

# Guide to P3-VALUE 2.0

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## User Guide & Concept Guide

February 2016



## Acronyms

Acronym	Definition
AP	Availability Payment
BCA	Benefit Cost Analysis
BS	Balance Sheet
CF	Cash Flow
CFADS	Cash Flows Available to Debt Service
DSCR	Debt Service Coverage Ratio
DSRA	Debt Service Reserve Account
GPL	General Purpose Lanes
IRI	International Roughness Index
IRR	Internal Rate of Return
ML/TL	Managed Lanes or Tolled Lanes
MMRA	Major Maintenance Reserve Account
O&M	Operations and Maintenance
PDBCA	Project Delivery Benefit-Cost Analysis
PL	Profit & Loss
PSC	Public Sector Comparator or Conventional Delivery
P3	Public-Private Partnership
V/C	Volume/Capacity Ratio
VDF	Volume Delay Function
WACC	Weighted Average Cost of Capital

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# Preface

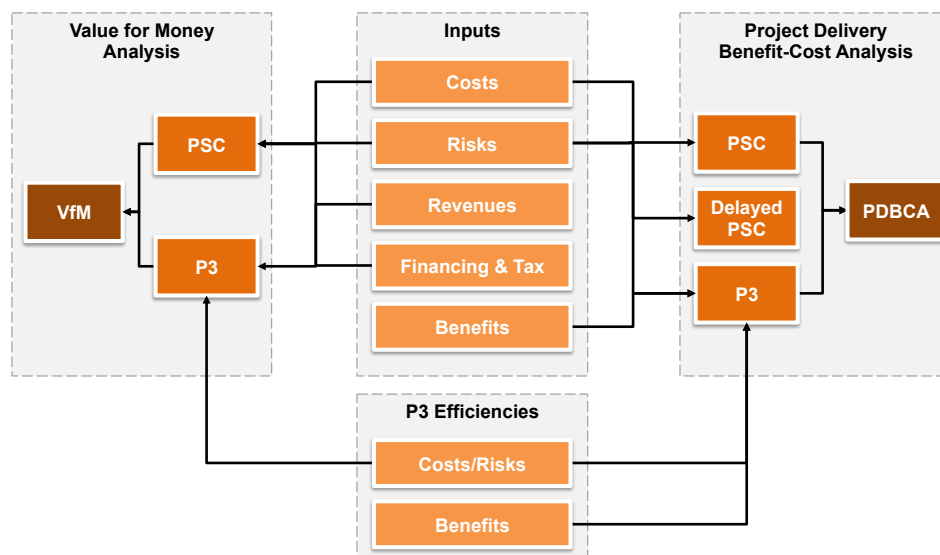
The purpose of this guide is to assist users in the use of the updated version of the Public-Private Partnership Value for Money Analysis to Learn and Understand Evaluation tool (P3-VALUE 2.0) and to provide insights into the concepts underpinning the new Project Delivery Benefit Cost Analysis (PDBCA) module for highway projects. The overall objective of this combined Value-for-Money (VfM) and PDBCA tool is to facilitate a consistent comparison of Conventional Delivery and Public-Private Partnership (P3) delivery.

Please refer to FHWA’s Guidebook for Value for Money Assessment for more information on VfM analysis. For more information on PDBCA, please refer to FHWA’s *Project Delivery Benefit-Cost Analysis: A Framework*. In short, VfM and PDBCA are separate analyses that take different perspectives and help provide answers to the following questions:

- **Value-for-Money:** The VfM analysis typically takes the perspective of the procuring Agency and asks the question: *what are the fiscal implications of procuring a project as a P3 compared to a conventionally procured project?*
- **Project Delivery Benefit Cost Analysis:** PDBCA is a benefit-cost analysis (BCA) comparison of different delivery models. A BCA typically takes the perspective of society as a whole and asks the question: *what are the economic efficiency impacts of a project?* In the case of PDBCA, the analysis determines the economic efficiency impacts of a project under various delivery models and compares these delivery models to assess the economic efficiency implications of P3 delivery.

The first version of the P3-VALUE tool consisted of four modules in separate Excel files that enabled users to conduct a VfM analysis. P3-VALUE 2.0 integrates all these separate modules into a single Excel-based tool and adds the PDBCA component to it. It should be noted that the development of P3-VALUE 2.0 was a continuous balancing act between flexibility (necessary for real-life calculations), simplicity (necessary for educational purposes) and complexity (necessary for more accurate calculations). The result is a tool that is relatively easy to use while still allowing for sufficient flexibility. The simplified overall structure of the P3-VALUE 2.0 is shown in the figure below.

**Figure 1: Simplified overall structure of P3-VALUE 2.0**



As shown in the figure, the tool compares the P3 delivery model to the Public Sector Comparator (PSC or Conventional Delivery, used interchangeably throughout this guide and in the tool) and Delayed PSC. For a discussion on the definition of Delayed PSC, please refer to Part II 5.1. As can be seen, the VfM analysis and PDBCA share a number of common elements such as project costs and risks. Other elements such as revenues and financing are used only for VfM, whereas economic benefits are only relevant for PDBCA. P3-VALUE 2.0 enables users to make assumptions regarding P3 efficiencies that may impact the project's costs, revenues, risks and/or benefits, hence helping users distinguish between conventional and P3 delivery. Before discussing the tool in more detail, it is important to explain what P3-VALUE 2.0 can and what it cannot do.

### What can P3-VALUE 2.0 do?

- P3-VALUE 2.0 enables users to perform a VfM analysis and PDBCA on stylized real-world transactions for educational purposes.
- P3-VALUE 2.0 is designed to help users understand the key concepts, assumptions, inputs, calculations, and outputs of VfM and PDBCA.
- P3-VALUE 2.0 enables users to evaluate the impacts of various project inputs, assumptions, and scenarios from the perspective of a procuring Agency (financial impacts, VfM) and from the perspective of a society as a whole (social impacts, PDBCA).
- P3-VALUE 2.0 can help users explain the analysis results and implications of a selected project delivery method to decision makers.
- P3-VALUE 2.0 can assist agencies in conducting an early stage VfM analysis and PDBCA for a real world brownfield highway project in order to estimate the potential financial and social benefits and disbenefits<sup>1</sup> related to different project delivery methods.
- P3-VALUE 2.0 can assist agencies in conducting a high level screening for potential P3 projects.

### What P3-VALUE 2.0 cannot do?

P3-VALUE 2.0 does not direct users to a decision about whether or not a project delivery method is the “correct” choice. The tool only educates users about potential benefits and outcomes of one delivery method compared to another. The ultimate decision as to whether a project should be procured as a P3 or not will need to be determined by further detailed and project-specific financial and economic analysis, as well as other social, institutional and legal considerations.

### Tool Objectives

P3-VALUE 2.0 has both an educational and a transactional objective. The tool aims to demonstrate to users how to perform a VfM analysis and PDBCA, thereby enabling them to reach the following educational objectives:

- Understand key concepts underlying VfM and PDBCA.
- Understand the impacts of various assumptions and inputs on VfM and PDBCA outputs.

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<sup>1</sup> A disbenefit is a negative benefit, such as an increase in delays or higher emissions.

- Explain the results and implications of analyses for selected project delivery methods.
- Conduct a VfM analysis and PDBCA at a conceptual level.

P3-VALUE 2.0 enables users to carry out a high level analysis of a real-world highway project, thereby enabling users to reach the following transactional objectives:

- Develop and analyze a simple customized transaction that captures key aspects of VfM and PDBCA.
- Provide guidance to financial experts performing VfM/PDBCA for a specific highway project.

## Teaching Methods

The P3-VALUE 2.0 tool incorporates a variety of technically challenging concepts and may be considered relatively complex due to the fact that it includes both VfM and PDBCA. Although this document provides a guide to navigate the tool, enter inputs, and review outputs, it does not aim to discuss in detail the calculations performed by the tool. However, the guide does explain the most important concepts used in the tool, which are discussed in the Part II of this guide. Furthermore, it is recommended that the user develop a thorough understanding of Value for Money and Benefit Cost Analysis (BCA) fundamentals before using this tool. In order to assist users in developing a thorough understanding of the BCA fundamentals used in this tool, FHWA has made available a guide on the Project Delivery Benefit-Cost Analysis framework. Additionally, a training module has been created to accompany the P3-VALUE 2.0 tool. It is recommended that users of P3-VALUE 2.0 attend one of the P3 evaluation training courses or webinars offered by FHWA. The training course and a series of webinars will help the user understand key concepts, and will provide the opportunity to become familiar with the tool using a stylized real-world example. Considering the aforementioned, the tool supports three types of methods for professionals to learn about the concepts covered in P3-VALUE 2.0:

- **Guided Learning:** The tool enables users to learn through in-person lectures, webinars, and instructional aids. This teaching method offers a structured curriculum, and instructs users with a step-by-step process on how to use the tool. The guided learning is led by experienced professionals, and it is taught to users with limited experience. A well-designed demonstration project case accompanies this training to highlight key aspects of VfM and PDBCA and to facilitate the learning process.
- **Self-Paced Learning:** The user can utilize a pre-populated scenario and learning material without instructors. The user has the ability to learn at their own pace or re-master the material taught from the guided learning phase. The tool enables users to experiment with various inputs and scenarios in order to enhance their understanding of VfM and PDBCA.
- **Action Learning:** The user can learn by applying concepts and methods taught in the previous two phases to projects that the user is intimately familiar with. The user, now with a general understanding of the drivers, calculations, and possible benefits of P3 delivery, can determine, at a conceptual level, how different types of project delivery may impact his/her own projects. It is to be noted that P3-VALUE 2.0 is not intended as a transactional model, and for detailed analysis, a customized financial model should be built.

## Guide Structure

This guide contains two separate parts to support a user's learning: User Guide (Part I) and Concept Guide (Part II). The User Guide describes in detail the tool's structure, how to use and navigate the model as well

as what inputs are required for the model to carry out the different analyses. Furthermore, the User Guide discusses the model's calculations and presents its various outputs. The Concept Guide on the other hand describes the key concepts that underpin P3-VALUE 2.0's calculations. As a result, Part II is more conceptual and less "hands on" than Part I.



# PART I: USER GUIDE

# 1 P3-VALUE 2.0 Tool Structure

This chapter discusses the modeling approach followed to develop P3-VALUE 2.0 as well as the tool’s structure. Furthermore, it presents the different worksheets in the tool.

## 1.1 Modeling Standards

The P3-VALUE 2.0 tool follows international best modeling practices, ensuring transparency and a logical model flow from inputs through calculations to outputs. More specifically, the P3-VALUE 2.0 tool uses the FAST modeling standard (for more details, see: <http://www.fast-standard.org>). FAST models break down complex modeling problems into simple and easy-to-understand components. FAST stands for:

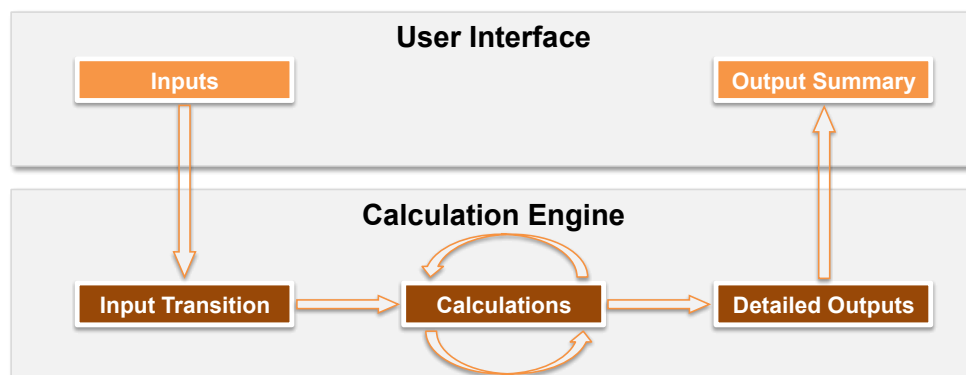
- **Flexible:** Easy to change, which is particularly important if FHWA were to require different functionalities in the future.
- **Appropriate:** Reflects key economic and financial drivers without being cluttered with unnecessary detail.
- **Structured:** Rigorously applies consistent design rules.
- **Transparent:** Builds models that other people can read and understand.

Some distinguishing features of FAST include:

- Calculation blocks for easy referencing to inputs.
- Flags to break up and simplify calculations.
- Automatic track changes in inputs or calculations during the modeling process.
- Checks to verify model integrity.

The FAST modeling standard minimizes the risk of errors and omissions and facilitates quality control and auditing. Furthermore, the FAST modeling standards help create a user-friendly and logical model structure, enabling the user to “read” the model and understand the full analysis, without necessarily having to understand all individual calculations. By adhering to the FAST modeling standards, the P3-VALUE 2.0 tool’s calculations are transparent, thereby reducing the risk that users perceive the tool as a “black box”. Furthermore, by adhering to FAST modeling standards, the P3-VALUE 2.0 tool can easily accommodate future adjustment or additions if required. Figure 2 shows how a model based on FAST standards maintains a strict separation of inputs, calculations, and outputs.

**Figure 2: FAST modeling approach to user interface separation**



## 1.2 Model Structure

The P3-VALUE 2.0 tool is organized into a number of modules. Each module has a specific objective. This modular approach enables users to “zoom” in on a specific issue without having to consult all other calculations and modules. The P3-VALUE 2.0 tool contains the following modules:

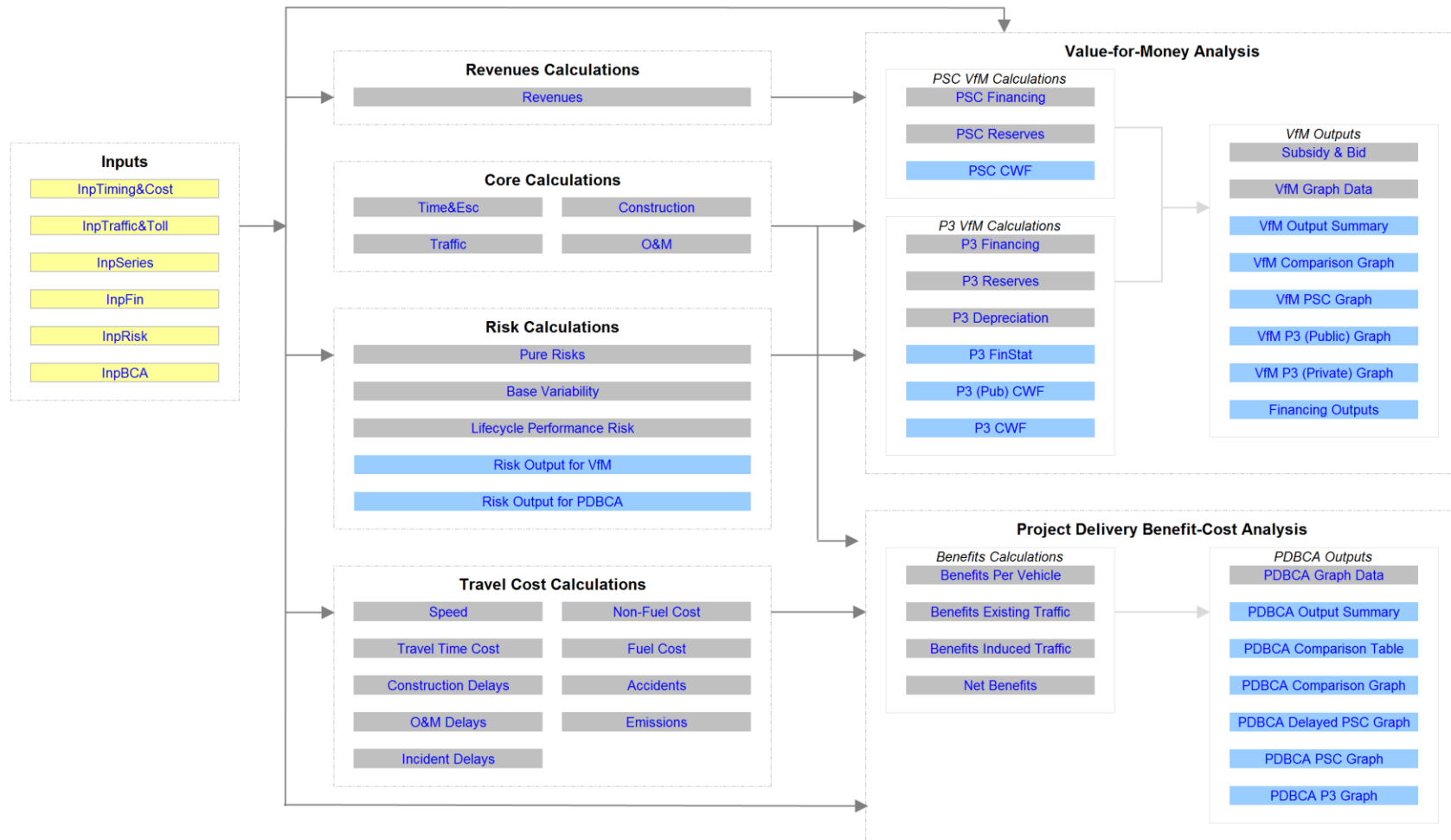
- Inputs (costs, timing, traffic, tolling, finance, risk, etc.)
- Core calculations (traffic, construction, O&M, escalations)
- Revenues
- Travel cost calculations
- Risk Assessment
- Value-for-Money Analysis
- Project Delivery Benefit-Cost Analysis

Each module has its own landing sheet, which visually presents how this module is connected to other modules. More specifically, the landing sheets show the following items:

- Elements used in the module (either inputs or elements calculated in other modules)
- Calculations in this module
- Impacted modules & outputs

Figure 3 presents the overall structure of the P3-VALUE 2.0 tool and the interactions between the different modules. For example, as can be seen by the arrows in the figure, the Value-for-Money Analysis module uses revenues, core calculations, and risks to calculate the VfM outputs. This structure is also presented on the home sheet of the P3-VALUE 2.0 tool. From the home sheet, users can access the various modules and sheets by double-clicking on the blue links.

**Figure 3: P3-VALUE detailed model structure**



### 1.3 Worksheets

Table 1 presents a comprehensive list of all P3-VALUE 2.0 worksheets and provides a short description of the purpose each sheet serves. Landing sheets for the various modules are shaded.

**Table 1: Worksheets in P3-VALUE 2.0**

Sheet	Description
<b>Home</b>	This sheet presents the structure of the model and the interactions between the inputs, the calculation modules, and the outputs.
<b>Key</b>	This sheet presents the key to the sheet tab colors, font colors, and cell shading in this spreadsheet model.
<b>Sheets</b>	This sheet presents an overview of all sheets contained in the tool.
<b>Inputs &gt;&gt;</b>	This is the Inputs landing sheet. It presents the structure of the Inputs module and the interactions between the inputs and the calculation modules.
<b>InpTiming&amp;Cost</b>	This sheet contains project timing, cost, and escalation inputs. In addition, it contains non-changeable (constant) inputs, which are used throughout the model.
<b>InpTraffic&amp;Toll</b>	This sheet contains traffic and tolling inputs, as well as roadway characteristics (lanes, free flow speed, etc.).
<b>InpSeries</b>	This sheet contains time series inputs for pre-construction, construction, traffic ramp-up, and subsidy/milestone payments.
<b>InpFin</b>	This sheet contains financial inputs including subsidies, interest rates, target Debt Service Coverage Ratios (DSCRs), equity returns, reserve requirements, etc.
<b>InpRisk</b>	This sheet contains pure risk, base variability, lifecycle performance risk, and revenue uncertainty adjustment inputs.
<b>InpBCA</b>	This sheet contains all additional inputs required for BCA calculations.
<b>Core Calculations &gt;&gt;</b>	This is the Core Calculations landing sheet. It presents the structure of the Core Calculations module and the interactions between the inputs, the calculation modules, and the outputs.
<b>Time&amp;Esc</b>	This sheet calculates the model’s scenario timelines, which are used in all of the other sheets. It also contains flags and counters, which allow complex calculations to be broken up into smaller pieces.
<b>Traffic</b>	This sheet calculates daily and annual traffic volumes for each year in the analysis period for both the No Build and Build alternatives.
<b>Construction</b>	This sheet calculates pre-construction and construction costs for each year in the analysis period for each delivery model: Public Sector Comparator (PSC or Conventional Delivery), Delayed Public Sector Comparator (Delayed PSC) and Public-Private Partnership (P3).
<b>O&amp;M</b>	This sheet calculates operations and maintenance costs for each year in the analysis period for each delivery model (PSC, Delayed PSC, P3).

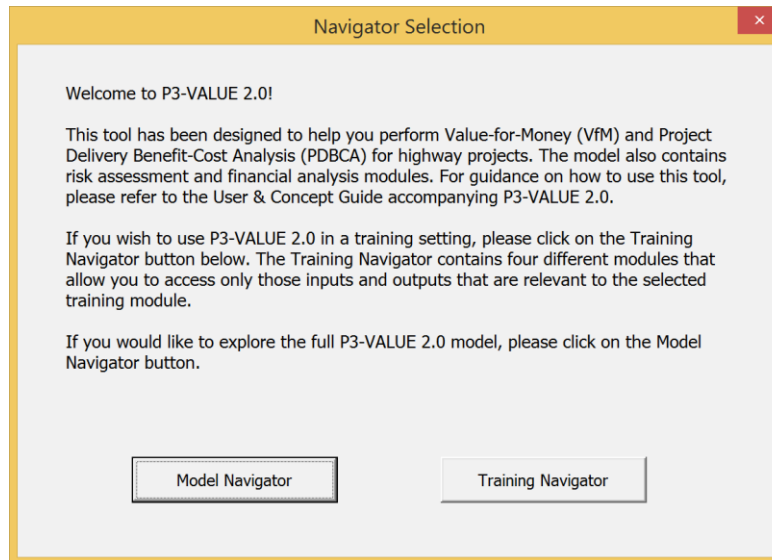
Sheet	Description
<b>Revenues Calculation &gt;&gt;</b>	This is the Revenues Calculation landing sheet. It presents the structure of the Revenues Calculation module and the interactions between the inputs, the calculation modules, and the outputs.
<b>Revenues</b>	This sheet calculates the revenue cash flows for PSC and P3.
<b>Risk Assessment &gt;&gt;</b>	This is the Risk Assessment landing sheet. It presents the structure of the Risk Assessment module and the interactions between the inputs, the calculation modules, and the outputs.
<b>Pure Risks</b>	This sheet calculates the pure risk cash flow for each delivery model (PSC, Delayed PSC, P3).
<b>Base Variability</b>	This sheet calculates base variability for the PSC, Delayed PSC, and P3 to create base variability cash flows.
<b>Lifecycle Performance Risks</b>	This sheet calculates the lifecycle performance risk premium and the revenue uncertainty adjustment for revenues flowing to the Agency.
<b>PSC VfM &gt;&gt;</b>	This is the PSC VfM landing sheet. It presents the structure of the PSC VfM module and the interactions between the inputs, the calculation modules, and the outputs.
<b>PSC Financing</b>	This sheet calculates funding requirements, debt drawdown and repayment, and DSCR for the PSC.
<b>PSC Reserves</b>	This sheet calculates the PSC Major Maintenance Reserve Account and the PSC Debt Service Reserve Account.
<b>PSC CWF</b>	This sheet presents the PSC cash waterfall. The cash waterfall shows how revenues are used to pay operating costs, service debt, and fund reserves.
<b>P3 VfM &gt;&gt;</b>	This is the P3 VfM landing sheet. It presents the structure of the P3 VfM module and the interactions between the inputs, the calculation modules, and the outputs.
<b>P3 Financing</b>	This sheet calculates funding requirements, debt drawdown and repayment, and DSCR for the P3.
<b>P3 Reserves</b>	This sheet calculates the P3 Major Maintenance Reserve Account and P3 Debt Service Reserve Account.
<b>P3 CWF</b>	This sheet presents the P3 cash waterfall. The cash waterfall shows how revenues are used to pay operating costs, service debt, and fund reserves.
<b>P3 Depreciation</b>	This sheet calculates P3 asset depreciation.
<b>P3 FinStat</b>	This sheet contains the Income Statement and the Balance sheet.
<b>P3 (Pub) CWF</b>	This sheet presents the P3 cash waterfall from the public Agency's point of view.
<b>VfM Outputs&gt;&gt;</b>	This is the VfM Outputs landing sheet. It presents the structure of the VfM Outputs module and the interactions between the inputs, the calculation modules, and the outputs.
<b>Subsidy &amp; Bid</b>	This sheet calculates the required subsidy/concession fee/availability payment to make the project viable.
<b>VfM Graph Data</b>	This sheet compiles the data to be used in the output graphs.
<b>VfM Output Summary</b>	This sheet presents VfM outputs as summary tables and charts.
<b>VfM Comparison Graph</b>	This sheet presents VfM comparison between PSC and P3.
<b>VfM PSC Graph</b>	This sheet presents VfM outputs for the PSC.

Sheet	Description
<b>VfM P3 (Public) Graph</b>	This sheet presents VfM outputs for the P3 from the public perspective.
<b>VfM P3 (Private) Graph</b>	This sheet presents VfM outputs for the P3 from the private perspective.
<b>Financing Outputs</b>	This sheet presents the relevant PSC and P3 financing outputs.
<b>Travel Cost Calculation &gt;&gt;</b>	This is the Travel Cost Calculation landing sheet. It presents the structure of the Travel Cost Calculation module and the interactions between the inputs, the calculation modules, and the outputs.
<b>Speed</b>	This sheet calculates speeds for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Travel Time Cost</b>	This sheet calculates travel time cost for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Construction Delays</b>	This sheet calculates construction-related travel delays for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>O&amp;M Delays</b>	This sheet calculates O&M-related travel delays for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Incident Delays</b>	This sheet calculates incident delays for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Non-Fuel Cost</b>	This sheet calculates non-fuel costs for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Fuel Cost</b>	This sheet calculates fuel costs for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Accidents</b>	This sheet calculates accident costs for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Emissions</b>	This sheet calculates emission costs for the No Build and each delivery model (PSC, Delayed PSC, P3).
<b>Benefits &gt;&gt;</b>	This is the Benefits landing sheet. It presents the structure of the PDBCA module and the interactions between the inputs, the calculation modules, and the outputs.
<b>Benefits Per Vehicle</b>	This sheet calculates benefits for the PSC, Delayed PSC, and P3 by subtracting the costs accrued by a user in the No Build from the costs accrued by a user for the respective Build alternative for each year in the analysis period.
<b>Benefits Existing Traffic</b>	This sheet calculates benefits for existing traffic for the PSC, Delayed PSC, and P3 by multiplying the benefits per vehicle for each benefit type by existing traffic for each year in the analysis period.
<b>Benefits Induced Traffic</b>	This sheet calculates benefits for induced traffic for the PSC, Delayed PSC, and P3 by calculating consumer and producer surplus.
<b>Net Benefits</b>	This sheet calculates net benefits for each year in the analysis period for each build alternative (PSC, Delayed PSC, and P3).
<b>PDBCA Outputs &gt;&gt;</b>	This is the PDBCA Outputs landing sheet. It presents the structure of the PDBCA Outputs module and the interactions between the inputs, the calculation modules, and the outputs.
<b>PDBCA Graph Data</b>	This sheet compiles the data to be used in the output graphs.
<b>PDBCA Output Summary</b>	This sheet presents PDBCA outputs as summary tables and charts.

Sheet	Description
<b>PDBCA Comparison Table</b>	This sheet summarizes net benefits for each of the three steps in the PDBCA framework (Step1: Project BCA, Step2: Acceleration Effects, and Step3: P3 Delivery Effects)
<b>PDBCA Comparison Graph</b>	This sheet presents PDBCA comparison output graphs.
<b>PDBCA Delayed PSC Graph</b>	This sheet presents a detailed benefit and cost graph for the Delayed PSC.
<b>PDBCA PSC Graph</b>	This sheet presents a detailed benefit and cost graph for the PSC.
<b>PDBCA P3 Graph</b>	This sheet presents a detailed benefit and cost graph for the P3.
<b>Checks &amp; Alerts</b>	This sheet summarizes the different checks and alerts used in the model.
<b>Navigation</b>	This sheet is used by the Model Navigator to navigate to different sheets within the model.
<b>HideUnhide</b>	This sheet is used by the Model Navigator to switch between high level, detailed level and training view.

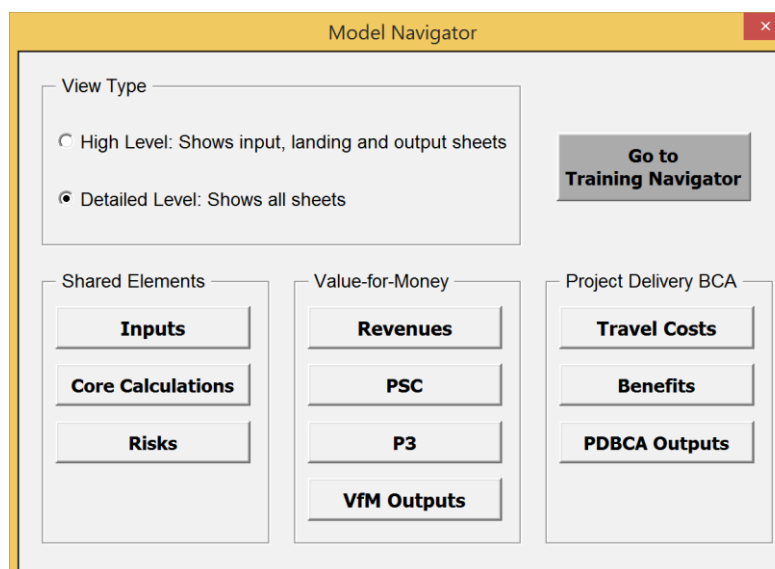
## 2 Using P3-VALUE 2.0

Upon opening P3-VALUE 2.0, click “enable editing” and/or “enable content” on the yellow bar across top of screen to enable critical macros built into the model. The form below will appear when the model is opened and prompts the user to select either the “Model Navigator” or “Training Navigator”. The “Training Navigator” contains four modules that provide access to only the relevant inputs and outputs in a training session, while the “Model Navigator” enables the user to access all the modules and sheets in the tool.



### 2.1 Model Navigator

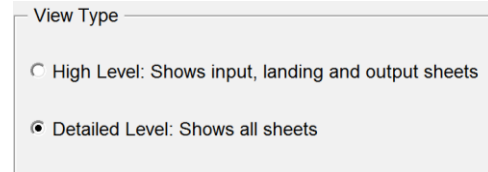
If “Model Navigator” is selected, the following user form will appear. If the user wishes to switch to the Training Navigator, he or she may do so by clicking the “Go to Training Navigator” button on the top right.



The user can exit the Navigator at any point by clicking on the exit “X” at the top right corner of the Navigator. To access the Navigator again, simply click on the “Navigator” button on the toolbar (see below).

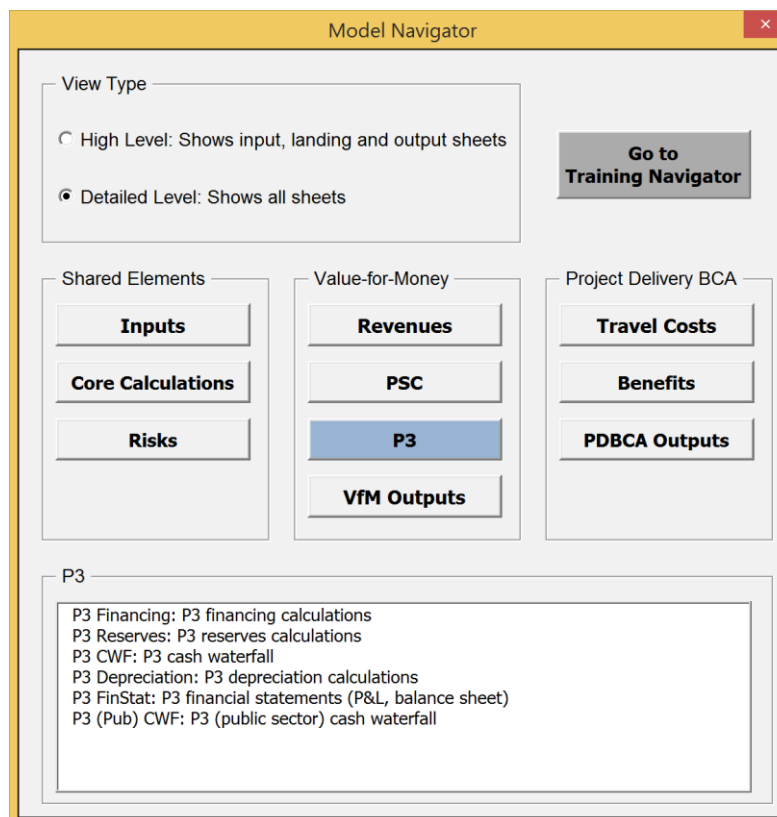
### 2.1.1 High Level vs. Detailed Level View

The Model Navigator has two different view options: a high level and a detailed level view. Users can choose between the high level view and detailed level view using the radio buttons at the top left of the Navigator.



In the high level view, the user has access only to the inputs, landing sheets (see discussion below) and outputs. Detailed calculation sheets are hidden to provide the user with overall understanding of the model flow and logic. By clicking on any of the buttons in the high level view, the Model Navigator will either list the relevant input sheets (for the “Inputs” button), output sheets (for the “Risks”, “VfM Outputs” and “PDBCA Outputs” buttons) or take the user to the relevant landing sheet (for all other buttons). For the listed input and output sheets, the user can click on them to navigate to these sheets.

In the detailed level view, all sheets are visible and accessible to the user. By clicking on any of the buttons in the detailed level view, the Model Navigator will list all relevant worksheets. The screenshot below shows what the user will see if he or she clicks on the P3 button (in the Value-for-Money section).



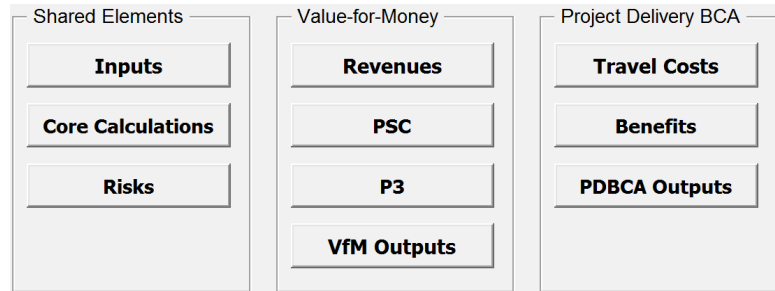
The user can click on any of the listed worksheets to navigate to a particular worksheet. While the high level view enables the user to navigate the model through landing sheets, the detailed level view enables the

user to navigate to each individual sheet in the model. Chapters 3 and 5 of the User Guide describe the input and outputs of the model (accessible in both high level and detailed level view), whereas chapter 0 discusses the model’s calculations (accessible in detailed level view only).

### 2.1.2 Navigator Elements

The Model Navigator is organized into three panels, which in turn provide access to different modules:

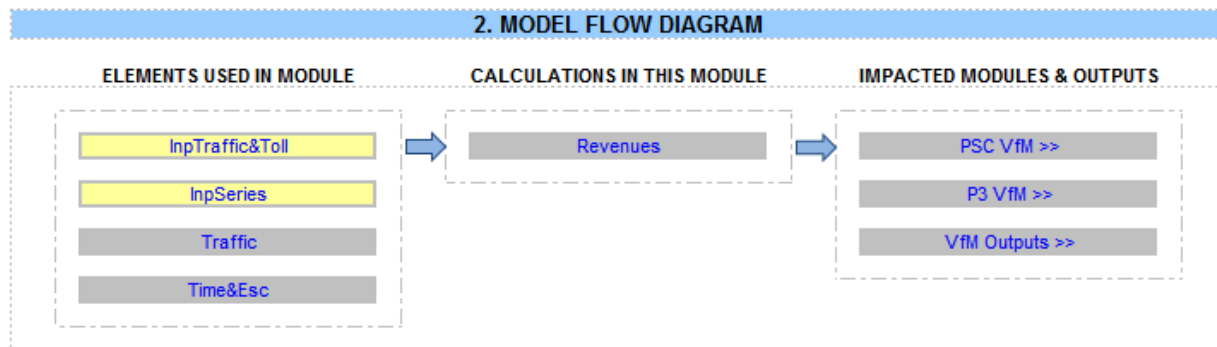
- Shared Elements:
  - a. Inputs
  - b. Core Calculations
  - c. Risks
- Value for Money:
  - a. Revenues
  - b. PSC
  - c. P3
  - d. Vfm Outputs
- Project Delivery BCA:
  - a. Travel Costs
  - b. Benefits
  - c. PDBCA Outputs



The following section describes the different modules.

## 2.2 Modules and Landing Sheets

This section describes the various modules and landing sheets that are accessible from the Model Navigator. Each of the tool’s modules has a landing sheet. The landing sheets provide an overview of the module’s components (elements used as inputs to the calculations in the module, calculations carried out within the module, and a list of outputs and modules that are affected by this module’s calculations) in a flow chart format. As an example, the screenshot below shows the landing sheet for the Revenues module. Please see Section 2.5 for the key to color codes used in the diagram and throughout the model.

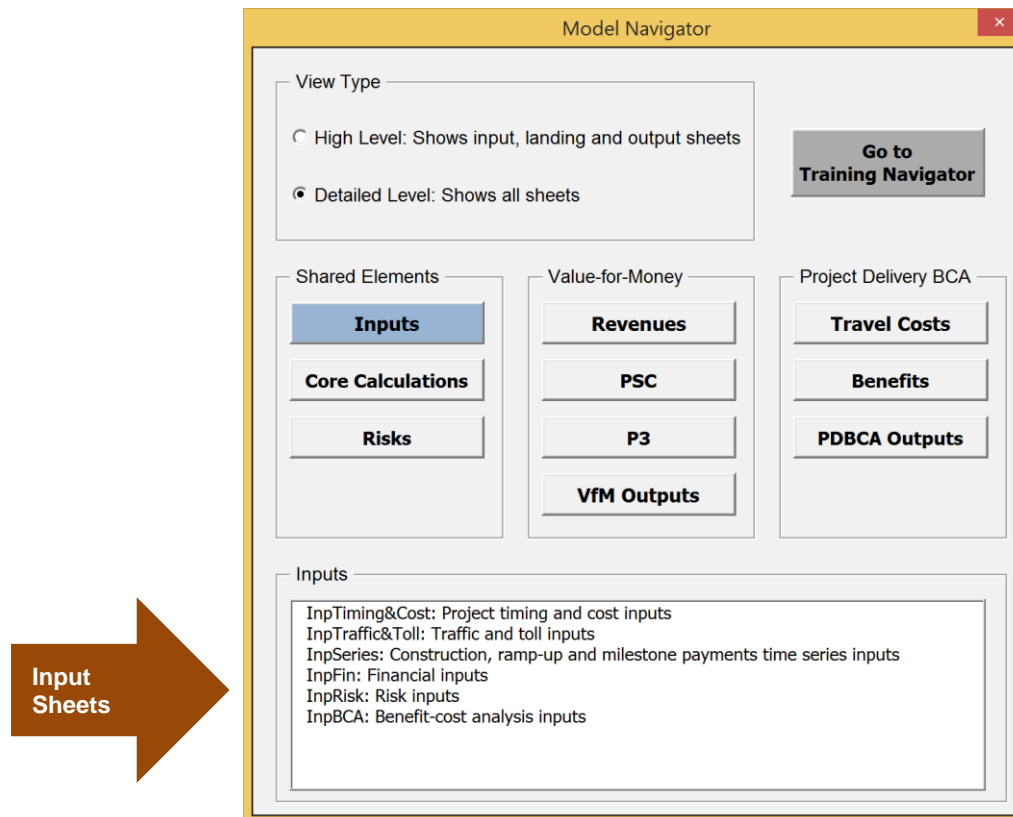


The landing sheet can also be used to navigate the model. To access the landing sheet, click on any button in the high level view. By double clicking on any of the sheet names listed on the landing sheet, the user will be taken to the selected sheet. This functionality works both in the high level and detailed level view (in the high level view, the selected sheet will in fact be unhidden to be visible to the user).

The remainder of this section will present the various modules and their landing sheets.

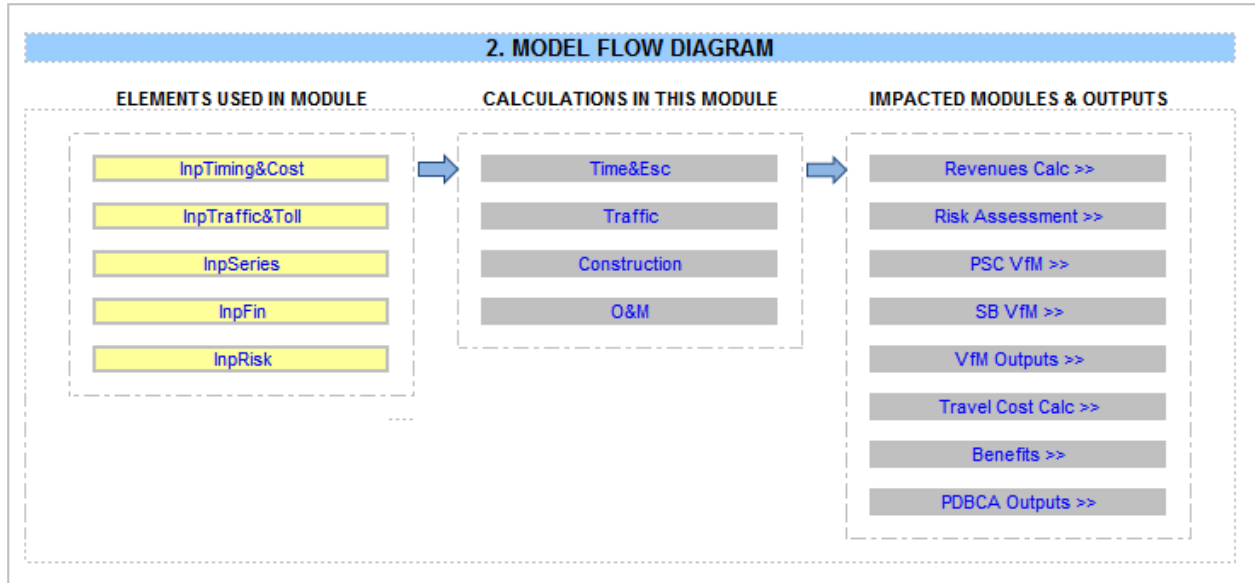
### 2.2.1 Inputs

Click on the Inputs button on the Model Navigator to navigate to the various input sheets. The Inputs Module contains the inputs that will be used throughout the model to carry out the required calculations. The screenshot below shows how the input sheets can be directly accessed from the Model Navigator (both in high level and detailed level view).



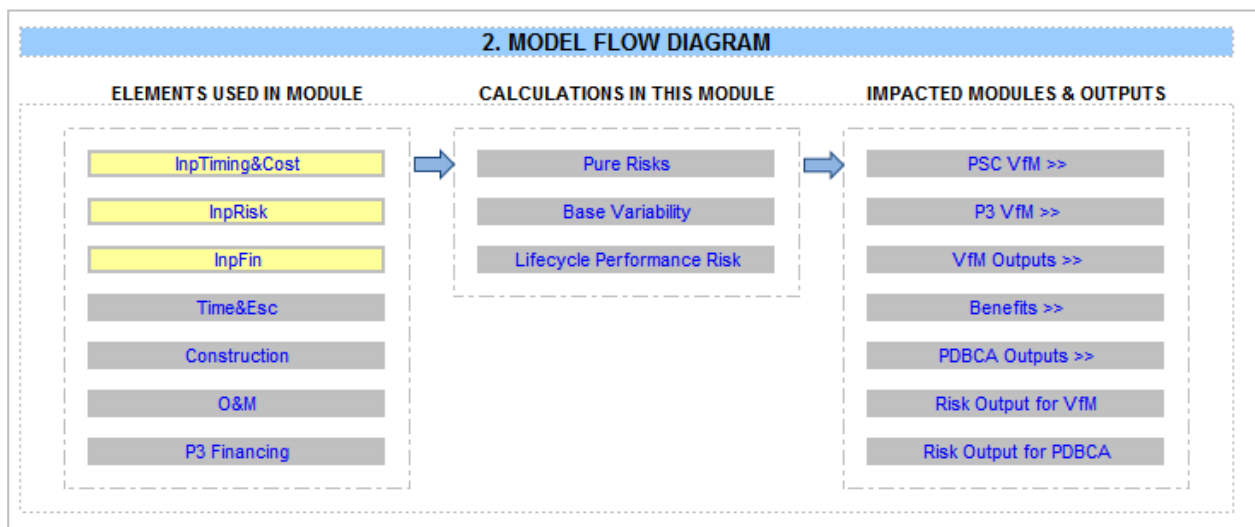
### 2.2.2 Core Calculations

Click on the Core Calculations button on the Model Navigator to navigate to the Core Calculations landing sheet in the high level view, or to one of the calculation sheets in the detailed level view. The Core Calculation Module contains the calculation of items that are used frequently throughout the model: flags, indexations, traffic, and costs. The following presents the Core Calculations landing sheet.



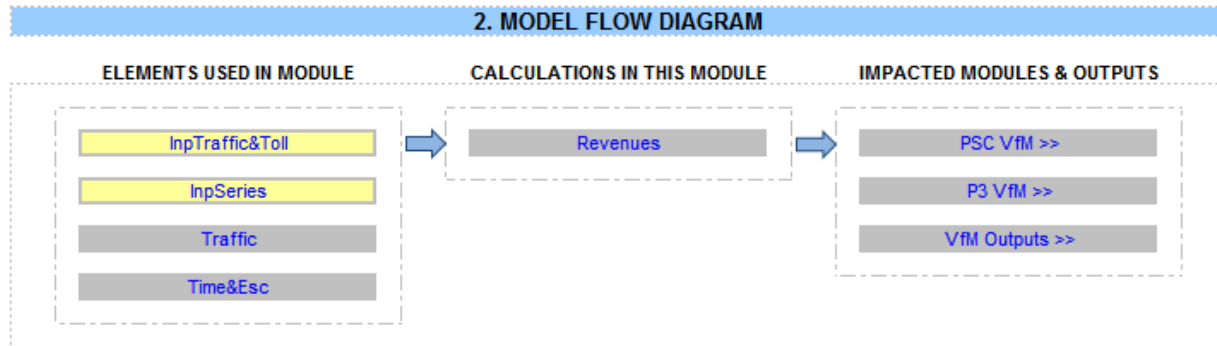
### 2.2.3 Risks

Click on the Risks button on the Model Navigator to navigate to the Risks Assessment landing sheet in the high level view, or to one of the calculation sheets in the detailed level view. The P3-VALUE 2.0 Risk Assessment Module demonstrates how quantitative risk assessments may be conducted as a part of a Vfm assessment and PDBCA. P3-VALUE 2.0 distinguishes three different types of risks: Pure risks, base variability, and lifecycle performance risk. The following presents the Risks Assessment landing sheet.



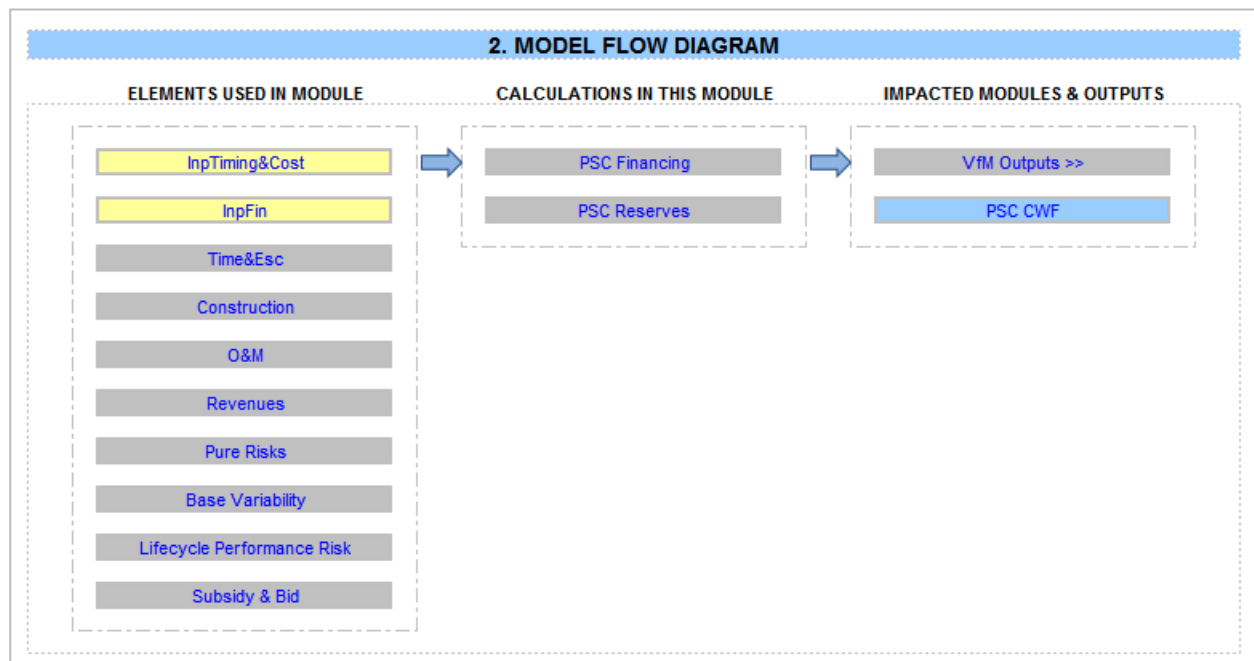
### 2.2.4 Revenues

Click on the Revenues button on the Model Navigator to navigate to the Revenues VfM landing sheet in the high level view, or to the revenue calculation sheet in the detailed level view. The Revenues Calculation Module calculates the toll revenues for the project. These revenues are only used in VfM assessment and not in PDBCA. The following presents the Revenues landing sheet.



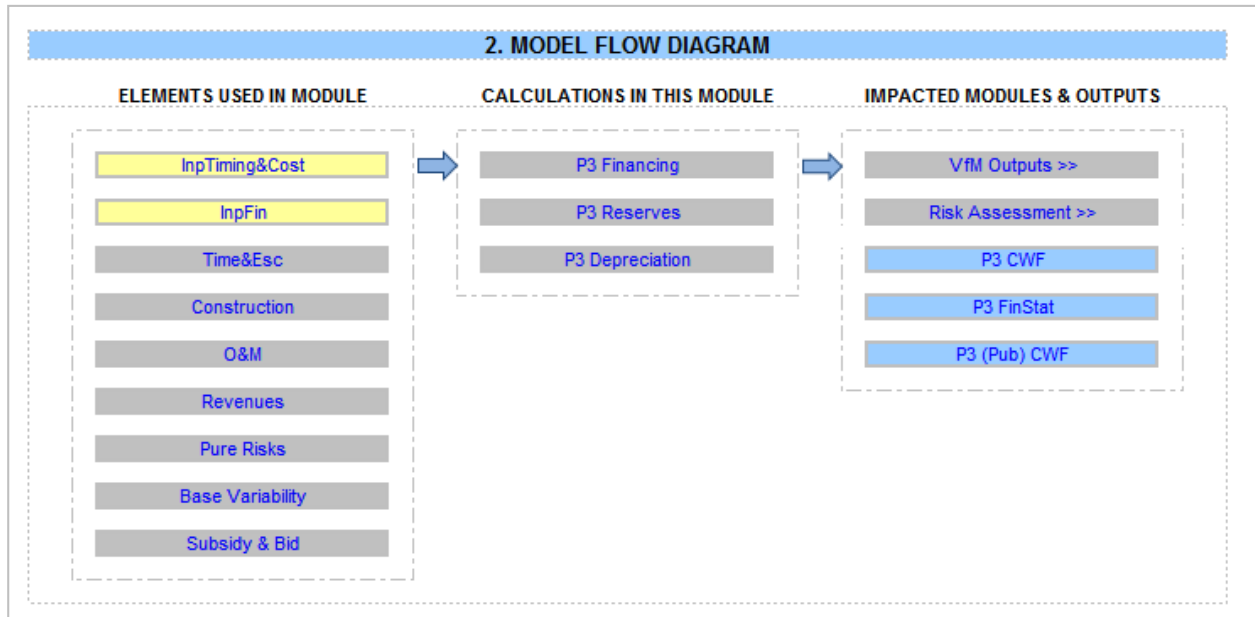
### 2.2.5 PSC

Click on the PSC button on the Model Navigator to navigate to the PSC VfM landing sheet in the high level, or to one of the calculation sheets in the detailed level view. The PSC module of the VfM assessment demonstrates how the PSC may be analyzed as part of a quantitative VfM. The following presents the PSC landing sheet.



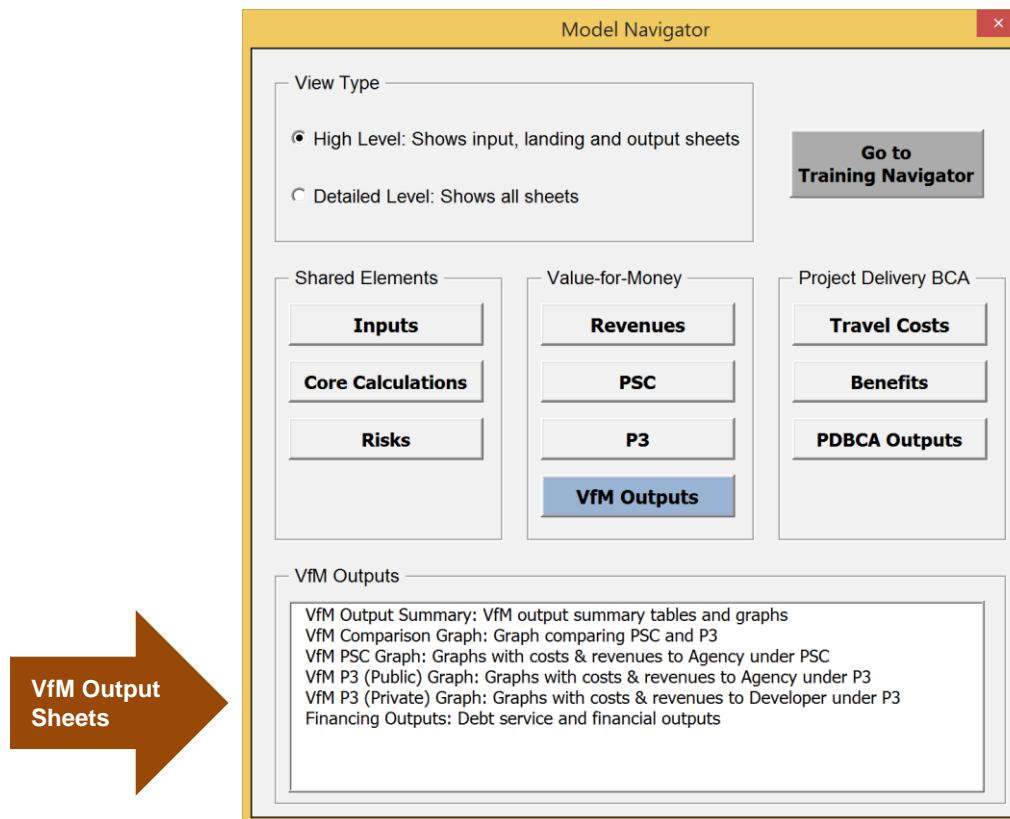
### 2.2.6 P3

Click on the P3 button on the Model Navigator to navigate to the P3 VfM landing sheet in the high level, or to one of the calculation sheets in the detailed level view. The P3 module of the Value-for-Money (VfM) assessment demonstrates how the P3 may be analyzed as part of a quantitative VfM. The following presents the P3 landing sheet.



### 2.2.7 VfM Outputs

Click on the VfM Outputs button on the Model Navigator to navigate to the various output sheets. The output section of the VfM assessment compares the cost and revenues of the PSC to the costs and revenues of the P3. It calculates the required subsidy (PSC and P3), Concession Fee for the P3, or Availability payment for the P3 and compares cash flow to/from Agency under PSC and P3. The screenshot below shows how the VfM output sheets can be directly accessed from the Model Navigator (both in high level and detailed level view<sup>2</sup>).



### 2.2.8 Travel Costs

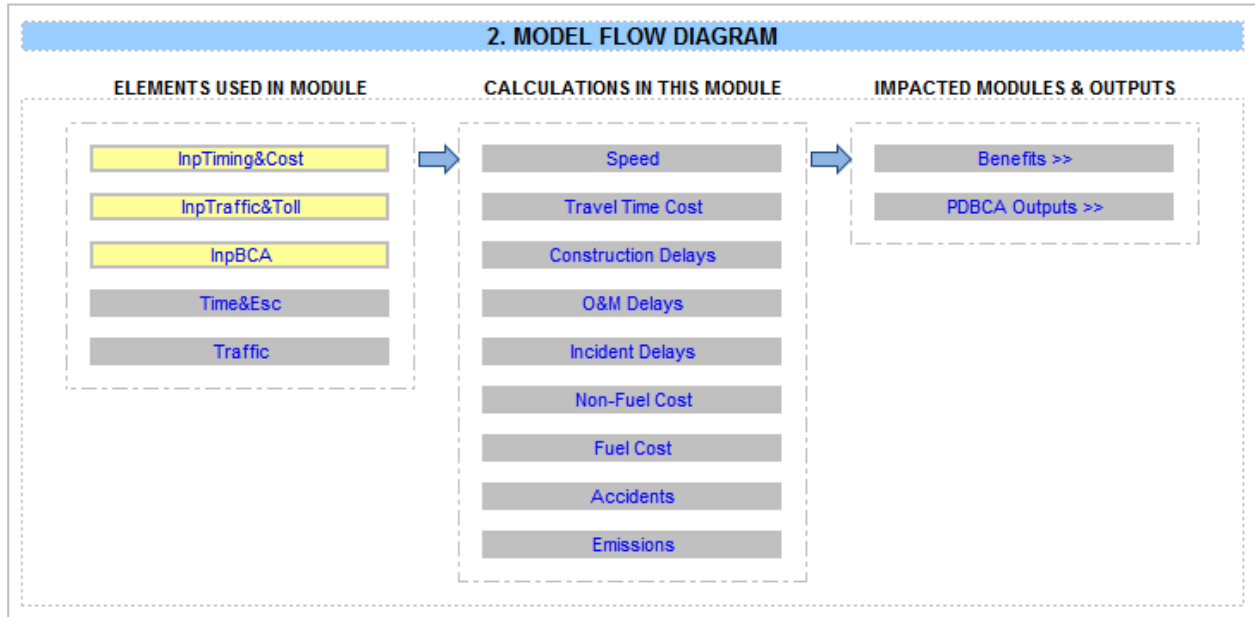
Click on the Travel Costs button on the Model Navigator to navigate to the Travel Costs Calc landing sheet in the high level view, or to one of the calculation sheets in the detailed level view. This module calculates different economic travel costs for the No Build, Delayed PSC, PSC, and P3 in order to be able to compare them in the PDBCA. These travel costs include:

- Travel time costs
- Construction delays (i.e., travel delays due to construction activities)
- O&M delays (i.e., travel delays due to O&M activities)
- Incident delays
- Non-fuel costs

<sup>2</sup> In the detailed level view, an additional sheet can be accessed: VfM Graph Data sheet.

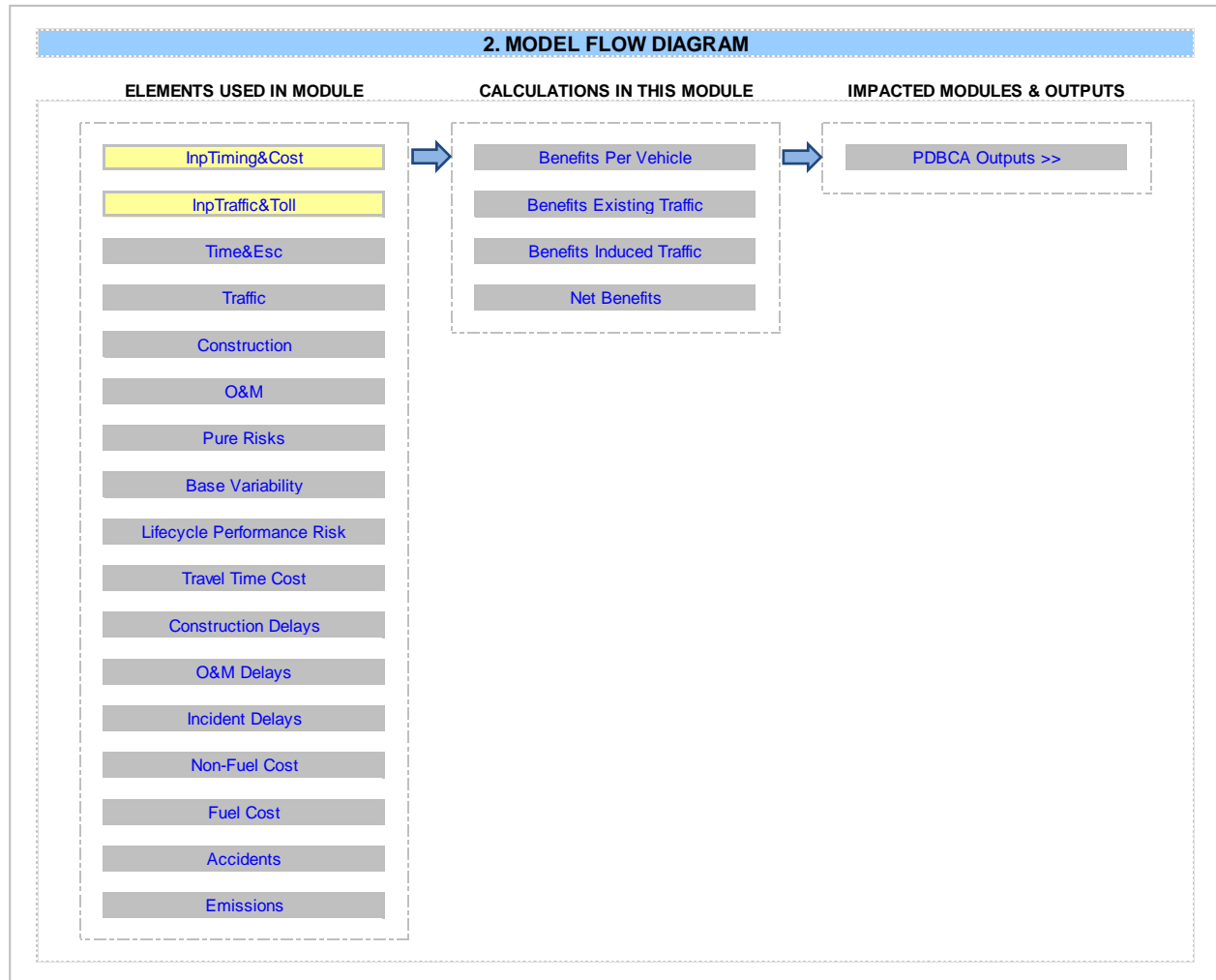
- Fuel costs
- Accidents
- Emissions

In order to be able to calculate some of these benefits, the model also calculates speeds for the No Build, Delayed PSC, PSC, and P3. The following presents the Travel Costs landing sheet.



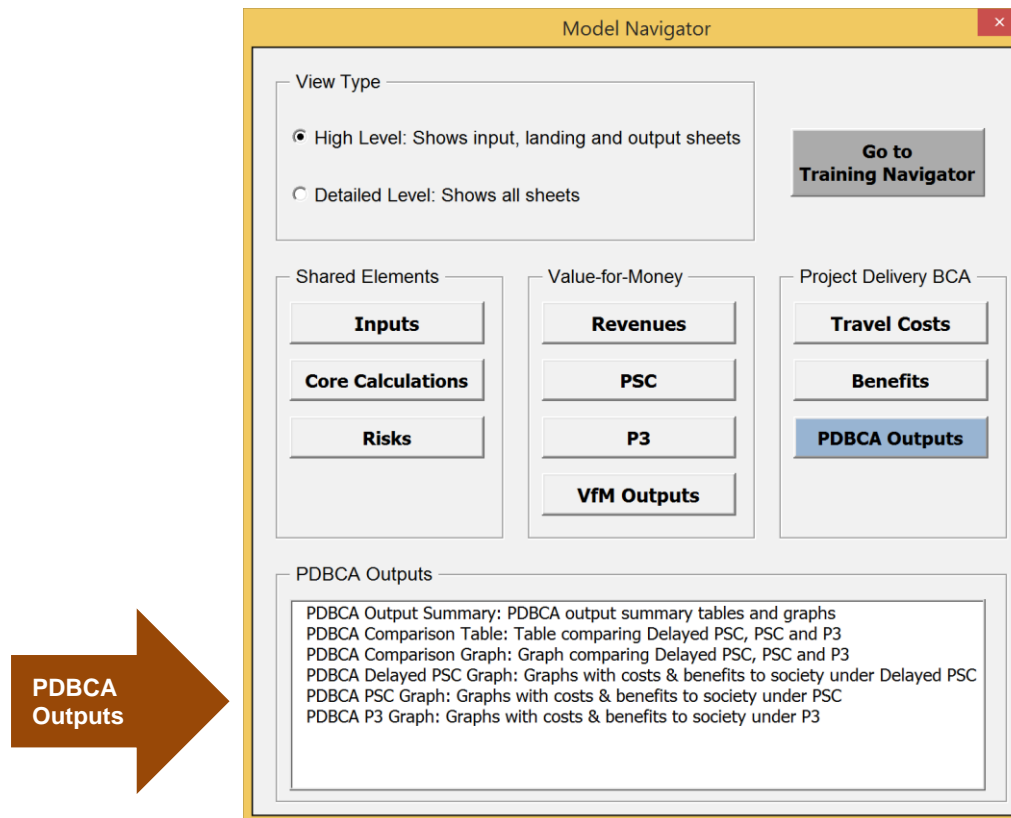
### 2.2.9 Benefits

Click on the Benefits button on the Model Navigator to navigate to the Benefits landing sheet in the high level view, or to one of the calculation sheets in the detailed level view. This module uses the calculated economic travel costs to determine the economic benefits of the Delayed PSC, PSC and P3 compared to the No Build. The following presents the Benefits landing sheet.



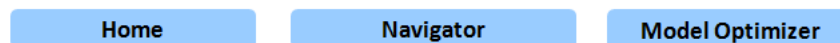
### 2.2.10 PDBCA Outputs

Click on the PDBCA Outputs button on the Model Navigator to navigate to the various output sheets. This module presents the outputs of the Project Delivery Benefit-Cost Analysis, in which the economic net benefits of the Delayed PSC, PSC and P3 are compared. The screenshot below shows how the PDBCA output sheets can be directly accessed from the Model Navigator (both in high level and detailed level view<sup>3</sup>).



### 2.3 Model Toolbar

The model also contains a toolbar that is visible in all worksheets (except on the Home worksheet). The toolbar contains the following three buttons.



The user can use the toolbar to navigate or optimize the model:

- Click the Home button to view the model flow diagram.
- Click the Navigator button to load the Model Navigator and navigate to a worksheet.
- Click the Model Optimizer button to calculate the required subsidy/availability payment while simultaneously optimizing the project’s financing (see Section 2.4 below for more detail).

<sup>3</sup> In the detailed level view, an additional sheet can be accessed: PDBCA Graph Data sheet.

## 2.4 Model Optimizer

The P3-VALUE 2.0 tool includes a full financing structure for both the Conventional Delivery and P3. Due to significant interdependence between the different elements of the financing and funding structure (e.g. the role of subsidies in determining the financing requirement and the optimal financing structure), as well as other parts of the model (in particular, the lifecycle performance risk calculation discussed below), many of the calculations need to be performed iteratively to arrive at the optimal financing structure. To determine the financing structure, the user needs to provide the debt-to-equity ratio (or gearing) as an input. Based on this, the Model Optimizer uses a set of macros to determine the lowest possible bid (for P3) and the lowest possible subsidy (for Conventional Delivery).

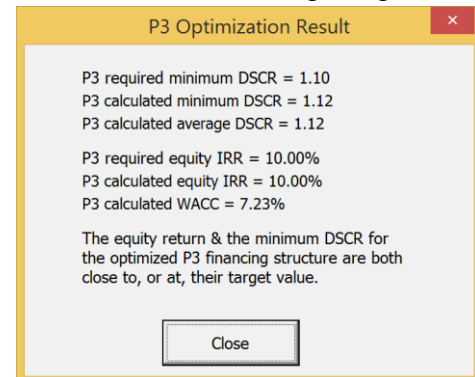
The Model Optimizer calculates the optimal subsidy/concession fee (for a toll concession) or availability payment, subject to a given debt-to-equity ratio, using an iterative optimization approach for the P3. In this context, “optimal” means the lowest possible cost to the Agency while simultaneously satisfying the following two requirements:

1. Calculated minimum Debt Service Coverage Ratio (DSCR) is equal to or exceeds the required minimum DSCR.
2. Calculated equity internal rate of return is equal to or exceeds the required equity return.

The Model Optimizer iteratively adjusts the subsidy/concession fee or availability payment (depending on which P3 structure is selected) until both criteria are satisfied. Further increasing the subsidy/concession fee or availability payment would result in unnecessary high returns for the equity investor and/or unnecessary high minimum DSCR values. Decreasing the subsidy/concession fee or availability payment would result in the target equity return or minimum DSCR not being met. Given the inputs (including the debt-to-equity ratio), the optimized result will be the most efficient solution with the lowest Weighted Average Cost of Capital (WACC).

It may, however, be possible to obtain a more efficient financing solution (with a lower WACC) by changing the debt-to-equity ratio. This is particularly relevant when the calculated DSCR significantly exceeds its target value (while the calculated equity IRR is equal to its target value), or when the calculated equity IRR significantly exceeds its target value (while the calculated DSCR is equal to its target value). In that case, adjusting the debt-to-equity ratio can further lower the required subsidy/concession fee or availability payment. To help the user in this process, the Model Optimizer provides guidance to the user on how to potentially change the debt-to-equity ratio to find a more efficient financing solution at the end of the optimization cycle (see sample P3 optimization result on the right). It should be noted, however, that debt providers have strict limitations on gearing and minimum DSCR, so users should make sure that the selected debt-to-equity ratio (as well as other financing conditions) is consistent with market practice.

For Conventional Delivery, the Model Optimizer uses an iterative approach to optimize the minimum subsidy amount required while ensuring that the public debt amount can be repaid and meets the minimum DSCR requirement. The optimized subsidy amount exactly meets the minimum DSCR requirement. A lower subsidy would cause the minimum DSCR requirement to be breached. A higher subsidy would not make full use of the project’s debt capacity and therefore would be inefficient.



To optimize the model after all inputs have been entered and reviewed, the user can simply click on the Model Optimizer button, which is included on almost all worksheets in the model. Once the model is optimized (which can take up to a couple of minutes), a brief P3 financing summary is displayed, showing the key financing results and providing guidance on how to potentially further improve the financing solution (see the screenshot on the right).

## 2.5 Key

The P3-VALUE 2.0 tool uses color coding (in sheet tab names, fonts, and shading) to help the user distinguish between inputs, calculations, and outputs. The tables below present the different color coding used in the model.

### 2.5.1 Sheet Tabs

Light Yellow	Input sheets
No color (default Excel tab color)	Calculation and documentation sheets
Pale Blue	Key output sheets
Turquoise	Quality control sheets

### 2.5.2 Cells

#### Font color only

Blue font	Imported from another sheet
Red font	Exported to another sheet (except from Input sheets)
Black font	Within-sheet link or calculation

#### Font + shade combinations

Black font + Light Yellow shade	Project specific inputs (inputs required by user)
Black font + Light Orange shade	Non-project specific inputs (default values may be used)
Black font + Light Grey shade on entire row	Within-worksheet counter-flow <sup>4</sup>
Blue font + Light Grey shade on entire row	Between-worksheet counter-flow
Empty Cell with Light Grey shade	Empty cells being deliberately referenced

#### Other

Black font + Pale Blue shade on entire row	Section separator
Light Turquoise shade	Stored/hard-coded outputs
Tan shade	Pre-model time line actuals

#### Error checks & alerts

Green shade	OK
Red shade	Error
Gold shade	Alert

The Key sheet also contains a list of abbreviations, name ranges, and Excel functions used in the model.

<sup>4</sup> Counter-flow refers to the use of elements that are calculated later in the model, either below the current calculation, or in a sheet to the right of the current calculation sheet. For example, interest calculations require the opening debt balance, whereas the opening debt balance may only be calculated at a later point in the calculation sheet.

## 2.6 Error Checks & Alerts

The model contains an auto-auditing feature to ensure that critical calculations within the model are carried out correctly. For example, if the capital expenditure profile doesn't add up to exactly 100% (in other words, the total expenses are more or less than the project costs), the model automatically informs the user through the error checks and alerts the user that something is wrong. The error checks and alerts are visible in each input and calculation sheet. The following shows sample error checks and alerts.















-	Error checks
2	Alerts

If an error check or an alert flag appears at the top of the input and calculation sheets, the user should navigate to the Checks sheet to determine what the cause of the error or alert may be. Error checks are critical and require immediate attention. If the model is functioning correctly, no error checks are to be expected. Alerts are not critical and are used to inform the user of the occurrence of non-critical events. For example, an alert will be displayed if the target balance for the Debt Service Reserve Account (DSRA) is not met (but all debt payments are still fulfilled on time). Please note that error checks and alerts will appear if the user makes changes to the inputs without optimizing the model. In that case, the user should click on the Model Optimizer button to initiate the optimization process. Upon completion of the optimization process, all error checks should disappear. Depending on the project's specifics, some alerts may remain.















Users can double click on the relevant error check or alert to be taken to the source of the error or alert. For this function to work, the user needs to enable the “detailed level view” in the Model Navigator. The following presents the various error checks and alerts in this model.

### 2.6.1 Error Checks

PSC - Modeling period check	-	check
P3 - Modeling period check	-	check
Delayed PSC - Modeling period check	-	check
PSC - Combined pre-construction profile check	-	check
PSC - Combined construction profile check	-	check
PSC - Input subsidy/Milestone payment profile check	-	check
Delayed PSC - Combined pre-construction profile check	-	check
Delayed PSC - Combined construction profile check	-	check
P3 - Combined pre-construction profile check	-	check
P3 - Combined construction profile check	-	check
P3 - Input subsidy/Milestone payment profile check	-	check
PSC - Financing requirement check	-	check
PSC - Debt balance check	-	check
PSC - Major maintenance balance check	-	check
PSC - DSRA balance - Check	-	check
P3 - Funding requirement check	-	check

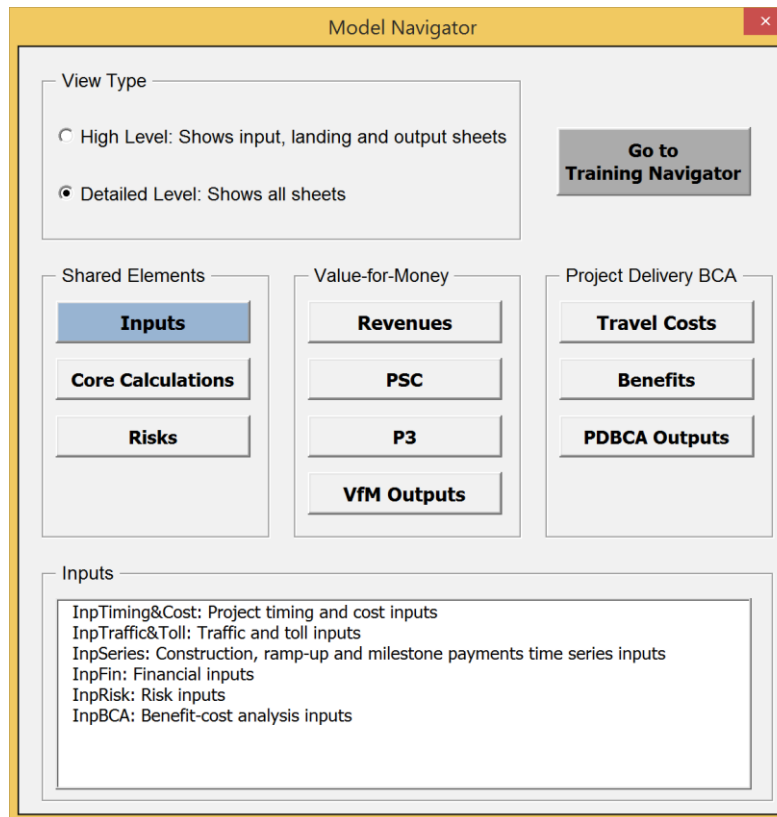
P3 - Debt balance check		-	check
P3 - Net cash flow NPV check		-	check
P3 - Major maintenance balance check		-	check
P3 - DSRA balance check		-	check
P3 - Negative cash flow to equity check		-	check
P3 - Fixed asset balance check		-	check
P3 - Major maintenance asset balance check		-	check
P3 - Cash flow to equity optimization check		-	check
P3 - FinStat - PL check		-	check
P3 - FinStat - CF check		-	check
P3 - FinStat - BS check		-	check
P3 - FinStat - PL column vs. row sumtotal check		-	check
P3 - FinStat - CF column vs. row sumtotal check		-	check
P3 - PL winding up check		-	check

### 2.6.2 Alerts

PSC - DSRA target balance vs. DSRA balance alert		-	alert
P3 - DSRA target balance vs. DSRA balance alert		-	alert
PSC - Negative cash flow alert		1	alert
P3 (Public) - Negative cash flow in operations period alert		1	alert
PSC - Periodic minimum DSCR vs. DSCR alert		-	alert
P3 - Periodic minimum DSCR vs. DSCR alert		-	alert
PSC - Interest capitalization alert		-	alert
P3 - Interest capitalization alert		1	alert
No Build - P50 - Traffic capacity breach alert		-	alert
ML/TL - P50 - Traffic capacity breach alert		-	alert
GPL - P50 - Traffic capacity breach alert		-	alert
No Build - 100% of P50 - Traffic capacity breach alert		-	alert
ML/TL - 100% of P50 - Traffic capacity breach alert		-	alert
GPL - 100% of P50 - Traffic capacity breach alert		-	alert

### 3 P3-VALUE 2.0 Inputs

The input sheets can be accessed through the Model Navigator. The following panel with the various input sheets will appear upon clicking on the Inputs button in the Model Navigator.



Alternatively, users can use the usual Excel navigation features to access the different sheets. Users will be required to input data in the different input sheets for the PSC and the P3 delivery models. For the Delayed PSC delivery model, the user only needs to input start and duration of pre-construction (see below), with all other values being equal to the PSC.

Users are only expected to provide inputs in cells that are yellow-shaded (for project specific inputs) or orange-shaded (for non-project specific inputs)

#### 3.1 InpTiming&Cost: Timing & Cost Inputs

This sheet seeks user inputs for the timeline and basic cost for the various delivery models to be considered in the analysis.

##### 3.1.1 Timing Inputs

In this section, the user will input the specific years in which project phases begin, as well as the duration of each phase for the various delivery models. Users should input data in the yellow-shaded cells.

- **Pre-construction start year:** Please enter the year the pre-construction phase begins.
- **Pre-construction duration:** Please enter the duration of the pre-construction duration (in whole years).
- **Construction start year:** Please confirm the year construction begins. If users want to modify the construction start year, please adjust the pre-construction start or duration (in whole years).
- **Construction duration:** Please enter the construction period duration (in whole years).
- **Operations start year:** Please confirm the year operations begin. If users want to modify the operations start year, please adjust the construction start or duration.
- **Operations duration:** Please enter the operations phase duration. For the P3 and Delayed PSC delivery models, the operations duration is automatically adjusted to ensure the same operation end year for PSC, Delayed PSC, and P3.
- **Operation end year:** Please confirm the year the operations phase will end. If users want to modify the operations end year, please adjust the operations start or duration.

The following provides sample timing inputs:

		PSC	Delayed PSC	P3
Pre-construction start year	year #	2015	2020	2015
Pre-construction duration	years	2	2	2
Construction start year	year #	2017	2022	2017
Construction duration	years	4	4	3
Operations start year	year #	2021	2026	2020
Operations duration	years	40	35	41
Operations end year	year #	2060	2060	2060

### 3.1.2 Cost Inputs

In this section of the InpTiming&Cost sheet, users will input all major costs items for each of a project’s phases:

- Pre-construction
- Construction
- O&M and Major Maintenance

Users may enter up to five pre-construction cost items, eight construction cost items, and eight O&M cost items. Users may also change the cost labels (column E in the InpTiming&Cost sheet) to customize the cost items. The cost input tables are similar for Pre-construction, Construction, O&M and Major Maintenance. The user should enter all costs in nominal dollar terms in the indexation base year (see section 3.1.3 below). Users should only input data in the yellow-shaded cells. For each of the cost items, the following inputs are required:

- **Cost label:** Please enter the label for the considered cost item (only for yellow-shaded cells).
- **PSC:** Please enter the cost amount of the considered cost item under PSC delivery (in thousands of dollars for pre-construction and construction or thousands of dollars per year for O&M).
- **P3 cost difference:** Please enter the expected cost difference under P3 delivery relative to conventional delivery (in percent). The P3 cost difference is the expected percentage difference in cost under P3 compared to PSC. A positive value indicates a reduction in cost under P3 compared

to conventional delivery. Based on this cost difference and the PSC cost, the model calculates the P3 cost amount of the considered cost item.

- **P3 cost overwrite:** Optionally, please enter the cost amount of the considered cost item under P3 delivery (in thousands of dollars for pre-construction and construction or thousands of dollars per year for O&M). If a value is provided in this cell, the model will use it as the P3 cost amount for the considered cost item. In other words, it overwrites the costs calculated using the P3 cost efficiency. If the cell is left blank, the model uses the cost amount calculated using the P3 cost efficiency.
- **P3 transferred cost:** Please enter the share of the P3 cost amount that will be transferred from the Agency to the P3 concessionaire (in percent).

The InpTiming&Cost sheet also contains a number of dedicated cost items that users should not rename. An explanation of what these cost items represent is provided below:

- **Public procurement cost (including compensation of losing bids):** Please enter the amount of the public procurement costs (in thousands of dollars). These are costs incurred by the Agency during the project preparation phase up to financial close, including any compensation that may be given to losing bids.
- **Private procurement costs (cost of winning bid):** Please enter the cost incurred by the winning bidder (in thousands of dollars).
- **Private procurement costs (cost of non-compensated bids, only considered in PDBCA):** Please enter the non-compensated cost incurred by the losing bidders (in thousands of dollars).
- **Handback costs:** Please enter the cost required to bring back the facility to the specified standards for each of the delivery models (in thousands of dollars). For a more detailed discussion on handback cost and residual value, please see Part II 2.4.
- **Major maintenance costs:** Please enter the major maintenance costs (in thousands of dollars per year). For example, if the user expects a \$10,000k major maintenance investment every 10 years (in nominal dollar terms in the indexation base year, see below), the input should be \$10,000k. The user will also be expected to provide the major maintenance periodicity for the different delivery models. In this case, the major maintenance periodicity would be 10 years.

Furthermore, users are expected to provide No Build annual O&M costs (in thousands of dollars per year), which are used to calculate the No Build O&M cost savings achieved by doing the project. The No Build annual O&M amount should include all operational costs that will not have to be incurred if the project is undertaken, including annualized costs of any contributions towards major maintenance.

Please note that P3-VALUE 2.0 does not adjust O&M costs for traffic. In other words, even if traffic is lower than expected, the O&M costs remain the same.

### 3.1.3 Escalation

This section of the worksheet prompts user input for escalation and indexing for costs and revenues. The user must input the **indexation base year** and should adjust the **indexation rate** as appropriate for each of the project costs and revenue sources. Please note that all input cost and revenue sources are assumed to be in nominal terms, using the indexation base year input as its base year. The indexation base year is also used as the base year for NPV calculations (see section 3.4.2). The following is an example of input for this section:

Indexation base year	2015	year #
Indexation rate - Construction	2.00%	% p.a.
Indexation rate - Operations	2.00%	% p.a.
Indexation rate - Toll rates	2.00%	% p.a.
Indexation rate - CPI	2.00%	% p.a.
Indexation rate - Subsidy	2.00%	% p.a.
Indexation rate - Availability payment	0.50%	% p.a.

### 3.1.4 Non Changeable Technical Inputs

This section of the worksheet presents non-changeable technical inputs. The user is not expected to change any of these inputs and can ignore them while performing a VfM analysis and PDBCA. Non-changeable inputs include view mode and navigator labels (used in a macro to switch from detailed level to high level, and from Model Navigator to Training Navigator), timeline labels (used to provide visual timelines in each calculation sheet) and a number of constants.

#### Navigator Labels

View mode (0 = Detailed level, 1 = High level) - Macro driven	Detailed level view	switch
Navigator option (0 = Model Navigator, 1 = Training Navigator)	Model Navigator	switch

#### Timeline Labels for PSC and P3

Project initiation period (PSC and P3)		label
Project initiation period (Delayed PSC)	Delayed	label
Pre-construction period	Pre-Constr.	label
Construction period	Construction	label
Operations period	Operations	label
Post-operations period	Post-Ops.	label

#### Timeline Labels for Delayed PSC

Project initiation period (PSC and P3)		label
Project initiation period (Delayed PSC)	Delayed	label
Pre-construction period	Pre-Constr.	label
Construction period	Construction	label
Operations period	Operations	label
Post-operations period	Post-Ops.	label

The constants include consumer surplus factor (equal to 1/2, please refer to Part II 5.10 explaining the calculation of consumer surplus), the number of directions in bidirectional traffic (equal to 2 directions), the variance quadratic factor, uniform variance factor, triangular variance factor (factors used in the calculation of variance for pure risks), goal seek precision multiplier (input used for the Model Optimizer), and various units.

#### Constants

View of model	Detailed level view	switch
Consumer surplus factor (for PDBCA)	0.5000	factor
Number of directions in bidirectional traffic	2	directions

Variance quadratic factor	2.0000	factor
Uniform variance factor	12.0000	factor
Triangular variance factor	18.0000	factor
Goal seek precision multiplier	1	#
Units in a hundred	100	units
Units in a thousand	1,000	units
No. of days in a year	365	days
Months in a year	12	months
Units in a million	1,000,000	units

Furthermore, the Model Optimizer requires a number of numerical inputs, which are listed below.

Model check tolerance level	0.0010	tolerance
Model check tolerance level amplifier	0.1000	tolerance
P3 - WACC for initial AP estimation in macro	8.00%	% p.a.
P3 - WACC for initial subsidy / concession fee estimation in macro	10.00%	% p.a.

Please note that the non-changeable technical inputs are not accessible under the high level view.

### 3.2 InpTraffic&Toll: Traffic and Toll Inputs

This sheet seeks user inputs for traffic volumes, toll rates, traffic characteristics and shares, speed, and roadway capacity.

#### 3.2.1 Traffic Inputs

The model enables users to input bidirectional P50 (or most likely) weekday traffic data for up to five different input years over the project analysis period. Users must provide traffic data for the No Build and Build (Managed Lanes or Tolled Lanes and General Purpose Lanes separately) for the model start year (PSC or P3 pre-construction start year, whichever is earlier). Users may also provide up to four additional traffic data points by entering the relevant traffic data point year and forecast. If the project is a simple toll road (as opposed to a Managed Lanes facility), traffic inputs on the General Purpose Lanes (GPL) should be zero. If the project is not tolled, traffic inputs on the Managed Lanes or Tolled Lanes (ML/TL) should be zero. If the project is a managed lane project, the user will input both tolled traffic (on ML/TL) and non-tolled traffic (GPL). Please note that Build traffic (Managed Lanes or Tolled Lanes and General Purpose Lanes traffic combined) should be equal to or exceed No Build traffic. The following shows sample inputs for a project involving the expansion of an existing facility to accommodate managed lanes along with free GPLs. The units are thousands of vehicles per weekday.

	Units	Year	No Build	ML/TL	GPL
Bidirectional P50 weekday daily traffic in model start year (2015)	000s	2015	140	20	130
Bidirectional P50 weekday daily traffic in input year 2	000s	2020	150	30	140
Bidirectional P50 weekday daily traffic in input year 3	000s	2030	167	40	155
Bidirectional P50 weekday daily traffic in input year 4	000s	2040	183	50	170
Bidirectional P50 weekday daily traffic in input year 5	000s	2050	200	60	185

Users are also expected to provide the annual traffic growth after the last input year. This input is used to project traffic beyond the last year of input. The following shows sample inputs. In the sample inputs, “> 2050” refers to traffic growth after 2050, the last year of input in the considered example.

Annual traffic growth after last input year	Units	Year	No Build	ML/TL	GPL
	% p.a.	> 2050	1.00%	3.00%	1.00%

The model has a built-in feature to ensure that project daily traffic does not exceed the facility’s daily capacity. Please refer to Part II 5.3 for more detail on this feature.

### 3.2.2 Toll Inputs

Users will need to input the toll rates for 2-, and 4-axle vehicles for weekday peak, weekday off-peak and weekends, for the No-Build, ML/TL, and GPL. The following shows sample inputs.

	Units	No Build	ML/TL	GPL
2 axle vehicles toll rates - Weekday - Peak	USD / vehicle	0.00	4.50	0.00
2 axle vehicles toll rates - Weekday - Off-peak	USD / vehicle	0.00	3.00	0.00
2 axle vehicles toll rates - Weekend	USD / vehicle	0.00	3.00	0.00
4+ axle vehicles toll rates - Weekday - Peak	USD / vehicle	0.00	8.00	0.00
4+ axle vehicles toll rates - Weekday - Off-peak	USD / vehicle	0.00	6.00	0.00
4+ axle vehicles toll rates - Weekend	USD / vehicle	0.00	6.00	0.00

In addition, the user is requested to enter the expected toll revenue leakage (as a percentage of total toll revenues).

Toll revenue leakage 1.00% %

### 3.2.3 Inputs for Traffic Characteristics and Shares

Besides the traffic and toll inputs, the PDBCA module also requires other traffic-related inputs. First, users are expected to provide a traffic sensitivity factor, which determines what share of the growth in traffic (i.e., P50 (or most likely) traffic above No Build base year traffic) will be considered in the PDBCA module. This traffic sensitivity factor captures uncertainty in traffic projections. The factor is applied to all traffic above the No Build base year traffic, both for the Build and No Build scenarios. If the sensitivity factor is set to 0%, the base year No Build traffic will be applied in all years (no traffic growth) to both the No Build and Build scenarios. The model allocates the No Build base year traffic on a pro rata basis to the Managed Lanes or Tolloed Lanes and General Purpose Lanes using the weekday daily traffic inputs. If the traffic sensitivity factor is set to 100%, the model directly uses the weekday daily traffic inputs. If a value between 0% and 100% (or above 100% for an upside sensitivity analysis) is selected, the factor is applied to all No Build and Build traffic above the No Build base year traffic.

In the VfM analysis, the uncertainty is captured through the revenue uncertainty adjustment (for the PSC) and the cost of capital (for P3). Please refer to Part II 3 for a more detailed discussion on risks and uncertainty.

Traffic sensitivity factor for PDBCA (applies to traffic above No Build base year traffic) 100.00% %

Furthermore, users will be expected to provide information on the facility’s segment length. The number of representative weekdays has a default value of 250 days per year (non-project specific default inputs are orange-shaded). The number of weekend days or holidays in a year is calculated automatically.

Segment length	20	miles
Weekdays in a year	250	days
Weekend days / holidays in a year	115	days

Users will also need to input the number of unidirectional peak hours in a day, and the number of unidirectional off-peak hours in a day. For example, a radial highway may experience an AM peak period of 3 hours in the direction of the central business district while a circumferential highway may experience an AM peak period of 3 hours and a PM peak period of 3 hours, i.e. a total of 6 hours of peak traffic. The following shows sample inputs.

No. of unidirectional peak hours in a day (during AM, PM or combined)	3	hours
No. of unidirectional off-peak hours in a day	15	hours

In the above example, the amount of traffic carried by the roadway for 6 hours at night (e.g., between 12:00 AM and 6:00 AM) is insignificant. Therefore, the off-peak period is 15 hours. The model requires users to input only the number of hours with significant traffic in order to ensure that off-peak congested speed is representative of real world conditions.

Next, users will need to input the number of lanes per direction as well as the relative share of unidirectional peak traffic (as a percentage of weekday traffic) and weekend traffic (as a percentage of weekday traffic), for the No Build, Managed Lanes/Tolled Lanes, and General Purpose Lanes. As the combined weekday traffic needs to be 100%, the unidirectional off-peak traffic percentage is calculated directly from the unidirectional peak traffic percentage. Sample inputs are shown below.

	Units	No Build	ML/TL	GPL
No. of lanes per direction	lanes	3	2	3
Unidirectional peak traffic percentage	%	30.00%	30.00%	30.00%
Weekend traffic (% of weekday traffic)	%	60.00%	60.00%	60.00%

In addition, users must enter 2-axle vehicle percentages for peak, off-peak, and the weekend. The 4+ axle traffic shares are calculated automatically using the 2 axle traffic shares. The following shows sample inputs.

	Units	No Build	ML/TL	GPL
2 axle vehicle percentage - Peak	%	95.00%	100.00%	95.00%
2 axle vehicle percentage - Off-peak	%	90.00%	100.00%	90.00%
2 axle vehicle percentage - Weekend	%	95.00%	100.00%	95.00%

### 3.2.4 Speed Inputs

In order to calculate travel time savings, the model requires users to provide free flow speeds for both 2 axle and 4+ axle vehicles. The following shows sample inputs.

	Units	No Build	ML/TL	GPL
Highway free flow speed - 2 axle	miles / hour	65	70	70
Highway free flow speed - 4+ axle	miles / hour	60	65	65

### 3.2.5 Volume and Capacity Inputs

Beyond traffic and speed inputs, the model requires additional information regarding the relation between speeds and traffic volumes to accurately predict delays due to high traffic volumes. More specifically, the model uses a volume delay function (VDF). Its default parameters are provided below, as well as the Level of Service C (LOS C) lane vehicle capacity (expressed as thousands of passenger car equivalents per lane per hour).

Bureau of Public Road Volume Delay Function parameter Alpha	0.15	constant
Bureau of Public Road Volume Delay Function parameter Beta	4.00	constant
Lane vehicle capacity at LOS C	1.50	000s/lane/hour

The capacity and VDF parameters used by the regional travel demand model (maintained by the Metropolitan Planning Organization) may be used as inputs for P3-VALUE 2.0 in order to ensure that the estimated traffic speeds and capacities are consistent. The user may alternatively use the Highway Capacity Manual to estimate capacity based on roadway characteristics if lane vehicle capacity information cannot be obtained from the travel demand model documentation. FHWA recommends using LOS C capacity to estimate congested speeds<sup>5</sup>.

As mentioned earlier, the model contains a built-in feature that ensures that future daily traffic does not exceed the facility’s daily capacity. To determine the facility’s daily capacity, the model requires two additional inputs: 1) An hourly-to-daily capacity conversion factor and 2) the ratio of LOS E capacity to LOS C capacity. Default inputs are provided for the No Build, Managed Lanes/Tolled Lanes, and General Purpose Lanes separately.

	Units	No Build	ML/TL	GPL
Hourly-to-daily capacity conversion factor	factor	15	10	15
Ratio of LOS E capacity to LOS C capacity*	factor	1.33	1.00	1.33

\* LOS E = maximum vehicle throughput, LOS C = vehicle throughput at or near free flow

In the traffic and toll input sheet, there is a daily traffic capacity breach check that indicates whether the daily traffic assumptions lead to traffic beyond capacity. If the check is green, projected traffic is less than the facility’s capacity. If the check is orange, projected traffic exceeds the facility’s capacity, in which case the model automatically constrains traffic at capacity. This check is also included in the “error checks and alerts” summary at the top of each input and calculation sheet.

Please note that the volume and capacity inputs are not accessible under the high level view.

<sup>5</sup> [https://www.fhwa.dot.gov/planning/tmip/publications/other\\_reports/delay\\_volume\\_relations/ch04.cfm](https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/delay_volume_relations/ch04.cfm)

### 3.2.6 P3-VALUE 2.0 Limitations & Guidelines for Input Assumptions

It is to be noted that P3-VALUE 2.0 has certain limitations with regard to the type of projects it can analyze. For example, there is only one lane type and associated traffic input for the No Build. If the No Build contains both high occupancy vehicle (HOV) lanes and general purpose lanes (GPL), the user would need to combine both types of traffic into a single input. While the combined traffic volumes can be directly input, the vehicle occupancy for the No Build would need to be adjusted to represent both sets of lanes. In addition, HOV lanes and the GPLs may in reality have different congested speeds. Since a single Volume Delay Function (VDF) would be applied to the combined traffic, the estimated congested speeds will not reflect actual conditions. The VDF will overestimate the speed of GPL traffic and underestimate the speed of HOV traffic. Therefore, use of P3-VALUE 2.0 for this type of project will not provide an accurate representation of congestion delays in the No Build scenario.

A second limitation of P3-VALUE 2.0 is that it assumes that Build traffic (all lanes combined) is higher than, or at least equal to, No Build traffic. However, the presence of a high toll could reduce traffic in the Build alternatives relative to the No Build case. In the presence of a relatively high toll, traffic may divert to other facilities. P3-VALUE 2.0 cannot be used in such a case, since a basic assumption in the model is that Build traffic will be equal to or higher than No Build traffic. A possible way to overcome this limitation might be to run the travel demand model using the higher toll to determine the No Build traffic under these conditions. Such an approach would allow for a comparison between the Build and No Build alternatives and ensures that the Build traffic is at least as much as the No Build traffic.

P3-VALUE 2.0 also cannot directly analyze reversible lanes. If the user wishes to analyze reversible lanes, it may be possible to conduct two separate analyses, one for each direction of travel, and combine the results.

Projects that are conducted to upgrade structurally deficient infrastructure (such as bridge replacement) or provide an emergency evacuation route may not yield a significant increase in travel cost savings compared to the No Build. If the user wishes to analyze such projects using P3-VALUE 2.0, the user may, for example, calculate the additional safety benefits exogenously and add them to the benefits calculated by P3-VALUE 2.0 in order to perform a more complete evaluation of costs and benefits.

### 3.3 InpSeries: Time Series Inputs

This sheet enables the user to input the timing of 1) expenses, 2) traffic ramp up, and 3) subsidies/milestone payments for the PSC and P3. For the Delayed PSC, the PSC time series inputs are used.

Users can allocate expenses, traffic ramp up, and subsidies/milestone payments over the pre-construction, construction, or operation timeline by entering percentages in the relevant period. To help the user allocate these percentages correctly and create the right profile, each time series input section contains the following two elements:

- **Period timeline:** This timeline indicates the year number of the relevant phase (pre-construction, construction, or operations) for each period: Year 1, year 2, year 3, etc.
- **Period year:** This timeline provides the calendar year for each period: 2018, 2019, 2020, etc.

For each time series input section, users must provide the expense/traffic ramp up/subsidy profile in the yellow-shaded cells. For the pre-construction cost, construction cost and subsidy/milestone payments, the

model checks if the sum of all percentages for each considered item equals 100%. If not, the model automatically raises an alert to inform the user that he/she should adjust the profile. An example of the PSC pre-construction time series inputs is provided below.

PSC - Pre-construction period timeline	labels		Year 1	Year 2			
PSC - Pre-construction period year #	year #	Total	2015	2016			
PSC - Pre-construction cost 1 - Profile	%	100.00%	50.00%	50.00%			
PSC - Pre-construction cost 2 - Profile	%	100.00%	25.00%	75.00%			
.....	%						

An example of the PSC construction time series inputs is provided below.

PSC - Construction period timeline	labels		Year 1	Year 2	Year 3	Year 4	
PSC - Construction period year #	year #	Total	2017	2018	2019	2020	
PSC - Construction cost 1 - Profile	%	100.00%	25.00%	25.00%	25.00%	25.00%	
PSC - Construction cost 2 - Profile	%	100.00%	25.00%	25.00%	25.00%	25.00%	
.....	%						

An example of the PSC traffic ramp up time series inputs is provided below. Users should make sure to enter traffic ramp up values in all years during the operations period.

PSC - Operations period timeline	labels	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
PSC - Operations period year #	year #	2021	2022	2023	2024	2025	2026
PSC - Traffic ramp up - Profile	%	50.00%	60.00%	70.00%	90.00%	100.00%	100.00%

An example of the PSC subsidy/milestone payment time series inputs is provided below.

PSC - Subsidy period timeline	labels		Year 1	Year 2	Year 3	Year 4	
PSC - Subsidy period year #	year #	Total	2017	2018	2019	2020	
PSC - Subsidy payment - Profile	%	100.00%	-	-		100.00%	

### 3.4 InpFin: Financial Inputs

The InpFin is the input sheet where users enter funding and financing inputs. This input sheet has many critical inputs, which can dramatically affect the outputs.

#### 3.4.1 PSC-P3 Comparison Scenario Selection

P3-VALUE 2.0 enables users to perform three different comparisons between PSC (Conventional Delivery) and P3, which are listed below. The first two comparison scenarios both consider a tolled highway, whereas the third scenario considers a non-tolled highway.

1. PSC tolled vs. P3 toll concession (toll revenue goes to concessionaire)
2. PSC tolled vs. P3 availability payment (toll revenue goes to public Agency)
3. PSC not tolled vs. P3 availability payment (no toll revenue for public Agency or concessionaire)

For the PSC in the first comparison scenario, the Agency will make use of conventional delivery such as a design-bid-build (DBB) or design-build (DB) contract, with all toll revenues directly flowing to the Agency. If the project is procured as a P3, the P3 concessionaire will be responsible for the construction and

operation of the facility but will also retain all toll revenues (“toll concession”). Furthermore, the P3 concessionaire may require a subsidy or may be willing to pay a concession fee, depending on the project.

For the second scenario, the PSC has exactly the same structure as the PSC under the first scenario. Under P3 for this second scenario, the P3 concessionaire will still be responsible for the construction and operation of the facility, but will not retain the toll revenues, which will flow to the Agency. In return, the Agency will pay the P3 concessionaire an availability payment for the duration of the concession period.

The last scenario is exactly the same as the second scenario, except that there is no tolling. This means that the Agency will not be able to use toll revenues to pay for the facility. Compared to the second scenario, the P3 concessionaire will not observe any real difference, as it will still receive a fixed availability payment from the Agency.

Users can select one of the above comparison scenarios using the dropdown menu at the top left of the InpFin input sheet (cell F6). The selected scenario is indicated with a ▼ symbol, as shown below.

Active scenario		▼		
Active scenario selection	PSC: Tollo P3: Toll concession	PSC: Tollo P3: Toll concession	PSC: Tollo P3: Availability Payment	PSC: Not tollo P3: Availability Payment

### 3.4.2 Analysis & Tax Inputs

In this section, the user will provide information regarding discounting and taxation.

Two elements are important for discounting. First, a net present value (NPV) always refers to a point in time. Therefore, the model needs to know what reference year will be used for NPV calculations. The second element required to discount cash flows is the discount rate. In the VfM analysis and the risk analysis, the model uses a project risk free discount rate to calculate the NPV of costs and revenues to the Agency. Cash flows to the P3 concessionaire, however, are discounted at the Weighted Average Cost of Capital (WACC). The project risk free discount rate reflects the time value of money and related uncertainties and risks (i.e., not including project risks), just like any interest rate. The term “project risk free” indicates that the discount rate does not reflect uncertainties and risks that are specific to a project. On the other hand, an interest rate in a project finance structure would reflect such project specific risks. The Agency’s borrowing rate can potentially be used as a proxy for the project risk free discount rate.

For the NPV calculations in the PDBCA, the model uses the social real discount rate. However, determining the social real discount rate can be challenging. Theoretically, the social discount rate should represent the benefits foregone from alternative use of those funds by the Agency or government. In practice, it may be difficult to determine the right value. As guidance, the user should use the state or Agency’s social discount rate or follow the Federal Office of Management and Budget’s (OMB) Circular A-94.

NPV base year (same as "Indexation base year" in InpTiming&Cost)	2015	year #
Project risk free discount rate (for VfM analysis & risk analysis)	4.00%	% p.a.
Social real discount rate (for PDBCA)	3.00%	% p.a.

Regarding tax, the model provides the option to input both federal and state tax rates for the P3 concessionaire. Whether or not the P3 concessionaire will pay tax depends on its legal structure. If the concessionaire is expected to pay tax (as opposed to its shareholders), the model allows the concessionaire to carry forward losses to future tax periods for a specified number of years.

Tax losses expiration period	20	years
P3 - Federal tax rate	0.00%	%
P3 - State tax rate	0.00%	%

Furthermore, to ensure a fair comparison between PSC and P3, the model enables users to apply a competitive neutrality adjustment. The competitive neutrality adjustment is achieved by adding the P3 tax liability to the PSC. The logic for this competitive neutrality adjustment is that the extra costs of P3 due to taxation will flow back to the government and should therefore not negatively impact the evaluation. To offset this effect, the same tax liability can be added to the PSC to reflect the effective tax impacts of not using P3 delivery. Depending on their perspective and preference, users can decide to exclude the competitive neutrality adjustment, or to include a competitive neutrality adjustment based on only state tax, or both state and federal tax.

Federal tax considered for competitive neutrality adjustment (0 = No, 1 = Yes)	1	switch
State tax considered for competitive neutrality adjustment (0 = No, 1 = Yes)	1	switch

### 3.4.3 PSC & P3 Inputs

Users only need to provide inputs for the yellow-shaded cells. Cells that are greyed-out relate to comparison scenario other than the one selected (see above). The list below provides an explanation of the various inputs required.

- **Subsidy/Milestone payment:** Please input the value of the upfront subsidy/milestone payment(s) available to the project (in thousands of dollars). The timing of the upfront subsidy/milestone payment(s) is defined in the InpSeries input sheet.
- **Public financing switch – PSC only:** Please indicate whether the PSC will finance the project (0=> No financing, 1=> Financing). If No financing is selected, the project will be funded from the Agency’s budget.
- **Cost of equity – P3 only:** Please input the cost of equity (i.e., the “hurdle” equity rate of return) for the P3 concessionaire (in percent).
- **Gearing (debt-to-equity ratio) – P3 only:** Please input the debt-to-equity ratio for the P3 concessionaire (in percent, with the percentage reflecting the debt share of the total financing amount).
- **Debt repayment type switch (0 => Sculpting, 1 => Annuity):** Please indicate the debt repayment type. If a sculpted repayment is selected, the debt repayment will be fully sculpted based on the Cash Flow Available for Debt Service (CFADS). Furthermore, under a sculpted repayment profile, interest capitalization during the first years of operations is also permitted. If an annuity-type (mortgage-style) repayment is selected, the debt service will be flat over time and no interest capitalization during operations will be allowed.
- **Debt maturity from first construction period:** Please input the maturity for debt (in years), counting from the first construction period to the last repayment period.

- **Debt grace period after operations start - for annuity-type repayment only:** Please input the debt grace period from the start of operations (in years).
- **Debt interest rate:** Please input the project debt interest rate (in percent).
- **Equity bridge loan interest rate:** Please input the equity bridge loan interest rate (in percent). The equity bridge loan is used to provide short-term financing that will be taken out by government subsidy. The equity bridge loan does not exist in the PSC as the Agency is assumed to prefinance any subsidy.
- **Debt issuance/arrangement fee:** Please input the debt issuance/arrangement fee (as a percentage of the total debt amount).
- **Minimum required DSCR:** Please input the minimum Debt Service Coverage Ratio (as a ratio of cash flow available for debt service in a given year divided by debt service for that year). The model uses a single DSCR value. In practice, P3 projects typically use multiple debt instruments. The value of the DSCR input should reflect the ratio of cash flow available for debt service in a given year divided by all combined debt service.
- **Interest rate for cash balances and reserve accounts:** Please input the interest rate for cash balance and reserve accounts (in percent).
- **No. of months of DSRA required:** Please input the number of months of debt service the Debt Service Reserve Account is required to hold.
- **Difference between AP WACC & TC WACC:** Please enter the expected difference in Weighted Average Cost of Capital (WACC) between a toll concession and an availability payment concession (in percent). This difference in WACC is used to quantify the revenue uncertainty adjustment and lifecycle performance risk premium (see Part II 3.5).

Please note that the above listed inputs determine the financing conditions of the PSC and P3. When inputting these values, users should be aware that the financing conditions should reflect the financiers' exposure to risks (including revenue risk for P3 toll concessions). As explained in the section 3.5 on Risk Inputs, P3-VALUE 2.0 uses the financing conditions to quantify the revenue uncertainty adjustment and lifecycle performance risk premium.

#### 3.4.4 Comparison Scenario Definition Inputs

The inputs listed below are used to define the three comparison scenarios. Users are not expected to change these inputs, which is why these cells have been grayed out.

- **PSC - Tolling case switch (0 => No toll, 1 => Toll):** Please indicate whether or not the PSC will be tolled.
- **P3 - AP / Tolling switch (0 => AP, 1 => Toll concession):** Please indicate whether the project will be an availability payment or toll concession.

Please note that the comparison scenario definition inputs are not accessible under the high level view.

### 3.5 InpRisk: Risk Inputs

In the InpRisk sheet, users are expected to provide project risk information. P3-VALUE 2.0 recognizes three separate risk categories: pure risk, base variability risk, and lifecycle performance risk. Furthermore, the model uses a revenue uncertainty adjustment to account for revenue uncertainty. For a detailed

discussion on how these risks are valued in the tool, please refer to Part II 3. The inputs required for each risk category are discussed below.

### 3.5.1 Pure Risk Inputs

Pure risks are also known as event risks and refer to individual risk events, such as an accident at the construction site. As a first input, the user must determine what probability level should be used for the pure risk analysis. The probability level is input as a percentage. Based on this percentage, the model determines the value of the pure risks at the given probability level. A sample input is shown below.

Probability level for pure risk analysis 70.00% %

Next, the user must provide detailed inputs for each individual pure risk. These risk inputs are separated into two tables: Construction period risk and operations period risks. Besides the fact that construction risks are expressed in total values whereas operation risks are expressed in value per year, the inputs for both risk groups are the same.

- **Risk label:** Please enter/adjust the risk label to describe the pure risk considered (provided default values for the risk labels are for illustrative purposes only).
- **Probability:** Please input the likelihood of occurrence for each risk item listed (in percent).
- **PSC most likely impact:** Please input the most likely impact or consequence of the pure risk occurring (in thousands of dollars for construction period risks or thousands of dollars per year for operations period risk). This impact is a monetary value that reflects both the potential direct costs as well as the costs of any delays caused by the risk's occurrence.
- **P3 risk difference:** Please enter the expected risk difference under P3 delivery relative to the PSC (in percent). The P3 risk difference is the expected percentage reduction in most likely risk impact under P3 compared to PSC. A positive value indicates a reduction in the most likely risk impact under P3. Based on this risk difference and the PSC most likely impact, the model calculates the most likely impact of the risk under P3.
- **P3 risk impact overwrite:** Optionally, please enter the most likely impact of the considered risk item under P3 delivery (in thousands of dollars for construction period risks or thousands of dollars per year for operations period risks). If a value is provided in this cell, the model will use it as the P3 most likely risk impact for the considered risk item. In other words, it overwrites the most likely risk impact calculated using the P3 risk efficiency. If the cell is left blank, the model uses the most likely risk impact calculated using the P3 cost efficiency.
- **P3 transferred risks:** Please enter the share of the P3 risk value that will be transferred from the Agency to the P3 concessionaire (in percent).
- **Minimum risk value:** Please enter the minimum value of the risk, as a percentage reduction of the most likely risk value (in percent). For example, the input “-5.00%” would mean the minimum value of the impact is five percent *less* than the most likely value. The minimum risk value is listed under the risk distribution in InpRisk.
- **Maximum risk value:** Please enter the maximum value of the risk, as a percentage increase of the most likely risk value (in percent). For example, the input “25.00%” would mean the maximum value of the impact is twenty-five percent *more* than the most likely value. The maximum risk is listed under the risk value distribution in InpRisk.

- **Risk value distribution:** Please indicate the distribution of the risk as either uniform or triangular. (0 = Uniform, 1 = Triangular). The distribution is listed under the risk distribution in InpRisk.

The most likely risk *value* is calculated by multiplying the likelihood of occurrence of a risk with its most likely impact.

The following tables serve as an example for the pure risks inputs. User are required to input data in the yellow-shaded cells only.

Construction period risk		Parameters >>	Probability	PSC inputs		Delayed PSC inputs		P3					Risk distribution				
			Likelihood of occurrence	Most likely impact	Most likely risk value	Most likely impact	Most likely risk value	Risk efficiency	Most likely impact	Risk impact overwrite	Most likely risk value	Transferred risks	P3 risk value	Agency risk value	Minimum risk value	Maximum risk value	Risk value distribution
Risk label		Units >>	%	USD k	USD k	USD k	USD k	%	USD k	USD k	USD k	%	USD k	USD k	%	%	0:Uniform, 1:Triangular
Design risk	Construction period risks*		30.00%	30,000	9,000	30,000	9,000	10.00%	27,000		8,100	90.00%	7,290	810	-25.00%	50.00%	0
Engineering & construction risk	Construction period risks*		50.00%	15,000	7,500	15,000	7,500	10.00%	13,500		6,750	90.00%	6,075	675	-25.00%	50.00%	0
Planning & approval risk	Construction period risks*		15.00%	5,000	750	5,000	750	10.00%	4,500		675	90.00%	608	68	-25.00%	50.00%	0
Environmental risk	Construction period risks*		50.00%	20,000	10,000	20,000	10,000	10.00%	18,000		9,000	90.00%	8,100	900	-25.00%	50.00%	0
Right of way/utilities risk	Construction period risks*		70.00%	10,000	7,000	10,000	7,000	10.00%	9,000		6,300	90.00%	5,670	630	-25.00%	50.00%	0
Commercial/ procurement risk	Construction period risks*		15.00%	0	0	0	0	0.00%	0		0	100.00%	0	0	-25.00%	50.00%	0
Latent defect	Construction period risks*		15.00%	0	0	0	0	0.00%	0		0	100.00%	0	0	-25.00%	50.00%	0
Force majeure	Construction period risks*		15.00%	25,000	3,750	25,000	3,750	10.00%	22,500		3,375	90.00%	3,038	338	-25.00%	50.00%	0
Political risk	Construction period risks*		15.00%	5,000	750	5,000	750	10.00%	4,500		675	90.00%	608	68	-25.00%	50.00%	0
Insurance risk	Construction period risks*		15.00%	0	0	0	0	0.00%	0		0	100.00%	0	0	-25.00%	50.00%	0
Public sentiment risk	Construction period risks*		15.00%	0	0	0	0	0.00%	0		0	100.00%	0	0	-25.00%	50.00%	0
Changes in law & policy	Construction period risks*		15.00%	0	0	0	0	0.00%	0		0	100.00%	0	0	-25.00%	50.00%	0

\* Impacts correspond to both cost and schedule

Operations period risk		Parameters >>	Probability	PSC inputs		Delayed PSC inputs		P3					Risk distribution				
			Likelihood of occurrence	Most likely impact	Most likely risk value	Most likely impact	Most likely risk value	Risk efficiency	Most likely impact	Risk impact overwrite	Most likely risk value	Transferred risks	P3 risk value	Agency risk value	Minimum risk value	Maximum risk value	Risk value distribution
Risk label		Units >>	%	USD k p.a.	USD k p.a.	USD k p.a.	USD k p.a.	%	USD k p.a.	USD k p.a.	USD k p.a.	%	USD k p.a.	USD k p.a.	%	%	0:Uniform, 1:Triangular
Latent defect	Construction period risks*		70.00%	625	438	625	438	10.00%	563		394	90.00%	354	39	-25.00%	50.00%	0
Operations risk	Construction period risks*		30.00%	500	150	500	150	10.00%	450		135	90.00%	122	14	-25.00%	50.00%	0
Maintenance risk	Construction period risks*		30.00%	625	188	625	188	10.00%	563		169	90.00%	152	17	-25.00%	50.00%	0
Force majeure	Construction period risks*		15.00%	750	113	750	113	10.00%	675		101	90.00%	91	10	-25.00%	50.00%	0
Insurance risk	Construction period risks*		15.00%	0	0	0	0	0.00%	0		0	100.00%	0	0	-25.00%	50.00%	0
Changes in law & policy	Construction period risks*		15.00%	0	0	0	0	0.00%	0		0	100.00%	0	0	-25.00%	50.00%	0

\* Impacts correspond to both cost and schedule

### 3.5.2 Base Variability Inputs

Base variability refers to the uncertainty in cost estimates. P3-VALUE 2.0 enables users to specify a separate mark-up for base variability for the three project phases and different delivery models.

- **Base variability on pre-construction costs:** Please input the variability on the pre-construction costs (as a percent of the pre-construction costs).
- **Base variability on construction costs:** Please input the variability on the construction costs (as a percent of the construction costs).
- **Base variability on O&M costs:** Please input the variability on the operations and maintenance costs (as a percent of the O&M costs).

Sample inputs for base variability are shown below.

		PSC	Delayed PSC	P3
Base variability on pre-construction costs	%	10.00%	10.00%	10.00%
Base variability on construction costs	%	17.00%	17.00%	17.00%
Base variability on O&M costs	%	10.00%	10.00%	10.00%

### 3.5.3 Lifecycle Performance Risk Inputs

Lifecycle performance risk refers to all risks that cannot be transferred to subcontractors but are retained by the P3 concessionaire. P3-VALUE 2.0 requires the user to specify whether to use market-based financing conditions to calculate the lifecycle performance risk or instead rely on a simple cost input.

- **Lifecycle performance risk switch (0 = Calculated premium, 1 = Cost input):** Please indicate whether to calculate the lifecycle performance risk premium using market-based financing conditions or a simple total cost input. (0 = Calculated premium, 1 = Cost input).
- **Lifecycle performance risk - Cost input\*:** If “Cost input” is selected, please enter the total lifecycle performance risk cost premium (in thousands of nominal base year dollars over the entire operations period).

Sample inputs for lifecycle performance risk are shown below.

Lifecycle performance risk switch (0 = Calculated premium, 1 = Cost input)	0	switch
Lifecycle performance risk - Cost input*	400,000	USD k

\* Total premium during operations

### 3.5.4 Revenue Uncertainty Adjustment Inputs

P3-VALUE 2.0 adjusts revenues flowing to the procuring Agency for uncertainty. This adjustment can be either calculated using information from market-based financing conditions or alternatively users can apply a simple percentage-based reduction from the P50 (or equivalent) revenues.

- **Revenue uncertainty adjustment switch (0 = Calculated, 1 = Input):** Please indicate whether to calculate the revenue uncertainty adjustment using market-based financing conditions or a simple revenue reduction input. (0 = Calculated, 1 = Input).
- **Revenue uncertainty adjustment (% of toll collection) - Input:** If “Input” is selected, please enter the percentage by which revenues should be reduced.

Sample inputs for the revenue uncertainty adjustment are shown below.

Revenue uncertainty adjustment switch (0 = Calculated, 1 = Input)	0	switch
Revenue uncertainty adjustment (% of toll collection) - Input	28.00%	%

### 3.6 InpBCA: Benefit-Cost Analysis Inputs

In the InpBCA sheet, users are required to provide additional inputs for the benefit-cost analyses calculations embedded in the PDBCA. These inputs are not used in the VfM analysis. For a detailed discussion on how the various benefits are calculated, please refer to Part II 5. The inputs required for the various benefit calculations are discussed below.

#### 3.6.1 Delay Inputs

The PDBCA module considers three different types of delays: Delays to travelers during construction and O&M activities and delays due to incidents. For the delays due to construction and O&M activities, the user is required to provide the following inputs:

- **Frequency of construction and O&M delays:** Please provide how many construction or O&M days per year are expected for the different lanes (No Build, ML/TL, and GPL) and time period (peak, off-peak, and weekend).
- **Average duration of construction and O&M activity:** Please provide the average duration of construction or O&M activities (in hours per construction or O&M day).
- **Average affected segment length:** Please provide the average length of the segment that is affected by the delay due to construction or O&M activities (in miles).
- **Speed adjustment factor:** Please provide the speed adjustment factor for delays due to construction or O&M activities (in percent reduction of the average speed prior to consideration of the construction or O&M activity).

The table below shows sample inputs for the number of construction and O&M days per year.

Parameters >>	Construction days per year	O&M days per year
Units >>	#	#
No Build - Peak	0	0
No Build - Off-peak	0	25
No Build - Weekends	0	20
ML/TL - Peak	0	0
ML/TL - Off-peak	200	25
ML/TL - Weekends	50	20
GPL - Peak	0	0
GPL - Off-peak	200	25
GPL - Weekends	50	20

The table below shows sample inputs for the average duration of delays.

Parameters >>	Average duration of construction	Average duration of O&M
Units >>	hours/day	hours/day
No Build	0.00	4.00
PSC	8.00	3.00
P3	7.00	2.75
Delayed PSC	8.00	3.00

The table below shows sample inputs for the average affected segment length and speed adjustment. For more background data on construction and O&M speed adjustment, please refer to Part II.5.

Parameters >>	Average affected segment length	Speed adjustment
Units >>	miles	%
Construction adjustment	4.00	45.00%
O&M adjustment	4.00	45.00%

The PDBCA module also considers delays due to incidents. Incident delay is related to the frequency of crashes or vehicle breakdowns and how easily those incidents are removed from the traffic lanes and shoulders. The basic procedure used to estimate incident delay in P3-VALUE 2.0 is to reduce the speed calculated by the model based only on recurring delay by a factor (i.e., a percent speed reduction). As discussed in Part II 5.6, the speed reduction factor accounts for the probability of incidents throughout the year and is therefore applied to all traffic on the entire considered highway section. The factor represents the effect of incidents on congested speeds estimated by the model. The user is expected to provide the annual average speed reduction due to incidents under the various delivery models. These factors may be estimated based on the congestion level – uncongested, moderate, heavy, severe or extreme – defined based on traffic volume per lane. Due to the relationship of traffic volume to queuing delay, the factor will increase quite dramatically with traffic volume. The table below provides illustrative speed adjustment factors based on FHWA’s TRUCE 3.0 model<sup>6</sup>. These values may be used to develop inputs for the project under consideration.

**Illustrative Speed adjustment factors for incidents (based on TRUCE 3.0 model)**

Level of congestion	Daily traffic volume per lane	Speed adjustment factor
Uncongested	Under 15,000	5%
Medium	15,001 -17,500	5%
Heavy	17,501 – 20,000	9%
Severe	20,001 – 25,000	18%
Extreme	Over 25,000	23%

<sup>6</sup> See TRUCE 3.0 Users Guide available at:  
[http://www.ops.fhwa.dot.gov/congestionpricing/value\\_pricing/tools/truce\\_model\\_guide.htm](http://www.ops.fhwa.dot.gov/congestionpricing/value_pricing/tools/truce_model_guide.htm)

Sample inputs for these speed adjustments are shown below, assuming severe congestion in the No Build case and heavy congestion in the Build alternatives, with a small reduction in incident delay under a P3 option. For more background data on the speed adjustment related to incidents, please refer to Part II 5.6.

Speed adjustment for incident delays - No Build	18.00%	%
Speed adjustment for incident delays - PSC	9.00%	%
Speed adjustment for incident delays - P3	8.50%	%
Speed adjustment for incident delays - Delayed PSC	9.00%	%

### 3.6.2 Accident Cost Inputs

The PDBCA module also considers the societal cost of accidents. In order to calculate these costs, the model requires users to enter accident rates and accident cost information for fatal accidents, injury accidents, and property damage only accidents, for the No Build and Build alternatives. Users will need to determine whether or not to expect a difference in accident rates between the No Build and Build alternatives based on the project’s safety features. The table below shows sample inputs for accident costs, which assumes lower accident rates for the Build alternatives compared to the No Build alternative. For more background information on accident calculation and inputs, please refer to Part II 5.8.

Parameters >>	Cost	No Build	Build
Units >>	USD/accident	#/m VMT	#/m VMT
Fatal accidents	9,200,000	0.0109	0.0106
Injury accidents	500,000	0.7700	0.7500
Property damage only accidents	15,000	1.9000	1.8500

Source for fatal accident cost value: TIGER Benefit-Cost Analysis (BCA) Resource Guide, 2014  
 Source for accident rates: NHTSA Fatality Analysis Reporting System (FARS) database (<http://www.nhtsa.gov/FARS>)

Only the cost of a fatal accident is a default input value (assuming a single fatality, which should be reflected in the accident rate inputs, which are in terms of fatalities per VMT rather than fatal accidents per VMT). The TIGER BCA Resource Guide provides guidance on how users can calculate the value of injury and property damage only accidents, based on a detailed analysis of accidents in the considered corridor.

### 3.6.3 Travel Time Cost Inputs

P3-VALUE 2.0 requires inputs for vehicle occupancy (for 2-axle vehicles) and value of time to calculate travel time cost and savings. The vehicle occupancy must be provided separately for the No Build, ML/TL, and GPL. The vehicle occupancy for 4+ axle vehicles is assumed to be 1.00. The table below shows sample inputs for vehicle occupancy for 2 axle vehicles.

Parameters >>	Peak	Off-peak	Weekend
Units >>	persons/vehicle	persons/vehicle	persons/vehicle
No Build	1.15	1.30	1.30
ML/TL	1.20	1.35	1.35
GPL	1.15	1.30	1.30

The model calculates the travel time cost and savings separately for 2 axle and 4+ axle vehicles, using different values of time for each vehicle type. The table below shows default inputs for value of time. However, as value of time is region specific, users are free to use alternative values.

Value of time - 2 axle	17.39	USD / hr / person
Value of time - 4+ axle	25.75	USD / hr / person

Source: TIGER Benefit-Cost Analysis (BCA) Resource Guide, 2014

### 3.6.4 Pavement Quality Inputs

P3-VALUE 2.0 also considers vehicle operating costs, including the potential impact of pavement quality on these costs. For that purpose, users must provide the expected pavement quality, using the International Roughness Index (IRI), measured in inches per mile. The table below shows sample inputs for the IRI.

IRI – No Build	150	inch/mile
IRI – PSC	140	inch/mile
IRI – P3	130	inch/mile
IRI – Delayed PSC	140	inch/mile

### 3.6.5 Vehicle Operating Cost & Emissions Inputs

Next, the model requires vehicle operating costs for 2 and 4+ axle vehicles. Non-fuel costs are expressed in dollar per vehicle mile traveled whereas fuel costs are expressed in dollars per gallon. The following shows default inputs for non-fuel and sample inputs for fuel costs.

Parameters >>	Non-fuel cost	Fuel cost
	Units >>	USD/gallon
2 axle	0.2978	2.5000
4+ axle	0.4470	2.4000

Source for 2 axle non-fuel cost: AAA Your Driving Costs, 2013 (costs per mile excluding fuel and non-economic costs, assuming 15,000 miles per year for average sized sedan)

Source for 4+ axle non-fuel cost: ATRI An Analysis of the Operational Costs of Trucking, 2014 (average cost per mile excluding fuel, tolls and driver costs)

For the fuel cost, users may consult AAA’s Daily Fuel Gauge Report (<http://www.fuelgaugereport.com>) to determine the average current or historic fuel cost in a given state or region.

To account for the impact of pavement quality on vehicle operating costs, P3-VALUE 2.0 requires fuel and non-fuel cost adjustment factors for 2 and 4+ axle vehicles as a function of pavement quality (IRI), expressed as a percentage of their unadjusted values. The table below shows a selection of the default values for the pavement cost adjustment factors. P3-VALUE 2.0 contains a full set of IRI-adjusted inputs, with IRI values ranging from 0 to 450 inch per mile (increments of 25 inch per mile). For a more detailed discussion of fuel and non-fuel operating cost, please refer to Part II 5.7.

Parameters >>	Fuel cost % adjustment		Non-fuel cost % adjustment	
	2 axle	4+ axle	2 axle	4+ axle
IRI	%	%	%	%
0	97.05%	96.07%	100.00%	100.00%
25	97.68%	96.53%	100.00%	100.00%
50	98.00%	97.04%	100.00%	100.00%
75	98.24%	97.53%	100.00%	100.00%
100	98.46%	97.99%	100.00%	100.00%
150	99.52%	99.31%	101.65%	101.84%
200	100.53%	100.74%	105.20%	105.78%
250	101.95%	102.57%	108.76%	109.73%

300	103.39%	104.68%	112.31%	113.67%
350	105.01%	107.03%	115.86%	117.62%
400	107.16%	109.96%	119.41%	121.57%
450	109.31%	112.89%	122.96%	125.51%

Source for fuel cost adjustment: *Surface Characteristics of Roadways: International Research and Technologies (1990) and Vehicle-Road Interaction (1994)*  
 Source for non-fuel cost adjustment: *ARRB Research Board TR VOC Model (NCHRP Report 720: Estimating the Effects of Pavement Condition on Vehicle Operating Costs)*

Lastly, the model requires inputs for fuel consumption and emissions costs for 2 and 4+ axle vehicles as a function of speed of travel. The table shows a selection of the default values for the fuel consumption and emission costs. P3-VALUE 2.0 contains a full set of speed-adjusted inputs, with speeds ranging from 1 to 80 miles per hour (in increments of 1 mile per hour).

Parameters >>	Fuel consumption		Emission costs	
	2 axle	4+ axle	2 axle	4+ axle
Speed	gallon/mile	gallon/mile	USD/VMT	USD/VMT
5	0.1439	0.2234	0.0753	0.1148
10	0.1074	0.1714	0.0600	0.0936
20	0.0670	0.1032	0.0433	0.0649
30	0.0485	0.0738	0.0358	0.0525
40	0.0405	0.0617	0.0326	0.0475
50	0.0390	0.0596	0.0320	0.0469
60	0.0433	0.0662	0.0336	0.0505
70	0.0515	0.0810	0.0368	0.0583
80	0.0520	0.0950	0.0370	0.0686

Source for fuel consumption: *California Air Resources Board, EMFAC2011, 2011 & 2031 average*  
 Sources for emission costs: *TIGER Benefit-Cost Analysis (BCA) Resource Guide, 2014 and Environmental Protection Agency’s MOVES software*

For more information on the calculation of emission costs, please refer to Part II 5.9.

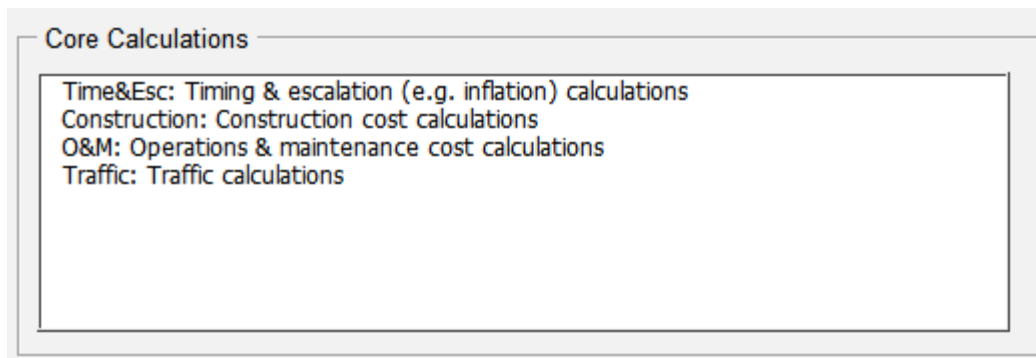
## 4 Calculations

This chapter provides a brief discussion of the various calculations performed in P3-VALUE 2.0. The chapter contains the following sections:

- Core calculations
- Risk assessment
- Revenue calculations
- PSC calculations for VfM
- P3 calculations for VfM
- VfM output calculations
- Travel cost calculations for PDBCA
- Benefits calculations

### 4.1 Core Calculations

The following section presents the core calculations, which include timing and escalation, construction and O&M costs and traffic calculations. The core calculations are used in both the VfM analysis and PDBCA. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator’s detailed level view pane with the different calculation sheets listed.



#### 4.1.1 Time&Esc: Timing & Escalation calculations

This sheet calculates the various delivery models’ timelines, which are shown at the top of each sheet. The sheet also contains flags and counters, which are used to simplify complex calculations. For example, a flag could indicate when the construction period ends and may be used in the subsidy calculation to ensure the subsidy is paid in the correct year. The Time&Esc sheet contains the following calculations:

- **Model Period:** Determines the overall model timeline using inputs from the InpTiming&Cost sheet.
- **PSC Model Timeline:** Determines the timelines for the different PSC project phases using inputs from the Model Period and the InpTiming&Cost sheet.

- **Delayed PSC Model Timeline:** Determines the timelines for the different Delayed PSC project phases using inputs from the Model Period and the InpTiming&Cost sheet.
- **P3 Model Timeline:** Determines the timelines for the different P3 project phases using inputs from the Model Period and the InpTiming&Cost sheet.
- **Maintenance Costs:** Using flags created by the three delivery model timelines and inputs from the InpTiming&Cost sheet, major maintenance costs flags are created for each of the three delivery models, which indicate when major maintenance costs are applied on the project.
- **PSC – Financing:** Using the PSC model timeline and inputs from the InpFin sheet, flags are created which will allow the model to determine when debt repayment will begin and end.
- **P3 – Depreciation:** Using the P3 model timeline and inputs from the InpFin sheet, flags are created which will allow the model to determine when to begin applying depreciation.
- **P3 – Financing:** Using the P3 model timeline and inputs from the InpFin sheet, flags are created which will allow the model to determine when debt repayment will begin and end.
- **Traffic:** Using traffic inputs, various flags are created which will be used in traffic calculations.
- **BCA:** Using the various model delivery timelines, various flags are created which will be used in the PDBCA module.
- **Indexation Factors:** Indexation factors and rates from the InpTiming&Cost sheet are used to determine the indexation factor for each of the model timeline years.
- **Discount Factor:** Discount rates from the InpTiming&Cost sheet are used to determine the discount factors for each of the model timeline years.
- **Toll Rates:** Using inputs from InpTraffic&Toll, toll rates for the No Build, ML/TL and GPL are determined for each of the model timeline years.

#### 4.1.2 Construction: Construction Cost Calculations

This sheet calculates the pre-construction and construction costs for each delivery model. Cost items are imported from the InpTiming&Cost sheet whereas cost expenditure profiles are imported from the InpSeries sheet. Furthermore, indexation factors are imported from the Time&Esc sheet. Combining the various inputs and calculations, cash flows for the construction and pre-construction costs are created. Based on the calculated nominal pre-construction and construction costs, real costs for the BCA calculations are computed.

#### 4.1.3 O&M: Operations & Maintenance Cost Calculations.

This sheet calculates the O&M and major maintenance costs for each delivery model. Cost items are imported from the InpTiming&Cost sheet whereas indexation factors are imported from the Time&Esc sheet. Combining the various inputs and calculations, cash flows for the O&M and major maintenance costs are created. Based on the calculated nominal O&M and major maintenance costs, real costs for the BCA calculations are computed.

The sheet also calculates the No Build cost savings for each delivery model. For this, annual No Build O&M costs are imported from the InpTiming&Cost sheet. The cost savings cash flows are created using the No Build O&M cost input and each delivery model's operation phase index flag from the Time&Esc sheet.

#### 4.1.4 Traffic: Traffic Calculations

This sheet calculates traffic volumes for each year in the analysis period for both the No Build and Build. The sheet distinguishes between P50 traffic (used in the VfM analysis in combination with revenue uncertainty adjustment where appropriate) and sensitivity-adjusted traffic (used in the PDBCA module). The calculated traffic volumes are used to compute revenues, speeds, travel costs, incident delays, O&M-related travel delays, construction-related travel delays, non-fuel costs, fuel costs, accident costs, and emissions costs. The sheet uses inputs from InpTraffic&Toll, InpSeries, and Time&Esc and contains the following traffic calculations.

- Traffic before capacity constraints
- Traffic after capacity constraints
- Peak, off-peak & weekend traffic, split into 2 axle & 4+ axle traffic
- ML/TL & GPL existing and induced traffic before ramp-up
- ML/TL & GPL traffic after considering ramp-up
- ML/TL & GPL existing traffic for travel costs calculations
- Peak, off-peak, & weekend traffic for speed calculation
- Annual total ML/TL & GPL traffic for weekdays & weekends
- Annual existing ML/TL & GPL traffic for weekdays & weekends
- Annual induced ML/TL & GPL traffic for weekdays & weekends
- Annual No Build traffic for weekdays & weekends

For a more detailed discussion on traffic projections, please refer to Part II 5.3.

## 4.2 Risk Assessment

This section presents the various calculations included in the risk assessment. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator’s detailed level view pane with the different calculation sheets listed.



#### 4.2.1 Pure Risks: Pure Risks Calculations

This worksheet calculates the pure risk cash flows for each delivery model. The risks are divided into construction period risks and operations period risks. The risk inputs, including the most likely risk values and other probability risk inputs, are imported from the InpRisk sheet. Indexation factors and flags are

imported from the Time&Esc sheet. Using the minimum, maximum, and mean values as well as the distribution of each individual risk, the model determines the variance of each risk in order to calculate the probabilistic combined risk value in a given year based on the desired input P-level. For P3, the pure risk values are divided into retained and transferred risks, using the risk transfer percentages from the InpRisk sheet. For a more detailed discussion on pure risks, please refer to Part II 3.2.

#### **4.2.2 Base Variability: Base Variability Calculations**

The base variability is calculated for each delivery model to create base variability cash flows. Base variability is calculated by importing the base variability inputs for each project phase (pre-construction, construction and operations) from the InpRisk sheet and the costs from InpTiming&Cost. For P3, the base variability is divided into retained and transferred base variability, using the cost transfer percentages from the InpTiming&Cost sheet. For a more detailed discussion on base variability, please refer to Part II 3.3.

#### **4.2.3 Lifecycle Performance Risk: Lifecycle Performance Risk & Revenue Uncertainty Adjustment**

The lifecycle performance risk is calculated for each delivery model to create lifecycle performance risk cash flows. The calculated lifecycle performance risk premium is generated on this sheet using the P3 financing cost (WACC) for an availability payment concession whereas the lifecycle performance risk cost input is imported from the InpRisk sheet. The switch that determines whether to use the calculated premium or the cost input approach is also imported from the InpRisk sheet. Using indexation factors and phase flags from the Time&Esc sheet, the annual lifecycle performance risk premium cash flow is calculated. For a more detailed discussion on lifecycle performance risk, please refer to Part II 3.4.

The sheet also calculates a revenue uncertainty adjustment cash flow to account for uncertainty in revenues flowing to the public Agency. The calculated revenue uncertainty adjustment is generated on this sheet using the P3 financing cost (WACC) for a toll concession whereas the revenue uncertainty adjustment input is imported from the InpRisk sheet. The switch that determines whether to use the calculated adjustment or the input approach is also imported from the InpRisk sheet. Using indexation factors and phase flags from the Time&Esc sheet, the annual revenue uncertainty adjustment cash flow is calculated. For a more detailed discussion on revenue uncertainty adjustment, please refer to Part II 3.5.

#### **4.2.4 Risk Output for VfM: Risk Outputs for VfM**

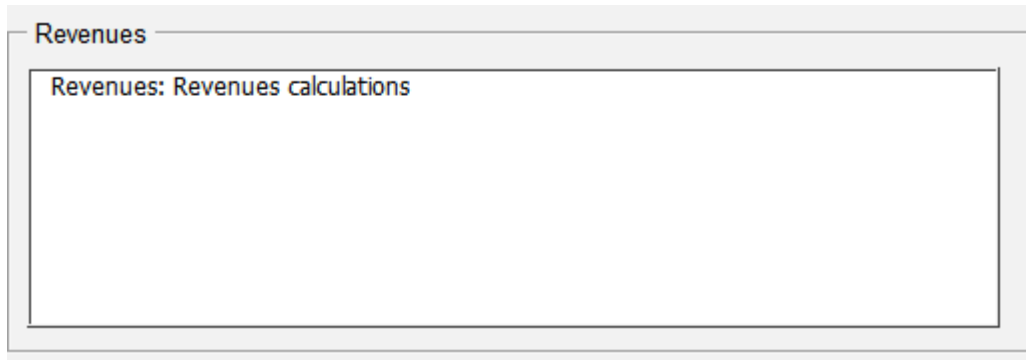
This sheet presents the Risk output table for use in the VfM analysis.

#### **4.2.5 Risk Output for PDBCA: Risk outputs for PDBCA**

This sheet presents the Risk output table for use in the PDBCA.

### **4.3 Revenues**

This section presents the revenue calculations, which are used in the VfM analysis. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator's detailed level view pane with the calculation sheet listed.



#### 4.3.1 Revenues: Revenues Calculation

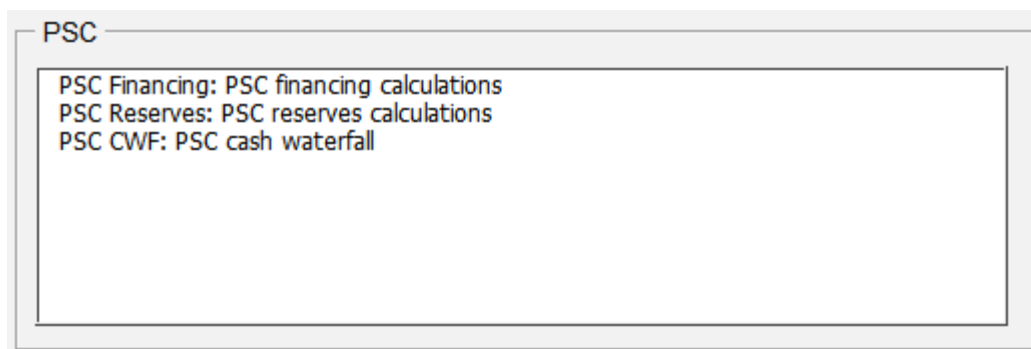
Revenues are calculated for tolled PSC and tolled P3 options. Revenues are not calculated for non-tolled facilities. Also, revenues are not calculated for the Delayed PSC as toll revenues are not relevant in the PDBCA module (Delayed PSC is not used in VfM). The Revenues sheet calculates three revenue cash flows: toll revenue, revenue leakage, and toll collection summary. The toll collection summary combines the first two and subtracts the revenue uncertainty adjustment calculated in the risk assessment.

Toll revenues are generated by 2 axle and 4+ axle vehicles. Their respective annual toll rates are imported from Time&Esc whereas traffic is imported from the Traffic sheet. Combining both yields the toll revenues before leakage. The toll leakage percentage is imported from the InpTraffic&Toll sheet and applied to the total toll revenue to determine the revenue leakage.

Subtracting the revenue leakage and the revenue uncertainty adjustment from the toll revenues yields the toll collection cash flow, which are used in the VfM analysis.

#### 4.4 PSC Calculations for VfM

This section presents the various PSC calculations for the VfM analysis. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator’s detailed level view pane with the different calculation sheets listed.



#### 4.4.1 PSC Financing: PSC Financing Calculations

This sheet contains the following main sections of calculations: Financing Requirements, Funding Contribution by Public Side, PSC Debt, and Debt Service Coverage Ratio (DSCR). Please note that the Model Optimizer will change some of the values on this sheet, as the macro will seek to optimize the required subsidy.

##### Funding & Financing Requirement

This section determines the total funding and financing requirement. To calculate this, data from several sheets is imported, including pre-construction and construction costs, and base variability and pure risks. Furthermore, issuance fees and interest during construction are brought in from further calculations on the PSC Financing sheet. Lastly, subsidies are considered to determine the total funding required during the construction period. The funding requirement is calculated using a copy-paste macro to cut circularity.

##### Funding Contribution by Public Side

This section determines the funding contribution by the public side. In particular, it determines if the Agency needs to pre-finance any subsidy it may receive later.

##### PSC Debt

This section calculates the debt drawdown, fees, interest and repayment.

For a fully sculpted loan, the repayment depends on the cash flows available for debt service (CFADS) over the entire repayment period, the outstanding balance at the start of operations, and the interest rate. Based on this, a target Debt Service Coverage Ratio (DSCR) is determined which will be applied for the entire loan repayment period. In any given year, CFADS are divided by the target DSCR to determine how much interest and principal can be paid. If the amount available to debt service falls short of the amount needed to pay interest in any given year, the interest is capitalized. As a result, the debt service profile closely follows the CFADS profile.

If an annuity-type repayment is selected, the principal repayment is determined by the debt outstanding in a given year, the number of repayment periods remaining, and the interest rate. The interest payment is based on the outstanding balance at the start of the period.

Under both PSC debt solutions, the Model Optimizer iteratively searches for a required subsidy or availability payment that results in the lowest acceptable minimum DSCR. For a more detailed discussion on the Model Optimizer, please refer to Part I 2.4.

##### DSCR

The DSCR section calculates the yearly DSCR and the minimum DSCR. To do so, the yearly cash flow available for debt service (CFADS) is divided by the debt service cash flow to yield the yearly DSCR values. The calculated minimum DSCR value is the lowest observed value during the debt service period and will be compared against the required minimum DSCR that is provided by the user as an input.

#### 4.4.2 PSC Reserves: PSC Reserves Calculations

The PSC Reserves sheet tracks the two reserve accounts: the Major Maintenance Reserve Account, and the Debt Service Reserve Account.

### Major Maintenance Reserve Account

Every year, deposits are made into the Major Maintenance Reserve Account (MMRA) to ensure sufficient funds will be available to pay for major maintenance. The amount deposited is calculated such that by the time major maintenance is required, the amount in the MMRA is equal to the amount of the withdrawal. The anticipated amount is calculated by combining input from the O&M sheet and the Base Variability sheet. The model also considers the annual interest earned on the balance in the MMRA.

### Debt Service Reserve Account

Debt service payments are imported from the PSC Financing sheet. Deposits and cash available for debt service payments are imported from the PSC CWF sheet. The previous balance, added deposits, and subtracted withdrawals result in the annual DSRA balance. Any balance in the account accrues interest.

#### 4.4.3 PSC CWF: PSC Cash Waterfall

The PSC CWF contains the high level cash waterfall data. On this sheet, a user can see the revenues, costs, debt service, deposits and withdrawals in reserve accounts, and net cash flows. The calculations flow from top to bottom and feed directly into the next set of cash flow calculations. Cash flows are imported from the following sheets:

- Revenues
- O&M
- Construction
- Base Variability
- Pure Risks
- Subsidy & Bid
- PSC Financing
- PSC Reserves

Together, these cash flows contribute to the calculation of:

- Operating cash flow
- Cash flow after other costs
- Pre-financing cash flow
- Cash flow available for MMRA
- Cash flow available for debt service
- Cash flow available for DSRA
- Net cash flow
- Retained cash balance

## 4.5 P3 Calculations for VfM

This section presents the various P3 calculations for the VfM analysis. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator's detailed level view pane with the different calculation sheets listed.

P3
P3 Financing: P3 financing calculations
P3 Reserves: P3 reserves calculations
P3 CWF: P3 cash waterfall
P3 Depreciation: P3 depreciation calculations
P3 FinStat: P3 financial statements (P&L, balance sheet)
P3 (Pub) CWF: P3 (public sector) cash waterfall

#### 4.5.1 P3 Financing: P3 Financing Calculations

This sheet contains the following main sections of calculations: Financing Requirement, Equity, Equity Bridge Loan, P3 Debt, Tax, Competitive Neutrality Adjustment, Debt Service Coverage Ratio (DSCR), and Weighted Average Cost of Capital (WACC) calculation. Please note that the Model Optimizer will change some of the values on this sheet, as the macro will seek to optimize the P3 bid.

##### Funding & Financing Requirement

This section determines the total funding & financing requirement. To calculate this, data from several sheets is imported, including pre-construction and construction costs, and base variability and pure risks. Furthermore, issuance fees and interest during construction are brought in from further calculations on the P3 Financing sheet. Lastly, subsidies are considered to determine the total funding required during the construction period. The funding requirement is calculated using a copy-paste macro to cut circularity.

##### Equity

In this section, the amount of equity injection is determined. The calculated funding requirement is used in conjunction with the gearing ratio to determine how much equity is required.

##### Equity Bridge Loan

In this section, the equity bridge loan drawdown and repayment is calculated. The equity bridge loan is used to provide short-term financing that will be taken out by government subsidy, and not included in the debt portion of the gearing ratio.

##### P3 Debt

This section calculates the debt drawdown, fees, interest and repayment.

For a fully sculpted loan, the repayment depends on the cash flows available for debt service (CFADS) over the entire repayment period, the outstanding balance at the start of operations, and the interest rate. Based on this, a target Debt Service Coverage Ratio (DSCR) is determined which will be applied for the entire loan repayment period. In any given year, CFADS are divided by the target DSCR to determine how much interest and principal can be paid. If the amount available to debt service falls short of the amount needed to pay interest in any given year, the interest is capitalized. As a result, the debt service profile closely follows the CFADS profile.

If an annuity-type repayment is selected, the principal repayment is determined by the debt outstanding in a given year, the number of repayment periods remaining, and the interest rate. The interest payment is based on the outstanding balance at the start of the period.

Under both P3 debt solutions, the Model Optimizer iteratively searches for a required subsidy or availability payment that results in the lowest acceptable minimum DSCR while still satisfying the equity return requirement. For a more detailed discussion on the Model Optimizer, please refer to Part I 2.4.

### Tax

In order to determine how much tax needs to be paid by the P3 concessionaire in a given year, income profits and losses are tracked. This sheet tracks all profits, losses, and losses carried forward to determine the annual taxable profits. Federal and state taxes are then calculated based on the taxable profits.

### Competitive Neutrality Adjustment

Based on the federal and state tax liability, the model calculates the competitive neutrality adjustment for each. Depending on the selected inputs, the model can include a competitive neutrality adjustment for either the federal tax, state tax, or both.

### DSCR

The DSCR section calculates the yearly DSCR and the minimum DSCR. To do so, the yearly cash flow available for debt service (CFADS) is divided by the debt service cash flow to yield the yearly DSCR values. The calculated minimum DSCR value is the lowest observed value during the debt service period and will be compared against the required minimum DSCR that is provided by the user as an input.

### WACC Calculation for Lifecycle Performance Risk Premium Determination

The lifecycle performance risk premium calculation and revenue uncertainty adjustment requires the P3 Weighted Average Cost of Capital (WACC). This section brings together all relevant financing cash flows to determine the project's effective WACC.

#### 4.5.2 P3 Reserves: P3 Reserves Calculations

The P3 Reserves sheet tracks the two reserve accounts: the Major Maintenance Reserve Account, and the Debt Service Reserve Account.

### Major Maintenance Reserve Account

Every year, deposits are made into the Major Maintenance Reserve Account (MMRA) to ensure sufficient funds will be available to pay for major maintenance. The amount deposited is calculated such that by the time major maintenance is required, the amount in the MMRA is equal to the amount of the withdrawal. The anticipated amount is calculated by combining input from the O&M sheet and the Base Variability sheet. The model also considers the annual interest earned on the balance in the MMRA.

### Debt Service Reserve Account

Debt service payments are imported from the P3 Financing sheet. Deposits and cash available for debt service payments are imported from the P3 CWF sheet. The previous balance, added deposits, and subtracted withdrawals result in the annual DSRA balance. Any balance in the account accrues interest.

#### 4.5.3 P3 CWF: P3 Cash Waterfall

The P3 CWF contains the high level cash waterfall data. On this sheet, a user can see the revenues, costs, debt service, movements in reserve accounts, and net cash flows. The calculations flow from top to bottom and feed directly into the next set of cash flow calculations. Cash flows are imported from the following sheets:

- Revenues
- O&M
- Construction
- Base Variability
- Pure Risks
- Subsidy & Bid
- P3 Financing
- P3 Reserves

Together, these cash flows contribute to the calculation of:

- Operating cash flow
- Cash flow after other costs
- Pre-tax pre-financing cash flow
- Post-tax pre-financing cash flow
- Cash flow available for MMRA
- Cash flow available for debt service
- Cash flow available for DSRA
- Net cash flow to equity
- P3 retained cash balance

#### 4.5.4 P3 Depreciation: P3 Depreciation Calculations

The P3 Depreciation sheet tracks two major assets: Fixed Asset and Major Maintenance Asset.

The model adds construction costs, pure construction risks, construction base variability costs, capitalized interest and debt fees during the construction phase to the fixed asset balance. Depreciation is calculated based on the remaining depreciation period and subtracted from the balance.

Expenses on major maintenance are added to the Major Maintenance Asset balance. Depreciation is calculated using a Major Maintenance Asset depreciation rate, which is based off the major maintenance periodicity.

#### 4.5.5 P3 FinStat: P3 Financial Statements

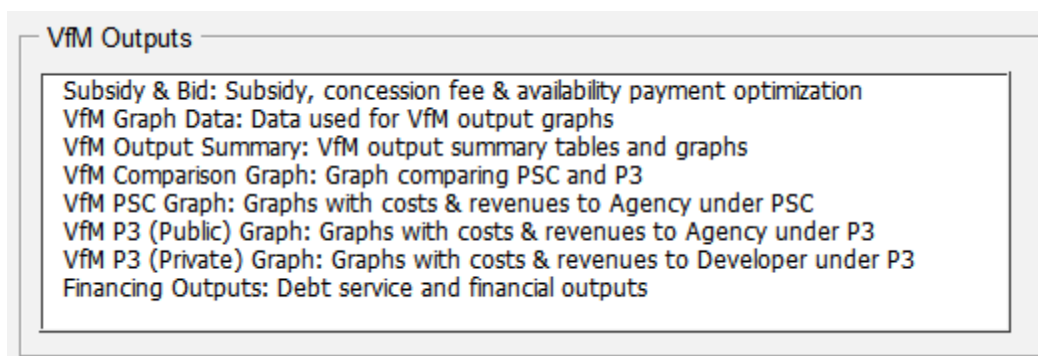
This sheet contains two financial statements: the Income Statement and the Balance Sheet. The income statement calculates the annual operating profit, profit before interest and tax, profit before tax, profit after tax / net cash flow, and retained earnings. The balance sheet calculates for each year the project's assets and liabilities.

#### 4.5.6 P3 (Pub) CWF: P3 (Public Sector) cash waterfall

This sheet tracks the cash waterfall from the public Agency’s point of view. Toll revenues for the public side are imported from the Revenues sheet. Any availability payments made are imported from the Subsidy & Bid sheet. Retained operations and maintenance costs, as well as the base variability of those costs, are imported from the O&M sheet and the Base Variability sheet. Retained construction costs are imported from the Construction sheet. Together, these cash flows are used to create the P3 (Public) net cash flows and retained cash balance.

## 4.6 VfM Output Calculations

This section presents the VfM calculations performed to compare P3 and PSC project delivery. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator’s detailed level view pane with the different calculation sheets listed.



#### 4.6.1 Subsidy & Bid: Subsidy, Concession Fee & Availability Payment Optimization

This sheet calculates the required PSC subsidy and the required P3 subsidy or availability payment. The sheet uses macros to determine the lowest acceptable subsidy/availability payment. The sheet contains the following elements:

- PSC – Subsidy initiation: Calculation to determine a starting value of the PSC subsidy for the macro optimization process.
- PSC – Calculated subsidy: Macro-driven PSC subsidy calculation.
- PSC – Subsidy/milestone payment calculation: Calculation of input subsidy/milestone payment.
- PSC – Project NPV: Calculation of project NPV under PSC.
- P3 – Availability payment initiation: Calculation to determine a starting value of the P3 availability payment for the macro optimization process.
- P3 – Availability payment calculation: Macro-driven P3 availability payment calculation.
- P3 – Subsidy / (concession fee) initiation: Calculation to determine a starting value of the P3 subsidy/concession fee for the macro optimization process.
- P3 – Subsidy / (concession fee) calculation: Macro-driven P3 subsidy/concession fee calculation.
- P3 – Subsidy/milestone payment calculation: Calculation of input subsidy/milestone payment.
- P3 – Cash flow to equity NPV calculation: Calculation of NPV of cash flow to equity.
- P3 – Equity IRR: Calculation of internal rate of return (IRR) of cash flow to equity.

#### 4.6.2 VfM Graph Data: Data Used for VfM Output Graphs

This sheet calculates the net present values of costs and revenues and contains data used in the various output tables and graphs.

#### 4.6.3 VfM Output Summary: VfM Output Summary Tables and Graphs

This sheet presents VfM output summary tables and graphs.

#### 4.6.4 VfM Comparison Graph: Graph Comparing PSC and P3

This sheet presents the VfM graph comparing PSC and P3.

#### 4.6.5 VfM PSC Graph: Graphs with Costs & Revenues to Agency under PSC

This sheet presents graphs with costs and revenues to the Agency under a PSC.

#### 4.6.6 VfM P3 (Public) Graph: Graphs with Costs & Revenues to Agency under P3

This sheet presents graphs with costs and revenue to the agency under a P3.

#### 4.6.7 VfM P3 (Private) Graph: Graphs with Costs & Revenues to Developer under P3

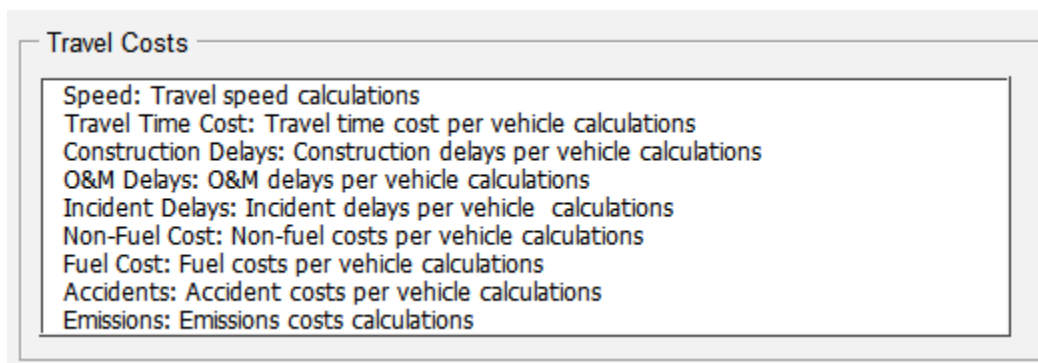
This sheet presents graphs with costs and revenue to the developer (i.e., concessionaire) under a P3.

#### 4.6.8 Financing Outputs: Debt Service and Financial Outputs

This sheet presents debt service and financial outputs.

### 4.7 Travel Cost Calculation

This section presents the travel cost calculations. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator’s detailed level view pane with the different calculation sheets listed.



#### 4.7.1 Speed: Travel Speed Calculations

This sheet calculates speeds for each year in the analysis period for the various delivery models. These speeds are used to compute travel time costs, incident delays, O&M-related travel delays, construction-

related travel delays, non-fuel costs, fuel costs, and emissions costs. The following presents the order of calculations in this sheet.

1. No Build and Build (ML/TL and GPL) capacities for peak, off-peak, and weekends are calculated using inputs from InpTraffic&Toll.
2. No Build and Build (ML/TL and GPL) V/C ratios for peak, off-peak, and weekends are calculated using traffic volumes from the Traffic sheet and capacities calculated in the above step.
3. No Build and Build (ML/TL and GPL) speeds for peak, off-peak, and weekends are calculated using volume/delay function (VDF) parameters, free flow speeds from the InpTraffic&Toll sheet, and the V/C ratios calculated above.

#### ***4.7.2 Travel Time Cost: Travel Time Cost per Vehicle Calculations***

This sheet calculates travel time costs for each year in the analysis period for the various delivery models. These travel time costs are also used to compute construction and O&M-related travel delays and incident delays.

No Build and Build (ML/TL and GPL) travel time costs for peak, off-peak, and weekends are calculated using segment length from the InpTraffic&Toll sheet, vehicle occupancy and value of time inputs from the InpBCA sheet, operations flags from the InpSeries sheet, and congested speeds from the Speed sheet. The calculations of congested travel time costs are performed separately for 2 axle and 4+ axle vehicles. For a more detailed discussion on calculation of travel time costs, please refer to Part II 5.4.

#### ***4.7.3 Construction Delays: Construction Delays per Vehicle Calculations***

This sheet calculates construction-related travel delay costs for each year in the analysis period for the various delivery models. No Build and Build (ML/TL and GPL) construction-related travel delay costs for peak, off-peak, and weekends for 2 and 4+ axle vehicles are calculated using input parameters from the various input sheets and travel time costs from the Travel Time Costs sheet. For a more detailed discussion on calculation of construction-related delays, please refer to Part II 5.5.

#### ***4.7.4 O&M Delays: O&M Delays per Vehicle Calculations***

This sheet calculates O&M-related travel delay costs for each year in the analysis period for the various delivery models. No Build and Build (ML/TL and GPL) O&M-related travel delay costs for peak, off-peak, and weekends for 2 and 4+ axle vehicles are calculated using input parameters from the various input sheets and travel time costs from the Travel Time Costs sheet. This sheet borrows calculations performed in the Construction Delays sheet so as to not repeat some of the calculations. For a more detailed discussion on calculation of O&M-related travel delays, please refer to Part II 5.5.

#### ***4.7.5 Incident Delays: Incident Delays per Vehicle Calculations***

This sheet calculates incident delay costs for each year in the analysis period for the various delivery models. No Build and Build (ML/TL and GPL) incident delay costs for peak, off-peak, and weekends for 2 and 4+ axle vehicles are calculated using speed adjustment factors from the BCA input sheets and travel time costs from the Travel Time Costs sheet. For a more detailed discussion on calculation of incident delays, please refer to Part II 5.5.

#### 4.7.6 *Non-Fuel Cost: Non-Fuel Costs per Vehicle Calculations*

This sheet calculates non-fuel costs for each year in the analysis period for the various delivery models. No Build and Build (ML/TL and GPL) non-fuel costs for peak, off-peak, and weekends for 2 and 4+ axle vehicles are calculated using input parameters from the various input sheets. These calculations incorporate pavement quality adjustments. For a more detailed discussion on calculation of non-fuel costs, please refer to Part II 5.7.

#### 4.7.7 *Fuel Cost: Fuel Costs per Vehicle Calculations*

This sheet calculates fuel costs for each year in the analysis period for the various delivery models. No Build and Build (ML/TL and GPL) fuel costs for peak, off-peak, and weekends for 2 and 4+ axle vehicles are calculated using input parameters from the various input sheets. These calculations incorporate pavement quality adjustments. For a more detailed discussion on calculation of fuel costs, please refer to Part II 5.7.

#### 4.7.8 *Accidents: Accident Costs per Vehicle Calculations*

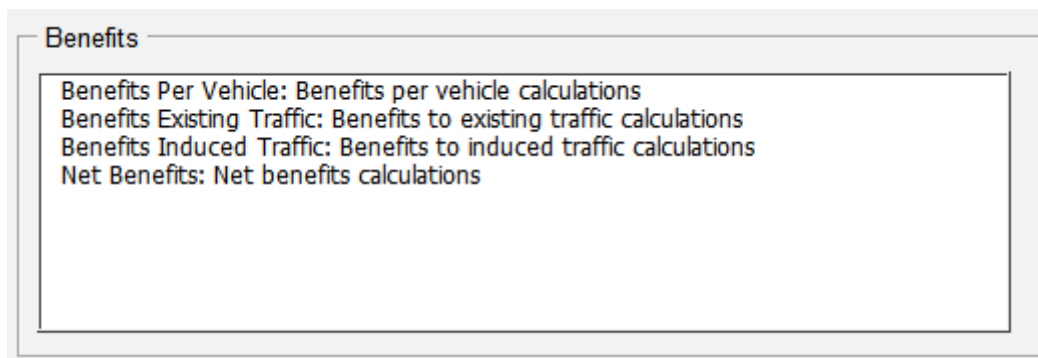
This sheet calculates accident costs for each year in the analysis period for the various delivery models. No Build and Build (ML/TL and GPL) accident costs for peak, off-peak, and weekends for 2 and 4+ axle vehicles are calculated using input parameters from the various input sheets. For a more detailed discussion on calculation of accident costs, please refer to Part II 5.8.

#### 4.7.9 *Emissions: Emissions Costs Calculations*

This sheet calculates emissions costs for each year in the analysis period for the various delivery models. No Build and Build (ML/TL and GPL) emissions costs for peak, off-peak, and weekends for 2 and 4+ axle vehicles are calculated using input parameters from the various input sheets as well as traffic projections from the Traffic sheet. For a more detailed discussion on calculation of emission costs, please refer to Part II 5.9.

### 4.8 **Benefits**

This section presents the benefits calculations. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator’s detailed level view pane with the different calculation sheets listed.



#### 4.8.1 *Benefits per Vehicle: Benefits per Vehicle Calculations*

This sheet calculates benefits per vehicle for the PSC, Delayed PSC, and P3 by subtracting the No Build cost per vehicle from the Build cost per vehicle for each year in the analysis period. The following benefits per vehicle are calculated in this sheet:

- Travel time benefits
- Construction-related travel delay reduction benefits
- O&M-related travel delay reduction benefits
- Incident delay reduction benefits
- Non-fuel cost reduction benefits
- Fuel cost reduction benefits
- Accident reduction benefits
- Emissions reduction benefits

#### 4.8.2 *Benefits Existing Traffic: Benefits to Existing Traffic Calculations*

This sheet calculates benefits for existing traffic for the PSC, Delayed PSC, and P3 by multiplying the benefits per vehicle for each benefit type by the existing traffic for each year in the analysis period. The following benefits are calculated in this sheet:

- Travel time savings
- Construction-related travel delay reduction benefits
- O&M-related travel delay reduction benefits
- Incident delay reduction benefits
- Non-fuel cost reduction benefits
- Fuel cost reduction benefits
- Accident reduction benefits

#### 4.8.3 *Benefits Induced Traffic: Benefits to Induced Traffic Calculations*

This sheet calculates benefits for induced traffic for the PSC, Delayed PSC, and P3. Induced traffic benefits consist of a consumer surplus and a producer surplus. To calculate the consumer surplus, the induced traffic is multiplied by half the difference in user costs between the No Build and Build. This “rule of half” (see Part II 5.10 for a discussion on the “rule of half”) is applied to capture the triangular shape of the consumer surplus, i.e., the triangle under the demand curve that corresponds to the induced traffic created by the shift in supply due to the road expansion. The user costs include:

- Travel time benefits
- Construction-related travel delay reduction benefits
- O&M-related travel delay reduction benefits
- Incident delay reduction benefits
- Non-fuel cost reduction benefits
- Fuel cost reduction benefits
- Accident reduction benefits
- Difference in tolls between No Build and Build

To calculate the producer surplus, the induced traffic is multiplied by the Build toll. The induced traffic benefits equal the sum of consumer and producer surplus. The induced traffic benefits are subsequently allocated to the different benefit categories, using the existing traffic benefit split. For a more detailed discussion on calculation of induced traffic benefits, please refer to Part II 5.10.

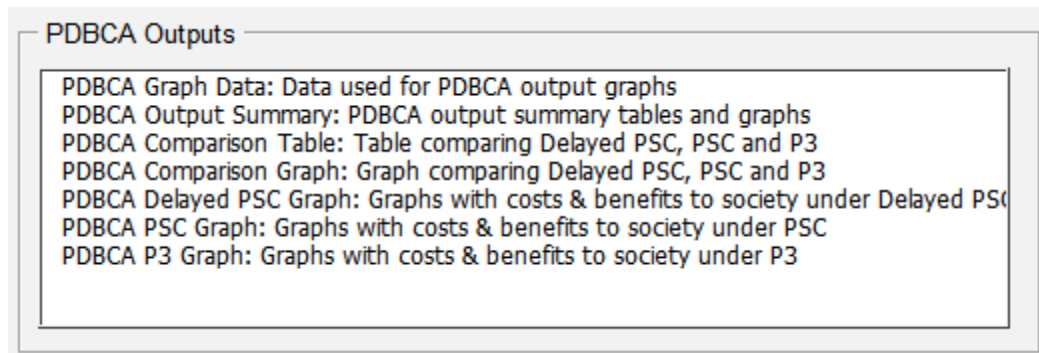
#### 4.8.4 Net Benefits: Net Benefits Calculations

This sheet calculates the net benefits for each year in the analysis period for the P3, Delayed P3, and P3 compared to the No Build. The following presents the order of calculations in this sheet.

- Total benefits are calculated by adding existing traffic benefits and induced traffic benefits.
- The net present value of total benefits is calculated using the social discount factor.
- The net present value of total costs and risks is calculated using the social discount factor.
- Impact summaries are calculated for each Build alternative.

## 4.9 PDBCA Output Calculations

This section presents the PDBCA calculations performed to compare P3, PSC, and Delayed P3 project delivery. In order to be able to view the sheets described in this section, please ensure you have enabled the detailed level view in the Model Navigator. The following figure shows the Model Navigator's detailed level view pane with the different calculation sheets listed.



#### 4.9.1 PDBCA Graph Data: Data Used for PDBCA Output Graphs

This sheet calculates the net present values of costs and benefits and contains data used in the various output tables and graphs.

#### 4.9.2 PDBCA Output Summary: PDBCA Output Summary Tables and Graphs

This sheet presents PDBCA output summary tables and graphs.

#### 4.9.3 PDBCA Comparison Table: Table Comparing Delayed P3, P3 and P3

This sheet presents tables comparing Delayed P3, P3, and P3.

#### 4.9.4 PDBCA Comparison Graph: Graph Comparing Delayed P3, P3 and P3

This sheet presents graphs comparing Delayed P3, P3, and P3.



#### 4.9.5 *PDBCA Delayed PSC Graph: Graphs with Costs & Benefits to Society under Delayed PSC*

This sheet presents graphs with costs and benefits to society under Delayed PSC.

#### 4.9.6 *PDBCA PSC Graph: Graphs with Costs & Benefits to Society under PSC*

This sheet presents graphs with costs and benefits to society under PSC.

#### 4.9.7 *PDBCA P3 Graph: Graphs with Costs & Benefits to Society under P3*

This sheet presents graphs with costs and benefits to society under P3.

## 5 Model Outputs

Based on the inputs provided, P3-VALUE 2.0 performs the calculations detailed in the previous chapter. This chapter presents the various outputs for the risk assessment, financial viability assessment, VfM analysis and PDBCA. These outputs help the user understand what financial and economic differences to expect from a public-private partnership compared to Conventional Delivery.

### 5.1 Risk Assessment Outputs

Based on the risk inputs and calculation, the model provides separate risk outputs for VfM and PDBCA. The table below shows sample outputs for VfM.

**Table 2: Sample risk assessment outputs for VfM**

Units >>	Conventional Delivery		Retained Risks under P3		Transferred Risks under P3	
	NPV @ 4.00% USD m	Nominal total USD m	NPV @ 4.00% USD m	Nominal total USD m	NPV @ 8.94% USD m	Nominal total USD m
<b>Pure risks (construction)</b>						
Design risk	10	11	1	1	7	9
Engineering & construction risk	8	9	1	1	6	8
Planning & approval risk	1	1	0	0	1	1
Environmental risk	11	13	1	1	8	10
Right of way/utilities risk	8	9	1	1	5	7
Commercial/procurement risk	-	-	-	-	-	-
Latent defect	-	-	-	-	-	-
Force majeure	4	5	0	0	3	4
Political risk	1	1	0	0	1	1
Insurance risk	-	-	-	-	-	-
Public sentiment risk	-	-	-	-	-	-
Changes in law & policy	-	-	-	-	-	-
<b>Pure risks (operations)</b>						
Latent defect	13	35	1	3	5	29
Operations risk	4	12	0	1	2	10
Maintenance risk	6	15	1	1	2	12
Force majeure	3	9	0	1	1	7
Insurance risk	-	-	-	-	-	-
Changes in law & policy	-	-	-	-	-	-
<b>Total pure risks</b>	<b>69</b>	<b>121</b>	<b>6</b>	<b>11</b>	<b>40</b>	<b>98</b>
<b>Base variability</b>						
Pre-construction cost	2	3	1	1	3	3
Construction cost	64	73	5	5	47	61
O&M cost	13	36	1	3	4	30
<b>Total base variability</b>	<b>79</b>	<b>112</b>	<b>7</b>	<b>10</b>	<b>54</b>	<b>94</b>
<b>Lifecycle performance risk premium</b>	<b>220</b>	<b>554</b>	<i>Transferred to P3</i>		<b>90</b>	<b>498</b>
<b>Revenue uncertainty adjustment</b>	<b>138</b>	<b>401</b>	-	-	<b>54</b>	<b>405</b>
<b>TOTAL RISKS</b>	<b>505</b>	<b>1,187</b>	<b>13</b>	<b>21</b>	<b>238</b>	<b>1,095</b>

The table below shows sample risk assessment outputs for PDBCA.

**Table 3: Sample risk assessment outputs for PDBCA**

Units >>	Delayed Conventional Delivery		Conventional Delivery		P3	
	NPV @ 3.00% USD m	Real total USD m	NPV @ 3.00% USD m	Real total USD m	NPV @ 3.00% USD m	Real total USD m
<b>Pure risks (construction)</b>						
Design risk	8	11	10	11	9	10
Engineering & construction risk	7	9	8	9	7	8
Planning & approval risk	1	1	1	1	1	1
Environmental risk	9	12	11	12	10	11
Right of way/utilities risk	6	8	7	8	7	7
Commercial/procurement risk	-	-	-	-	-	-
Latent defect	-	-	-	-	-	-
Force majeure	3	4	4	4	4	4
Political risk	1	1	1	1	1	1
Insurance risk	-	-	-	-	-	-
Public sentiment risk	-	-	-	-	-	-
Changes in law & policy	-	-	-	-	-	-
<b>Pure risks (operations)</b>						
Latent defect	8	18	10	21	10	19
Operations risk	3	6	4	7	3	7
Maintenance risk	4	8	4	9	4	8
Force majeure	2	5	3	5	3	5
Insurance risk	-	-	-	-	-	-
Changes in law & policy	-	-	-	-	-	-
<b>Total pure risks</b>	<b>52</b>	<b>83</b>	<b>62</b>	<b>88</b>	<b>57</b>	<b>80</b>
<b>Base variability</b>						
Pre-construction cost	2	2	2	2	4	4
Construction cost	53	68	61	68	57	62
O&M cost	8	18	10	21	10	19
<b>Total base variability</b>	<b>63</b>	<b>88</b>	<b>74</b>	<b>91</b>	<b>71</b>	<b>86</b>
<b>Lifecycle performance risk premium</b>	<b>142</b>	<b>297</b>	<b>179</b>	<b>339</b>	<b>165</b>	<b>307</b>
<b>TOTAL RISKS</b>	<b>257</b>	<b>468</b>	<b>315</b>	<b>518</b>	<b>293</b>	<b>473</b>

## 5.2 Financial Viability Assessment Outputs

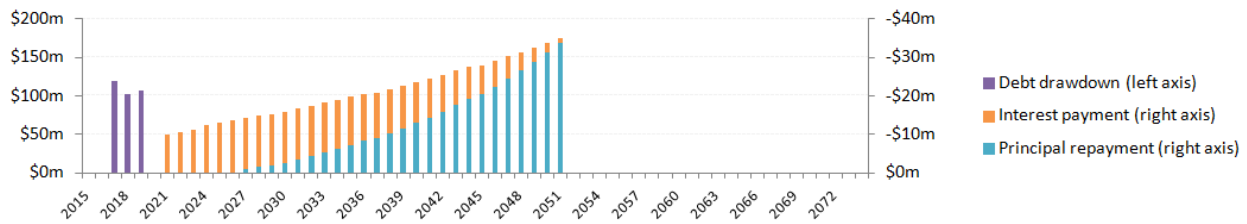
Based on the financial inputs and calculation, the model provides the following financial outputs for both the Conventional Delivery and P3:

- Debt repayment profile
- Debt Service Coverage Ratios (DSCR)
- Sources of funding and financing

Furthermore, the model provides a number of additional outputs for the private financing structure. Please note that the financial viability assessment outputs can be found under the VfM outputs in the model.

The figure below shows a sample debt service profile for either Conventional Delivery or P3.

**Figure 4: Sample Conventional Delivery or P3 debt service profile**



The table below shows sample key financial outputs under Conventional Delivery.

**Table 4: Sample Conventional Delivery key financial outputs**

<b>Conventional Delivery - Debt service coverage ratio</b>	<b>Ratio</b>	<b>Unit</b>
Average calculated DSCR	1.30	ratio
Minimum calculated DSCR	1.30	ratio
Minimum calculated vs. minimum required DSCR alert		alert

<b>Conventional Delivery - Sources of funding and financing</b>	<b>Amount</b>	<b>Unit</b>
Debt amount	328,793	USD k
Subsidy/milestone payment	110,408	USD k
Additional required subsidy	176,896	USD k
<b>Total sources of funding and financing</b>	<b>616,096</b>	<b>USD k</b>

The table below shows sample key financial outputs under P3.

**Table 5: Sample P3 key financial outputs**

<b>P3 - Debt service coverage ratio</b>	<b>Ratio</b>	<b>Unit</b>
Average calculated DSCR	1.63	ratio
Minimum calculated DSCR	1.63	ratio
Minimum calculated DSCR vs. minimum required DSCR alert		alert

<b>P3 - Sources of funding and financing</b>	<b>Amount</b>	<b>Unit</b>
Debt amount	238,618	USD k
Subsidy/milestone payment to Developer	108,243	USD k
Additional required subsidy to Developer	96,812	USD k
Equity contribution	79,539	USD k
<b>Total sources of funding and financing</b>	<b>523,212</b>	<b>USD k</b>

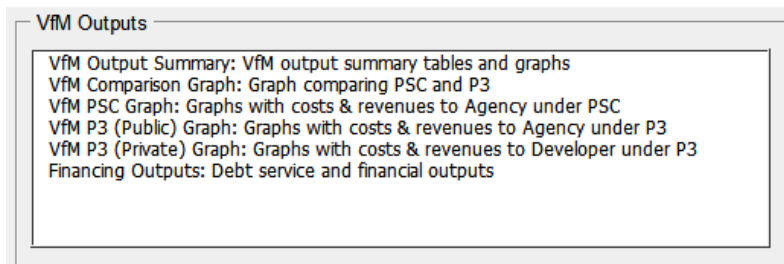
  

<b>P3 - Financial outputs</b>	<b>Value</b>	<b>Unit</b>
Equity IRR (post tax)	12.00%	% p.a.
P3 WACC	8.84%	% p.a.
Additional required subsidy from Agency (if applicable)	96,812	USD k
Concession fee to Agency (if applicable)		USD k
Annual availability payment (if applicable)		USD k
Interest capitalized during operations? (Yes, No)	Yes	text
No. of years interest is capitalized during operations	6	years
Maximum outstanding debt	248,739	USD k
Maximum debt-to-equity ratio*	75.77%	%

\* Maximum debt-to-equity ratio may exceed the input debt-to-equity ratio due to interest capitalization during the early years of the concession (only if sculpted debt financing is used).

### 5.3 VfM Outputs

This section presents the VfM outputs. The following figure shows the Model Navigator’s high level view pane with the different VfM output sheets listed.



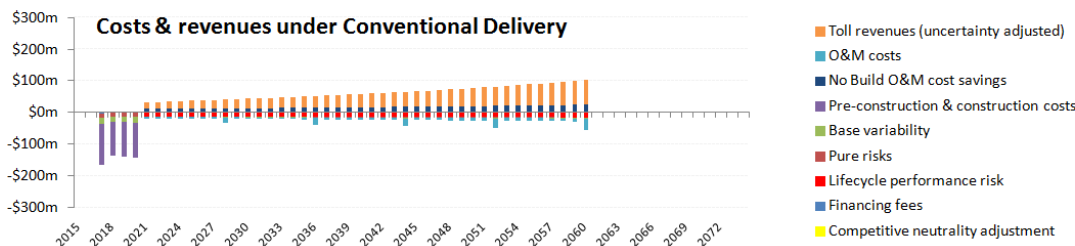
#### 5.3.1 VfM Output Summary

The VfM Output Summary sheet contains a summary of all relevant cash flows to either the Agency or the P3 concessionaire under Conventional Delivery and P3:

- Costs and revenues under Conventional Delivery
- Costs and revenues to Agency under P3
- Costs and revenues to Developer (i.e., Concessionaire) under P3

Sample outputs for a conventionally procured project are presented in the table and figure below.

**Figure 5: Sample cash flows under Conventional Delivery**

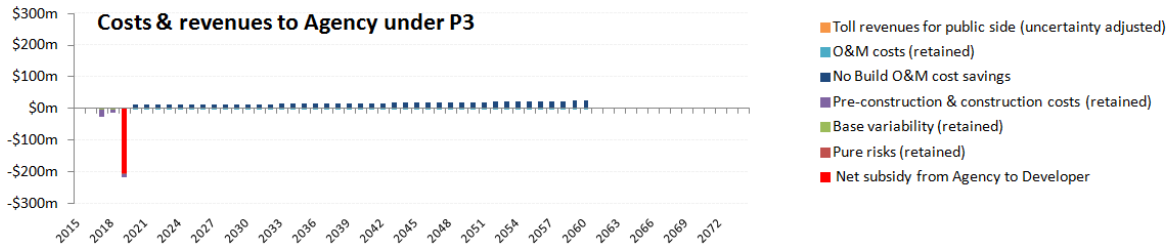


**Table 6: Sample costs & revenues under Conventional Delivery**

Costs & revenues under Conventional Delivery	Units >>	NPV @ 4.00% USD m	Nominal total USD m
Toll revenues		756	2,198
Toll revenues uncertainty adjustment		(138)	(401)
Pre-construction & construction costs		(397)	(454)
O&M costs		(129)	(363)
No Build O&M cost savings		250	680
Base variability		(79)	(112)
Pure risks		(69)	(121)
Lifecycle performance risk		(220)	(554)
Financing fees		(3)	(3)
Competitive neutrality adjustment		-	-
<b>Total net revenues / (costs) under Conventional Delivery</b>		<b>(29)</b>	<b>870</b>

If the project is procured as a P3, a distinction can be made between cash flows (and costs/revenues) to the Agency and to the Developer (i.e., Concessionaire). First, the Agency’s perspective is presented.

**Figure 6: Sample cash flows to Agency under P3**

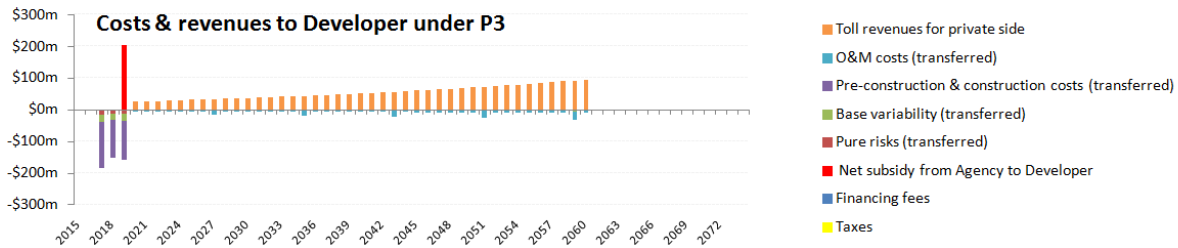


**Table 7: Sample costs & revenues to Agency under P3**

Costs & revenues to Agency under P3	Units >>	NPV @ 4.00% USD m	Nominal total USD m
Toll revenues (for public side)		-	-
Toll revenues uncertainty adjustment (for public side)		-	-
Pre-construction & construction costs (retained)		(39)	(43)
O&M costs (retained)		(12)	(33)
No Build O&M cost savings		259	691
Base variability (retained)		(7)	(10)
Pure risks (retained)		(6)	(11)
Net subsidy from Agency to Developer		(175)	(205)
<b>Total net revenues / (costs) to Agency under P3</b>		<b>19</b>	<b>389</b>

Next, the Developer’s perspective is presented in the graph and table below.

**Figure 7: Sample cash flows to Developer under P3**



**Table 8: Sample costs & revenues to Developer under P3**

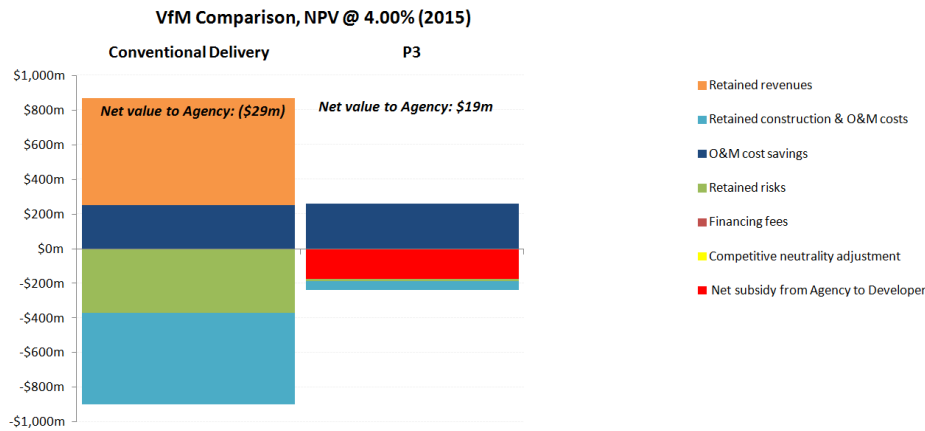
Costs & revenues to Developer under P3	Units >>	NPV @ 8.84% USD m	Nominal total USD m
Toll revenues for private side		298	2,224
Pre-construction & construction costs (transferred)		(304)	(390)
O&M costs (transferred)		(43)	(296)
Base variability (transferred)		(54)	(94)
Pure risks (transferred)		(40)	(98)
Net subsidy from Agency to Developer		146	205
Financing fees		(2)	(3)
Taxes		-	-
<b>Total net revenues / (costs) to Developer under P3</b>		<b>(0)</b>	<b>1,548</b>

### 5.3.2 VfM Comparison Graph

The next element in the VfM outputs is the VfM Comparison Graph. This graph visually compares the net present value of costs and revenues to the Agency and provides a clear indication to users whether P3 delivery is expected to yield Value-for-Money to the Agency.

Sample outputs are presented in the figure below.

**Figure 8: Sample VfM comparison graph**



### 5.3.3 Detailed Cost & Revenue Graphs

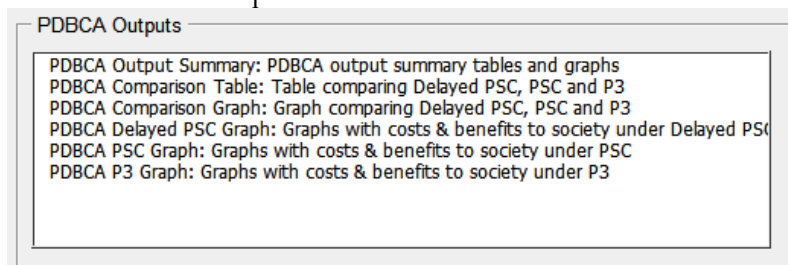
Lastly, the model provides three detailed cost and revenue graphs showing the relevant cash flows to either the Agency or the P3 concessionaire under Conventional Delivery and P3:

- Costs and revenues under Conventional Delivery
- Costs and revenues to Agency under P3
- Costs and revenues to Developer under P3

These are the same graphs as those included on the VfM Output Summary sheet, but are larger to enable users to better identify the timing and size of various cost items.

## 5.4 PDBCA Outputs

This section presents the PDBCA outputs. The following figure shows the Model Navigator’s high level view pane with the different PDBCA output sheets listed.



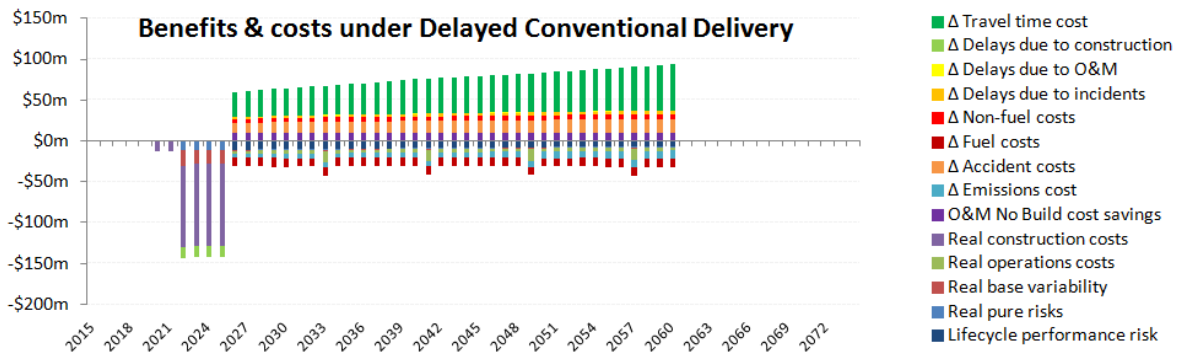
### 5.4.1 PDBCA Output Summary

The PDBCA Output Summary sheet contains a summary of all relevant costs and benefits under Delayed Conventional Delivery, Conventional Delivery and P3:

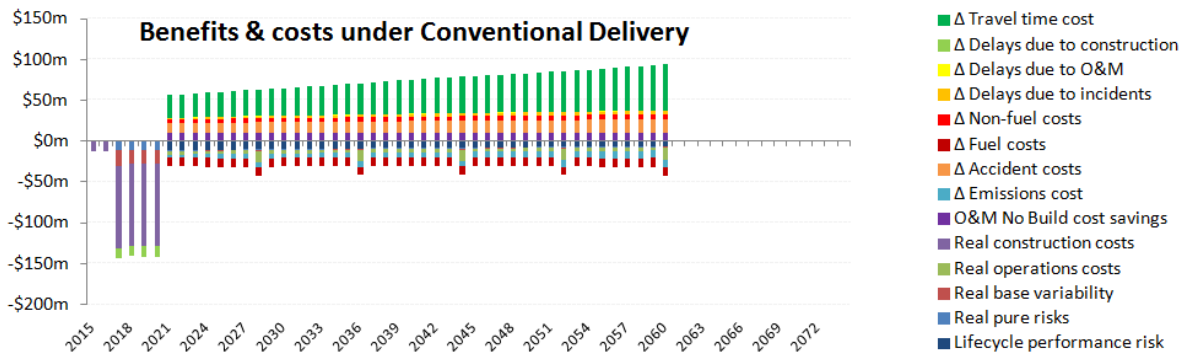
- Benefits and costs under Delayed Conventional Delivery
- Benefits and costs under Conventional Delivery
- Benefits and costs under P3

Sample benefits and costs for the three delivery models are presented in the figures below.

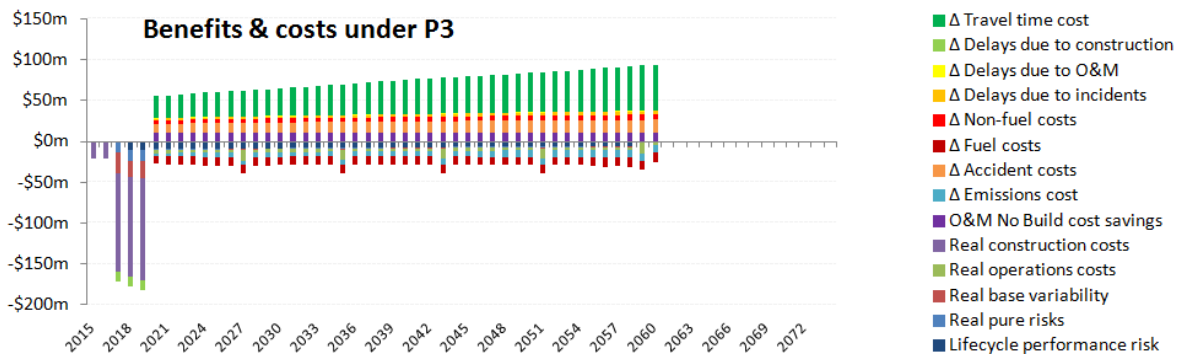
**Figure 9: Sample benefits and costs under Delayed Conventional Delivery**



**Figure 10: Sample benefits and costs under Conventional Delivery**



**Figure 11: Sample benefits and costs under P3**



The tables below present the same benefits and costs for the three delivery models.

**Table 9: Sample benefits and costs under Delayed Conventional Delivery**

Benefits & costs under Delayed Conventional Delivery Units >>	NPV @ 3.00% USD m	Real total USD m
Δ Travel time cost	659	1,520
Δ Delays due to construction	(42)	(54)
Δ Delays due to O&M	7	15
Δ Delays due to incidents	50	114
Δ Non-fuel costs	87	195
Δ Fuel costs	(167)	(366)
Δ Accident costs	227	511
Δ Emissions cost	(104)	(242)
O&M No Build cost savings	160	350
Real construction costs	(333)	(425)
Real operations costs	(81)	(180)
Real base variability	(63)	(88)
Real pure risks	(52)	(83)
Lifecycle performance risk	(142)	(297)
<b>Total benefits / (costs) under Delayed Conventional Delivery</b>	<b>207</b>	<b>970</b>
<b>Benefit cost ratio under Delayed Conventional Delivery</b>	<b>1.4054</b>	<b>N/A</b>

**Table 10: Sample benefits and costs under Conventional Delivery**

Benefits & costs under Conventional Delivery Units >>	NPV @ 3.00% USD m	Real total USD m
Δ Travel time cost	774	1,665
Δ Delays due to construction	(46)	(52)
Δ Delays due to O&M	8	17
Δ Delays due to incidents	58	125
Δ Non-fuel costs	105	218
Δ Fuel costs	(208)	(419)
Δ Accident costs	276	572
Δ Emissions cost	(123)	(267)
O&M No Build cost savings	199	400
Real construction costs	(386)	(425)
Real operations costs	(102)	(210)
Real base variability	(74)	(91)
Real pure risks	(62)	(88)
Lifecycle performance risk	(179)	(339)
<b>Total benefits / (costs) under Conventional Delivery</b>	<b>242</b>	<b>1,108</b>
<b>Benefit cost ratio under Conventional Delivery</b>	<b>1.4006</b>	<b>N/A</b>

**Table 11: Sample benefits and costs under P3**

Benefits & costs under P3 Units >>	NPV @ 3.00% USD m	Real total USD m
Δ Travel time cost	798	1,693
Δ Delays due to construction	(33)	(36)
Δ Delays due to O&M	10	21
Δ Delays due to incidents	60	127
Δ Non-fuel costs	109	223
Δ Fuel costs	(217)	(429)
Δ Accident costs	286	584

Δ Emissions cost	(127)	(272)
O&M No Build cost savings	208	410
Real construction costs	(378)	(410)
Real operations costs	(96)	(193)
Real base variability	(71)	(86)
Real pure risks	(57)	(80)
Lifecycle performance risk	(165)	(307)
<b>Total benefits / (costs) under P3</b>	<b>328</b>	<b>1,245</b>
<b>Benefit cost ratio under P3</b>	<b>1.5858</b>	<b>N/A</b>

#### 5.4.2 PDBCA Comparison Table

The PDBCA Comparison Table provides an incremental BCA analysis of the different delivery models. It first compares the Delayed Conventional Delivery to the No Build (Step 1) to determine whether the project's benefits outweigh its costs. Next, the model compares the Conventional Delivery to the Delayed Conventional Delivery to analyze the impact of the funding constraint (Step 2). Lastly, it compares P3 to Conventional Delivery to determine the impact of P3 delivery (Step 3). Sample output tables for the incremental analysis are shown below.

**Table 12: Compare Delayed Conventional Delivery to No Build (Step 1)**

<b>Step 1: Compare Delayed Conventional Delivery to No Build</b>	<b>NPV @ 3.00%</b>
Travel time savings (Delayed PSC - No Build)	659
Change in delays due to construction (Delayed PSC - No Build)	(42)
Change in delays due to O&M (Delayed PSC - No Build)	7
Change in delays due to incident (Delayed PSC - No Build)	50
Change in non-fuel costs (Delayed PSC - No Build)	87
Change in fuel costs (Delayed PSC - No Build)	(167)
Change in accident costs (Delayed PSC - No Build)	227
Change in emissions cost (Delayed PSC - No Build)	(104)
No Build O&M cost savings (Delayed PSC - No Build)	160
Real costs (Delayed PSC - No Build)	(671)
<b>Step 1 - Total net benefits / (costs)</b>	<b>207</b>

**Table 13: Compare Conventional Delivery to Delayed Conventional Delivery (Step 2)**

<b>Step 2: Compare Conventional Delivery to Delayed Conventional Delivery</b>	<b>NPV @ 3.00%</b>
Travel time savings (PSC - Delayed PSC)	115
Change in delays due to construction (PSC - Delayed PSC)	(4)
Change in delays due to O&M (PSC - Delayed PSC)	1
Change in delays due to incidents (PSC - Delayed PSC)	9
Change in non-fuel costs (PSC - Delayed PSC)	18
Change in fuel costs (PSC - Delayed PSC)	(41)
Change in accident costs (PSC - Delayed PSC)	48
Change in emissions cost (PSC - Delayed PSC)	(19)
No Build O&M cost savings (PSC - Delayed PSC)	40
Real costs (PSC - Delayed PSC)	(132)
<b>Step 2 - Total additional net benefits / (costs)</b>	<b>34</b>

**Table 14: Compare P3 to Conventional Delivery (Step 3)**

Step 3: Compare P3 to Conventional Delivery	NPV @ 3.00%
Travel time savings (P3 - PSC)	24
Change in delays due to construction (P3 - PSC)	13
Change in delays due to O&M (P3 - PSC)	2
Change in delays due to incidents (P3 - PSC)	2
Change in non-fuel costs (P3 - PSC)	4
Change in fuel costs (P3 - PSC)	(9)
Change in accident costs (P3 - PSC)	10
Change in emissions cost (P3 - PSC)	(4)
No Build O&M cost savings (P3 - PSC)	9
Real costs (P3 - PSC)	35
<b>Step 3 - Total additional benefits / (costs)</b>	<b>86</b>

The above tables are then summarized, as shown in the following sample table.

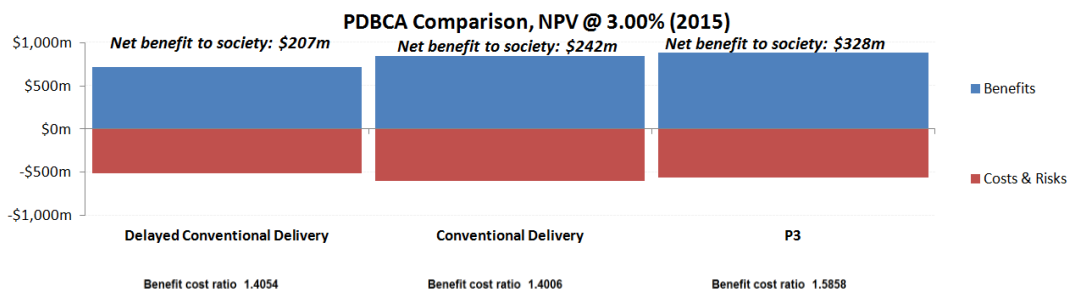
**Table 15: Compare P3 to Conventional Delivery (Step 3)**

PDBCA Outputs	NPV @ 3.00%
Step 1: Compare Delayed Conventional Delivery to No Build	207
Step 2: Compare Conventional Delivery to Delayed Conventional Delivery	34
Step 3: Compare P3 to Conventional Delivery	86
<b>Total net benefits / (costs)</b>	<b>328</b>

5.4.3 PDBCA Comparison Graph

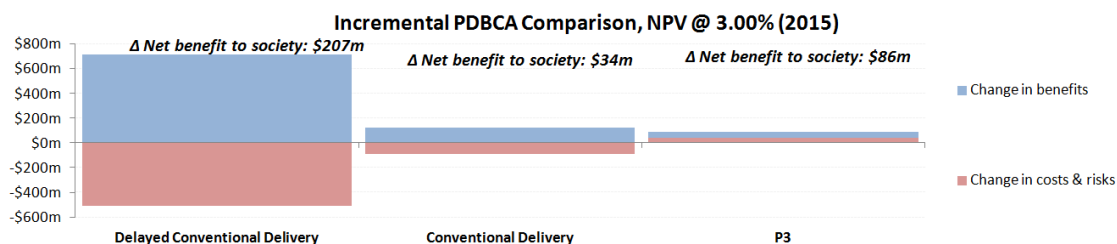
The PDBCA Comparison Graph sheet presents the above analysis graphically. The figure below shows sample BCA results for the Delayed Conventional Delivery, Conventional Delivery and P3.

**Figure 12: Sample PDBCA Comparison**



The next figure shows sample outputs for the incremental BCA analysis.

**Figure 13: Sample Incremental PDBCA Comparison**



For the hypothetical project depicted in the figures above, the P3 has the highest net benefit to society.

#### 5.4.4 Detailed Benefit & Cost Graphs

Lastly, the model provides three detailed benefit and cost graphs:

- Benefits and costs under Delayed Conventional Delivery
- Benefits and costs under Conventional Delivery
- Benefits and costs under P3

These are the same graphs as those included on the PDBCA Output Summary sheet, but are larger to enable users to better identify the timing and size of various cost and benefit items.

# PART II: CONCEPT GUIDE

# 1 Introduction

The Concept Guide provides a detailed discussion on a number of concepts used to develop P3-VALUE 2.0. More specifically, the Concept Guide contains the following sections:

- General model considerations
- Risk and uncertainties
- VfM and financial considerations
- PDBCA considerations

The Concept Guide is not a comprehensive document in the sense that not all possible topics relevant to risk analysis, financial feasibility assessment, value for money and project delivery benefit-cost analysis are discussed. This Concept Guide focuses on those topics that were considered key in the development of P3-VALUE 2.0. For more comprehensive discussions of the concepts, the reader is advised to review the various guidebooks available in the P3 Toolkit section of the website of FHWA’s Office of Innovative Program Delivery – including the Risk Assessment Guidebook, the Value for Money Analysis Guidebook, the P3 Project Financing Guidebook, and the Project Delivery Benefit-Cost Analysis Framework guide.

## 2 General Model Considerations

This chapter discusses the following general considerations related to the P3-VALUE 2.0 model:

- Model periodicity
- Varying perspectives
- Transaction costs
- Residual value of facility

### 2.1 Model Periodicity

A financial model is by definition an abstraction of actual cash flows. For example, a toll road concessionaire receives toll revenues on a daily basis, whereas financial models typically aggregate such revenues on a monthly, quarterly, half yearly or yearly basis. In the original P3-VALUE tool, certain inputs and calculations were annual (e.g., traffic forecasts), whereas other elements of the model were semi-annual.

It is a good practice in financial modeling to keep – to the extent possible – one single periodicity throughout the entire model. That approach, however, does not specify what periodicity should be used: monthly, quarterly, half yearly or yearly.

Although a shorter periodicity allows for more detailed and more precise modeling of, for example, construction schedule and debt service payments, it also increases the number of cells in the model. A quarterly model would require roughly four times the number of cells as a yearly model, which in turn results in a significant increase in the size of the model. Another consideration is that benefit-cost analyses typically use an annual periodicity. Taking into account these different considerations, P3-VALUE 2.0 uses a single annual periodicity throughout the entire model.

### 2.2 Varying Perspectives

Financial models are typically built for one particular client or group of users. In the case of P3 infrastructure projects, this could be a procuring Agency, a project developer, lenders, or even a federal Agency. P3-VALUE 2.0, however, can be used by different groups of users, each with their own perspective.

P3-VALUE 2.0 can perform both financial and economic efficiency analysis: VfM analysis and PDBCA. VfM analysis typically takes the perspective of the procuring Agency and asks the question: what are the fiscal implications of procuring a project as a P3 compared to a conventionally procured project. In this perspective, federal discretionary grants, and federal loan subsidies (e.g., TIFIA loans) would typically not be considered a cost. However, if a federal Agency were to carry out the same analysis, such subsidies would be considered a cost to the government.

A benefit-cost analysis (BCA) asks the question: what are the economic efficiency impacts of a project? Traditionally, a BCA takes the perspective of society to determine the societal costs and gains. Therefore, it could be argued that the BCA is best carried out from a national perspective, as this captures all of society. As a result, federal subsidies would have to be accounted for as costs. In practice, however, agencies may be

more concerned with the economic costs to their state, in which case they may choose to ignore the costs associated with federal subsidies.

It is relatively easy to adjust a project's costs in the BCA to accommodate the preferred perspective. In P3-VALUE 2.0, if the Agency does not want to consider a federal subsidy in the PDBCA, it can simply decide to reduce the costs by the amount of the federal subsidy, or ignore the amount of the subsidy.

On the benefits side however, it is much more challenging to accommodate the preferred perspective, because benefits accrue to all users of the facility and it may not be possible to easily distinguish between in-state and out-of-state users. P3-VALUE 2.0 does not distinguish between benefits accruing to in-state and out-of-state users.

### 2.3 Transaction Costs

Due to the difference in perspectives between VfM and PDBCA, project costs may be treated somewhat differently by each analysis. Besides the fact that the VfM analysis is carried out in nominal terms and the PDBCA in real terms, there are also some cost items that may be relevant for one but not for the other. More specifically, the PDBCA may consider economic costs such as the bid preparation costs of unsuccessful bidders, which would typically be ignored in a VfM analysis. These transaction costs are true costs to society as the resources required to prepare the unsuccessful bid could have been used elsewhere. Hence the transaction costs are included in the PDBCA, but as they do not directly impact the financial position of the Agency, they are excluded from the VfM analysis.

P3-VALUE 2.0 distinguishes between the following procurement costs:

- Public procurement costs (including compensation of losing bids)
- Private procurement costs (costs of winning bidder)
- Private procurement costs (cost of non-compensated losing bids)

The first two are included in both VfM analysis and PDBCA, whereas the last procurement cost item is only considered in the PDBCA.

### 2.4 Residual Value of Facility

A comprehensive VfM analysis or PDBCA should not only consider what happens to the facility under different delivery models during the operations period, but also what may happen thereafter. Therefore, the analysis period should at least cover the proposed concession period but should also take into consideration the residual value of the facility at handback. If appropriate handback provisions are included in the P3 agreement, the remaining useful life of the facility under a P3 procurement may be assumed to be the same as under conventional delivery at the end of the concession period.

However, the residual value at the end of a concession period of a facility procured as a P3 could also be different from the anticipated residual value under conventional procurement. As a result, the model should be able to deal with this difference in residual value. It should be noted, though, that the effect of different residual values discounted over the lifetime of the analysis period will most likely be small or even negligible.

To calculate the residual values under different delivery models, a model should ideally use an infinite evaluation horizon, in which future costs and benefits for each alternative are capitalized into a steady-state sum. In practice, however, Excel-based models require a finite timeline so the user will need to estimate the present value impact of the difference in residual values at the end of the concession period.

P3-VALUE 2.0 can accommodate a variation in residual value of the facility under various delivery models. In order to take this variation into consideration, the user must determine the cost associated with bringing the facility back to the specified standards for each delivery model. By including these costs in the VfM analysis and PDBCA, the user can make a fair comparison of the different delivery models while allowing for variations in residual value of the facility.

## 3 Risks and Uncertainties

A fair valuation of risks and uncertainty for both delivery models is essential to allow for an apples-to-apples comparison of P3 and Conventional Delivery. This chapter discusses how risk and uncertainties are valued in P3-VALUE 2.0.

### 3.1 Risk Framework

In line with the FHWA Guidebook for Risk Assessment in Public-Private Partnerships, P3-VALUE 2.0 recognizes the following risk categories:

- Pure risks, event risks, or non-systematic risks (“Pure risks”) Example: Accident at construction site, causing cost overrun and/or delays.
- Base variability or non-systematic uncertainties (“Base variability”). Example: Uncertainty in volume of asphalt.
- Systematic risks, long-term performance risks, and project coordination risks that cannot be transferred to subcontractors but are retained by the concessionaire (“Lifecycle Performance Risks”). Example: Conflicts between DB and O&M contractors, supervening events exceeding liability caps, inflation.

These risk and uncertainties are all considered to carry a potential cost to the Agency, concessionaire or society.

#### 3.1.1 Risk Framework Applied to Costs

In principle, the three risk categories apply to project costs (relevant for both VfM analysis and PDBCA), project revenues (relevant for VfM analysis) and project benefits (relevant for PDBCA). When applying the above risk framework to project costs, the following challenges can be identified:

- Distinction between pure risks and lifecycle performance risks may be difficult for long-term risks and costs.
- Contingencies are often used for a variety of possible cost overruns (including pure risks and uncertainties/base variability, but also for change orders and inflation), which may reduce the applicability of typical contingency information.

The P3-VALUE 2.0 tool assumes that practitioners can effectively identify the relevant risks according to this framework and avoid double counting.

#### 3.1.2 Risk Framework Applied to Revenues and Benefits

For project revenues (only relevant in the case of a toll facility) and benefits, the application of the above risk framework with three different types of risk is more challenging as risks and uncertainties may overlap. Therefore, P3-VALUE 2.0 deals with risk and uncertainty for project revenues and benefits by developing uncertainty adjustments for traffic and revenues. In order to do so, the model uses the most likely traffic projection (P50 equivalent) as a starting point. For the VfM analysis, the associated revenue stream is used without any risk or uncertainty adjustment for the P3 concession. In that case, P3-VALUE 2.0 considers that uncertainties associated with revenues are already captured in the P3 cost of capital.

The project risk free discount rate used for the PSC in the VfM analysis does not consider revenue risk and uncertainties. Therefore, the traffic and revenues need to be adjusted to take into consideration risk and uncertainty. In the VfM analysis, P3-VALUE 2.0 calculates a revenue uncertainty adjustment for the PSC based on the difference in financing conditions between an Availability Payment P3 and a Toll Concession P3. The exact calculation method used will be discussed in more detail below.

For benefit-cost analysis, the traditional means by which analysts have evaluated risk is through sensitivity analysis. In a typical sensitivity analysis, the value of an input variable identified as a significant potential source of uncertainty is changed (either within some percentage of the initial value or over a range of reasonable values) while all other input values are held constant, and the amount of change in analysis results is noted. This sensitivity process is repeated for other input variables for which risk or uncertainty has been identified. The input variables may then be ranked according to the effect of their variability on BCA results.

Sensitivity analysis allows the analyst to get a feel for the impact of the variability of individual inputs on overall economic results. In general, if the sensitivity analysis reveals that reasonable changes in an uncertain input variable will not change the relative economic ranking of project alternatives or undermine the project's economic justification, then the analyst can have reasonable comfort that the results are robust. Alternatively, a dramatic change in outcomes as a result of a reasonable change in an uncertain input value could severely undermine the project's economic justification.

As explained above, risks on the cost side of BCA are accounted for in the same manner in P3-VALUE 2.0 as for the VfM analysis. On the benefits side of the BCA analysis, the most significant variable affecting benefits is generally the traffic projections. In the PDBCA module, the P3-VALUE 2.0 tool discounts all cost and benefit flows at the (real) social discount factor. As this discount factor does not consider uncertainty, the traffic forecast used to calculate the different economic benefits must be uncertainty adjusted and/or tested using sensitivity analysis.

P3-VALUE 2.0 therefore includes a traffic sensitivity factor that can be used to estimate the impacts on net benefits of the uncertainty in traffic projections. The factor is a percentage (less or more than 100%) of the P50 (or equivalent) traffic and hence lowers or increases the traffic growth projections to be considered in the PDBCA sensitivity analysis. In P3-VALUE 2.0, the traffic sensitivity factor is applied only to traffic above the No Build base year traffic. If, for example, daily traffic growth forecasted for the Build scenarios is 15,000 vehicles under P50 for the first year of operations and the Agency would like to assess the impact of a 20% variation in the Build traffic growth above the No Build base year traffic, the appropriate traffic sensitivity factors to be used would be 80% and 120%. In this example, if the No Build base year weekday traffic is 100,000 vehicles and the Build traffic is 115,000 vehicles in the base year, the BCA module would need to be re-run first with an 80% factor, yielding 112,000 vehicles per day (i.e.,  $100,000 + 80\% \times 15,000$  vehicles). Next, it would be run with a 120% factor, yielding 118,000 vehicles per day. If traffic growth in the last year of operations is 50,000 vehicles per day, the corresponding Build traffic would be calculated as 140,000 vehicles per day with an 80% sensitivity factor and 160,000 vehicles per day with a 120% sensitivity factor. Please note that the same factor is applied to traffic projections in the No Build case. Thus, for example, if No Build traffic is projected at 120,000 vehicles per day in the last year of the operating period (20,000 vehicles above No Build base year traffic), corresponding No Build traffic would be calculated as 116,000 vehicles per day with an 80% factor and 124,000 vehicles per day with a 120%

factor. The purpose of these sensitivity test runs is to calculate the various societal costs and benefits under alternative traffic growth scenarios in order to check whether the economic justifications for the project as well as for the project acceleration and project delivery option still hold.

### 3.2 Pure Risks

The pure risks identified in the risk framework above can be incorporated into the analysis in two ways:

- **Bottom-up approach:** Practitioners develop a comprehensive risk register for the proposed project. Each risk is valued on the basis of its expected value (likelihood of occurrence x impact).
- **Top-down approach:** Based on the overall project risk profile, practitioners use expert judgment to determine a realistic contingency for all cost components.

The drawback of the bottom-up approach is that developing a fully comprehensive risk register may be (almost) impossible, as it is difficult to be certain that no risks have been overlooked. To avoid potentially underestimating the overall risk, an additional risk mark-up can be used. Alternatively, practitioners can use the top-down approach, which effectively replaces the risk register by a single overall risk that captures the project's overall risk profile.

The P3-VALUE tool enables users to use either approach. For the bottom-up approach, the user must develop a comprehensive risk register (possibly including an additional risk mark-up to compensate for any incompleteness of risk register) for both the construction and the operation periods. For the top-down approach, the user must develop (at least) one risk category for each project phase (construction phase and operations phase) with a realistic contingency for the considered cost components. For each risk category, under either approach, the user must provide the following details:

- Label for considered risk
- Probability of occurrence
- Most likely risk impact (including both cost and timing impacts, expressed in monetary terms)
- Risk value distribution, including:
  - Minimum value (in percent reduction from most likely risk value)
  - Maximum value (in percent increase from most likely risk value)
  - Distribution shape (triangular or uniform)

Furthermore, for P3, the user must provide the risk allocation (how much of the risk is transferred to the private sector and how much is retained by the Agency) and the expected P3 risk difference (how much lower or higher the most likely risk impact might be due to differences in conventional vs. P3 risk management).

Based on the risk value distribution and the probability level, the value of each pure risk can be calculated. If multiple risks are provided, the P3-VALUE 2.0 tool assumes that these risks are independent and employs the central limit theorem to estimate the combined value at a given probability level.

A simplified sample calculation is provided below to illustrate the above approach. In this example, the project faces three independent risks, each with their own risk distribution.

Risk Item	Probability of occurrence (A)	Most likely impact (B)	Most likely value C = A x B	Minimum value (D)	Maximum value (E)	Shape
Risk 1	20%	\$10,000k	\$2,000k	-20%	+50%	Uniform
Risk 2	25%	\$4,000k	\$1,000k	-20%	+50%	Uniform
Risk 3	50%	\$4,000k	\$2,000k	-20%	+50%	Uniform

Using the statistical properties of a uniform distribution<sup>7</sup>, the following values can be calculated.

Risk Item	Minimum value F = C – D%	Maximum value G = C + E%	Mean value H = ½ x (F + B)	Variance I = (G – F) <sup>2</sup> / 12
Risk 1	\$1,600k	\$3,000k	\$2,300k	\$163,333k
Risk 2	\$800k	\$1,500k	\$1,150k	\$40,833k
Risk 3	\$1,600k	\$3,000k	\$2,300k	\$163,333k
<b>Total</b>	<b>\$4,000k</b>	<b>\$7,500k</b>	<b>\$5,750k</b>	<b>\$376,500k</b>

Given the total mean value of \$5,750k and a standard deviation of \$606k (square root of the total combined variance) and using the central limit theorem<sup>8</sup>, the value of the combined risk at a given probability level can be calculated using the NORMINV function in Excel. For the example above, the total risk value equals \$6,068k for an assumed P70 risk tolerance level. The calculation process would be the same if the risks were to have a triangular distribution, with the exception that the statistical properties of a triangular distribution<sup>9</sup> would be used.

P3-VALUE 2.0 performs the above calculation for each year, both during construction (for construction risks) and operations (for operations risk).

### 3.3 Base Variability

The exact magnitude of costs is typically uncertain because of lack of (more precise) information. In practice, these uncertainties are often covered in a base variability mark-up. This mark-up can be a function of the stage in design development. If the design development is more advanced, typically the mark-up can be reduced. Alternatively, non-systematic uncertainties can be analyzed using probabilistic analysis.

The P3-VALUE 2.0 tool requires the user to provide separate base variability mark ups for pre-construction costs, construction costs and O&M. These mark ups apply to costs only; risks are assumed to already incorporate base variability.

<sup>7</sup> Mean =  $\frac{1}{2}(\text{min} + \text{max})$ , Variance =  $\frac{1}{12}(\text{max} - \text{min})^2$

<sup>8</sup> According to the central limit theorem, the distribution of the sum of a sufficiently large number of independent random variables is approximately normal.

<sup>9</sup> Mean =  $\frac{a + b + c}{3}$ , Variance =  $\frac{a^2 + b^2 + c^2 - ab - ac - bc}{18}$ , with  $a$  and  $b$  being the minimum and maximum value respectively, and  $c$  being the most likely value (peak of the triangular probability density function).

### 3.4 Lifecycle Performance Risk

As explained earlier, lifecycle performance risk refers to the risks that cannot be transferred to subcontractors but are retained by the concessionaire. The value of these risks is already accounted for in the concessionaire’s bid. However, on the PSC side, these risks are typically not considered. The PSC therefore needs to be adjusted for lifecycle performance risk to ensure a fair comparison between the PSC and P3. This adjustment is effectively an equalizer between the PSC and P3 to account for possible cost overruns (above those already considered under base variability and pure risks), interface risk, systematic risks, etc. on the PSC side.

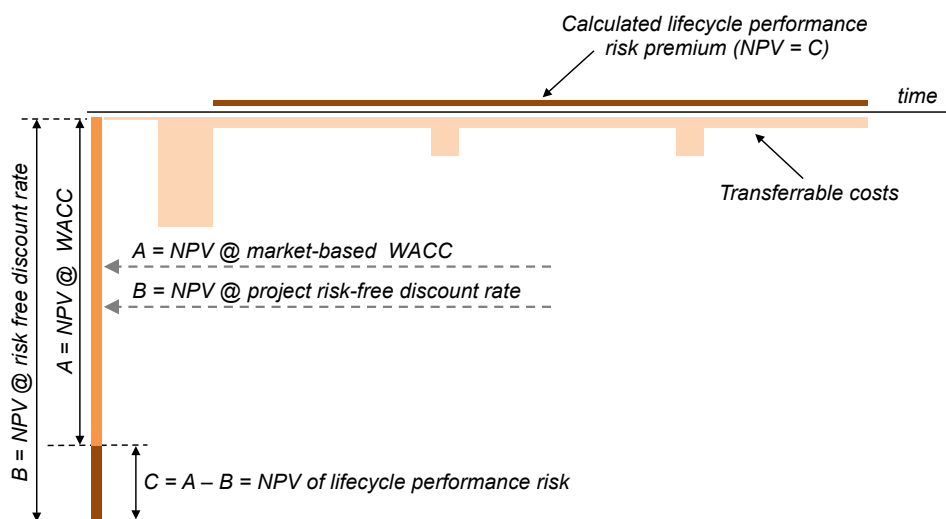
P3-VALUE 2.0 offers two approaches to value lifecycle performance risk:

1. If an Agency has specific data on lifecycle performance risk cash flows, it may use these cash flows in the VfM analysis and PDBCA. To do so, the user must select “cost input” under the “Lifecycle performance risk calculation switch” in the model (see InpRisk input sheet).
2. If the Agency does not have specific information on lifecycle performance risk cash flows, the user may use market-based financing information to determine the value of lifecycle performance risk. To do so, the user must select “calculated premium” under the “Lifecycle performance risk calculation switch” in the model.

Under the first approach, the model simply adds the input lifecycle performance risk cash flows to the PSC costs, which result in lifecycle performance risk-adjusted costs in the VfM analysis and PDBCA.

Under the second approach, P3-VALUE 2.0 uses market-based financing information to determine the value of the above risks. More specifically, the model compares the net present value (NPV) of the project costs that would have been transferred to a concessionaire (“transferrable costs”) if the project were to be procured as a P3 under two different discount rates: 1) a market-based Weighted Average Cost of Capital (WACC) and 2) a project risk free discount rate. The difference between the two NPVs is a measure of the value of the systematic risks, long-term performance risks and project coordination risks that a P3 concessionaire would have taken on. This difference in NPVs can then be converted into an annuity-style premium over the project’s life. The calculation of the lifecycle performance risk is illustrated in the figure below.

**Figure 14: Lifecycle performance risk premium calculation**



To calculate the lifecycle performance risk premium, both a market-based WACC and the project risk free discount rate are required. P3-VALUE 2.0 calculates the market-based WACC from the P3 financing structure included in the model. In order to do so, the model calculates the internal rate of return of all financing cash flows combined<sup>10</sup>, which is the project’s WACC. A challenge in this approach is that the market-based WACC may also include other risks. For an availability payment (AP) project, the P3 WACC reflects the systematic risks, long-term performance risks and project coordination risks, which are mainly related to operational issues. However, the WACC for a toll concession (TC) project also reflects revenue uncertainty. P3-VALUE 2.0 therefore uses the AP WACC when calculating the lifecycle performance risk premium to ensure a fair evaluation of lifecycle performance risk in a toll concession.

In order to determine the AP WACC when evaluating a toll concession (in which case the calculated WACC by the model is the TC WACC), the model requires the user to input the difference between a TC WACC and an AP WACC. To determine what this difference in WACC should be, the user should change the active scenario in the P3-VALUE 2.0 tool (see InpFin input sheet, cell F6) from a toll concession (“PSC: Tolloed, P3: Toll concession”) to an AP concession (“PSC: Tolloed, P3: Availability Payment”). The user must simultaneously verify that the financing conditions under the AP concession are in line with market conditions (typically higher gearing, lower DSCR and lower required equity returns for an AP transaction compared to a toll concession). Now that both the AP WACC and the TC WACC are known, the user can calculate the difference and enter the “difference between AP WACC & TC WACC” into the model (see InpFin input sheet, row 71).

The other element required to determine the lifecycle performance risk premium is the project risk free discount rate. The project risk free discount rate reflects the time value of money and related uncertainties and risks, just like any interest rate. The project risk free discount rate does not reflect uncertainties and risks that are specific to a project, like an interest rate in a project finance structure for a project would. The project risk free discount rate is a separate input that could be based on the Agency’s borrowing rate (see InpFin input sheet, cell F14). Using these various elements, the model calculates the lifecycle performance risk premium, which is included as an offsetting risk cost in the PSC (and Delayed PSC) to allow for a fair comparison with the P3, both for the VfM analysis and PDBCA.

### 3.5 Revenue Uncertainty Adjustment

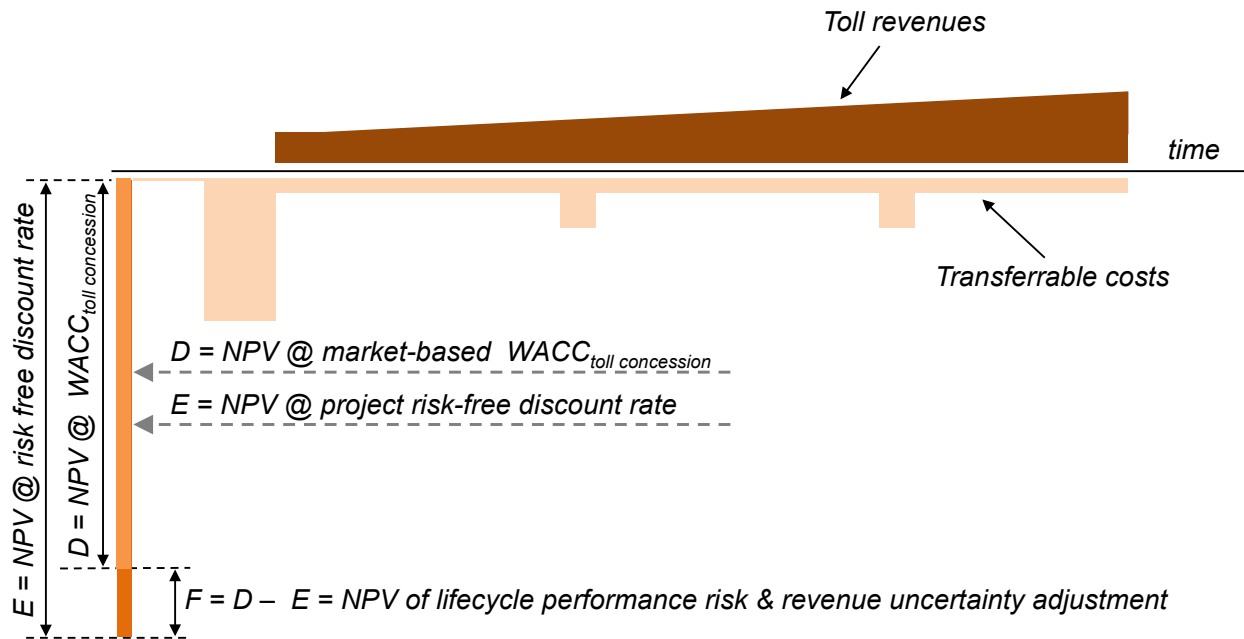
Traffic and revenues are inherently difficult to predict. In their bids for toll concessions, bidders (and their financiers) take revenue uncertainty into consideration through the financing conditions. Public Agencies that take revenue risk (under a PSC or a P3 availability payment concession) also face the same revenue uncertainty. However, it may be difficult for Agencies to value these uncertainties. P3-VALUE 2.0 allows for two different approaches to capture revenue uncertainty. Under the first approach, the user can provide a percentage reduction (an input) to toll revenues flowing to the Agency to account for uncertainty. For example, if the user inputs 20%, this means that the revenues flowing to the public Agency will be reduced by 20%. The second approach uses market-based information to determine the value of revenue uncertainty and will be discussed in more detail below.

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<sup>10</sup> Equity investment, loan/bond drawdowns, debt service, reserve movements, and dividend payments

As explained in the previous section, the difference between the AP WACC and project risk free discount rate is a reflection of the lifecycle performance risk. Furthermore, in a toll concession, the WACC reflects both lifecycle performance risk and revenue uncertainty. P3-VALUE 2.0 uses this logic to determine the magnitude by which revenues flowing to the Agency should be reduced to account for uncertainty. To do so, the model compares the NPV of all transferrable project costs and toll revenues under 1) a market-based WACC for a toll concession and 2) a project risk free discount rate. The difference between the two NPVs is a measure of the combined value of the lifecycle performance risk and revenue uncertainty adjustment, as illustrated in the figure below.

**Figure 15: Revenue uncertainty adjustment calculation**



The difference between the NPV of lifecycle performance risk ( $C$ , see Figure 14) and the NPV of the lifecycle performance risk & revenue uncertainty adjustment ( $F$ , see Figure 15) is a measure for the revenue uncertainty adjustment.

P3-VALUE 2.0 calculates the relative value of the revenue uncertainty adjustment compared to the overall revenues (in NPV terms) to determine the percentage-based reduction that should be applied to the revenues flowing to the Agency.

## 4 VfM and Financial Considerations

This chapter discusses the following considerations related to VfM analysis and project financing:

- Financing in P3-VALUE 2.0
- Sculpted vs. annuity debt service
- Financing vs. funding of retained costs
- Subsidized financing

### 4.1 Financing in P3-VALUE 2.0

Financing is an important part of project delivery in general but especially for P3 delivery. Across the globe, procuring agencies use various methodologically correct ways to consider financing in a VfM assessment. Some of these approaches do not include financing at all, typically because agencies believe that financing should not be a determining factor in the comparison of delivery models. According to these agencies, the underlying valuation of risks and potential cost efficiencies should be the determining factors. They also believe that including the financing structure can make the analysis overly (and unnecessarily) complex and may turn the VfM assessment into a black box. For these reasons, some agencies alternatively prefer to use a very simple approach to consider financing in the VfM assessment, based on a weighted average cost of financing, instead of a full financing structure.

P3 VALUE 2.0 distinguishes between financing as part of the P3 delivery cash flows on the one hand, and financing under Conventional Delivery on the other hand. Regarding the first, the financing structure and financing conditions form an integral part of the “shadow bid” in the P3 VALUE 2.0 model. That makes the model somewhat more complicated as a full financing structure needs to be modeled, but also has important advantages. The main advantages for including the financing for P3 delivery are listed below:

1. It clarifies the relevance, structure, and optimization process for financing under a P3, which is important from an educational perspective.
2. It provides the actual financial and fiscal implications (including financing) of P3 delivery, which is necessary for an affordability assessment or fiscal impact assessment.
3. It allows for a relatively sophisticated optimization of the P3 financing structure that is necessary to get to a reasonable estimate of the P3 bid, which is relevant for a screening level assessment of real life projects.

For Conventional Delivery, there are two considerations regarding the inclusion of financing. First, including financing can lead to unintended distortions of the analysis. Differences between the discount rate used for the calculation of the net present value of Conventional Delivery cash flows and the public financing interest rates for Conventional Delivery can distort the results of the VfM assessment. This can be avoided by not including financing in the Conventional Delivery model. Second, public financing structures tend to be less tailored to the project cash flows, which creates “inefficiencies” from a project perspective. One could argue that these “inefficiencies” need to be taken into account in the VfM assessment, because they are the inherent result of Conventional Delivery, which would be an argument for including financing in the Conventional Delivery. At the same time, excess financing at the project level does not necessarily lead to inefficiencies at the portfolio or government level, which could make it unfair and incorrect to

attribute the inefficiencies to the Conventional Delivery. It may therefore be fairer and cleaner to not incorporate financing in the Conventional Delivery model.

In order to address these challenges, the P3-VALUE 2.0 tool allows for a Conventional Delivery analysis solely on the basis of operational cash flows and presents the primary VfM analysis results only on the basis of operational cash flows. As a result, for example, expected construction costs under P3 delivery can be directly compared with construction costs under Conventional Delivery. At the same time, the P3-VALUE 2.0 tool still offers the option to include financing in the Conventional Delivery model and also presents the Conventional Delivery and P3 debt financing cash flows in a worksheet separate from the primary VfM analysis results, in order to allow the user to better understand the project implications from a financing perspective and facilitate the financial viability assessment.

## 4.2 Sculpted vs. Annuity-Type Debt Service

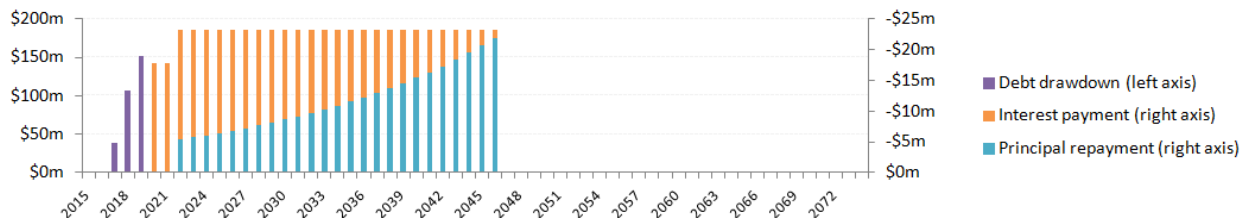
P3 projects typically have complex financing structures, potentially involving a large number of debt and equity instruments. The P3-VALUE 2.0 tool allows users to develop a variety of financing structures. On the P3 side, the financing/funding structure would typically include equity, debt and public Agency subsidy payments. On the PSC side, the financing/funding structure can include debt and public Agency funding.

For both the PSC and P3, debt service can be structured in two ways:

- Annuity-type (mortgage-style) debt service
- Fully sculpted debt service

Under annuity-type debt service, no interest capitalization beyond construction is considered. Furthermore, the model enables users to provide a grace period (number of years after substantial completion) during which only interest is due. The remainder of the tenor will be used to repay the principal. The total debt size under annuity-type debt service is determined by the minimum Debt Service Coverage Ratio (DSCR, an input) and the minimum cash flows available for debt service (CFADS), which typically occur in the early years. An example of an annuity-type debt service is shown below.

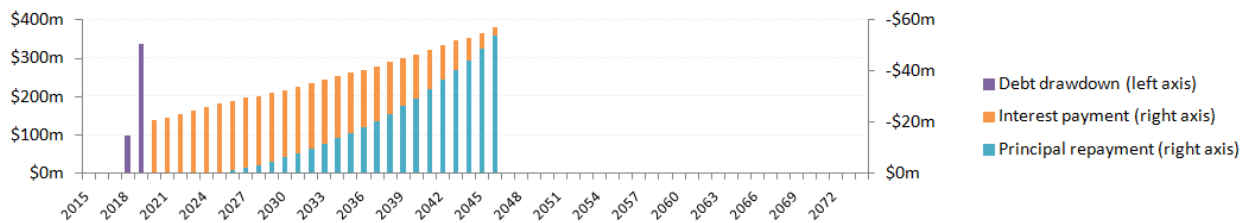
**Figure 16: Annuity-type debt service**



Under a fully sculpted debt service, the model uses the project’s cash flows available for debt service (CFADS) in each year to create a perfectly sculpted repayment profile. This means that the DSCR will be constant throughout the debt service period. Under this approach, the total debt size is determined by the minimum DSCR and the CFADS over the entire debt service period. This may also lead to some interest capitalization during the early years of operation if CFADS in these early years is insufficient to make early interest payments. Although the CFADS under both debt service types are equal, a fully sculpted repayment makes more efficient use of these CFADS by “pushing back” debt service to future periods with higher revenues. As a result, the debt capacity of a fully sculpted debt solution will be larger than the debt capacity of an annuity-type debt solution. Due to the potential interest capitalization in the early years of the

concession, the debt-to-equity ratio may increase through the end of construction. In the Financing Outputs sheet, the model indicates whether and for how many years interest capitalization is occurring. Furthermore, it provides the maximum outstanding debt as well as the maximum debt-to-equity ratio.

**Figure 17: Fully sculpted debt service**



In reality, P3 transactions will typically try to create a more or less sculpted debt profile using various debt instruments. The P3-VALUE 2.0 tool gives users the opportunity to analyze the impact of different financing structures.

### 4.3 Financing vs. Funding of Retained Costs under P3

Under the PSC, agencies can decide to either fund the project (which means it is paid from the Agency’s budget) or finance it using debt. In the model, both approaches are possible. If the Agency finances the project, debt will be used to the extent possible (subject to the DSCR requirement) with the remainder funded through subsidies.

Under P3, the concessionaire's financiers will finance all costs and risks transferred to the concessionaire. The costs and risks that are not transferred to the concessionaire (and therefore retained by the Agency) could theoretically be either funded or financed. P3-VALUE 2.0 assumes that all retained costs and risks are directly funded by the Agency.

### 4.4 Subsidized Financing

Many financing structures for P3s in the US include TIFIA loans and/or tax exempt debt. These financing sources include (implicit) subsidies. The financing conditions therefore do not accurately reflect the project’s risk profile. The relevant consequences from a state perspective are that:

- P3 financial cash flows do not necessarily reflect the total value of the risks.
- P3 WACC (calculated from the P3 financial cash flows) does not reflect the total value of the risks, which means that the calculated lifecycle performance risk premium underestimates the total value of the risk (if the P3 WACC is used for the calculation of the lifecycle performance risk premium).
- Comparison between P3 and Conventional Delivery remains fair, however, because the same “subsidized” risk value (i.e., based on the P3 WACC) is used to estimate the lifecycle performance risk (which is added to the PSC cost). Indeed, the equalizing effect of the lifecycle performance risk calculation ensures that the risk is underestimated by the same proportion in both P3 and PSC.

If the analysis is done from the federal perspective, there are two potential approaches:

- **Approach 1:** Adjust both the PSC and P3 by applying market-based financing conditions instead of TIFIA/tax exempt conditions (or the dollar value equivalent of the difference between

TIFIA/tax exempt and market-based financing conditions). While the total costs for each alternative will be higher, there will be no difference in the comparison as both sides will be adjusted by the same proportion.

- **Approach 2:** Ignore the subsidy, because 1) it does not affect the comparison of delivery models to the extent that TIFIA and tax exempt debt are equally available under both delivery models, and 2) it makes no difference in the comparison, which is the key metric of interest in VfM.

To keep things as simple as possible, approach 2 is preferred. P3-VALUE 2.0 allows for both approaches; the user determines the approach by the providing of the appropriate inputs (no changes under approach 2, or more expensive financing conditions under approach 1).

## 5 PDBCA Considerations

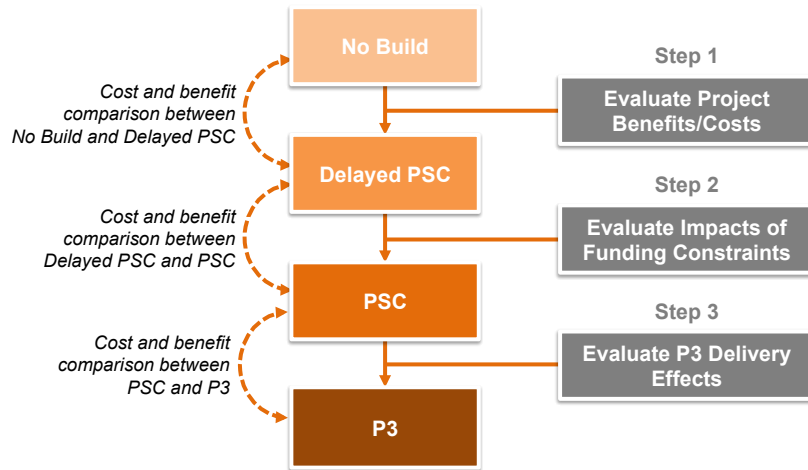
In order to develop the PDBCA framework and the P3-VALUE 2.0 PDBCA module, a number of concepts were developed while other existing concepts were adapted to the new framework. Furthermore, in order to be able to compare different delivery models, the PDBCA module required a calculation methodology for each potential benefit (or disbenefit) considered. This chapter discusses a number of the key concepts and describes the calculation methodology for the various benefits considered in the PDBCA framework, including:

- Definition of Delayed PSC
- Treatment of value of time
- Traffic projections
- Travel time costs
- Delays due to construction and O&M activities
- Delays due to incidents
- Non-fuel and fuel vehicle operating costs
- Accidents
- Emissions
- Induced traffic benefits

### 5.1 Definition of Delayed PSC

In the VfM analysis, the PSC is compared to the P3 in order to determine the fiscal impact on the Agency of P3 procurement. A key requirement for a VfM analysis to be valid is that the PSC and the P3 are implemented in a similar timeframe. For the PDBCA, there is no such requirement. Under PDBCA, a delayed project can be compared to an accelerated project without any conceptual challenges. This means that the PDBCA framework allows practitioners to evaluate the impact of funding constraints that could delay projects. As shown in the figure below, P3-VALUE 2.0 uses three steps to distinguish between the impacts of public funding constraints on the one hand, and impacts due to P3 cost and benefit efficiencies on the other.

**Figure 18: PDBCA framework**



In order to evaluate the impacts of funding constraints (step 2 in the figure above), a third delivery model is therefore introduced: the Delayed Public Sector Comparator (Delayed PSC).

The Delayed PSC has the exact same characteristics as the PSC, with only one exception: the start date of the project. If, for example, due to fiscal constraints an Agency can only afford to start building a project in 2025 instead of 2018, both the incurred costs as well as the benefits accruing to society will be delayed as can be seen in the figure below.

**Figure 19: Comparison of economic costs & benefits between Delayed PSC and PSC**



Depending on the exact profile of costs and benefits, accelerating a project may result in lower or higher net benefits to society.

## 5.2 Treatment of Value of Time

Value of Time (VOT) reflects the economic value of time spent by travelers on their journey. The P3-VALUE 2.0 tool uses VOT to calculate differences in travel time cost (i.e., travel time cost savings) between the No Build and various Build options (Delayed PSC, PSC, and P3). VOT is typically not project-specific but may vary by region. For example, a region with a high median income is expected to have a higher VOT when compared to a region with a low median income.

The P3-VALUE 2.0 tool enables users to evaluate a variety of highway projects, including projects with general purpose lanes (GPL) and/or tolled lanes/managed lanes (TL/ML). For a managed lanes project, users of the facility have a choice between taking the GPL and not paying a toll vs. paying a toll to access the ML in order to enjoy greater travel time savings. Typically, people willing to pay tolls tend to value their time at a higher rate. Therefore, VOT is expected to be higher for ML users. As the overall average VOT for the Build and No Build alternative should be equal, VOT of the GPL users could theoretically be determined from the relative traffic shares on the MLs and GPLs (in combination with the VOT of the No Build and the ML users). Given the already significant complexity of the traffic calculations<sup>11</sup> in P3-VALUE 2.0, P3-VALUE applies a uniform VOT to GPL and ML/TL users.

## 5.3 Traffic Projections

Traffic plays an important role in the PDBCA module as the various benefits and disbenefits are directly related to the number of users on the facility. To determine traffic on the facility, P3-VALUE 2.0 requires users to provide average weekday daily traffic (AWDT). More specifically, the user must provide a most likely traffic projection (P50 equivalent) by inputting a minimum of two (but up to five) traffic data points (traffic in a specified year). The tool uses a simple straight line interpolation for the intermediate years. Beyond the last year of input, the tool uses a constant growth factor (input provided by user) to project future traffic.

To avoid unrealistically high traffic projections, the model automatically limits overall daily traffic to the following daily capacity (maximum number of vehicles that can use the facility per day):

$$\begin{aligned} \text{Daily capacity} &= \text{hourly-to-daily capacity conversion factor} \times \text{ratio of LOS E capacity to LOS C capacity} \\ &\times \\ &\text{lane vehicle capacity at LOS C} \times \text{number of lanes} \end{aligned}$$

The hourly-to-daily capacity conversion factor is defined as the ratio of the maximum daily traffic divided by the level of service (LOS E) hourly capacity. The LOS E to LOS C capacity ratio is defined as the ratio of the vehicle service volume at LOS E divided by the vehicle service volume at LOS C, i.e., the service volume used in the volume-delay function (VDF) used to calculate congested speeds, which is discussed below. The variables in the above formula are all user inputs. For example, if the hourly-to-daily capacity

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<sup>11</sup> P3-VALUE 2.0 traffic calculations distinguish between: 1) GPL vs. ML/TL traffic, 2) peak vs. off peak traffic, 3) weekday vs. weekend traffic, 4) 2 axles vs. 4+ axles traffic, 5) No Build vs. Build traffic. The model uses user inputs (percentage of daily traffic) to compute peak, off-peak, and weekend traffic. In addition, it uses 2 and 4+ axle vehicle percentages for each period (peak, off-peak and weekend) to compute traffic for each vehicle type and period.

conversion factor is 12, in combination with a LOS E to LOS C capacity ratio of 1.33<sup>12</sup>, lane vehicle capacity at LOS C of 1,500 vehicles per lane per hour and 6 lanes, the maximum traffic accepted by the model is 143,640 vehicles per day.

If the user-generated daily traffic inputs or model forecasts based on input growth rates exceeds the facility's maximum daily capacity, the model cuts off any excess traffic and informs the user through alerts that the traffic capacity has been breached. In that case, the capped maximum daily capacity is used to calculate the various traffic streams (peak vs. off-peak, weekday vs. weekend, 2 axles vs. 4+ axles traffic). The maximum daily capacity also constrains the traffic projections used for the toll revenue calculation in the VfM analysis.

## 5.4 Travel Time Savings

One of the key benefits of a highway expansion project is likely to be the reduction of travel time cost (or travel time savings) for its users. To determine the travel time savings to users, P3-VALUE 2.0 calculates the travel time under the different delivery models and compares it to the No Build travel times. To determine the travel times, the model calculates the actual congested speeds due to recurring congestion under the traffic projections provided.

Congested speeds due to recurring congestion are computed for each of the delivery models using each year's traffic volume and capacity by period. The cost of travel is calculated by multiplying the congested travel time by the value of time (input). The travel time cost difference between the various delivery models considered and the No Build is the travel time benefit. The rest of this section details how congested speeds and travel time costs are computed.

### 5.4.1 Congested Speed

P3-VALUE 2.0 calculates congested speeds due to recurring congestion for each year and delivery model considered, for the different portions of the facility (GPL and ML/TL), for each vehicle type (2 and 4+ axle), and for each time period (peak, off-peak, and weekend) using the Bureau of Public Roads' Volume-Delay Function (VDF):

$$\text{Congested Speed} = \frac{\text{Free Flow Speed}}{1 + \alpha \times \left(\frac{V}{C}\right)^\beta}$$

While the form of the VDF function cannot be changed within the tool, the parameters ( $\alpha$  and  $\beta$ ) can be changed by the user. The default value for  $\alpha$  is 0.15 and  $\beta$  is 4. The user can modify these parameters to calibrate congested speeds to observed congested speeds for the existing facility. The capacity used in the formula is the hourly capacity at Level of Service C (LOS C capacity), not the maximum hourly capacity (LOS E capacity). Thus, a freeway lane with an LOS E capacity of 2,000 vehicles per lane per hour would have a LOS C capacity of approximately 1,500 vehicles per lane per hour, resulting in the 1.33 LOS E vehicle-capacity factor used on the previous page. In order to obtain accurate speeds, it is important to use

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<sup>12</sup> Assuming a level of service (LOS) E capacity of 2,000 vehicles per lane per hour and a LOS C capacity of 1,500 vehicles per lane per hour.

the LOS C capacity as input. Using LOS E capacity as input would cause an underestimation of congested speeds, and result in an underestimation of benefits from increasing capacity. If the user inputs traffic volumes and VDF parameters from a well-calibrated and validated travel demand model, the congested travel speeds on the existing facility should be comparable to the observed travel speeds. If the user does not have access to a calibrated travel demand model, then the user may seek assistance from a travel demand modeler to help calibrate the VDF parameters.

#### 5.4.2 Travel Time Cost

P3-VALUE 2.0 computes travel time costs for every year in the analysis period for the No Build and each of the delivery models considered. The model uses the following formulae to calculate the travel time cost for each period (peak, off-peak, and weekend), vehicle type, and lane type (GPL and ML/TL):

$$\text{Travel Time Cost/Vehicle} = \text{Vehicle Occupancy} \times \text{Value of Time} \times \frac{\text{Project Length}}{\text{Congested Speed}}$$

$$\text{Travel Time Cost Savings/Vehicle} = \text{Travel Time Cost/Vehicle}_{\text{Build}} - \text{Travel Time Cost/Vehicle}_{\text{No Build}}$$

$$\text{Travel Time Cost Savings} = \text{Travel Time Cost Savings/Vehicle} \times \text{Existing Traffic}$$

The model calculates and compares the travel time costs of the various Build delivery models with the travel time costs of the No Build to determine the travel time cost savings per vehicle for each delivery model. The total travel time benefit is the travel time cost savings per vehicle multiplied by the existing traffic volume (i.e., the No Build traffic volume, which excludes induced traffic, see below).

### 5.5 Delays due to Construction and O&M Work Zone Practices

P3-VALUE 2.0 also considers the social impact of delays due to lane unavailability during construction as well as operations and maintenance (O&M). The model uses the following formula to calculate the delay cost per vehicle.

$$\text{Delay Cost/Vehicle} = \text{Travel Time Cost/Vehicle} \times \left( \frac{1}{1 - \text{Speed Adjustment Factor}} - 1 \right)$$

The right part of the equation above represents the increase in travel time (and therefore travel time cost) of a reduction in speed. For example, if a user usually travels at 50 miles per hour, he/she will take 24 minutes to cover a road segment of 20 miles. If his/her speed is reduced by 20% to 40 miles per hour, he will now take 30 minutes to cover the same distance. This is equal to a 25% increase in travel time and travel time cost. The right part of the formula calculates this percentage increase in travel time cost.

Using the above, the model uses the following formulae to calculate the social cost of delays for each delivery model, period (peak, off-peak, and weekend), vehicle type, and lane type (GPL and ML/TL):

$$\Delta \text{Delay Cost/Vehicle} = \text{Delay Cost/Vehicle}_{\text{Build}} - \text{Delay Cost/Vehicle}_{\text{No Build}}$$

$$\text{Traffic Affected (\%)} = \frac{\text{Construction days/O\&M days per year} \times \text{Delay Duration}}{\text{Hours in a year}}$$

$$\text{Segment Affected (\%)} = \frac{\text{Length of Affected Segment}}{\text{Total Segment Length}}$$

$$\text{Annual Delay Cost} = \text{Traffic Affected} \times \text{Segment Affected} \times \Delta\text{Delay Cost/Vehicle} \times \text{Existing Traffic}$$

The model calculates and compares the delay costs of the various Build delivery models with the delay costs of the No Build to determine the change in delay costs per vehicle for each delivery model. Based on the share of traffic affected, the length of the section of the facility affected, the calculated change in delay costs and the existing traffic, the model calculates the annual delay costs for each of the delivery models.

A key input for the delay calculation is the speed adjustment factor, which determines by how much speed is adjusted based on number of lanes that are open. For work zones, this speed adjustment is to a large extent due to the lower posted speed limits that require vehicles to slow down. Table 16-A presents speed adjustment factors for work zones. Based on the number of open lanes and the free flow speed, the table provides a speed adjustment factor. The shaded cells in the table (ranging from 0.52 to 0.57) present the most common situation for work zones on highways. P3-VALUE 2.0 uses the average of the highlighted cells as a default value (0.55, or a 45% speed reduction), but users may modify this input to better fit regional conditions.

**Table 16-A: Speed adjustment factors for work zones (construction and O&M delays)**

Lanes Open	55 mph	60 mph	65 mph	70 mph	75 mph
1	0.60	0.56	0.53	0.50	0.47
2	0.62	0.58	0.55	0.52	0.49
3	0.64	0.60	0.57	0.54	0.51
4	0.66	0.62	0.58	0.55	0.52
5	0.68	0.64	0.60	0.57	0.53

Source: Table G.9. Capacity and Minimum Free-Flow Speed Adjustment Factors for Work Zones from SHRP 2 Project L08, Freeways ([http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2\\_S2-L08-RW-1.pdf](http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-L08-RW-1.pdf))

As explained above, P3-VALUE 2.0 determines the additional travel time cost due to construction and O&M delays. These include delays in work zones due to speed reductions but exclude any additional queuing delays. As construction and O&M activities are usually carried out during off-peak hours and weekends, queuing will typically be limited. To capture the effects of queuing, users may choose to input a speed reduction factor based on regional observations and/or modify the affected segment length. The model does not calculate the change in vehicle operating, accidents and emission costs caused by these travel delays. Instead, the model uses average annual (congested) speeds to calculate these costs for the different vehicle types and periods (peak, off-peak, and weekend) as will be discussed below.

### 5.6 Delays due to Incidents

Besides delays due to construction and O&M activities, P3-VALUE 2.0 also considers the travel cost impact of delays due to incidents. The model uses the following formula to calculate the delay cost per vehicle due to incidents.

$$\text{Incident Delay Cost/Vehicle} = \text{Travel Time Cost/Vehicle} \times \left( \frac{1}{1 - \text{Speed Adjustment Factor}} - 1 \right)$$

The right part of the equation above represents the increase in travel time (and therefore travel time cost) of a reduction in expected average speed for all vehicles when the probability of incidents (throughout the year) is taken into consideration. It should be noted that the speed adjustment represents an average for the whole year. On days that incidents do occur, the actual average speed would of course be much lower (and delays higher), while on days when no incidents occur the actual speeds would be higher (and delays lower). An important difference with the calculation of delays due to construction and O&M is therefore that the average speed adjustment related to incidents is applied to all traffic on the entire highway facility being analyzed.

The model uses the following process to calculate the social cost of delays for each delivery model, period (peak, off-peak, and weekend), vehicle type, and lane type (GPL and ML/TL):

$$\Delta \text{Incident Delay Cost/Vehicle} = \text{Incident Delay Cost/Vehicle}_{\text{Build}} - \text{Incident Delay Cost/Vehicle}_{\text{No Build}}$$

$$\text{Annual Incident Delay Cost} = \Delta \text{Incident Delay Cost/Vehicle} \times \text{Existing Traffic}$$

The model calculates and compares the incident delay costs of the various Build delivery models with the incident delay costs of the No Build to determine the change in incident delay costs per vehicle for each delivery model.

A key input for the incident delay calculation is the speed adjustment factor, which determines by how much average (congested) speed is adjusted to account for incident delays. For incidents, this speed adjustment is to a large extent due to queuing that occurs as a result of capacity reduction. Table 16 presents the speed adjustment factors for various levels of recurring congestion severity, based on data from unpublished estimates of average speed by level of congestion for Los Angeles area freeways<sup>13</sup>. The P3-VALUE 2.0 user may use this table, along with information about the level of congestion severity under the No Build, Build PSC and Build P3 scenarios respectively to derive an appropriate speed adjustment factor. Please note that P3-VALUE 2.0 assumes the speed adjustment factor to be constant over time.

**Table 16-B: Speed adjustment factors for incidents (based on TTI data)**

Level of congestion	Speed with no incidents (avg mph)	Speed including incidents (avg mph)	Speed adjustment factor (% reduction in speed)
<b>Uncongested</b>	60.0	57.1	5%
<b>Medium</b>	55.7	53.0	5%
<b>Heavy</b>	51.4	46.7	9%
<b>Severe</b>	41.5	34.1	18%
<b>Extreme</b>	35.0	27.1	23%

<sup>13</sup> Texas Transportation Institute’s (TTI’s) Urban Mobility Report, <http://mobility.tamu.edu/ums/national-congestion-tables/>, as documented in FHWA’s TRUCE 3.0 model

## 5.7 Fuel and Non-Fuel Vehicle Operating Costs

Besides the travel time costs discussed above, the model also considers other service quality effects. One of these service quality effects could be a different pavement ride quality under a P3. P3-VALUE 2.0 allows users to specify as inputs the pavement ride quality under different delivery models.

Better pavement ride quality could potentially have the following impacts:

- Increased travel time savings due to higher speeds
- Lower fuel vehicle operating costs
- Lower non-fuel vehicle operating costs

In practice, the impact of pavement ride quality on speed is not significant. If the Pavement Smoothness Index (PSI) exceeds 2.5, there is no impact on speed<sup>14</sup>. Below that, there is a limited impact on speeds. Given that pavement quality on U.S. highways tends to be well above a PSI of 2.5, P3-VALUE 2.0 does not adjust speeds for pavement quality. Pavement quality does have an impact on fuel and non-fuel vehicle operating costs, which will be discussed below.

### 5.7.1 Fuel Cost

P3-VALUE 2.0 computes fuel costs for each year within the analysis period. For each delivery model, period (peak, off-peak, and weekend), vehicle type, and lane type (GPL and ML/TL), the tool takes into consideration the impact of pavement ride quality on fuel cost. The model uses the following formulae to calculate these costs:

$$\text{Fuel Cost/Vehicle} = \text{Segment Length} \times \text{Fuel Consumption Rate} \times \text{Fuel Price} \times \text{Pavement Quality Fuel Adjustment Factor}$$

$$\text{Fuel Cost} = \text{Fuel Cost/Vehicle} \times \text{Existing Traffic}$$

Fuel costs per vehicle are computed by multiplying the segment length, fuel consumption rate, fuel price and the pavement ride quality fuel consumption adjustment factor. Total fuel costs are calculated by multiplying existing traffic by the fuel cost per vehicle.

As fuel consumption rates vary by speed of travel, the tool looks up the fuel consumption rate based on the average speed for each delivery mode, period, vehicle type, and lane type. P3-VALUE 2.0 provides default values for the speed-adjusted fuel consumption rates, but users are free to change these. Furthermore, the tool applies a pavement quality fuel consumption adjustment factor based on the delivery model’s International Roughness Index (IRI). Table 17 presents the default inputs for the pavement quality fuel consumption adjustment factor.

**Table 17: Pavement Quality Fuel Consumption Adjustment Factors**

IRI	Auto	Truck	IRI	Auto	Truck
0	0.97	0.96	250	1.02	1.03

<sup>14</sup> FHWA’s BCA.Net Reference Manual, November 2006

25	0.98	0.97	275	1.03	1.04
50	0.98	0.97	300	1.03	1.05
75	0.98	0.98	325	1.04	1.06
100	0.98	0.98	350	1.05	1.07
125	0.99	0.99	375	1.06	1.08
150	1.00	0.99	400	1.07	1.10
175	1.00	1.00	425	1.08	1.11
200	1.01	1.01	450	1.09	1.13
225	1.01	1.02			

Source: *Surface Characteristics of Roadways: International Research and Technologies (1990) and Vehicle-Road Interaction (1994)*

### 5.7.2 Non-Fuel Cost

P3-VALUE 2.0 also calculates non-fuel vehicle operating for each year within the analysis period. For each delivery model, period (peak, off-peak, and weekend), vehicle type, and lane type (GPL and ML/TL), the tool takes into consideration the impact of pavement ride quality on non-fuel vehicle operating cost. The model uses the following formulae to calculate these costs:

$$\text{Non-Fuel Cost /Vehicle} = \text{Segment Length} \times \text{Operating Cost/Mile}$$

$$\times \text{Pavement Quality Non-Fuel Adjustment Factor}$$

$$\text{Non-Fuel Cost} = \text{Non-Fuel Cost/Vehicle} \times \text{Existing Traffic}$$

Non-fuel costs per vehicle are computed by multiplying the segment length and the cost per mile. To adjust for the effects of the pavement quality, a pavement quality non-fuel vehicle operating cost adjustment factor is applied based on the delivery model’s International Roughness Index (IRI). Table 18 presents the default inputs for this adjustment factor. Total non-fuel costs are calculated by multiplying existing traffic by the non-fuel cost per vehicle.

**Table 18: Pavement Quality Non-Fuel Vehicle Operating Cost Adjustment**

IRI	Auto	Truck	IRI	Auto	Truck
0	1.00	1.00	250	1.09	1.10
25	1.00	1.00	275	1.11	1.12
50	1.00	1.00	300	1.12	1.14
75	1.00	1.00	325	1.14	1.16
100	1.00	1.00	350	1.16	1.18
125	1.00	1.00	375	1.18	1.20
150	1.02	1.02	400	1.19	1.22
175	1.03	1.04	425	1.21	1.24
200	1.05	1.06	450	1.23	1.26
225	1.07	1.08			

Source: *ARRB Research Board TR VOC Model (NCHRP Report 720: Estimating the Effects of Pavement Condition on Vehicle Operating Costs)*

## 5.8 Accidents

Another potential difference between delivery models could be the societal cost of accidents. P3-VALUE 2.0 calculates these costs for each delivery model, period (peak, off-peak, and weekend), vehicle type, and

lane type (GPL and ML/TL). The model uses the following formulae to calculate the social costs of accidents:

$$\text{Accident Cost/Vehicle} = \text{Segment Length} \times \text{Accident Rate/mile} \times \text{Cost/Accident}$$

$$\text{Accident Cost} = \text{Accident Cost/Vehicle} \times \text{Existing Traffic}$$

Accident costs per vehicle are computed by multiplying the segment length, accident rate per mile, and cost per accident. Total accident costs are calculated by multiplying accident costs per vehicle by existing traffic.

Based on their features, accident rates may vary between different delivery models. Users of P3-VALUE 2.0 will have to determine whether and to what extent accident rates vary between different delivery models. The table below presents accident rates from the National Highway Traffic Safety Administration (NHTSA), which may be used as default values in the model.

**Table 19: Accident Rates**

Accident Type	Rate (accident/million VMT)
Fatal accidents	0.0109
Injury accidents	0.7700
Property damage only accidents	1.9000

Source: NHTSA Fatality Analysis Reporting System (FARS) database (<http://www.nhtsa.gov/FARS>)

P3-VALUE 2.0 also requires inputs for the social cost of accidents by accident type. The table below can be used as guidance for the first two input categories (fatal and injury accidents).

**Table 20: Costs by Type of Accident**

AIS <sup>15</sup> Level	Accident Severity	Fraction of Value of a Statistical Life	Unit value
AIS 1	Minor	0.003	\$ 27,600
AIS 2	Moderate	0.047	\$ 432,400
AIS 3	Serious	0.105	\$ 966,000
AIS 4	Severe	0.266	\$ 2,447,200
AIS 5	Critical	0.593	\$ 5,455,600
AIS 6	Unsurvivable	1.000	\$ 9,200,000

Source: TIGER Benefit-Cost Analysis (BCA) Resource Guide, 2014

The TIGER BCA Resource Guide provides guidance on how users can calculate the value of injury and property damage only accidents, based on a detailed analysis of accidents in the considered corridor.

## 5.9 Emissions

The last benefit category included in the PDBCA module is emissions. P3-VALUE 2.0 calculates the social cost of emissions for each delivery model, period (peak, off-peak, and weekend), vehicle type, and lane type (GPL and ML/TL). To do so, the model uses the following formula:

<sup>15</sup> Abbreviated Injury Scale

$$\text{Emissions Cost} = \text{Segment Length} \times \text{Combined Emissions Cost/Mile} \times \text{Traffic (existing + induced)}$$

The emissions costs are calculated by multiplying the segment length, combined emissions costs per mile, and total traffic (existing and induced traffic combined). Note that the combined emissions cost per mile input merges all emission costs (carbon dioxide, nitrogen oxides, etc.) into a single parameter. To arrive at the combined emissions cost per mile, the social cost of emissions (see table below) is multiplied by the emission rates for the various emission types obtained from the Environmental Protection Agency’s (EPA) MOVES software.

**Table 21: Social Cost of Emissions**

Emission Type	\$ / long ton (\$2013)	\$ / metric ton (\$2013)
Carbon dioxide (CO <sub>2</sub> )	\$40	\$39
Volatile Organic Compounds (VOCs)	\$1,813	\$1,999
Nitrogen oxides (NO <sub>x</sub> )	\$7,147	\$7,877
Particulate matter (PM)	\$326,935	\$360,383
Sulfur dioxides (SO <sub>x</sub> )	\$42,240	\$46,561

*Source for other emissions: TIGER Benefit-Cost Analysis (BCA) Resource Guide, 2014*

To avoid having to input large tables of emission rates, this calculation is performed separately outside of the P3-VALUE 2.0 tool. The resulting default emission costs per mile are included as inputs (see InpBCA). Users are encouraged to update the emission rates for the considered project’s region using the Environmental Protection Agency’s MOVES software.

As the emission costs per mile vary by speed of travel, the tool looks up the emission costs per mile based on the average speed for each delivery model, period, vehicle type, and lane type (GPL and ML/TL). To calculate the social emission costs, the model multiplies the VMT by the speed adjusted combined emissions cost per mile for each vehicle type and period.

## 5.10 Induced Traffic Benefits

P3-VALUE 2.0 calculates benefits for both existing traffic and induced traffic. For existing traffic, the model compares user costs and benefits between the No Build and different Build alternatives to determine the net effects on society. This section discusses how P3-VALUE 2.0 calculates induced traffic benefits.

### 5.10.1 Traffic Categories

Following a capacity enhancement of a highway facility, traffic typically increases due to induced traffic. At the facility level, we can distinguish the following sources of traffic:

- **Existing traffic:** Current users of the facility.
- **Induced traffic:** Current users of other roads in the region that will shift to the enhanced facility once it is completed (a.k.a. “diverted” traffic) as well as new trips due to changes in mode, schedule, frequency and preferred destination due to improvement of the facility.

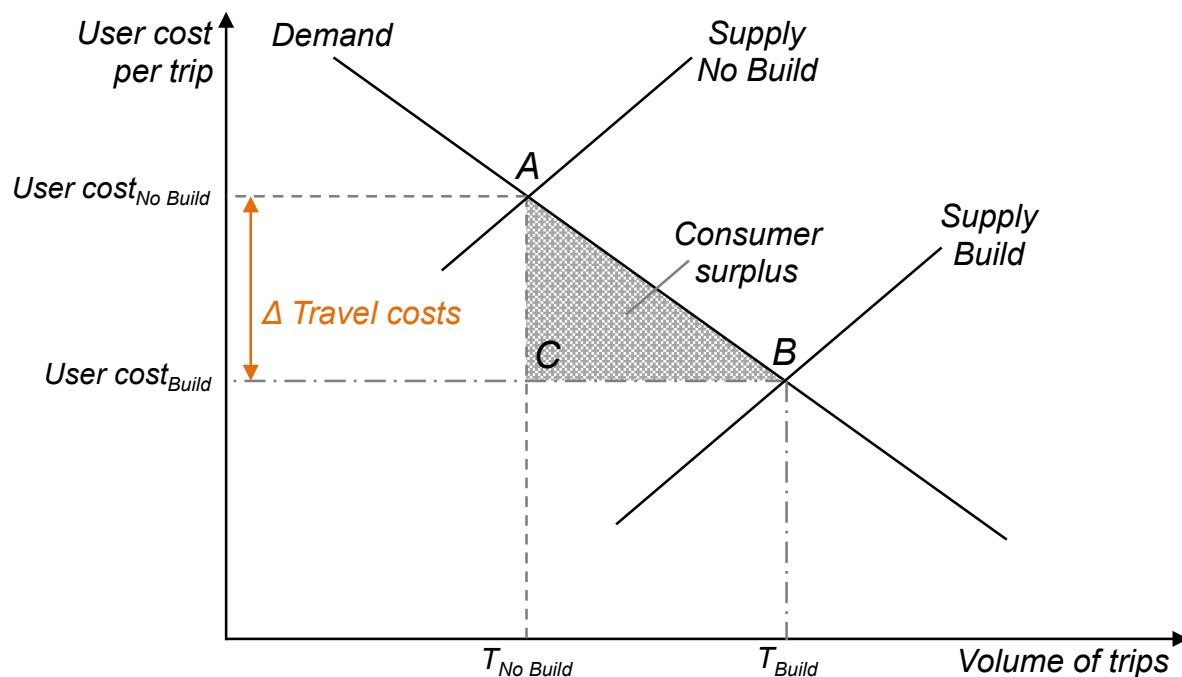
As FHWA’s Highway Economic Requirements System (HERS) model report indicates, induced travel defined at the facility level will include traffic diverted from other routes<sup>16</sup>. As P3-VALUE 2.0 is a facility-based tool, induced traffic in the tool’s PDBCA module includes both traffic diverted from other facilities and new trips. This approach is in line the treatment of induced traffic in HERS.

### 5.10.2 Effect of Induced Traffic on User Costs and Benefits

If the capacity of a facility is enhanced (i.e., an increase in supply), the new equilibrium for a given demand curve results in a higher number of trips and a lower user cost per trip, as can be seen in the figure below (equilibrium between supply and demand shifts from point A to point B in the graph).

To determine the user benefits (consumer surplus) for induced traffic, the “rule of half” is applied. This means that the benefits per trip derived from the use of the enhanced facility by induced traffic is half of the additional benefits accruing to existing traffic as a result of the facility enhancement. The logic behind the “rule of half” comes from the shape of the gray area under the demand curve (area ABC) that is created by the facility enhancement, which is a triangle if the demand curve is (approximately) a straight line.

**Figure 20: Effect of induced demand on user cost per trip and volumes of trips**



The concept of induced traffic is important to determine user benefits and costs for new and diverted users (i.e., private benefits and costs). These private benefits and costs include:

- Travel time costs/savings (including consideration of any additional delays due to incidents and work zone practices)

<sup>16</sup> Appendix A, "Induced Traffic and Induced Demand" (Lee, et al., 2002) in the HERS-ST v2.0 Technical Report

- Vehicle operating costs/savings
- Accident costs/savings

For costs and benefits that are mainly societal such as emissions, there will be no distinction between induced traffic and existing traffic. In other words, the societal costs of emissions are assumed to be equal for both existing and new traffic.

### 5.10.3 Determination of Induced Traffic

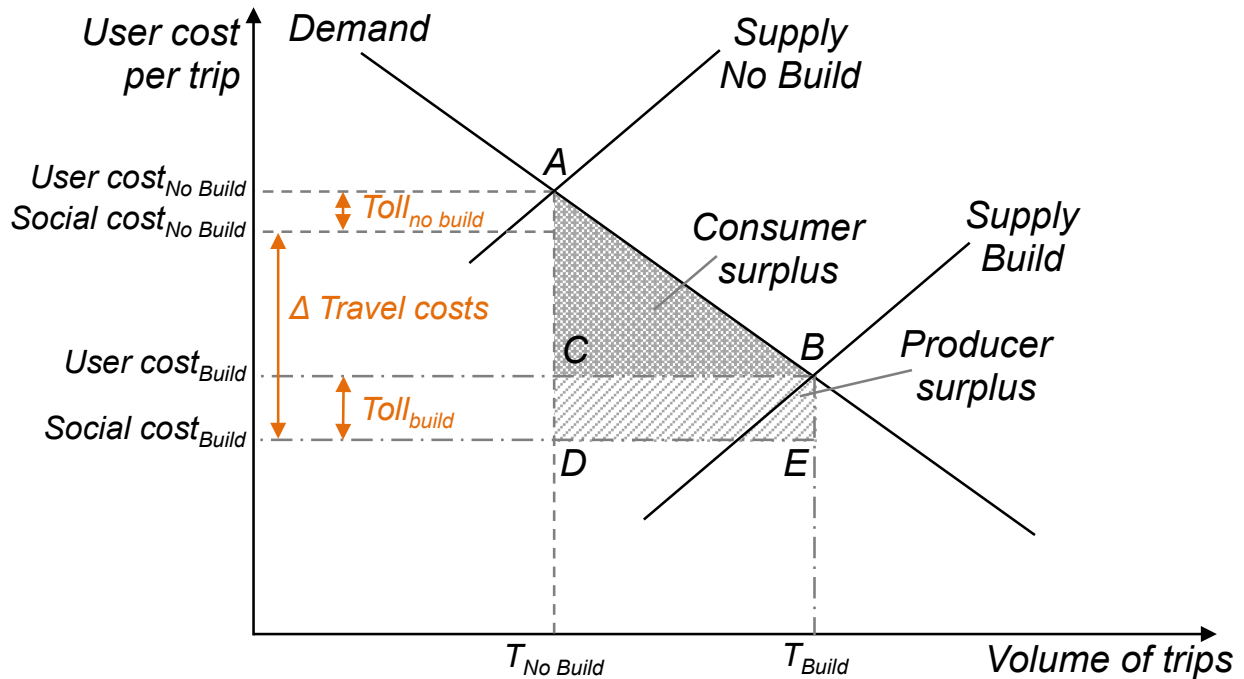
The users of P3-VALUE 2.0 will be required to provide traffic projections for both the No Build and Build alternatives. Typically, these projections will be generated using a travel demand model. The difference between the No Build and Build traffic projections is induced traffic. These induced traffic projections are then used in the model to calculate the costs and benefits to society of induced traffic.

### 5.10.4 Benefit Calculations and Relevance of Tolls in PDBCA

The total number of trips on a road is determined by traffic demand and supply of roadway capacity. The demand curve shows the relation between the number of trips and user costs per trip. These user costs include tolls, as the user will consider the cost of tolls when deciding whether or not to make a trip. The user cost also includes travel time costs, vehicle operating costs and accident costs. However, users may not consider the costs of emissions in their decision making process. In other words, private costs (including tolls but excluding emissions) ultimately determine the number of trips taken on a road.

For existing traffic, the introduction of tolls or change in toll levels between the No Build and Build alternatives does not modify the calculation of societal benefits. To determine the societal benefits of a facility expansion for existing traffic, the social costs of travel (i.e., excluding tolls which are transfers) for each existing user before and after the expansion are evaluated. The difference in travel costs multiplied by the number of existing users is the net benefit to society of the facility enhancement.

For induced traffic, the rule of half can be used to calculate the societal costs and benefits if both the No Build and Build alternatives are not tolled. However, if the road is tolled in the Build or even in the No Build alternative, the rule of half alone can no longer be applied as the shape under the demand curve that represents the net benefits to society now has both a triangular consumer surplus and a rectangular producer surplus, as can be seen in the figure below. The producer surplus is equal to the toll level under the Build alternative multiplied with the induced traffic (CBDE in the figure below). The consumer surplus calculation (ABC in the figure below) includes the consideration of tolls borne by users under both the Build and the No Build cases.

**Figure 21: Effect of toll on consumer surplus and producer surplus**


P3-VALUE 2.0 calculates the consumer surplus (net benefits to consumers) and the producer surplus (additional benefits to society due to the irrelevance of tolls/transfers from an economic perspective) for induced traffic separately. In P3-VALUE 2.0, consumer and producer surplus are calculated using the following formulae:

$$\text{Consumer surplus} = \frac{1}{2} \times (\Delta_{\text{user travel costs}} + \text{toll}_{\text{No Build}} - \text{toll}_{\text{Build}}) \times \text{induced traffic}$$

$$\text{Producer surplus} = \text{toll}_{\text{Build}} \times \text{induced traffic}$$