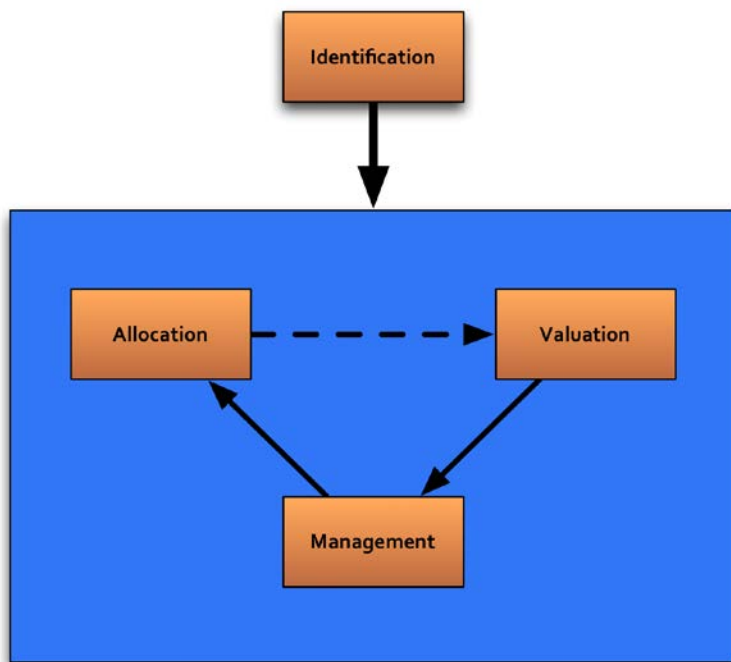
There are four major steps in risk assessment, shown graphically in Figure 2-1 below:

1. Risk identification
2. Risk management
3. Risk allocation
4. Risk valuation

By necessity, identifying risks is the first step. This is followed by allocation conducted in parallel with management, on the basis of which valuation can be determined. Once a project is underway, the management of risks may affect the allocation and valuation. New information may also become available throughout the project life cycle, making regular updates a necessity.<sup>2</sup> After describing the different steps in detail in the chapters that follow, every chapter provides further guidance with respect to process, timing, information, and the experts needed.

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<sup>2</sup> This is discussed in detail in the following sections.

**Figure 2-1. Risk Assessment Steps**

Risk assessment remains a dynamic process throughout the total project cycle. The process illustrated above is repeated at certain intervals or when relevant information becomes available to the practitioner. However, as stated earlier, the risk assessment is not equally detailed throughout all project phases. In the early phases a high level assessment will suffice, whereas in later phases—for example when a P3 transaction is structured or when doing a VfM assessment on the basis of real P3 bids—a much more detailed analysis may be performed.

## 2.2 Be clear on the goal(s) of the risk assessment

Within the larger purpose of project management, risk assessment seeks to develop::

- ▶ Realistic **risk valuation** as part of financial feasibility analysis and VfM assessment;
- ▶ Effective **risk management** measures and strategies; and
- ▶ Efficient and realistic **risk allocation** to be used in structuring a contract.

The methodologies used in risk assessment differ from project to project. When beginning an assessment, it is important to determine the goal of the analysis in order to fine-tune the methodology. The relative importance of the three goals listed above changes based on the different project phases. Roughly speaking, risk valuation is most relevant during the project assessment and project development stages. Risk allocation is usually most important during the procurement stage, and risk management is most relevant in the project implementation stage.

The three goals do not exist separately, but are instead interrelated. Risk management provides input for risk allocation and helps when answering the question, “Which party is best able to manage a risk?” The ability to manage—and thus accept—the risk influences and determines its valuation. This cycle can also be iterative in nature; constant information updates occur in any given project, therefore risk assessment is a continual process. When new information becomes available, the risk management strategy may change in parallel with risk allocation and valuation.

To conduct a risk assessment as part of the VfM assessment, the following steps are typically followed:

1. Identification of risks
2. Initial allocation of risks between the public and private entity for different delivery methods
3. Initial valuation of risks
4. Identification of risk management strategies
5. Optimization of expected value of risks, by choosing the optimal risk management strategy and allocation

#### **Textbox 1: Expected value**

Transportation projects typically involve investments that are meant to last for decades. All future cash flows, including risks, are uncertain. Therefore, the valuation of risks results in an expected value. This expected value can be reported in different ways: the most likely or average of possible outcomes, or the full range of possible outcomes, including their probabilities. For risks, the goal of risk management is to minimize their expected value and therefore optimize the expected value of the project.

### I-13: The cyclical nature of the risk assessment

Additional research on ground conditions along I-13 was carried out by PDOT, leading to the convincing conclusion that there is little risk related to ground conditions. The risk management strategy will change now that one of the most important measures has been executed. The results of the research also change the value of the risk, because the estimated probability of potential damage due to unknown ground conditions is reduced. Likewise, this may lead to a change in the opinion on the risk allocation, since the private sector may be better able to manage the risk now.

## 2.3 Project characteristics affect the nature of the risk assessment

To determine the nature and complexity of the risk assessment, it is necessary to examine the project's characteristics. Some of the most relevant risk characteristics are listed in Table 2-1.

### I-13: Project characteristics and their impact on the risk analysis

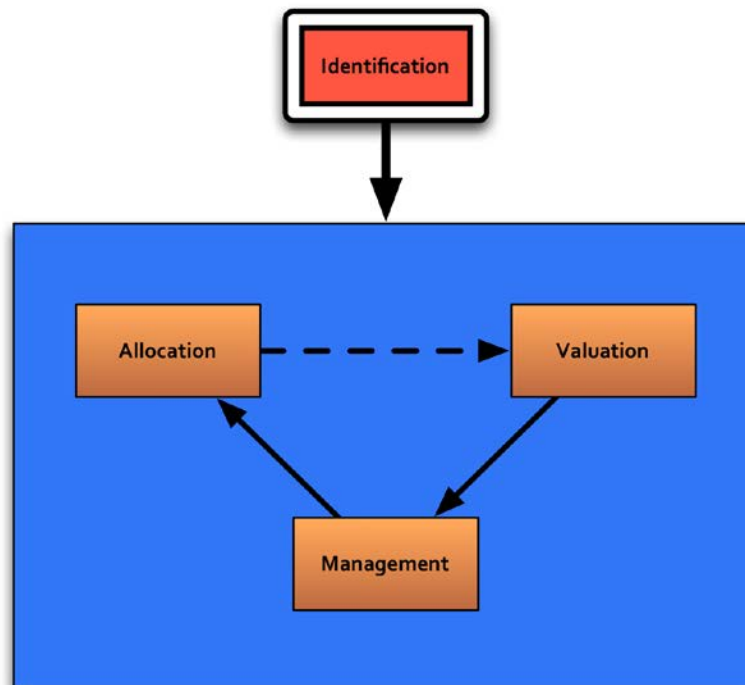
The project is an expansion of an existing highway, therefore the scope is that of a brownfield project. This means that the riskiness is relatively low in comparison with a greenfield project because, for example, the terrain and stakeholders are known. Since the highway will generate toll revenues, revenue risk must be considered. Risk allocation differs depending on the contracting form. This could also influence the valuation of the risk. The types of contracts compared in the VfM assessment are design-bid-build, an availability payment-based P3 contract, and a toll revenue-based P3 contract. The latter assumes that most of the revenue risk (upside and downside) will be transferred to the private party. This risk allocation differs from the traditional approach where most risks remain with the public entity.

**Table 2-1. Project Characteristics and Risk Assessment**

<b>Project characteristic</b>	<b>Example</b>	<b>Consequence for risk assessment</b>
Magnitude of costs	<ul style="list-style-type: none"> <li>• Investment costs</li> <li>• Life cycle costs</li> </ul>	The larger the project, the more detailed the risk assessment required
Scope	<ul style="list-style-type: none"> <li>• Greenfield or brownfield</li> <li>• Innovative or traditional</li> <li>• Multi-functional (combined with, for instance, rail or urban development) or mono-functional (road only)</li> <li>• Managed lane or full toll facility</li> <li>• Revenue-based or funded by public budget</li> </ul>	Greenfield, innovative, revenue-based, and multifunctional projects increase the complexity of the risk assessment
Phase	<ul style="list-style-type: none"> <li>• Identification/initiation</li> <li>• Scoping</li> <li>• Feasibility assessment</li> <li>• Procurement</li> <li>• Implementation</li> </ul>	Typically the risk assessment is generic and basic in the early stages, becoming more specific and detailed closer to project procurement and project implementation
Type of contract	<ul style="list-style-type: none"> <li>• Design-Build (DB)</li> <li>• Design-Bid-Build (DBB)</li> <li>• Build-Operate-Transfer (BOT)</li> <li>• DBFOM concession (DBFOM)                             <ul style="list-style-type: none"> <li>○ Availability payment based</li> <li>○ Toll revenue based</li> </ul> </li> </ul>	The type of contract affects the risk allocation; risk assessment provides inputs for developing the optimal contract
One or more transportation modes	<ul style="list-style-type: none"> <li>• Road</li> <li>• Bus Rapid Transit (BRT)</li> <li>• Rail</li> </ul>	Multiple modes affect complexity of the risk assessment (interface risks) and potentially also the risk allocation

### 3 Risk Identification

Figure 3-1. Risk Identification



#### 3.1 Risk identification is the foundation of risk assessment

Risk identification is not a goal itself; rather it is a step that directly serves the other elements of risk assessment: risk valuation, risk management, and risk allocation. The level of detail of the identification can vary depending on the nature of the analysis. For the purpose of risk valuation, it is important to be complete. Risk management requires the identification of the most important risks, including those present during the development phase as shown in Figure 3-1. Risk management does not require practitioners to identify every single risk, but only the biggest ones.

The emergence of P3s has revealed explicit risks that practitioners were unaware of, prompting changes to the methodology for addressing risks when using innovative delivery methods. In most



conventional contracts, risks are explicitly transferred to the private party while all other unidentified risks essentially remain with the public agency. In a P3 contract, the risk transfer is the other way around. The contractor becomes responsible for the project and all of the risks attached, except for the ones explicitly retained by the public agency.

This change can create confusion because it is often not entirely clear, or easy to identify, which risks the public agency retains in a conventional delivery method and which ones are transferred to the private sector in a P3 procurement. Given that under the P3 delivery scenario these previously unidentified risks are now transferred and priced, the P3 option may appear extremely expensive. This may be true when comparing a private bid to a Public Sector Comparator (PSC) in situations where these risks are not valued, but that is akin to comparing “apples to oranges.”

Whereas the risk identification method and process may vary depending on the goal of the risk assessment (as discussed in 2.2), the overall purpose of risk identification is fourfold:

- ▶ Identifying the risks of a project (section 3.2.2) within the scope of the risk assessment (3.2.1);
- ▶ Verifying that project stakeholders have a common understanding of the risks (3.2.3);
- ▶ Prioritizing and identifying the most important risks (3.2.4); and,
- ▶ Structuring the risk register and assessing the overall risk profile (3.2.5).

## **3.2 Conducting an excellent risk identification requires proper scoping, completeness checks, detailed descriptions, and prioritization**

### **3.2.1 Defining the scope is the starting point of risk assessment**

An often forgotten but very important step is determining the overall scope of the risk assessment. It may seem like an unnecessary step, but identifying the scope of the risk assessment is important because it can vary significantly depending on the purpose and intended use of the risk assessment. See Figure 3-2 for the Risk Assessment Scope Definitions.

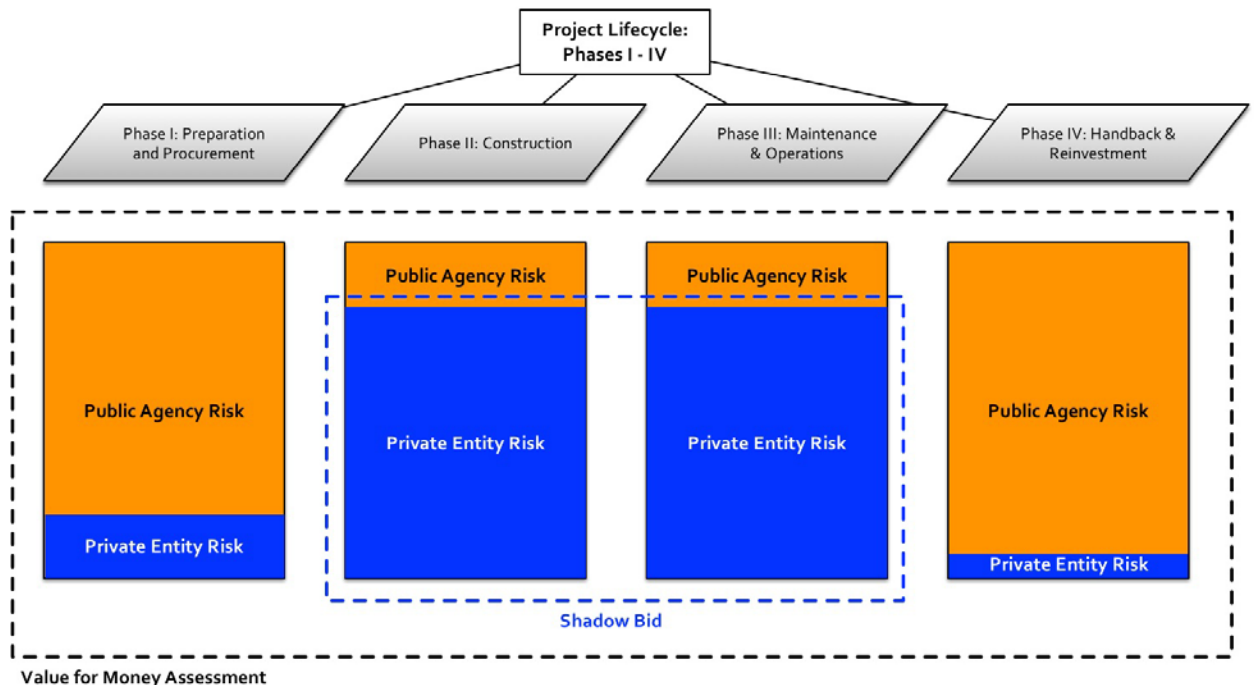
### I-13: Scope and purpose of the risk assessment

Mr. Regan (risk manager of the I-13 Project) intends to use risk assessment at multiple stages in the project and for different purposes. This leads to different scopes for the risk assessment:

- ▶ The scope of a risk assessment that is used for project management in the early development phase focuses on all of the risks threatening the project, up to and including contracting and financial close.
- ▶ The scope for developing a shadow bid (an indication of the expected bid that is used to compare delivery methods in a VfM assessment) is defined by the risks that are being transferred to the private sector in the P3 agreement, after contracting and financial close.
- ▶ The scope for a VfM analysis can be as broad as the full project for the duration of the P3 agreement being considered—and maybe even beyond—but can also focus on the risks for which we expect a difference to be found between the P3 and conventional approach.

Currently, the question of concern to Ms. Brown and Mr. Regan is: “Which delivery method is most attractive for this project from the PDOT perspective?” A VfM comparison between the contracting forms “Design-Bid-Build,” “P3 toll,” and “P3 availability payment” will help answer this question, and a thorough risk assessment is essential for the VfM assessment. For the purpose of valuing the risks of a project to provide financial inputs for the VfM comparison, it is important for Ms. Brown and Mr. Regan to first decide if they want to identify all of the risks in their analysis, *or* if they should focus only on the risks that differ between the three contracting forms.

To avoid overlooking important risks, they decide to start with the full identification of all risks. Then, they will identify the risks that differ between the three contracting forms, proceeding with those in the risk valuation step.

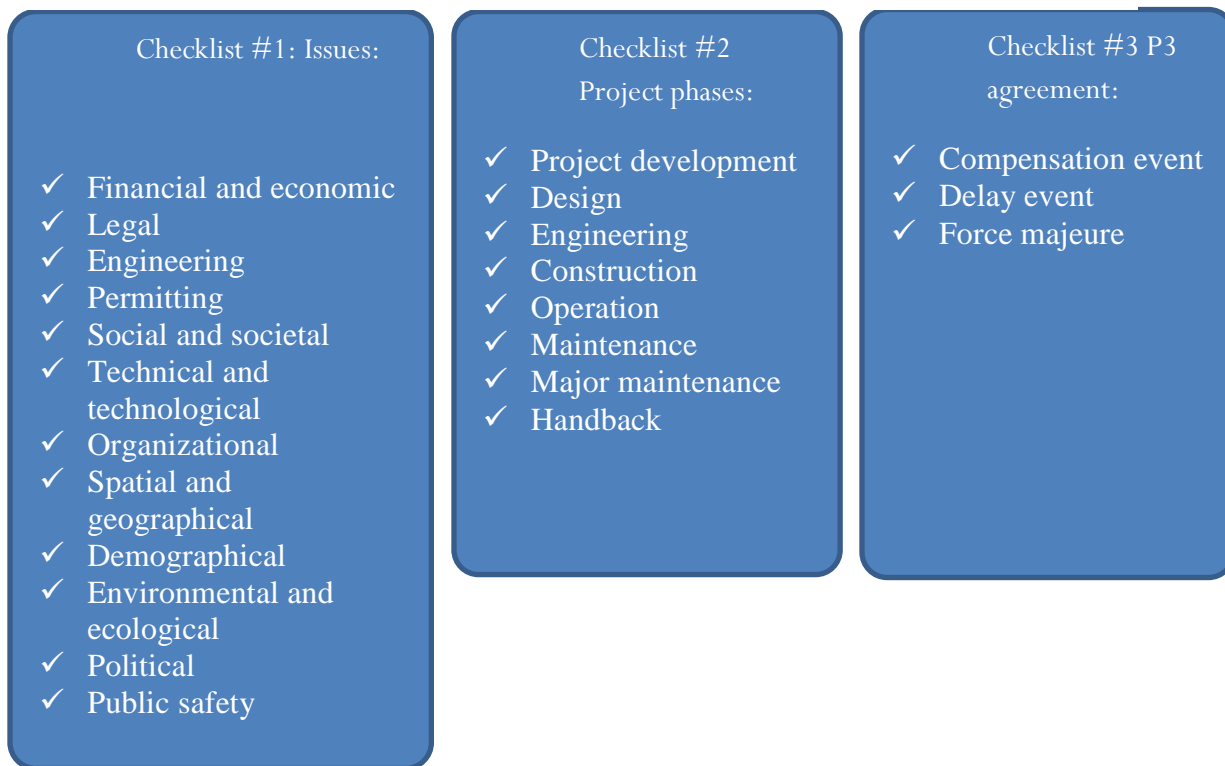
**Figure 3-2. Risk Assessment Scope Definitions**


### 3.2.2 The next step is to identify all risks and avoid any “blind spots”

During the initial risk identification, one of the major challenges is avoiding blind spots. These blind spots can occur when areas are overlooked, either because of negligence or from paying too much attention to certain risks but not to others.

To avoid having to create a new process, several approaches for developing a complete risk identification process are described below:

- ▶ Have all relevant expertise perspectives involved and present in the risk workshops. Staff members and experts with knowledge and experience in all of the fields listed in Checklist #1 (below) should be involved in the process.
- ▶ Use existing risk assessments for inspiration. This should not be a simple “cut and paste” exercise; instead, it is tailored to the specific project, while simultaneously utilizing information from previous projects as guidance.
- ▶ Use standard categories and checklists to facilitate completeness. The most relevant checklists are the following:

**Figure 3-3. Risk Identification Workshop Checklists**

The checklists identified in Figure 3-3 should be used *after* a project-specific brainstorm to check for completeness rather than as a starting point, because that can lead to tunnel vision and reduce the session's creativity.

### I-13: A workshop is organized to identify all risks

Mr. Regan organizes a risk identification workshop. In addition to cost estimation experts, he invites technical and legal experts as well as representatives of stakeholder groups, such as county and city representatives, and the property owners who live close to the highway. After a brainstorming session in which all participants contribute to the list of risks, the group uses the checklists to make sure nothing is overlooked.

Mr. Regan then realizes that he forgot to invite a permitting expert, which is why risks in this area have been overlooked. After consulting two permitting experts that are familiar with the project, additional risks are added to the risk register.

Furthermore, Mr. Regan concludes that there was a great deal of attention paid to construction risks, but less focus on maintenance. This happened because maintenance occurs after completion, and therefore, fell through the cracks because the group was not paying close enough attention to all phases of the project. With the help of the checklist, the risk register is completed.

A list of randomly chosen risks excerpted from the preliminary risk register is provided below:

	<b>Risk</b>
14	Toll authorization procedure delayed.
15	Governor decides to change scope because of local interests.
16	Cost increase because of rising oil prices.
17	A concrete truck hits a construction worker.
18	Vandalism during operations period.
19	Leakage in excavation for tunnel during construction.
20	Decision makers unavailable during election period.
21	Uncertainty in cost estimates due to preliminary stage of design.

### 3.2.3 Describing different aspects of the risks generates a better overall understanding

A meaningful subordinated step in the identification phase is to create a joint and clear understanding of risks. This can help in avoiding the potential for project stakeholders to miscommunicate and “talk past each other.”

### I-13: The importance of understanding the cause and impact of the risks

One of the participants in the risk identification workshop mentions that there is a risk of unknown ground conditions. The other participants mistakenly thought the discussion was about underground streams. It was only after Ms. Brown asked for further clarification about the causes of this risk that most participants fully grasped that the main risk is the potential of finding explosives buried near a decommissioned military base. Likewise, Ms. Brown asks about the impact, which results in the conclusion that this risk would not only lead to unexpected additional costs, but also to significant delays.

It is important to emphasize that people will understand each other better if they elaborate on both the cause and the impact of potential risks as accurately as possible. To this end, it is helpful to convey a clear understanding by describing the cause of the risk and the consequences of a risk occurring in the easily understood terms of time, money, and quality.

This step not only creates a better common understanding of the risks, but also helps determine whether or not a defined risk belongs within the scope of the risk assessment. Moreover, it assists in optimizing risk allocation and defining risk management measures.

#### **3.2.4 Risk prioritization is a vital element for risk management purposes**

The objective of risk prioritization is to preselect significant risks in order to separate them from insignificant risks. This step can save a great deal of time in the long run, because it prevents undue attention being given to the management of risks that, in actuality, matter very little. The FHWA *Primer on Risk Assessment for P3s* defines this step as a *qualitative risk assessment* and describes a commonly used approach for prioritization. The qualitative risk assessment determines two factors: the likelihood of a risk occurring, and the consequences of it occurring. These factors are assigned the qualitative values of very high, high, medium, low, or very low. These judgments are then entered into a risk impact matrix to determine the risk rating. See Figure 3-4 below for a sample risk analysis guidance chart.

Figure 3-4. Sample Risk Analysis Guidance Chart

			Cost Consequence				
			Greater than 25%	10% to 25%	3% to 10%	1% to 3%	Less than 1%
Scale			5	4	3	2	1
Probability	Greater than 70%	5	Very High	High	High	Medium	Low
	40% to 70%	4	High	High	Medium	Medium	Low
	20% to 40%	3	High	Medium	Medium	Low	Low
	5% to 20%	2	Medium	Medium	Low	Low	Low
	0% to 5%	1	Low	Low	Low	Low	Very Low

Source: Virginia DOT's PPTA Risk Analysis Guidance, September 2011

This prioritization is used to determine whether a risk is negligible, extremely important, or lies somewhere in between. This decision is, of course, variable and the criterion for what passes as “negligible” and what is “extremely important” must be defined on a project-specific basis.

The extent to which a prioritization is relevant depends on the objective of the risk assessment. If the objective is to value risks as part of the development of a financial feasibility analysis or a VfM assessment, prioritization is less relevant. The reasoning for this is that prioritization reduces the number of risks accounted for, but in a VfM analysis and financial feasibility analysis the goal is to value the *full risk profile*, not just a selection of individual risks. However, if the main objective is to manage risks, prioritization can be extremely relevant because it focuses the risk manager’s efforts in the proper direction.

The prioritization method also indicates the value of a risk and is therefore referred to as a *semi-quantitative* assessment. In cases where no detailed pricing information is available, this semi-quantitative assessment can even be used for determining the value of the risks, to be further discussed in chapter 6.

### 3.2.5 Creating structure in the risk overview

Most projects will have a high number of identified risks, and finding order within this list can be extremely challenging. This difficulty is overcome by structuring the risk register in a way that indicates the relationships between the identified risks.

Unfortunately, some traditional listings of risks have no hierarchy or structure whatsoever—just one list with potentially hundreds of risks annotated on it. These lists do not create any useful insights aside from listing the risks but create the potential for double counting, listing redundant risks, and listing risks that occupy different “levels of abstraction.”

As mentioned, some traditional lists may have limited use because the important interrelationships between the risks are not visible to practitioners unless they look very carefully to discover the

connections, a task that can be challenging or almost impossible when there are hundreds of risks present.

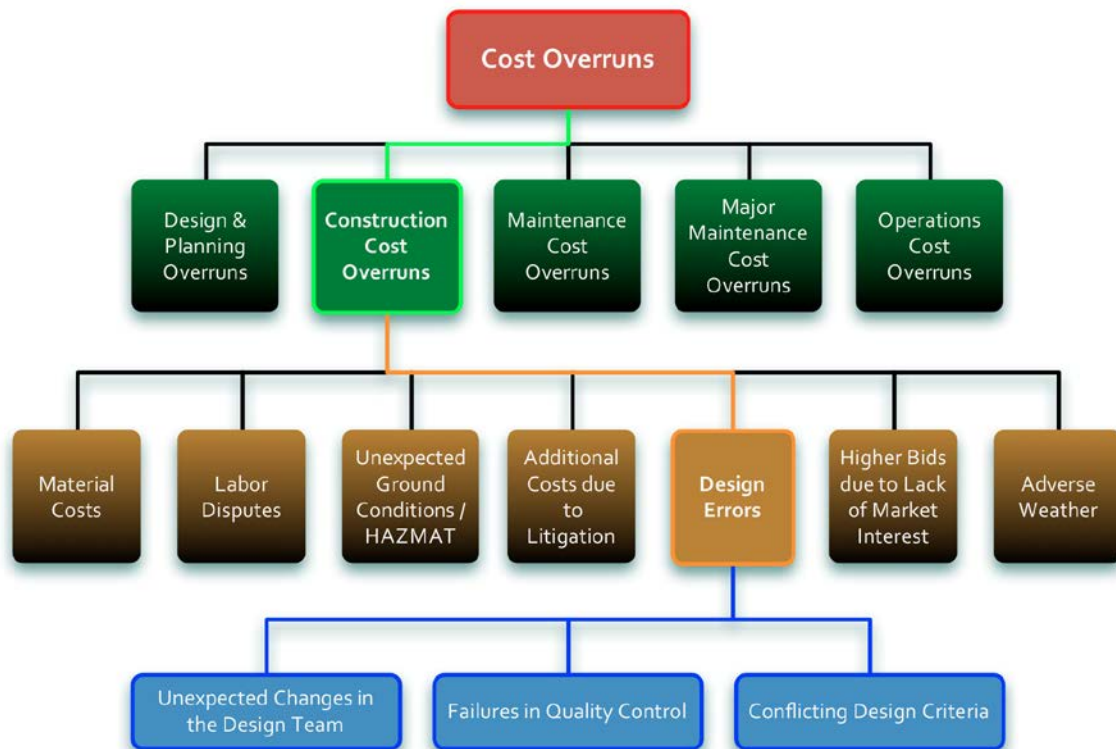
Applying order to this chaos increases the overall understanding of the risk profile of a project and provides the practitioner with better leveraging opportunities for control and measurement. A good way to do this is to establish a **risk relation map (RRM)**. In the RRM, risks are presented with cause-and-effect relationships diagrammed between them, clearly demonstrating their linkages and hierarchy. An RRM allows the structuring of risks based on the project management goals, and defines the top risks as threats to these overall project goals. This step not only creates a better common understanding of the risk profile, but also assists the practitioner in recognizing blind spots. See Figure 3-5 for a sample RRM.

#### I-13: Levels of abstraction of risks

One major risk in the I-13 Project is cost overruns. As Mr. Regan wanted to better understand the underlying risks and causes, he decided to develop a risk relation map (RRM) indicating the causes and effects of all of the underlying risks leading to cost overruns. This RRM clearly shows the multiple layers of risk residing beneath the same top risk—in this case cost overruns.



Figure 3-5. Sample Risk Relation Map (RRM)



#### I-13: Structuring risks top-down to understand linkages and hierarchy

The most important threats to the I-13 Project are delays in completion, budget overruns, poor road quality, and safety issues. Similar to the cost overrun RRM, Mr. Regan suggests structuring RRMs for the other top threats.

### 3.3 Process, timing, information, and expertise needed

Risk identification is most effective when the team conducts multiple risk identification workshops. These workshops should ideally include all of the key participants in order to yield the best results when identifying risks.

**Purpose of the workshop:** The identification of risks is not just a goal in itself. The initiator of a risk identification workshop will ideally define the purpose of the risk identification. Typically, the initiator of the risk assessment is the project manager, the risk manager, or the financial



controller of a project. The person executing the risk assessment should be knowledgeable about risk management and workshop facilitation.

**Timing:** Risk assessment should be continuous. The first risk assessment is carried out in the early stages of a project and is then repeated on a regular basis to continually update risk identification. As the project moves closer to procurement, the risk assessment becomes extensive..

**Information:** A simple risk identification workshop can be carried out with nothing more than paper and pencils. The facilitator asks all of the participants to write down the risks they have identified, focusing on each member's area of expertise. It is important to conduct this exercise before starting a group brainstorming session to avoid the potential problems of tunnel vision and "group think." The facilitator then collects and structures the risks. This process can be repeated, adding new areas on which to focus each time, and concentrating on different project phases or risk categories. After the workshop is completed, the risks are transferred into the risk register.

Supporting material for conducting workshops is available on various State websites..<sup>3</sup> It is also possible to use various software tools during the risk identification workshop. These tools are suitable for the more elaborate risk identification utilized in large and/or highly complex projects. The tools come in either standardized versions, or may be customized for the project upon request of the customer.

The software tools enable participants to add to a web-based list during a round of brainstorming, obviating the need to convene the meeting in person. This makes it possible to include a wider range of participants. Workshops held in this manner can also concentrate on discussing specific risks to enhance common understanding and add risks for identified blind spots. The risk identification tools also automatically produce a risk register.

**Expertise:** As discussed before, it is important to strive for completeness of information. This requires different lines of expertise to be harnessed for the risk identification process. Typically, technical expertise is primarily involved during the early stages of a project. One of the challenges during this phase is to be sure to include financial and legal expertise.

A dynamic risk assessment—with repeated risk identification workshops—will progressively reveal which type of expertise is needed. For instance, if there is revenue risk, it is useful to include a toll specialist to provide more depth to the risk assessment concerning toll revenues.

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<sup>3</sup> See for example, <http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/>

Other examples include tunnel safety experts, geologists for specific ground conditions, environmental experts, and local experts when appropriate.

### 3.4 Output: The identification process produces a risk register

The development of the **risk register**—in spreadsheet or database—is the ultimate outcome of the initial risk identification process. The items in the risk register should be mutually exclusive and exhaustive; there should be no overlaps and/or gaps remaining. Risks can be pooled or categorized related to the goal of the risk assessment (allocation, management, or valuation). The risk register may serve as a checklist for P3 contracts to make sure that all risks are allocated.

After the risk register is created, continual updates should be made throughout the risk management process as the project progresses. When updating the risk register, the practitioner should include: the cause, description, and effect of the risk; the timing of the risk based on project phase; and any information that makes it possible to check for completeness, such as risk category or perspective.

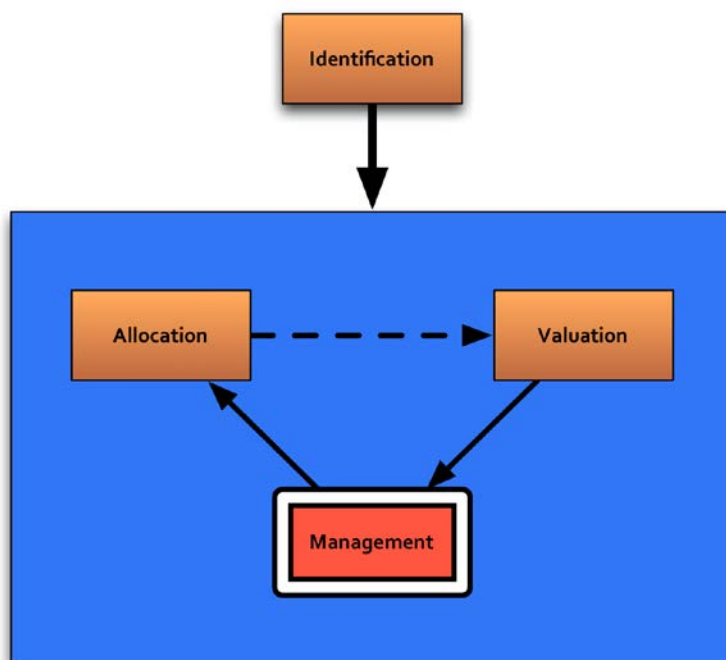
#### I-13: Risk register

Mr. Regan decides to build a risk register in Excel, which he and his team are going to use throughout the project development process. He decides to start with the following fields for all risks:

1. Risk ID number
2. Risk name
3. Risk category
4. Risk description
5. Impact phase
6. Cause(s)
7. Impact(s)
8. Probability level (1-5)
9. Impact level (1-5)
10. Risk management measures
11. Risk allocation
12. Risk valuation method
13. Risk value

## 4 Risk management

Figure 4-1. Risk Management



### 4.1 Purpose and principles of risk response planning

The purpose of risk management (see Figure 4-1) is to minimize the negative effects of risks on project goals. Whereas a valuation produces an expected value of all risks, risk management actively influences risks in order to reduce their value.

### 4.2 Risk management generally focuses on three major steps

#### 4.2.1 The first step is to decide on which risks to manage

The **risk identification** step described in chapter 3 is the first step for risk management. It is useful to structure the risks in risk management according to: (1) the relation to project goals (time, money, quality, or safety); and (2) an indication of value. Ideally the risk valuation outputs are used for the indication of value. If these are not available, it is also possible to use a qualitative indication.

This qualitative indication typically scores all risks on the basis of **probability and effect**, using a five-point scale. Multiplying chance and effect returns a score between 0 and 25 for each risk on

the list. The top 10 (or more) of this list—in terms of total score—provide guidance on which risks to focus on. In addition, it can be useful to scan the list for risks that are managed easily and at a low cost. For risks that are not actively managed, the default strategy is to accept or—depending on the type of P3 contract—transfer the risk to the private party.

#### 4.2.2 The second step is to define risk management measures

Just as risks are identified in a brainstorming session, risk management measures can also be inventoried this way. To challenge practitioners to think creatively about control measures, different perspectives should be used. These different perspectives are:

**Preventive or Corrective:** A preventive measure is one that attempts to decrease the probability of a risk’s occurrence. A corrective measure tries to minimize the damage once the risk has already occurred. These two types of measures are often complementary. If a preventive measure is not 100 percent effective, then a corrective measure should also be defined.

**Differentiate types of control measures—allocate, avoid, adapt, accept:** Allocation of risks in terms of P3 contracts, such as between a public and private party, is covered in the next chapter. There are other forms of allocation, such as insurance of risks or specific financial products that cover price or interest rate risk (futures, forwards, interest rate swaps, etc.). The art of avoiding and adapting risks is related to optimizing the scope of the project and the planning process. Typical measures for this include avoiding innovation and complexity if the benefit does not outweigh the cost, choosing a realistic delivery date, or planning crucial building activities during the summer so there is less risk of weather-related delays. Another possibility is to just accept the risk. This is rational when the cost of the control measure outweighs the value of the risk, or when there is no other measure available. If a risk is accepted, then it is logical to include the potential impact as a buffer in project planning (risk of delay) or in the financial model (risk of additional cost).

##### **Textbox 2: Project adaption as a mitigation measure (or real options in construction)**

“Adaptation” refers to the potential to change, in order to be prepared for changing circumstances. One documented application of adaptation to a transportation project is described by Gesner and Jardim (1988)<sup>1</sup> and considers the Tagus River Bridge in Lisbon, Portugal. The original design of the bridge, constructed in 1966, constituted of a single deck four-lane road. In the original construction future expansion was made possible by utilizing a stronger-than-necessary structure. In 1993, traffic rates had increased to the point where it was attractive to exercise the option to expand. The bridge was expanded with two road lanes and a railroad deck.

Adaptation as a mitigation measure will typically be very project specific. However, there are some general steps that can be followed:

1. Identify the main risks that might require scope changes (demand risk, interaction

- with other projects such as urban development, parallel or crossing infrastructure).
2. Identify the consequences if the project is not flexible in adapting to these risks.
  3. Develop design or scope alternatives that allow for adaptation to the risk. General categories are:
    - a. Growth option: Phased development; for instance constructing a 4-lane road now, while reserving land and designing growth options for future expansion.
    - b. Timing option: Delay the project until crucial information becomes available.
    - c. Switching option: An example is developing a bus transit lane now, but designing the infrastructure in such a way that scaling up to light rail in the future is possible.
  4. Evaluate whether the cost of the option (for instance constructing a stronger bridge) is worth the potential benefits (risk reduction).

### 4.2.3 The third step is to select and implement risk management strategies

In this final step, the best risk management measures are selected and combined in a risk management strategy. Step two provided a long list of risk management measures to choose from. For a single risk, a set of measures can be selected that form an effective and efficient risk management strategy in combination with one another. Development of the best strategy not only takes into account the effectiveness and cost of implementing individual risk measures, but also considers effectiveness of the combination of risk measures (and to what extent the probability or the impact is mitigated).

## 4.3 Process, timing, information, and expertise needed

Just as for risk identification, conducting multiple risk control measure identification workshops with key participants is the most effective way to identify risk management measures.

**Purpose:** Identify or update the risk management measures. Typically, the initiator of the risk assessment is the project manager, the risk manager, or the financial controller of a project. The person executing the risk assessment should be knowledgeable about risk management and workshop facilitation.

**Timing:** Ideally, risk management is a dynamic process. The first risk assessment is carried out in the early stages of a project and is then repeated on a regular basis to continually update the risk

identification. The execution of risk management is usually most intense during the construction phase of the project.

**Information:** A simple risk control measure identification workshop can be carried out with nothing more than paper and pencils. The workshop takes a three-step approach, in line with the methodology. First, the facilitator asks all of the participants to write down the risk control measures for several of the risks on the list. It is important to conduct this exercise before starting a group brainstorming to avoid the potential problems of tunnel vision and group think. The facilitator then collects the risk control measures. This is very similar to the risk identification workshop as described above.

Second, the group can discuss which control measures are considered most efficient. Third, implementation actions are added to each combination of risk and control measures. These actions include the person responsible for implementation, the timing of the control measure, and the status of the control measure. After the workshop is completed, the risk control measures and implementation variables are transferred into the risk register.

As discussed previously, it is also possible to use various software tools during the risk management workshop. These can be very useful for more elaborate risk management in large and/or highly complex projects. The tools come in either standardized versions, or may be customized for the project upon request of the customer.

After the timing and responsible people are added into this risk register—including all contact information—the risk register can serve as a tool to manage the implementation of risk mitigation measures.

**Expertise:** It is useful to include professionals with different types of expertise because it will lead to more variety in the control measures. The same rules for selection of participants apply as for the risk identification workshops discussed in chapter 3.

#### 4.4 Output: Risk management updates of the risk register

The update of the **risk register** is the practical outcome of the risk management process. Each priority risk now includes information for the control measures.

When building the risk register, each control measure will ideally include:

- ▶ Timing of control measure—this can be different from the timing of the risk
- ▶ Responsible person(s) for executing the control measure
- ▶ Where the control measure is implemented

► Status of the control measure (none, planned, executed)

I-13: Each manageable risk is matched with one or more risk control measure.

The workshop results in identification of control measures for each risk. Those identified for Risks 14-21 are listed below.

	<b>Risk</b>	<b>Control measure</b>
14	Toll authorization procedure delayed.	Avoid risk by optimizing planning: start as early as possible with procedures to mitigate the effects of delays in procedures.
15	Governor decides to change scope because of local interests.	Gain early agreement with local governments to prevent unexpected demands.
16	Costs increase because of rising oil prices.	Buy a hedging product.
17	A concrete truck hits a construction worker.	Preventive strategy: Prepare a construction traffic control safety plan and educate workers to reduce the likelihood of construction accidents. Accept (remaining) risk and include a reserve for the insurance premium in project cost.
18	Vandalism during operational period.	Preventive strategy: the highway is secured with measures to discourage vandalism. Corrective strategy: clean up as soon as possible after vandalism incident. Include cleaning costs in project cost.
19	Leakage in building excavation for tunnel during construction.	Preventive strategy: choose design and construction methods to avoid occurrence of leakage as much as possible. Accept (remaining) risk and include a reserve for insurance premium in project cost.
20	Decision makers unavailable during election period.	Preventive strategy: Risk is avoided by planning important decision-making meetings outside of the election period, optimizing planning. Corrective strategy: Project team flexibility after occurrence to speed up the process to make up for lost time. Accept (remaining) risk as an unavoidable delay in the project.
21	Uncertainty in cost estimates due to preliminary stage of design.	Include an allowance in cost estimates, based on a probability analysis. Adjust this estimate as the design becomes more detailed.

Specific risk measures are also documented in plans, such as in the contract, financial model, project planning, and insurance policy. It is important to control and update the status of risks and add new risks as they arise. After the risk register is completed, it should be continually updated



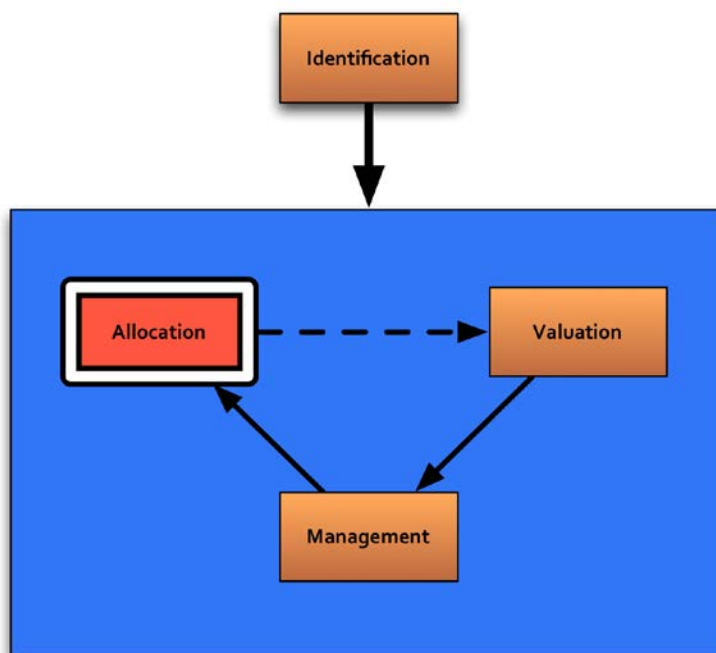
throughout the risk management process as the project progresses. In addition, management of the overall risk control strategy is facilitated by regular reports on the most prominent risks.

#### I-13: A review of the risk register is performed during the procurement process

The VfM assessment that was carried out by the team reveals that a P3 toll concession is the favorable option. Procurement is about to start. After intense discussions with an environmental group, an agreement is reached. The agreement provides that the group will abstain from any demonstrations on the construction site in return for including specific environmental mitigation measures that exceed the requirements in the environmental impact statement. This changes the risk register entry. In order to prepare the bidders with the latest risk register for the tender documents, the risk register is updated.

## 5 Risk Allocation

Figure 5-1. Risk Allocation



### 5.1 Purpose and principles of risk allocation

Risk allocation (see Figure 5-1) between the public agency and private sector entity is one of the core principles of P3s. International and domestic studies show that the transfer of risk accounts for a large portion of the total forecasted VfM of the P3 approach. Therefore, the purpose of risk allocation as part of a risk assessment is to optimize this risk transfer from the public agency to the private sector.

### 5.2 Several tips and tools for good risk allocation include using VfM as a guiding principle, assessing manageability per actor, and additional criteria

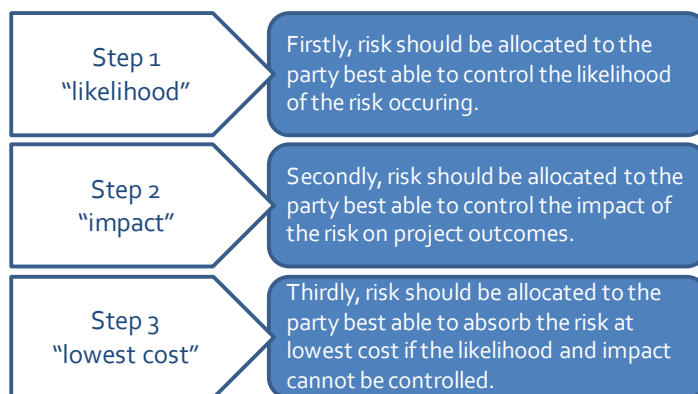
### 5.2.1 The guiding principle for an optimal risk allocation is VfM

A generally accepted principle is that risk should be allocated on the basis of both the *ability* and *willingness* of different entities to manage each risk. Risks that the private sector is more capable of managing are transferred; risks that the public agency is more capable of managing are retained.

Transferring too much risk to the private sector will result in higher risk premiums, making the project more costly and decreasing VfM. Public agencies that are starting to explore the potential of P3s for the first time may make the mistake of trying to transfer too much risk to the private sector. Conversely, transferring too little risk to the private sector constrains the magnitude of the VfM that can be achieved. .

The P3 reference guide of the World Bank’s *Public-Private Infrastructure Advisory Facility* (PPIAF) summarizes the risk allocation principles in three steps as seen below in Figure 5-2:<sup>4</sup>

**Figure 5-2. Risk Allocation Principles**



<sup>4</sup> PPIAF. *Public Private Partnership Reference Guide*. 2012.

<http://wbi.worldbank.org/wbi/news/2012/04/10/now-available-public-private-partnerships-reference-guide-version-10>

## 5.2.2 Risk allocation is also about marketability and incentives

A successful P3 is not just about the party that is best able to manage the risk, but also:

- ▶ **An assessment of marketability for sponsors, subcontractors, and financial institutions:** Continuous discussions between the procurement agency on the one hand, and concessionaire, subcontractors, and financial institutions on the other hand will help structure a risk allocation that is both workable and optimal for the creation of maximum VfM. The outcome depends heavily on the private sector's risk appetite; this willingness to accept risks can change over time due to better information on risks.
- ▶ **Structuring of incentives:** Even if it is clear that the private sector is not able to control a certain risk (e.g., vandalism) it may still create VfM if part of that risk is transferred by letting the contractor share in the cost consequences of such an event. Whereas the contractor may not be able to fully control the probability of the event happening, it can take risk mitigation measures to reduce the probability of the occurrence and can also influence the potential damage by designing vandalism proof assets to reduce the costs of repair. Providing these incentives aligns the interests of the private sector bidders with those of the public agency to minimize the negative financial effects of external risks.
- ▶ **Ensuring a holistic approach that limits exceptions:** The starting point for a P3 contract is that the private operator is responsible for all tasks and risks, unless the contract states differently. If the contract is laden with exceptions with regard to what the private operator is responsible for, “gray areas” are introduced that can cause large transaction costs. An example of this is exceptions in maintenance responsibility due to weather circumstances. This is not efficient and can seriously harm VfM, only becoming visible after financial close.

## 5.2.3 Key questions to be answered

Deciding which risks to allocate to which party brings up a number of questions that must be answered from the perspective of both the public agency and the private entity. For instance, it is important for the practitioner to ask: “To what extent can the public agency...

- ▶ Manage the likelihood of this risk occurring?
- ▶ Manage the impact of this risk?
- ▶ Absorb the impact of the risk?
- ▶ Take specific measures to manage the risk?”

Naturally, the same questions must be asked concerning the ability of the private entity in a P3 procurement. The information above allows the most important question of all in risk allocation to be answered: “Who is best able to manage and absorb this risk?”

In addition to the above considerations, checks should be made to answer the following:

- ▶ **Similar contracts:** Are there specific reasons to deviate from the risk allocation chosen in earlier transactions and described in the model P3 contracts?
- ▶ **Marketability:** Are there any reasons to assume that the private sector will not accept the risk or price the risk at an unreasonably high value?
- ▶ **Incentives:** Do any of the potential risk allocation mechanisms create unintended incentives for the private sector?
- ▶ **Holistic approach:** Do any of the potential risk allocation mechanisms create “gray areas” in terms of responsibility?

I-13: The risk should be allocated to the party best able to control it.

The team develops proposals for allocation of risks. The allocation proposals for risks 14-21 are shown below.

	<b>Risk</b>	<b>Allocation</b>
14	Toll authorization procedure delayed.	The authorization procedure cannot be controlled by the contractor. The contractor can, to a certain extent, control the consequences (by preventing variable operational cost of toll operations whenever there is no toll revenue collection), which is why <b>a sharing mechanism</b> is applied in the P3 agreement
15	The Governor decides to change the scope because of local interests.	The risk cannot be managed by the private party at all and would be expensively priced if transferred, which is why <b>PDOT</b> retains this risk.
16	Costs increase because of rising oil prices.	The private party procures material in large quantities and is experienced in using hedges to mitigate cost increases. Therefore, the risk is transferred to the <b>private party</b> .
17	A concrete truck hits a construction worker.	The risk is related to the construction site. This is managed best by the <b>private party</b> .
18	Vandalism during operational period.	The private company can decrease the probability of this risk by implementing anti-vandalism measures. The risk is transferred to the <b>private party</b> .
19	Leakage in excavation for tunnel during construction.	The private party can influence the probability of the event by following all plans and procedures in this circumstance. Furthermore, they can mitigate the damage by applying measures to stop the leakage quickly. The risk is transferred to the <b>private party</b> .
20	Decision makers are unavailable during an election period.	The public party is responsible for the planning and the availability of its staff. The risk is retained by the <b>public agency</b> .
21	Uncertainty in cost estimates due to preliminary stage of design.	This risk can be transferred to the <b>private party</b> , because it is experienced at dealing with this.

### 5.3 Process, timing, information, and expertise needed

**Process:** Risk allocation is at the core of the structuring of any delivery method, and requires transaction experience and market knowledge. To a large extent the allocation determines the success of a contract and the VfM expected and achieved, and this is why risk allocation is an extremely important step in any P3 preparation process. The purpose of this step is not only to define the risk allocation, but also to develop the mechanisms to refine the risk allocation. An example of this is defining compensation events in the P3 agreement and also developing payment mechanisms. The financial and legal teams typically execute this because it requires both distinct disciplines.

**Timing:** The initial risk allocation has to be determined before the drafting of the P3 agreement is completed. In practice, the process of drafting the agreement often triggers discussions on risk allocation, and this can be facilitated by a sound risk assessment.

**Information:** Optimal risk allocation in a P3 is by definition project-specific and evolves over time. At the same time, 95% of the risk allocation should be similar to other projects based on the same delivery method. In order to avoid “reinventing the wheel,” a good starting point is to look at earlier transactions to understand the considerations in the risk allocation. Optimal risk allocation in a P3 evolves over time; therefore it is advised to look at more recent and up-to-date contracts.

Defining the optimal risk allocation can be quite challenging. In a risk allocation workshop, participants are asked to jointly answer the key questions as described in section 5.2.3. There is no need to do this individually, but it is more important to jointly determine a convincing argument for a risk allocation for each of the risks. In some instances, the VfM assessment not only proves helpful for the allocation of individual risks, but more importantly for maintaining the focus on VfM as the leading principle throughout the project’s development.

The next step is to define the mechanisms reflecting this risk allocation. Most mechanisms—like the definition of, and compensation for, supervening events—are standard, and have been used in most prior P3 transactions. However, project-specific considerations may lead to adjustments in these mechanisms.

**Expertise:** As in all other steps in risk assessment, risk allocation requires input from a range of disciplines:

- ▶ Technical, environmental, permitting, and traffic and revenue experts to determine the risk measures and manageability by risk type.
- ▶ Costing experts, to determine the costs of risk mitigation measures.
- ▶ Insurance experts, to determine insurability of certain risks (facilitating risk transfer to the private sector).
- ▶ Legal experts, to provide the risk allocation framework to be defined in the P3 agreement.
- ▶ Finance experts, to determine the marketability of certain risks.

Preferably these experts have also been involved in project risk identification to ensure that everyone present has a good understanding of the specific risks.



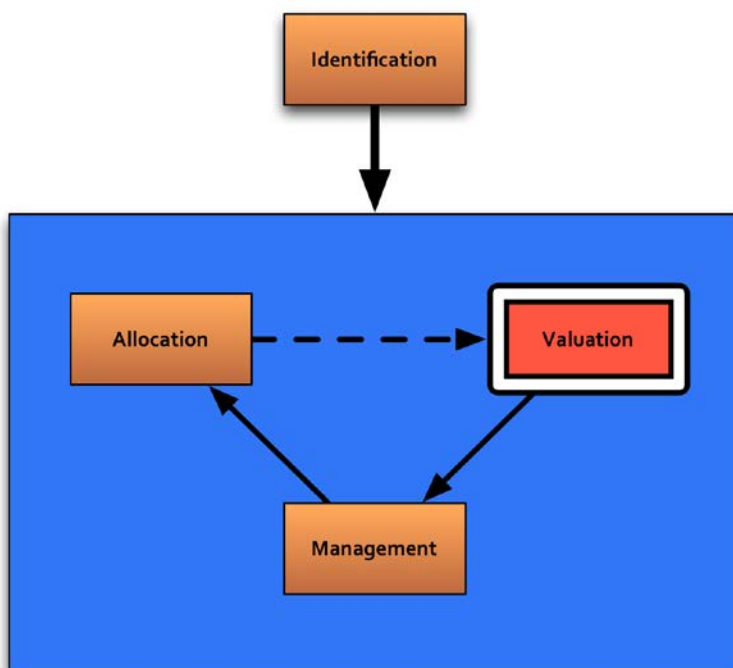
#### 5.4 Output: Optimal risk allocation

The output of this process is an **optimal risk allocation** to be included in the P3 agreement, and the reflection of the risk allocation—and retained risks—in the PSC and the shadow bid. The outcome of the analysis can be used in the VfM assessment to assist in choosing the optimal delivery method.



## 6 Risk valuation

Figure 6-1. Risk Valuation



### 6.1 The purpose of risk valuation

The purpose of risk valuation is to obtain an accurate value of the risks of the project in order to make well-informed financial decisions. Proper risk valuation is essential for determining the project's financial feasibility ("go or no-go" decision), and for comparing different delivery methods. Risk valuation also offers a quantified basis for choices on the best risk management strategy and risk allocation. In reverse, choices on the risk management strategy and risk allocation affect the expected value of risks (see Figure 6-1). This cyclical nature of optimization drives a risk valuation that is an iterative process utilizing new information when it becomes available.

Risk valuation is also one of the inputs for the VfM assessment. FHWA's VfM Assessment Guidebook describes how to make adjustments for differences in risk valuation between delivery methods.

## 6.2 Key tips and tools to conduct a good risk valuation include a categorization based on valuation methods, a bottom-up and top-down approach, and use of several valuation methods

### 6.2.1 Risk categorization as a stepping stone to valuation

The risk categorizations as discussed in chapter 3 and depicted in Figure 6-2 below are intended to facilitate risk identification based on the nature of the project, the different stages of the project, and different disciplines and perspectives. These categorizations can lead to long lists of risks. In general, guidance on risk valuation focuses on applying the commonly utilized **probability x impact** approach to all or part of these risks. This guidebook starts from the assumption that different categories of risks require different valuation methods, and that the simultaneous use of more than one valuation approach can increase the reliability of information.

The first relevant distinction is between **exogenous** and **endogenous risks**. Exogenous risks are caused by external events. An accident at a construction site is an example of an exogenous risk. Endogenous risks are caused by the project stakeholders themselves; the decision to change the design of the project is an example of an endogenous risk. From the perspective of valuation, this is a useful distinction because endogenous risks are not part of the risk valuation, but are rather choices made that can affect costs.

**Figure 6-2. Risk Categorization**


The second distinction is between **risks before contract close** and **risks after contract close**. The distinction between these categories is tied to the point at which the effective risk transfer begins and the public agency commits to the project and the contract. Typically, during the development and procurement of a project the people involved will be able to identify many risks before contract close because these often occur in the short term. Therefore the long-list of risks will include many of these risks, which typically will not need to be valued. From the perspective of valuation, this is a useful distinction because risks before contract close are typically not part of the risk valuation but still require effective risk management.

A third distinction is between **systematic** and **non-systematic uncertainties**. Systematic uncertainties are risks that are related to changes in the economic climate. Examples are inflation, interest rate, and revenue risk for toll projects. These risks are, by definition, not manageable by a single actor but can be diversified in a portfolio strategy. Non-systematic uncertainties are not related to economic conditions and are considered to be manageable to some extent through risk management (either of risk occurrence or undesirable outcome). Examples of this are accidents at the construction site or adverse weather impacts. Natural disasters also fall under this category.

Apart from the fact that there are different methods for risk valuation for each respective category, this distinction also helps in placing risk with the partner best able to manage or minimize the impact of the risk.

In the non-systematic uncertainty category distinctions are made between:

1. **Pure risks:** unforeseen uncertain events, resulting in some sort of damage; and,
2. **Regular uncertainties:** uncertainties that are not related to market conditions, but are directly caused by a lack of information during, for example, the preliminary design stage of a project.

Table 6-1. offers a categorization that can assist in selecting the valuation method.

**Table 6-1. Risk Categories Linked to Valuation Method**

	<b>Category</b>	<b>Example</b>	<b>Description</b>
1.	Decision uncertainties	Change in toll technology	Uncertainties affecting the project (scope) and caused by the project stakeholders themselves
2.	Risks before contract close	Delay in go decision on project due to elections	Potential project-related events with a chance of occurrence and a negative impact; mainly present before the project starts
3.	Systematic uncertainties	Inflation risk	Uncertainties in cost, revenue, and risk estimates; related to market circumstances
4.	Pure Risks	Accident at construction site	Potential project-related events with a chance of occurrence and a negative impact (a loss, catastrophe, or other undesirable outcome), leading to an expected valuation
5.	Regular uncertainties	Uncertainty in volume of asphalt	Uncertainties in cost, revenue, and risk estimates, not related to market circumstances but instead to intrinsic lack of certainty

### 6.2.2 A top-down approach to complement the risk valuation

As was mentioned in the previous chapters, a P3 transfers risks normally retained by the public agency in the conventional delivery method to private parties. Unfortunately these risks are not always easy to identify and value. They include risks associated with long-term quality (related to the performance regime) and interfaces between project elements (road sections, crossings, arterials, and exits) and project phases (design, construction, maintenance, and operations). If the goal of the risk assessment is to determine the project's feasibility or to compare delivery methods, it is important to include all of these risks in the analysis as well.

A recent guidebook on risk assessment tools by the Transportation Research Board (TRB)<sup>5</sup> describes the following issues relating to unidentified risks:

At any stage in the development of a project, cost estimates will be composed of three components for which there are differing amounts of information: 1) known and quantifiable costs; 2) known but not quantified costs; and 3) costs that are unknown and therefore cannot be quantified in advance. The base estimate includes the known and quantifiable costs. The contingency percentage is intended to include both the known but not quantified and the unknown costs.

A focus on identified risks—and not on unidentified risks—will invariably lead to project cost overruns. Also, these unknown risks distort the fairness of VfM assessments, because private-sector bids include a valuation of all transferred risks, but the public sector comparator (PSC) may not.

A way of dealing with “unknown-unknowns” is to utilize both a bottom-up and a top-down approach to risk identification and valuation. Most risk assessment methods are bottom-up approaches, because they focus on identifying and quantitatively assessing individual risks. A top-down approach focuses on the risk profile of the project as a whole, on the basis of a number of project characteristics. Appendix 4 provides an example of a simple tool to assess the overall risk profile of a project.

### **6.2.3 Several risk valuation methods can be used simultaneously**

In some cases, a detailed quantitative risk assessment may not be meaningful. This occurs when a risk assessment is carried out in the very early stages of project development, when little quantifiable information about the project is available. In addition, when considering small and simple projects a detailed quantitative risk assessment may be unnecessary. In these cases, a qualitative top-down analysis—resulting in a quantitative assessment of the risk profile of the project as a whole—is sufficient.

In most cases a quantitative risk assessment is meaningful and necessary. Table 6-2. presents the most commonly used valuation methods for the different categories of risk.

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<sup>5</sup> Transportation Research Board. Guidebook on Risk Analysis Tools and Management Practices to Control Transportation Project Costs. National Cooperative Highway Research Program (NCHRP) Report 658. June 2010.

**Table 6-2. Risk Categories and Valuation Methods**

Category	Valuation Method
1. Decision uncertainties	<ul style="list-style-type: none"> <li>No valuation, just multiple scenario analysis</li> </ul>
2. Risks before contract close	<ul style="list-style-type: none"> <li>No valuation, just multiple scenario analysis</li> </ul>
3. Systematic uncertainties	<ul style="list-style-type: none"> <li>Beta analysis on the basis of the capital asset pricing model (CAPM)<sup>6</sup></li> <li>Probability distribution (Monte Carlo analysis) and realistic confidence level on market related cost and revenue estimates</li> <li>Market-based risk premium in the discount rate on the basis of the weighted average cost of capital (WACC)</li> </ul>
4. Pure risks	<ul style="list-style-type: none"> <li>Probability x damage</li> <li>Typical contingency in cost estimate</li> <li>Probability distribution (Monte Carlo analysis) and realistic confidence level on pure risks</li> <li>Insurance premiums</li> <li>Cost estimate of risk mitigation measures</li> <li>Market-based markup for risk profile</li> </ul>
5. Regular uncertainties	<ul style="list-style-type: none"> <li>Probability distribution (Monte Carlo analysis) and realistic confidence level on cost and revenue estimates</li> <li>Typical allowance in cost estimate</li> <li>Market-based markup for uncertainties</li> </ul>

Whereas the risks and uncertainties in the first two categories will not be valued, the acknowledgement of these categories is very relevant, because it facilitates the distinction between risks that matter and risks that do not matter in the overall risk register. In the following sections the focus will be on the last three categories.

Note that cost estimates typically include contingencies (covering pure risks) and allowances (covering regular uncertainties). In a VfM assessment the starting point is a raw PSC, based on cost estimates without any contingencies and allowances. This also helps prevent double counting of risks and uncertainties. Of course, the estimated contingencies and allowances can be an important source of information for risk valuation. Typically, the contingencies and allowances focus on construction, which is why one should verify to what extent these values are realistic reflections of all of the risks and uncertainties throughout the life cycle of the project.

<sup>6</sup> See Appendix 2 for further discussion on the Capital Asset Pricing Model.

### I-13: Risks are categorized in order to prepare valuation

Mr. Regan had initially used a top-down general risk valuation per category. Due to the characteristics of the project (brownfield, mono-functional, toll) the initial values were chosen as follows:

- ▶ Decision uncertainties: no valuation
- ▶ Regular uncertainties: bandwidth of 30% on cost estimates
- ▶ Pure risks: contingency allowance of 15% on cost estimates
- ▶ Discount rate: 4% risk-free rate plus 5% risk premium to account for systematic uncertainties

However, now that the risk register has been developed, the risk manager wants to build a parallel bottom-up valuation of all risks. He starts by categorizing all the risks in the register. The results for risks 14-21 are provided below.

	<b>Risk</b>	<b>Category</b>
14	Toll authorization procedure delayed.	Decision uncertainty
15	Governor decides to change scope because of local interests.	Decision uncertainty
16	Cost increase because of rising oil prices.	Systematic uncertainty
17	A concrete truck hits a construction worker.	Pure risk
18	Vandalism during operations period.	Pure risk
19	Leakage in excavation for tunnel during construction.	Pure risk
20	Decision makers unavailable during election period.	Decision uncertainty
21	Uncertainty in cost estimates due to preliminary stage of design.	Regular uncertainty

For each risk, a valuation method is determined. The results are shown below for risks 14-21.

	<b>Risk</b>	<b>Valuation method</b>
14	Toll authorization procedure delayed.	NA
15	Governor decides to change scope because of local interests.	NA
16	Cost increase because of rising oil prices.	Valuation based on market data (trend and volatility), include in probability analysis
17	A concrete truck hits a construction worker.	Insurance premium
18	Vandalism during operations period.	Probability and frequency of occurrence. Cost of cleaning
19	Leakage in building excavation for tunnel during construction.	Insurance premium
20	Decision makers unavailable during election period.	NA
21	Uncertainty in cost estimates due to preliminary stage of design.	Probability analysis (see appendix 3)

### 6.2.3.1 Systematic uncertainties

Systematic uncertainties can be dealt with in a similar fashion as regular uncertainties, which is not uncommon for toll revenues. Another approach is to reflect the risk profile in the discount rate. The establishment of the appropriate discount rate for a project is covered in appendix 2.

#### I-13: Cost increase related to systematic uncertainty

For the cost increase due to rising oil prices, Mr. Regan uses market data from the U.S. Energy Information Administration (EIA), which publishes the relevant statistics.<sup>7</sup> The site provides data on average price and volatility. These numbers will be used in the probability analysis.

#### I-13: Toll revenue risk

Ms. Brown hires a highly qualified traffic and revenue (T&R) expert to develop robust traffic and revenue forecasts for the I-13 project. She requests that they also develop a probability analysis for the forecast. The probability analysis shows a high uncertainty in project revenues, particularly because this is a managed lanes project. In order to value this risk, Mr. Regan suggests two approaches to valuing the risk:

1. Use the Probability 70 (P70) revenues (which are much lower than the P50—or most likely—revenues) in the net present value (NPV) calculations
2. Use the P50 revenues and a market-based discount rate—based on a benchmark of weighted average costs of capital (WACCs) for similar toll projects—to reflect the risk profile in the NPV calculations

Mr. Regan discovers that the outcomes of both analyses are not exactly the same. After discussing this with the project team, Ms. Brown decides to use the market-based discount rate to reflect the toll revenue risk, mainly because: (1) the team found that the two approaches lead to similar risk values; (2) the team feels there is no reason to price this risk differently from the market price; and (3) this will enable the team to make a fair and easy-to-explain comparison between the PSC and shadow bid.

### 6.2.3.2 Pure risks

The pure risk category is expected to contain the bulk of the risks from the long list in the risk register. Therefore, it is useful to distinguish between top-down methods to deal with the valuation of all risks in this category and bottom-up methods to value individual risks. The methods complement each other.

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<sup>7</sup> [www.eia.gov](http://www.eia.gov)



To get an indication of overall risk valuation, this category can be valued by benchmarking the project with similar projects. This is the same as assuming that the specific risks in this category are still unknown, but that it is expected that some risks will occur, and therefore a financial buffer is to be applied. Usually, this valuation method consists of a percentage of the total direct and indirect investment costs. This percentage can be in the range of 15% to 50% depending upon project characteristics and complexity, and cost estimation methods.

For the detailed (bottom-up) valuation, there are several methods to value each risk. The most important are: calculation of probability multiplied by damage for each risk; use of insurance premiums for individual risks or packages of risks; and cost estimates of risk mitigation measures.

#### I-13: Pure risks and insurance

The team concludes that some risks are typically covered by insurance, such as construction site accidents. Mr. Regan asks an insurance specialist to provide up-to-date quotes for these risks. The insurance will usually cover a bundle of risks and not one specific risk. After gaining this information, the risk register is adjusted accordingly. As soon as the risk is insured, and there is no risk remaining, this risk is considered “managed” and becomes a cost rather than a risk.

### 6.2.3.3 Regular uncertainties

Typically, this risk category includes uncertainty about the volume and price estimates for different cash flows such as capital expenditures, operational costs, and revenues. Estimate uncertainties about the pure risks can also be included in this category.

The typical valuation method is to develop a probability distribution on the basis of expert inputs for minimum, most likely, and maximum values. In addition, the expert will identify the distribution type as normal, lognormal, triangular, uniform, or discrete (which are the most common types). This leads to an overall probability distribution of the net present value (NPV) of all project cash flows together. Depending on the risk appetite of the stakeholder, a certain probability level is then accepted. Selecting probability levels between 70% (P70) and 90% (P90) is common practice. It is generally recommended that P70 be used as a starting point. The difference between the most likely NPV, and the NPV at this probability level, is considered to be the *value* of this risk category. Appendix 3 discusses probability analysis in further detail.

### I-13: Delay risk

Some of the risks in the risk register lead to project delays. The team decides to perform a probability analysis on the project's completion date using these project delay risks. The P50 value turns out to be two months later than the original completion date. The P10 value lies one month before the original completion date, and the P85 is a full 12 months late. The team decides to use the P50 as a new baseline and develops three different methods to value this risk:

- ▶ One month delay = the costs of accelerating the project one month by having construction crews work night shifts; cost estimators develop an increase estimate of **\$300,000**.
- ▶ One month delay = one month additional ongoing construction overhead costs and a loss of one month of toll revenues; T&R experts and construction cost experts value this loss at **\$650,000**.
- ▶ One month delay = social and economic impacts of an additional month of traffic congestion, mainly reflected in travel time gains; these are valued by economists at around **\$1 million** in addition to negative non-quantified effects on the regional airport.

The team decides to use the first valuation method. They use this value to transform the schedule's probability analysis into financial values. The team believes the 10 month difference between P85 and P50 is a fair reflection of the value of this risk, thus valuing it at \$3 million in real terms. The timing of the risk is at the completion date. Escalation of the risk value is the average index for all construction costs.

A risk assessment often focuses on risks that inflict a negative impact, because cost and revenue estimates tend to assume no major drawbacks. In reality, there is a possibility that cost and revenue values may turn out to be better than expected. In the probability analysis this is reflected in the minimum and maximum value for cash flows, leading to overall probability distributions expressing the uncertainty in cash flows. Although the value of that uncertainty is still a negative cash flow, it accounts for the fact that there can also be an upside. (The value of uncertainty is always negative because uncertainty is the potential deviation from expected value<sup>8</sup>). Therefore, in theory, there can also be positive pure risks. If that is the case, these can be dealt with in the same way negative pure risks are dealt with. It is recommended to always check whether any positive risks can be expected.

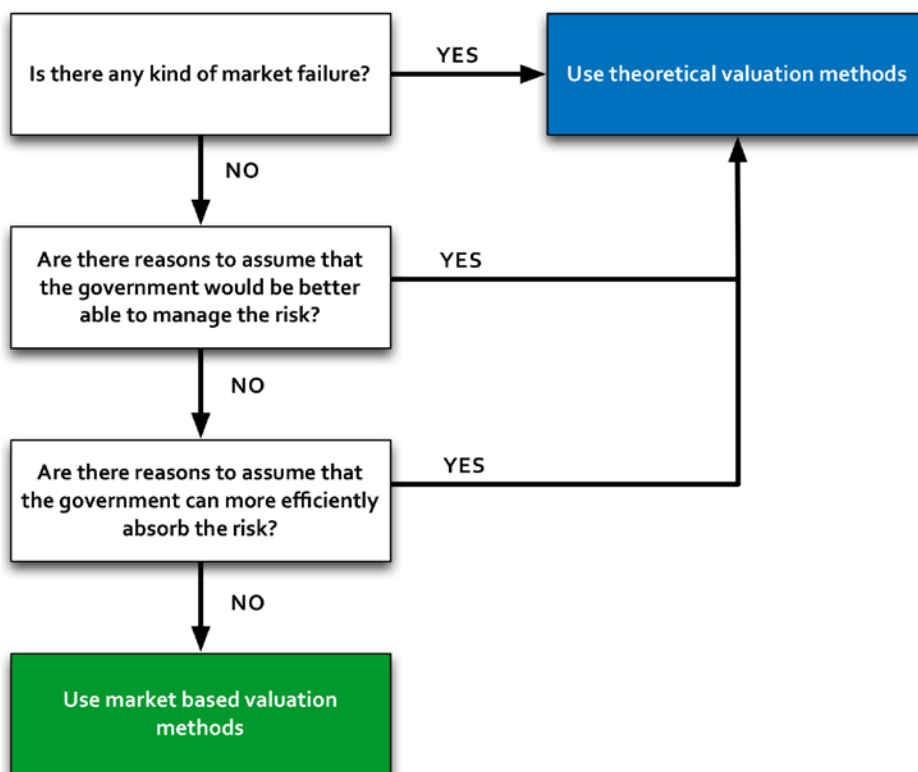
Choosing the proper valuation method may be challenging. To further guide practitioners, the following three principles can be used:

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<sup>8</sup> For example, if you have two choices: (1) a certain amount of \$100,000; or (2) an uncertain amount between \$80,000 and \$120,000 that you would receive based on a normal distribution, you would prefer the first choice. This is why uncertainty has a negative value.

1. Use all information available, and if possible, use different approaches as well to develop the most robust understanding of the risks.
2. Use market prices, unless there is a clear market failure or there are convincing reasons to expect that the government is better able to manage a risk (see Table 6-3. below for further guidance).
3. Benchmark to similar projects; this is an important source of information for the assessment of the risks.

Figure 6-3. Valuation Method Decision Tree



**Textbox 3: Different agencies have different risk tolerances**

Not all agencies value risks in the same way. This risk tolerance needs to be taken into account in the risk valuation. For instance, an agency that owns a large number of buildings might decide to forego buying fire-insurance. This is because the insurance premium could be more expensive for the agency than just accepting the risk of fire and subsequently accounting for the possible costs of damage. If the chances of a fire are 1 in 100 per year and the agency owns 100 buildings, then it is statistically probable that every year one building will suffer from a fire incident. Purchasing insurance might be disadvantageous in this case if it is more expensive to insure 100 buildings due to advisory fees. However, for an agency owning only one building the converse is likely to be true because this agency is not “diversified.” The undiversified agency would place a higher value on the specific risk.

Another example is a company that produces products in Europe, but exports and sells to customers in the United States. This company is exposed to currency risk because it has liabilities in euros and generates revenues in dollars. This is different from a U.S.-based company that sells only to local customers, and thus has no such risk.

In general, the risk tolerance of an agency depends on the total portfolio of projects and its ability to effectively diversify the risks.

### 6.3 Process, timing, information, and expertise needed

Workshops for risk valuation are just as useful as they are during the risk identification phase. They should include experts from each of the major fields of expertise relevant to the project.

**Purpose of the workshops:** Valuation of risks is a crucial element in risk assessment, and has a major effect on financial feasibility and VfM analysis. The risk assessment coordinator must therefore consciously organize a professional project valuation process.

**Timing:** The risk assessment coordinator can convene a workshop for risk valuation or gather input in one-on-one meetings. A workshop has the advantage of better coordination between experts assessing potentially overlapping risk areas and therefore mitigates the possibility of double-counting risks.

**Information:** In the early stage of project development, the risk assessment coordinator may decide that the prioritization assessment is sufficiently thorough. In that case, the question is whether the information is up-to-date and complete. As a rough indication, the median of the bandwidth in each category can be used for the **probability x impact** calculation.

In a risk valuation workshop participants can be asked to individually determine the probability value and impact value, in terms of cost, revenue, and/or schedule. The participants may also define minimum and maximum values of the impact, and a distribution type, on the basis of which a Monte Carlo analysis can be performed with specialized software. Appendix 3 describes how to perform a probability analysis in more detail.

Cost estimation experts may be asked to come up with:

- ▶ Minimum and maximum values and a distribution type for the cost, schedule, and revenue estimates
- ▶ Realistic contingencies and allowances for a project with the specified risk profile
- ▶ An estimate of market-based mark-ups for the risks that are transferred to the private sector on the basis of previous comparable projects

It is important to precisely define the scope of the contingency, allowance, and mark-up estimates to prevent any possibility of double counting.

Insurance experts may be asked to provide market-based insurance premiums. They may also be asked for their expert opinion on market liquidity and whether or not they believe there is any market failure or reason to assume that the insurance premium does not reflect the value of the risk. Here it is also very important to precisely define the scope of the applicable insurance policy, to prevent double counting.

Finance experts may be asked to come up with a reliable indication of the “risk-free” discount rate and a project-specific risk premium. In order to do so, these experts may need to develop a simplified financing model, reflecting both the project characteristics (most importantly construction cost, construction schedule, and repayment schedule) and the expected financing conditions (most importantly financial leverage, debt service coverage ratio, interest rates, and return on equity). A detailed discussion on the determination of the discount rate is addressed in appendix 2, and FHWA’s Value for Money guidebook discusses a method to calculate a “virtual insurance premium” that may be used to represent certain risks in cash flows.

**Expertise:** Since the outcomes of financial feasibility analyses and VfM analyses will be extremely sensitive to the risk valuation, the risk assessment coordinator should involve the best experts available from the following fields: technical experts, cost estimation experts, traffic and revenue experts, insurance experts, and finance experts.

These experts should also be involved in the project risk identification to make sure that everyone has a good understanding of the specific risks.

## 6.4 Output: Risk valuation quantifies and assigns a value to risks

The output of the risk valuation is typically:

- ▶ An expected value of risks based on a Monte Carlo analysis for regular costs and revenues
- ▶ Values of individual risks and aggregate risk profile of the project at a specific confidence level
- ▶ The project-specific discount rate

The risk valuation provides input for the risk management strategy and for the risk allocation. Also, the risk valuation provides input for the VfM assessment. The risk adjustments that are made for the different delivery methods are described in FHWA's VfM Assessment Guidebook.



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## Appendix 2 Determination of the discount rate

### Definition of discount rate

In risk valuation there is a distinction between categories of risk. The discount rate may be used to value systematic uncertainties. This FHWA guidebook on risk assessment offers guidance on how to value the other risk categories as shown in Table A-2-1.

**Table A-2-1. Categories of Risk**

Category	Example	Description
Decision uncertainties	Change in toll technology	Decisions affecting the project (scope)
Risks before contract close	Delay in go decision on project due to elections	Decisions affecting mainly time before the project starts
Systematic uncertainties	Inflation risk	Uncertainties due to market circumstances
Pure risks	Accident at construction site	Potential project-related events with a negative impact
Regular uncertainties	Uncertainty in volume of asphalt	Uncertainties in quantities or prices, related to the level of design of the project

Depending on which theoretical framework is used, the term discount rate can refer to different rates as shown in Table A-2-2:

**Table A-2-2. Discount Rates**

	Excluding inflation	Including inflation
Risk free	Real risk-free rate	Nominal risk-free rate
Including standardized risk premium	Real rate including risk	Nominal rate including risk
Including project-specific risk premium	Real rate including project-specific estimation of systematic risk	Nominal rate including project-specific estimation of systematic risk

The main purpose of the discount rate is to make it possible to compare cash flows over time. To determine the most appropriate discount rate several decisions need to be made:

1. Preference for simplicity and consistency (standardized discount rate) or preference for best possible valuation (project-specific discount rate).

2. Preference for explicit risk valuation of systematic risk (in the numerator through cash flows) or implicit valuation of systemic risk (in the denominator through discount rate).

We note that various countries have guidelines recommending different discount rates for different types of appraisal. For instance:

- ▶ Australia uses a nominal rate including risk for both project appraisal and bid evaluation.
- ▶ The Netherlands uses a real rate including project-specific risk for project appraisal, and a nominal rate including project-specific risk for bid evaluation and VfM analysis.
- ▶ The UK has used a real risk-free rate since 2003 (and a real rate including risk prior to that), arguing that risks should be made transparent in the cash flows of a project.

Discussed below are several approaches to determining the different components of the discount rate. Note that it is almost never possible to derive the “true” project-specific discount rate because it is almost always necessary to use historical or peer group data. The discount rate will always be an educated guess based on available benchmarking information.

#### **Determination of risk-free rate**

From a financial perspective, the risk-free rate is determined by accounting for the most recent market information. The asset that is traded in the markets that best approaches “risk-free” is a Federal government bond. For a standardized discount rate, governments tend to look at long-term historical averages. For instance the Netherlands used a discount rate of 4% (real risk-free rate) until 2008, and then subsequently reset it to 2.5%. We note that in financial markets only the nominal rate is observable, therefore to determine the real rate a correction has to be made for inflation. For instance, if a 15-year government bond has an interest rate of 3.5%, and the average Consumer Price Index (CPI) has been 2% over the last ten years, then the real discount rate would be approximately 1.5%.

The risk-free rate of the project should be determined in relation to the respective financing terms. Overall financing can be sliced into “tranches” with different durations based on the project cash flows. The tranches with early repayment have a shorter duration, which is reflected in the interest rate. In addition, in this case the rate should be the forward expected rate. The rate needs to account for the fact that the first drawdowns will occur after the date of the VfM assessment, therefore forward prices should be used to determine this expected rate. In similar fashion to the pricing of an interest rate swap, blended rates can be determined for all tranches together, facilitating the use of a single discount rate.

Pricing is a complicated exercise, and it is important to consider whether this approach is necessary for the sole purpose of conducting a VfM assessment. During the early stages of the project in particular this is often not the case, and a simpler alternative on the basis of today's rates for the indicative average duration can be used. However, after receipt of the bids, this simpler approach should be abandoned because it may inhibit a fair comparison.

### **Determination of the risk premium using a theoretical approach**

If systematic risk has not been incorporated in the cash flows of a project, then it should be accounted for in the discount rate. Financial theory offers the Capital Asset Pricing Model (CAPM) to determine the relevant risk premium. The CAPM states that each asset has a correlation (beta) to the general market risk ( $r_m$ ). For relatively low-risk assets the beta is below one and for high-risk assets the beta is above one; therefore the beta is used to assess how the market's movements affect the magnitude of the value of an asset's movements. Typically, government projects such as highways are not traded on financial markets. To determine a beta for a specific highway project (or highway projects in general) it is possible to select assets (i.e., companies) that are traded on markets that best reflect the risk profile of the project, deriving a beta for this "peer group" that can be applied to the project.

The alternative to estimating a project-specific premium is to use a shortcut stating that the average beta for all assets is 1 (true by definition) and therefore the standardized risk premium equals the market risk premium. This approach can either lead to an overestimation of risk for low-risk projects—such as building extra capacity for a busy road—or an underestimation of risk for high-risk greenfield or technological innovation projects.

The market risk premium can be estimated or derived from available literature. In this literature, the market risk premium is estimated to be between 3% and 9%.<sup>9</sup> If a specific highway project has a beta of 0.5 (based on benchmark analysis of highway projects) and the average market risk premium is 6%, then the risk premium for this project would be 3%.

### **Determination of the risk premium using market-based information (WACC)**

An alternative way to estimate the risk premium for projects is to look at information from bids on previous similar projects. We can then apply the weighted average cost of capital (WACC) formula to derive the average cost of finance, which is an estimate for the discount rate.

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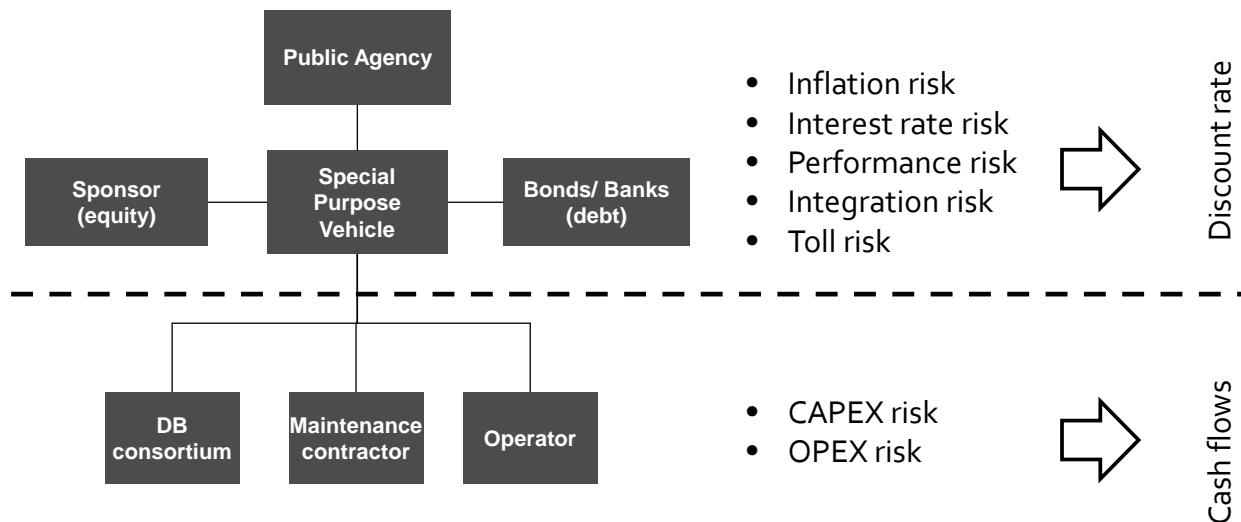
<sup>9</sup> For instance: MorningstarUS, International Cost of Capital Report, Bloomberg, Damadoran  
<http://pages.stern.nyu.edu/~adamodar/>

The Weighted Average Cost of Capital formula is:

$$WACC = (1 - \tau_c) \frac{D}{V} r_d + \frac{E}{V} r_e$$

Where  $\tau_c$  is the tax rate,  $D$  is the total amount of debt,  $V$  is the total amount of financing,  $r_d$  is the interest rate on debt,  $E$  is the total amount of equity, and  $r_e$  is the return on equity. Bids from similar projects can provide clues as to the value of all of these variables, although typically this information is confidential.

In a P3 approach, a substantial portion of the risk profile is reflected in the WACC. The pricing follows the organizational structure of a P3 special purpose vehicle (SPV). Most of the risks are typically subcontracted and therefore shown in the cash flows in the bid. Some of the risks are explicitly or implicitly retained by the SPV (for example through caps on liabilities in subcontracts). These are not only typical systematic risk categories (for example inflation, interest rate, and toll risk) but also risk categories that are associated with the long-term and integrated characteristics of the contract (long-term performance risk and project coordination risks). This needs to be carefully taken into consideration to avoid double-counting, and for consistency when comparing the PSC and shadow bid/actual bid. For instance, if the cash flows of a project include an interest rate swap, transferring the variable interest rate risk to a swap counterpart will result in higher cash flows, because the interest rate will now include a premium for the swap transaction. The interest rate risk is now valued in the cash flows and should no longer be reflected in the discount rate.

**Figure A-2-1. P3 Organizational Structure**


The Figure A-2-1 shows that depending on the risk allocation, some systematic risk may be valued through the discount rate and some risk may be valued in the cash flows. For the cash flows a probability analysis based on Monte Carlo analysis may be used for risk valuation. Since risks are not valued in both the discount rate and the cash flows, the confidence level chosen for the probability analysis is not related to the risk premium in the discount rate.

Combined with the previous (theoretical) method this gives two estimates, which together yield a range of possible discount rates.

## Appendix 3 Quantitative risk analysis

### Purpose of quantitative risk analysis

Quantitative risk analysis can be used to determine the value for the risk categories: pure risk and regular uncertainties. There are two main methods for performing such an analysis:

1. Deterministic analysis (formula based)
2. Probabilistic analysis (simulation based)

### Deterministic analysis

Deterministic analysis produces a single value for risks, which is expected to be the most likely. To do a deterministic analysis, the following steps are taken:

1. Determine a probability of occurrence for each risk.
2. Determine an impact level (minimum, maximum, and most likely).
3. Calculate the value of each risk by using a formula, e.g.:

$$\text{Risk value} = \text{Probability} \times (\text{minimum} + \text{maximum} + 4 \times \text{most likely}) / 6.$$

4. Add all individual values and add a percentage for unknown risks.
5. Perform sensitivity analysis by changing critical assumptions to gain insight into the possible spread of the total risk value.

### Probabilistic analysis

Probabilistic analysis produces a risk spread including a confidence level. This outcome is more difficult to interpret, and the single value the deterministic analysis produces is much more straightforward. However, the real value of the risks will in practice almost always be different from the single value. Therefore, the probabilistic analysis produces a more accurate outcome, and requires more expertise. There are software programs available to run a probabilistic analysis.

To do a probabilistic analysis, the following steps are taken:

1. Select risk probability and a distribution type for impact of each risk, for instance normal, lognormal, triangular, uniform or discrete.

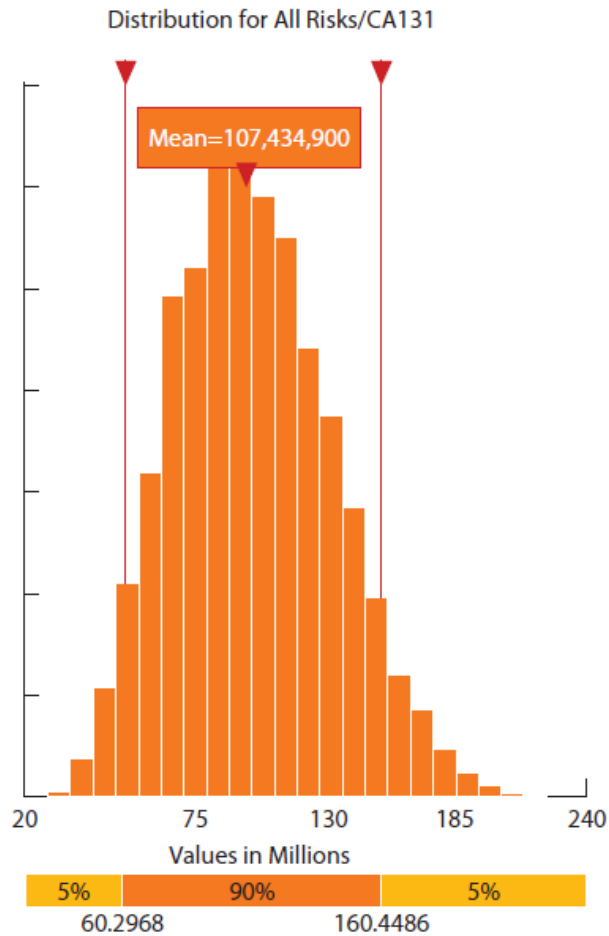


2. Determine the impact levels (depending on distribution type): most likely, minimum, maximum, or mean, and standard deviation. For risks having both upside and downside, these can include both positive and negative values.
3. Determine correlations between risks.
4. Run simulation by using risk software.
5. Determine confidence levels for risk valuation.

Risks may be interrelated. Risks can be dependent inclusive (the subordinate risk will only occur if the dominant risks occurs), or exclusive (the subordinate risk will not occur if the dominant risks occurs), or unrelated. Risks can also be correlated. This correlation can either be positive, negative, or zero. The standard assumption is that risks are not dependent or correlated. For more extensive analysis, the inter-relations can be indicated for each specific risk.

The simulation may include as many as 1000 or more different runs. In each run, the program randomly chooses where each risk will be on the distribution. Therefore, each run produces a different outcome. The result of the simulation is a summary of all these runs, which is a distribution, as shown in figure A-3-1 below.

**Figure A-3-1. Sample Distribution**



Source: Virginia DOT's PPTA Risk Analysis Guidance, September 2011.

The distribution shows the spread of the risk value. The mean value in the graph is 107 million dollars, however, the value may vary between 60 and 160 million. It is now up to the public entity to choose an acceptable confidence level. To be safe, it may choose a 95% confidence level which means that only for 5% of the time, the actual value of risks will be higher. Another option is to assume the mean value, which means that 50% of the time the actual value will be higher.

## Appendix 4 Top-down approach for risk valuation

Most risk assessment methods are bottom-up approaches, because they focus on identifying and quantitatively assessing individual risks. A top-down approach is focused on the risk profile of the project as a whole on the basis of a number of risk-related project characteristics.

A sample checklist for such a top-down approach is shown in table A-4-1 below:

**Table A-4-1. Example Checklist Top-down Approach for Risk Assessment**

Project characteristics	Scoring risk profile (1 = low, 5 = high)				
	1	2	3	4	5
<b>Capital Expense (CAPEX)</b>					
Work complexity					
Construction methods complexity					
Interface complexity					
Risk of damage to environment					
Risk of damage by third parties					
Permits and procedures risks					
Soil conditions					
...					
<b>Operating Expense (OPEX)</b>					
Work complexity					
Maintenance methods complexity					
...					

This checklist provides an indication of the risk profile of the project and thereby also an indication of a typical contingency or allowance—in terms of a percentage of total project cost—that could be applied on the basis of past experience, and in relation to the applicable cost estimate methodology.

## Appendix 5 Risk allocation in different delivery methods

Table A-5-1 below illustrates different risk allocations based on conventional and P3 delivery methods. It is used as a high-level illustration and does not include every unique risk found in a project.

**Table A-5-1. Example Risk Allocation Matrix**

Risk	Design– Bid–Build	Availability Payment P3	Toll Concession P3
Design errors	Public	Contractor	Contractor
Change in scope	Public	Public	Public
Delay in permits	Public	Shared	Shared
Delay in right-of-way acquisition	Public	Public	Public
Construction cost overruns	Contractor	Contractor	Contractor
Construction risks	Contractor	Contractor	Contractor
Archeological findings	Public	Public	Public
Delay in relocation of cables and pipes	Public	Contractor	Contractor
Unknown ground conditions	Public	Contractor	Contractor
Hazmat	Public	Shared	Shared
Security	Public	Contractor	Contractor
Major maintenance cost overruns	Public	Contractor	Contractor
Snow and ice removal cost overruns	Public	Contractor	Contractor
Regular maintenance	Public	Contractor	Contractor

Traffic information systems	Public	Public	Public
Incident management	Public	Contractor	Contractor
Toll revenue risk	Public	Public	Contractor
Financing risks	Public	Contractor	Contractor
Force majeure	Public	Shared	Shared

## Appendix 6 Glossary of Terms

**Allocation:** The act of assigning responsibility for a given risk to the public or private entity, or both if the risk is shared between the two.

**Availability Payment:** Compensation paid to a private concessionaire for its responsibility to design, construct, operate, and/or maintain a tolled or non-tolled roadway for a set period of time. The public agency makes these payments based on the availability of the infrastructure (in terms of meeting performance standards), and also when certain milestones are met (see *milestone payments*).

**Benefit Cost Analysis (BCA):** A method to monetize the costs and benefits of a specific procurement method; in a P3 analysis this is also used to quantify the social benefits and costs of a project.

**Bidder:** A respondent to a request for Expressions of Interest or an invitation to submit a bid in response to a Project Request for Proposals (RFP). Typically, a bidder will be a consortium of parties, each responsible for a specific element, such as constructing the infrastructure, supplying the equipment, or operating the business. Government normally contracts with only one lead party (bidder) who is responsible for the provision of all contracted services on behalf of the consortium.

**Brownfield:** A project that requires modification, renovation, or demolition of previously built infrastructure.

**BRT (Bus Rapid Transit):** A bus-based rapid transit system that incorporates design features often utilized in rail transit (stations, platforms, dedicated right-of-way, etc.). BRT's are designed to remove delays and reduce congestion along a bus route.

**CAPM:** Capital Asset Pricing Model (see appendix 2 for an explanation).

**Consumer Price Index (CPI):** A measure that examines the weighted average of prices of a basket of consumer goods and services, such as transportation, food and medical care. The CPI is calculated by taking price changes for each item in the predetermined basket of goods and averaging them; the goods are weighted according to their importance.

**Contingency:** An allowance included in the estimated cost of a project to cover unforeseen circumstances.

**Concessionaire:** Private entity that assumes ownership and/or operations of a given public asset (e.g., highway, train station, bus operation) under the terms of a contract with the public sector.

**Debt Service Coverage Ratio:** The amount of cash flow available to meet annual interest and principal payments on debt, divided by the amount of debt service payments.

**Design-Build (DB):** Under a DB, the private sector delivers the design and construction (build) of a project to the public sector. The public sector maintains ownership, operations, and maintenance responsibility for the asset.

**Design-Bid-Build (DBB):** Under a DBB, the private sector delivers a design and bids for construction of a project in two separate processes. Once the private sector has been awarded the construction contract, it assumes responsibility of project construction (build).

**Design-Build-Finance-Operate-Maintain (DBFOM):** Under a DBFO or a DBFOM, the private sector delivers the design and construction (build) of a project to the public sector. It also obtains project financing and assumes operations and maintenance of an asset upon its completion.

**Discount rate:** The discount rate is a percentage by which a cash flow element in the future (i.e., project costs and revenues) is reduced for each year that cash flow is expected to occur.

**Environmental Impact Statement (EIS):** An EIS is a full disclosure document that details the process through which a transportation project was developed. It includes consideration of a range of reasonable alternatives, analyzes the potential impacts resulting from the alternatives, and demonstrates compliance with other applicable environmental laws and executive orders. The EIS process is completed in the following ordered steps: Notice of Intent (NOI), draft EIS, final EIS, and record of decision (ROD).

**Endogenous Risks:** Created within a project or under the direct influence of the key project stakeholders.

**Exogenous Risks:** Caused by external events.

**Force majeure:** An event occurring from nature, i.e., not manmade (e.g., earthquakes, hurricanes).

**Greenfield:** A greenfield project is one that is designed from the beginning with no constraints from the existence of prior facilities that need to be modified or removed.

**Ground Conditions:** Conditions (often underground) that are unforeseen and can cause delays in construction. Examples include underground rivers, discovery of hazardous materials, etc.

**Handback:** The process of returning a privately operated and maintained asset to the public after a concession expires.

**HAZMAT:** Hazardous materials.

**Interest Rate Swap:** A transactional agreement between two counterparties to exchange one stream of future interest payments for another based on a specified principal amount. Interest rate swaps often exchange a fixed payment for a floating payment that is linked to an interest rate.

**Leveraging:** Leveraging is the degree to which an investor or business is utilizing borrowed money. The leverage ratio is defined as the ratio of borrowed money to equity, and can reach high levels in project finance.

**Loan Life Coverage Ratio (LLCR):** A financial ratio used to estimate the ability of the borrowing company to repay an outstanding loan. The LLCR is calculated by dividing the net present value (NPV) of the cash available for debt repayment over the term of the loan by the amount of senior debt owed by the company.

**Monte Carlo Simulation:** A problem solving technique used to approximate the probability of certain outcomes by running multiple trial runs, called simulations, using random variables. Often conducted during risk assessments and value for money assessments to determine the probability of risk outcomes.

**National Environmental Policy Act (NEPA):** Requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions, leading to an *environmental impact statement* (see above definition of EIS).

**NPV:** Net present value.

**Office of Innovative Program Delivery (OIPD):** The OIPD is a part of the FHWA that provides tools and expertise regarding innovative finance approaches including P3s.

**Public Private Partnership (P3):** In a P3, a private entity assumes responsibility for more than one development phase, accepting risks and seeking rewards. This document is concerned primarily with forms of P3s where the private sector partner enters into a long-term contract to perform most or all the responsibilities conventionally procured separately and coordinated by the government.



**Private Activity Bonds (PAB):** PABs are a new type of financing that provides private developers and operators with access to the tax-exempt bond market, lowering the cost of capital significantly.

**Project Life Cover Ratio (PLCR):** The PLCR is the ratio of the net present value of the Cashflows Available for Debt Service (CFADS) over the remaining full life of the project to the outstanding debt balance in the period. This ratio is similar to LLCR, however in LLCR the CFADS is calculated over the scheduled life of the loan, whereas the cashflow for PLCR is calculated over the life of the project or term of the P3 concession.

**PSC (Public Sector Comparator):** A PSC represents the most efficient public procurement cost (including all capital and operating costs and share of overheads) after adjustments are made for competitive neutrality, retained risk, and transferable risk to achieve the required service delivery outcomes. This benchmark is used as the baseline for assessing the potential value for money of private party bids in projects.

**Retained risk:** The value of those risks or parts of a risk that a government proposes to bear under a P3 arrangement.

**Risk Relation Map (RRM):** A diagram demonstrating the cause-and-effect relationships between risks, clearly demonstrating their hierarchy and linkages.

**RFP:** Request for Proposals.

**RFQ:** Request for Qualifications.

**Risk Allocation Matrix:** A table used as a management tool throughout the procurement process to provide an overview of the major risk categories to be considered when developing procurement, to explain why the risks are transferred, shared, or retained under different procurement options. As each deal will have project-specific risk, the Risk Allocation Matrix is only a tool to help understand the principles regarding risk allocation. For each project, the actual risk allocation will need to consider the principles of allocation and the circumstances of the deal.

**Risk Free Rate ( $R_f$ ):** The “risk free rate” is the theoretical rate of return of an investment with zero risk. U.S. Treasury Bonds (with a matching maturity to the loan) are generally used as a proxy for the risk-free rate.

**Risk Register:** A document that provides an overview of all identified risks, and describes the key characteristics of the risks.

**Risk Transfer:** The process of moving the responsibility for the financial consequences of a risk from the public to the private sector.

**ROD:** Record of Decision (see EIS).

**Return on Equity (ROE):** The amount of net income returned to investors as a percentage of the shareholder's equity. In a P3, the return on equity is used to compensate investors for the riskiness of the project.

**Scope:** A project management term for the combined objectives and requirements necessary to complete a project. Properly defining the scope of a project allows a manager to estimate the costs and time required to complete the project.

**Special Purpose Vehicle (SPV):** An SPV is a legal entity comprised of multiple shareholders created for a specific project to reduce risk exposure of its individual members and to protect the project from unrelated liabilities of its individual members. In a typical P3, an SPV is created to bid on a project and to obtain project financing.

**Systematic Uncertainties:** Uncertainties due to market circumstances; these risks are not diversifiable by a single actor (also referred to as *market risk*).

**Value for Money (VfM):** The procurement of a P3 project represents VfM when, relative to a public sector procurement option, it delivers the optimum combination of net life cycle costs and quality that will meet the project objectives.

**WACC (Weighted Average Cost of Capital):** In project finance the WACC is used to help determine the discount rate used. The WACC is a cost of capital weighted as a percentage of debt and equity (see appendix 2).