Manual

Project Risk Management and Contingency Development Process Manual

First Edition

March 2023

Queensland Government

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Feedback

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Manual management plan

Purpose of the update

The Department of Transport and Main Roads (department) guidelines and manuals are routinely updated to ensure they align with the most up-to-date processes and policies of both state and federal governments.

This manual is managed through the following roles:

Role	**Position / person**
Manual customer	General Manager – Portfolio Investment and Programming
Manual sponsor	Executive Director – Program Development and Performance
Manual manager	Director (Program Management Improvement (PMI))
Manual review team members	Director (Delivery Risk) – PMD Manager (Estimating and Risk Evaluation) – PMI Principal Advisor (Estimating and Risk Evaluation) – PMI Senior Advisor (Estimating and Risk Evaluation) – PMI Regional / District estimating champions

Amendment and review strategy

Portfolio Investment and Programming branch welcomes feedback about this manual. Please send feedback via tmr.techdocs@tmr.qld.gov.au who will acknowledge all feedback, suggested changes and improvement requests.

The manual owner and review team are responsible for ensuring the manual is maintained and updated to meet the department's needs. To this end, the manual owner, in collaboration with the manual review team, will:

- review feedback and comments
- monitor the context / environment that the manual operates within, and
- recommend appropriate actions.

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Acronyms

Acronym	Expansion
3PCM	Portfolio, Program, Project and Contract Management system
APDV	Approved Project Delivery Value
DITRDCA	Department of Infrastructure, Transport, Regional Development and Communication and the Arts
EFCT	Estimate for comparison of tender
IA	Infrastructure Australia
MPE	Maintenance, Preservation and Environment
NPA	National Partnership Agreement
PAF	Project Assurance Framework
PAI	Principal Arranged Insurance
PCEM	Project Cost Estimating Manual
PERT	Program Evaluation and Review Technique
PIP	Portfolio Investment and Programming
PLSL	Portable Long Service Leave
PMBOK	Project Management Body of Knowledge
PPI	Policy, Planning and Investment Division
PPR	Project Proposal Report
QTRIP	Queensland Transport and Roads Investment Program
RCP	Risk context profile
RO	Road Operations
S1D	Development phase stage 1 design estimate
S2D	Development phase stage 2 design estimate
SME	Subject Matter Expert

1 Purpose of this document

The aim of this manual is to lay the foundation for adopting risk management practices that are in place at the project level in the department. This manual complements the department's Risk Management Framework (available on request via email to Risk_Advisory_Team_Mailbox@tmr.qld.gov.au) and other related policies, tools and processes at corporate, portfolio and program levels.

This manual aims to guide engineers, planners, cost estimators, project managers and other interested stakeholders, to manage project risks across all business units such as the department, Translink and Maritime Safety by applying consistent policies, principles and processes.

Cost estimating is an integral part of the project management process because the department uses cost estimates for project planning, to seek funding from the Australian Government, options analysis, benefit cost analyses and budget preparation. The cost estimates prepared for Queensland Transport and Roads Investment Program (QTRIP) projects require meeting 'unlikely to be exceeded at a 90% confidence level', or P90 status, through effective development of contingency allowance to provide confidence in project priority, affordability and strategic fit.

The quantification of a realistic contingency allowance, a measure of perceived detrimental financial impact to cater for residual project risks, forms part of every cost estimate. Often developing a realistic contingency allowance is a real challenge for many departmental cost estimators and project managers.

Through effective risk management practice, cost estimators and project managers can develop a sufficient contingency allowance in the project budget to cater for residual risks.

2 Who should read this document?

The project risk management process in this manual focuses on the pre-construction phases of the project life cycle. It starts as early as commencing project planning and supports the planning, concept and development phases of QTRIP projects; therefore, the contents of this document are useful for all staff who are responsible for managing project risks and developing contingencies for QTRIP projects during these phases.

The risk management process evolves over the course of project development, as further project knowledge is gained. Project risks are continually being assessed as the project progresses through its life cycle, whereby contingency is adjusted accordingly to reflect the appropriate risk assessment applicable for the project stage.

This manual is targeted to engineers, planners, cost estimators (including staff responsible for developing Project Proposal Reports (PPRs)), project managers and other interested stakeholders (internal or external to the department), who are developing cost estimates and business cases for QTRIP projects, to improve the accuracy of cost estimates when seeking release of funding from the Australian Government.

3 Related policies, frameworks and guidance

The department has a responsibility to establish and maintain appropriate systems to manage project risks as required in the *Financial Accountability Act 2009* (Qld) and the *Financial and Performance Management Standard 2019*.

This manual outlines the principles and processes involved in project risk management, within the departmental environment, during project planning, concept and development phases.

This document should read and its concepts applied in the context of, and with regard to, the following associated departmental and federal government policy and guidance documents:

- the department's *Risk Management Organisational Policy* (available on request via email to Risk_Advisory_Team_Mailbox@tmr.qld.gov.au)
- the department's Risk Management Framework (available on request via email to Risk_Advisory_Team_Mailbox@tmr.qld.gov.au)
- federal Guidance Note 2 – *Base Cost Estimation*
- federal Guidance Note 3A – *Probabilistic Contingency Estimation*
- federal Guidance Note 3B – *Deterministic Contingency Estimation*
- related departmental policies (*Risk Management Organisational Policy*, Engineering Policy 153 *Risk Context Profiles* (July 2020))
- OnQ project management framework
- the department's *Project Cost Estimating Manual* (PCEM) – specifically sections on risk and contingency, and
- ISO 31000:2018 *Risk Management – Guidelines*.

4 Risk management structure

Risk management is a living process along the project life cycle, as the required contingency for desired confidence level moves up or down, depending on a variety of factors over the life of the project. For effective decision making, development of a consistent methodology is necessary to manage project risks up to the program level and consolidation into the portfolio level.

This manual acknowledges that a different approach is needed when managing risks at the portfolio or program levels, compared to project level. The interrelationship between the portfolio, program and project level risks are shown in Figure 4.

Figure 4 – The interrelationship between the portfolio, program and project level risks

The portfolio risk is 'the effect of uncertainty on portfolio objectives' which is, if a certain set of events or conditions occur, these can have either positive or negative effects on portfolio objectives. The identification of portfolio risks typically comes from an assessment of strategic and program level risks.

Similarly, a program risk is 'the effect of uncertainty on program objectives' which is, if an event or series of events or conditions occur, these may affect the success criteria of the program. The identification of program risks typically comes from an assessment of strategic, portfolio and project level risks.

Portfolio and program managers must consistently use transparent risk controls, criteria matrices and metrics for assessing and managing risks similar to those used on a project; for example, while a one-month delay may be a high consequence for a six-month project, this delay may only be considered a minor consequence for a three-year program.

Conversely, a relatively small delay (from a project perspective), may have a significant effect (that is, potential reputational consequences) on the portfolio.

The risks identified, evaluated and managed at portfolio and program levels, may be transferred into project levels.

There are different approaches to manage risks at portfolio and program levels and users must refer to the corresponding program level and risk management guidance documents for further information (available on request via email to Risk_Advisory_Team_Mailbox@tmr.qld.gov.au).

4.1 Major project gating and risk assessment

The projects included in QTRIP require appropriate governance structure for authorised decision making. Not all projects have the same governance structure, due to the different funding sources, program types, project types, sizes and complexities. The major project gating process introduced in the department's *QTRIP Governance Principles* document (available on request via email to PIP_Publication_and_Governance@tmr.qld.gov.au) applies to all investments with an estimated capital expenditure of $100 million or more, or those of significant risk and/or complexity that warrant a higher standard of risk evaluation. The use of project gating informs decision making across the life cycle of major projects.

The major project gating process ensures:

- all major project initiatives are reviewed at critical stages, ensuring that project outputs and program benefits contribute to the Queensland Government's strategic objectives and corporate plans and the department's portfolio outcomes
- increased investment confidence for the department, as high-risk projects will have completed three gating reviews prior to an investment decision, and
- improved efficiencies within project and program delivery, by reaffirming that major project initiatives are on target to meet deliverables and realise outputs and program benefits.

Project risk assessments should be completed at project commencement, which is the responsibility of project owners. Those projects, assessed as having medium to high risk, must be submitted to the department's Policy, Planning and Investment Division (PPI) to review and record in the Portfolio Investment Register (available on request via email to PIP_Publication_and_Governance@tmr.qld.gov.au).

As part of the QTRIP publication review process, PPI will examine the portfolio to identify any medium to high risk projects and will liaise with the project owner to verify their assessment of risk at the project and investment program levels.

Transport and Main Roads projects are required to submit the completed applicable departmental Project Assurance Framework (PAF) template for major project gating requirements.

4.2 OnQ Type 1 project gating and risk assessment

The OnQ Type 1 project gating process applies to projects with an estimated capital expenditure between $50 million and less than $100 million, or those projects with significant risk and/or complexity below this financial threshold. Transport and Main Roads projects are required to submit a completed OnQ 5 in 1 template for OnQ Type 1 project gating requirements.

5 Project risk management in a departmental context

The department recognises that the definition for project risk is:

- the effect of uncertainty on project objective, or
- the chance of something happening that will influence achieving the project intent, or
- the possibility that the expected outcome is not achieved / replaced by another, or
- a combination of some / all.

Project risks are two-dimensional, meaning they are measured in terms of likelihood and consequence. The likelihood is the probability or chance of risk occurrence during the project delivery and the consequence is the possible result or impact of an event, often expressed as a qualitative rating. Consequence is expressed quantitatively in cost estimates.

In the context of estimating and cost planning, risk management is the systematic application of principles, approaches and processes for identifying, assessing and managing risks and then followed through with the planning, implementing of appropriate risk treatments and quantifying the impact.

As formal risk management processes have an important role in project success, effective and collaborative approach and innovation strategies are necessary in the overall risk management process, to ensure compliance with policies, standards and processes. Risk managers must ensure that departmental regulations, specifications, systems and standards are understood, upheld and applied throughout the project delivery process by all stakeholders.

During the delivery of infrastructure projects in QTRIP, the department endorses and mandates the use of a systematic risk management approach based on ISO 31000:2018.

6 Australian Government requirements

QTRIP projects receiving Australian Government funding are subject to additional conditions over and above OnQ and PAF requirements.

- Transport and Main Roads projects are required to submit a completed Queensland Project Proposal Report template and required attachments (see Annexure D of this manual) for all projects seeking Australian Government funding approval. Project cost estimates are to include a Project Cost Breakdown (PCB) for the whole project, not just the phase or phases that the PPR relates to – the exception being the identification phase PPR, and when the commitment is less than $25 million.

- PCBs must include a P50 and P90 scenario.
- Project cost estimates should include actual costs for phases already complete.
- The Department of Infrastructure, Transport, Regional Development and Communication and the Arts (DITRDCA) escalation rates are to be applied to cost estimates, noting that, for projects with a total commitment greater than $25 million, a PCB spreadsheet must be completed – the PCB spreadsheet will determine the escalation rates to be used.

It is a mandatory requirement that a probabilistic cost estimation process be used for projects for which federal funding is sought, with a total outturn P90 cost (including contingency) greater than $25 million.

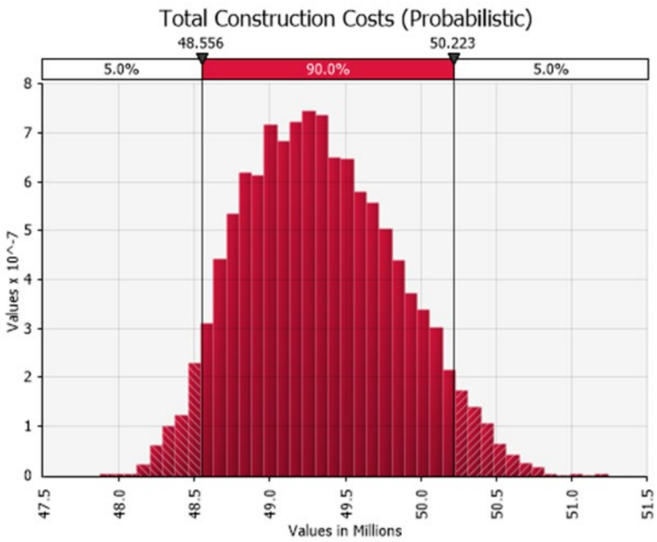
Cost estimates with a P90 confidence level, are generally developed based on a quantitative approach and using probabilistic risk evaluation software such as @Risk.

QTRIP projects receiving Australian Government funding greater than $25 million require submission of the following risk analysis information with the PPR submissions:

- details of the risk workshop/s undertaken, and subject matter experts consulted, including the list of most significant risks and details of the mitigation strategies proposed
- copy of the risk register underpinning the contingency included in the project costings (where a probabilistic cost estimation process has been used, this will be the source of much of the cost estimation tool risk input data)
- cost estimation tool (for example, @RISK and Crystal Ball) output report files which must, at a minimum, include charts of project cost probability distribution and associated cumulative probability distribution (S-curve), simulation summary details (that is, sampling type, number of iterations, random number generator, a tornado diagram and accompanying regression and rank information table, and summary statistics for the project cost, including the project cost estimate (un-escalated) at 5% intervals from 5% to 95% confidence), and
- cost estimation tool input data files in spreadsheet format, that include sufficient information to permit the department or its contractors to rerun the probabilistic cost estimation simulation.

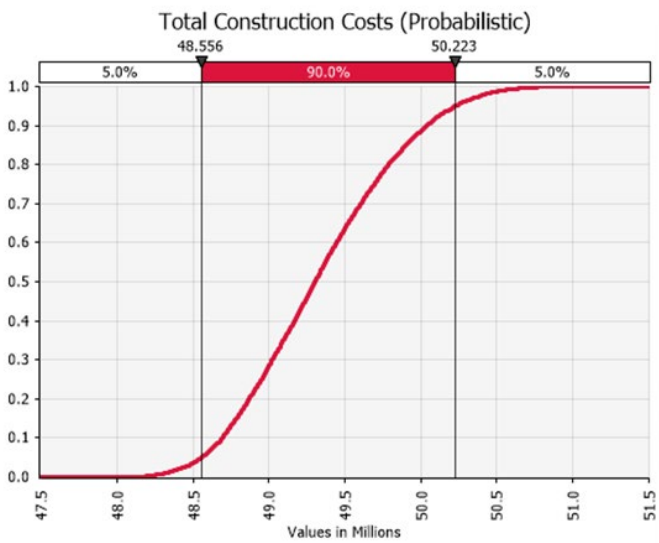
Figure 6(a), Figure 6(b), Figure 6(c) and Figure 6(d) show the mandatory project cost probability distribution charts that are required by the Australian Government with every PPR submission for projects greater than $25 million.

Figures 6(a) – Sample project cost probability distribution (Histogram)



Statistics	Total Construction ...
1%	48,312,582.01
2.5%	48,443,204.05
5%	48,555,553.45
10%	48,693,111.19
20%	48,868,361.28
25%	48,951,478.55
30%	49,021,066.88
35%	49,094,286.76
40%	49,169,606.94
45%	49,236,194.62
50%	49,301,436.98
55%	49,370,527.73
60%	49,444,033.81
65%	49,519,320.33
70%	49,606,056.02
75%	49,692,189.53
80%	49,786,618.03
90%	50,037,604.49
95%	50,222,809.92

Figure 6(b) – Cumulative probability distribution (S-curve)



Statistics	Total Construction ...
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55%	49,370,527.73
60%	49,444,033.81
65%	49,519,320.33
70%	49,606,056.02
75%	49,692,189.53
80%	49,786,618.03
90%	50,037,604.49
95%	50,222,809.92

Figure 6(c) – Tornado diagram

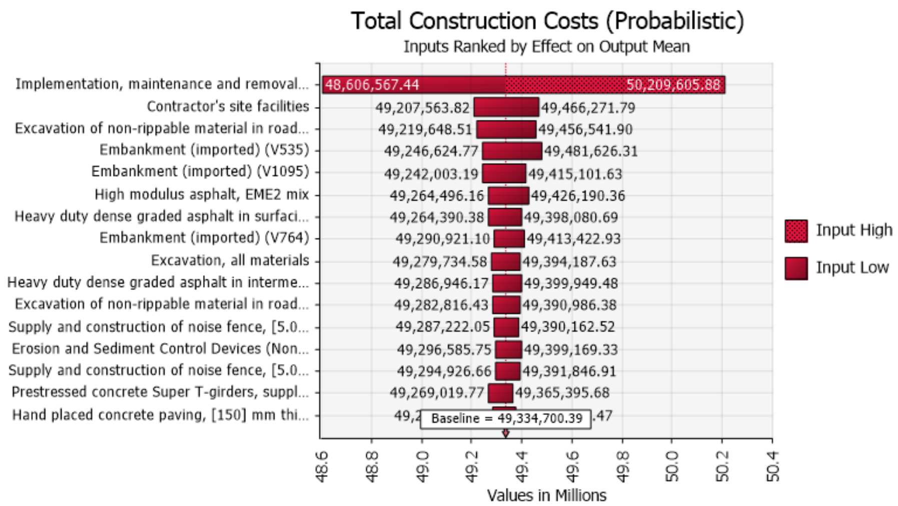
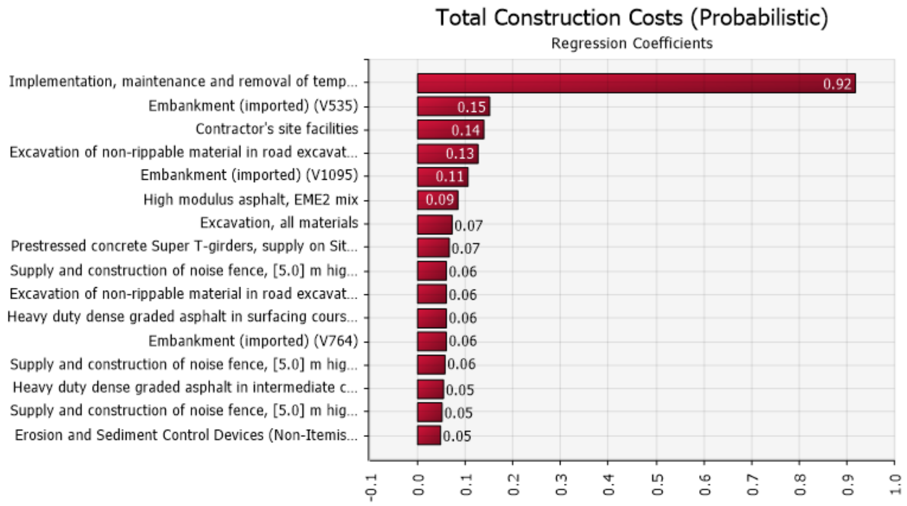


Figure 6(d) – Regression and rank information diagram



QTRIP projects receiving Australian Government funding of less than $25 million uses a short form PPR template. Projects may use a deterministic methodology where it is recommended but using the probabilistic cost estimation method if possible.

Regardless of the value in the funding submission, the Australian Government requires the risk identification process, with a list of most significant risks and details of the mitigation strategies proposed by the department, with PPRs (refer to *Notes on Administration for Land and Transport Infrastructure Projects 2019-2024*, issued by the Australian Government).

All PPRs include a summarised risk register table (refer to Annexure D of this manual).

In addition to Australian Government funding requirements, Infrastructure Australia (IA) requires proposals for projects to be submitted using the relevant IA templates:

- to have the proposal considered for the Infrastructure Priority List, IA will determine if the proposal is nationally significant and suitable for the Infrastructure Priority List, and
- for review where $250 million or more in Australian Government funding has been committed, as IA is required to evaluate business cases with funding committed above this threshold.

For projects within these IA thresholds, IA provides a peer review of the project cost report; therefore, additional information for costs and their inputs / assumptions must be submitted to IA for each option and the base case, including:

- list of assumptions
- project cost report providing defining estimate class
- capital cost estimate, including probabilistic P50, expected value and P90 estimates, and
- operational cost estimate, including operation and routine and periodic maintenance.

6.1 Risks that should not be captured

Due to events which have a significant likelihood of occurring in the foreseeable future, the Australian Government requires that jurisdictions do not capture risks that may incur large cost increases in PPR submissions.

Guidance Note 3A – *Probabilistic Contingency Estimation*, issued by the Australian Government in 2022, recommends that, if there is a strategic need to embark on work that could be subject to a very large cost increase, it is best managed as a standalone contingent funding requirement, with an agreed trigger and controls on the release of funds.

The Australian Government believe such risks may be categorised as special requirements and will be best managed apart from the general funding of a project.

The following are some of the risk events where the Australian Government may sanction jurisdictions from incorporating in project risk registers for national projects:

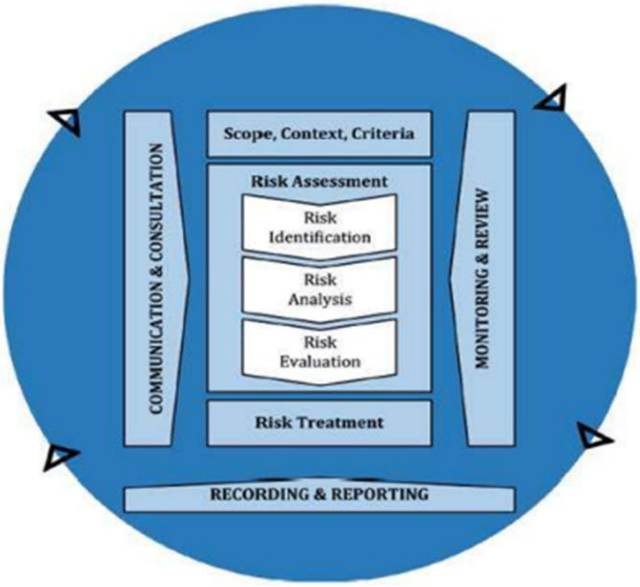
- work to reduce a serious threat, such as emergency flood mitigation, stabilisation of collapsing infrastructure or reinstatement of a critical, washed-out transport route
- projects constrained by fixed dates such as Olympic Games or similar situations, and
- contagious deceases such as COVID-19.

Refer to Section 9.2 of this manual and federal Guidance Note 3A – *Probabilistic Contingency Estimation* manual for further details.

7 Risk management process

The department's overall risk management process was streamlined in accordance with the procedures and practices outlined in ISO 31000 (refer to Figure 7).

Figure 7 – ISO 31000 – Risk management process



Reproduced from the *ISO 31000:2018, Risk management — Guidelines*

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The key estimating risk management strategy stages of the ISO 31000 are:

1. establish the scope, context and criteria
2. risk assessment:
    a) identify all risks
    b) analyse risks, and
    c) evaluate risks
3. risk treatment
4. communication and consultation, and
5. monitoring and review.

7.1 Establish the scope, context and criteria

Establishing the risk context defines the scope for the risk management process and sets the criteria against which the risks will be assessed. The scope should be determined within the context of the department's organisational objectives.

ISO 31000:2018 requires risk managers to consider determining the scope, the context in which the risk assessment takes place and the criteria which is applicable to the risk management process from the outset.

7.1.1 Establishing the scope

ISO 31000:2018 recommends the following elements be considered when defining the scope-related details:

- objectives and decisions that need to be made
- outcomes expected from the steps to be taken in the process
- time, location, specific inclusions and exclusions
- appropriate risk assessment tools and techniques
- resources required, responsibilities and records to be kept, and
- relationships with other projects, processes and activities.

It should be remembered that some risks not only relate to the project, but also link to portfolio and program level considerations.

In the context of a project, the project manager must consider all uncertainties and make a judgment as to the likelihood and consequences of a risk emerging that will threaten the project objectives.

7.1.2 Establishing the context

Understanding of the context ensures that risks are clearly defined and appropriate for the project, prior to implementing controls and treatments.

Setting the context also determines the environment in which the project operates and the basic parameters for risks to be managed. Risks may occur which could significantly impact project objectives and economic performances identified in the project intent.

Developing and documenting the risk assessment context is critical, as it provides the basis for establishing and justifying assertions within risk control effectiveness and risk identification and assessment stages. Ideally, the risk assessment context also underpins the case for making treatment recommendations, which is clearly a pivotal aspect of the risk assessment process.

The department's *Risk Management and Ratings Matrix* (Annexure B of this manual) provides risk dimensions and consequence levels relevant to the departmental environment and the risk context profiles (RCP) provide the project-specific risks to be considered when establishing risk context.

7.1.2.1 Defining risk dimensions

As defined in the *Risk Management and Ratings Matrix*, each identified project risk must be categorised into risk dimensions. This process ensures that all related risks are considered and included in the project risk register.

The risk dimension areas defined in the *Risk Management and Ratings Matrix* are:

- workplace health and safety
- time or schedule delay
- assets, operations and services
- performance and capability
- historical and indigenous heritage
- environmental / climate
- media and reputation, and
- financial.

Once the risk dimension areas are clearly defined, the risks can be classified into RCPs according to Engineering Policy 153.

7.1.2.2 Risk context profiles

According to the department's Engineering Policy 153, project managers are expected to profile project-specific risks per the following categories, and incorporate into the project risk register.

The current RCP includes:

1. geotechnical
2. environment, weather, Cultural Heritage and Native Title
3. vulnerable road users
4. stakeholders
5. procurement
6. project management
7. safety and well-being
8. contract administration
9. construction, and
10. finalisation.

It is important to note that, when profiling risks, both internal and external risks need be considered.

7.1.2.3 Risk register

The project risk register is the most essential document in the project risk management process. It includes all information about identified risks such as nature of the risk, level of risk, who owns it, mitigation measures and likelihood and consequence (in dollar value). The risk register is also used to monitor and control risks during the concept and development phases of the project.

Typically, risk registers are created at the start of a project (planning stages of every project). It is regularly referenced and updated throughout the life of the project by adding new risks, removing the risks that no longer require monitoring and adjusting the likelihood and consequence parameters. Frequency requirements of project risk reviews are based on different project types (refer to Figure 7.7.2 for further details).

Project managers are expected to consult the contract administrator during the implementation stages to ensure:

a) risks owned by the contractor are not duplicated in the Principal's risk register

b) Principal owned risks in the contract administrator's risk register are included in the Principal's risk register, and

c) any new Principal owned risks that are identified by the tender assessment process, based on an understanding of how the contractor is managing contractor-owned risks (being risks for potential contractual claims), are included in the Principal's risk register.

At the end of a project, risk registers become a source of information on how well the risks were assessed at the beginning of a project; whether the likelihood of each risk was accurate (did it eventuate?) and whether the severity of that risk was correctly estimated (how bad was it?) and so on.

The department mandates that a risk register is developed with presentation of the most significant risks into the relevant Transport and Main Roads project management template for all major projects, and OnQ Type 1 and Type 2 projects, at project gating approvals. The risk register must be prepared using the corporate risk register format, except for lower-risk asset maintenance projects (such as Road Maintenance Performance Contracts) and the projects in the Maintenance, Preservation and Environment (MPE) and Road Operations (RO) Elements.

For Australian Government-funded projects, submission of the risk identification process, risk register, and details of the mitigation strategies proposed for the most significant risks by the department are mandatory for projects equal to or greater than $25 million in total outturn costs or where a probabilistic cost estimating process has been used, as supporting information to PPRs submitted by Transport and Main Roads to the Australian Government (DIDRDCA) as part of the approval processes and administrative requirements as set out in the federal *Notes on Administration* to apply to all projects listed in the National Partnership Agreement (NPA) schedules with the exception of maintenance and *Black Spot* projects.

Transport and Main Roads aims to progressively implement the capturing of the risk registers for QTRIP projects into the department's Portfolio, Program, Project and Contract Management System (3PCM), with an exception to asset maintenance projects (such as Road Maintenance Performance Contracts) and the projects in the MPE and RO elements. The risk registers for major projects and significant projects (high risk and/or high profile) must be updated and captured in 3PCM at the project gating approval stages (see Section 7.7.2 of this manual for further details).

The project lessons learnt must also be captured in the learnings register for subsequent use in the project manager's completion report when required and to facilitate subsequent benchmarking purposes (refer to *Notes on Administration for Land and Transport Infrastructure Projects 2019 – 2024*).

7.1.3 Establishing the criteria

The *ISO 31000:2018 Risk Management Guidelines* suggest that risk assessors should ensure that the criteria applied to assessments is consistent / aligns with any existing risk frameworks. In the departmental environment, this criterion was established under the Risk Management Framework.

When assessing departmental project risks, risk managers are required to understand the criterion established in the Risk Management Framework.

7.2 Identify the risks

The objective of the risk identification process is to generate a comprehensive list of risks based on events that may create, enhance, prevent, degrade, accelerate, or delay the achievement of objectives.

Comprehensive risk identification is critical for all projects because a risk that is not identified or acknowledged at its early stage may be excluded from evaluation and analysis processes later. Subsequently, such risks may miss the contingency assessment.

The identification process should consider all risks associated with the project, irrespective of whether their source is under control, if the risk source is unknown, or the cause is not evident.

The project manager should use appropriate methodologies, tools and strategies to identify, assess, review and apply risk treatments that may be best-suited to achieve project objectives.

Gathering relevant and current information is important for the risk identification process, which should also consider appropriate background information where possible. Suitably qualified and experienced individuals should be engaged to undertake the risk identification process for QTRIP projects.

The following facilitates the identification of project risks:

- document reviews – a structured review of all available documentation (for example, design plans, assumptions and historical information)
- information gathering techniques:
  - brainstorming sessions and structured interviews, with experienced people involved in similar projects
  - surveys and questionnaires
  - scenario analysis
  - root cause analysis
  - business case analysis
  - results from external project audits and reviews (for example, gateway review), and
  - inspections and site visits
- historical data from previous programs and projects and lessons learnt:
  - gain risk insights from similar or relevant projects

- checklist analysis:
  - risk identification checklists and knowledge accumulated from previous programs / sources
- assumption analysis:
  - identifying risks arising from inaccurate or inconsistent assumptions made, hypotheses and scenarios upon which the project is based
- diagramming techniques:
  - application of cause and effect diagrams and use of process flowcharts
- SWOT analysis (Strength, Weaknesses, Opportunities and Threats):
  - identifying the internal strengths and weaknesses associated with project resources and determining opportunities and any threats that can compromise the project outcomes, and/or
- assumptions:
  - defining the assumptions that determine any event could be a risk. These assumptions need be verified, to ensure that they continue to be valid through the duration of the risk life. If the assumptions change, the likelihood and consequence of the risk can also change.

7.3 Analyse risks

The purpose of risk analysis is to understand the nature of risks and their characteristics. Risk managers require a detailed consideration of risks relating to risk causes and sources, events and various scenarios that impact on multiple project objectives.

After identifying and classifying project risks, it is necessary to examine the likelihood and consequences of each risk to establish the level of risk to the project. Risk analysis determines which risks would potentially have a greater impact on the project and, therefore, must be managed with particular care.

Risk analysis also requires providing input to risk evaluation and to the decisions around whether the risks need to be treated and, if so, selecting the most appropriate risk treatment strategy to apply; hence, risk analysis informs the decision making process where choices are made around the options that involve different types and levels of risks.

The confidence in determining the level of risk, and its sensitivity to preconditions and assumptions, should be considered during the risk analysis process and communicated to decision makers as appropriate.

Risk analysis can be undertaken with varying degrees of detail, depending on the risk, the purpose of the analysis, the information and data and the resources available. Analysis can be qualitative, semi-quantitative, quantitative, or a combination of these depending on the circumstances.

In the department, risk analysis is undertaken using the departmental *Risk Assessment and Ratings Matrix* (Annexure B of this manual). In using the departmental *Risk Assessment and Ratings Matrix* for risk analysis, the following steps should be considered:

1. risk dimensions (impact area) for the risk (there can be multiple areas)
2. consequences or dimension levels if the risk eventuated with current controls in place (there may be multiple consequences: in such situations, the highest level may be chosen)
3. likelihood or probability of the risk eventuating to the level indicated in step 2 above, and
4. establish the risk rating based on the pre-determined criteria.

The risk analysis process commences with developing a risk register for a project: therefore, all cost estimates are deemed to have an appropriately developed risk register with provisions for residual risks.

7.3.1 Risk workshops

Despite the wide range of risk analysis methodologies available, a successful risk workshop is a vital component in the project risk management process. To ensure risks are at a manageable level, risk workshops should be conducted at every milestone of the project delivery process, or as determined by the project manager, appropriate for the project.

The primary focus of the risk workshop is to keep the process and stakeholder group functioning effectively in identifying risks, exploring treatments and planning risk responses.

The risk workshop usually has three phases:

1. Before the workshop, the facilitator will lead participants in the required preparatory actions and provide available information to all participants. The amount of information available depends on the risk assessment objectives, participants' risk management maturity, time and resources, as well as the project's complexity and scope.
2. During the workshop, to achieve consistent risk management outcomes, as well as high-quality risk data for further risk assessment, the facilitator will explain which elements are to be defined as risks and which are to be excluded. RCPs should be completed prior to assessment of qualitative and quantitative data (refer Engineering Policy 153).
3. After the workshop, the facilitator will create a draft assessment report, including the relevant information gathered during the workshop and will share it with all workshop attendees for comment and further analysis. Once finalised, the risk assessment report should be made available to decision makers and other relevant stakeholders.
4. A workshop at post-contract award should be convened to reassess risks that are contractually transferred to the contract. Project managers are required to manage project contingency which is informed by quantified risk in the risk register and in the approved budget. Risk characteristics continually change over a project lifecycle and fundamentally change when a delivery contract is formed.

   Prior to contract award, the Principal owns all risks. Upon award, the contract defines which party owns specific risks. A tendering contractor understands the risks the Principal and contract terms are seeking to transfer to them and makes appropriate allowances in their offer. Once the contract is awarded, it is essential the project risk register is amended to reflect those risks 'sold' to the contractor in accepting the contract price. These risks should be removed from the risk register as they are no longer owned by the Principal. Care should be taken to ensure no residual risk remains when deleting risk. This action immediately impacts the level of contingency previously relevant prior to contract award.

7.4 Evaluate risks

After potential risks are identified and analysed, the project team must evaluate the risks based on the likelihood and potential consequence associated with the risk events. Not all risks are equal: some risk events are more likely to occur than others with the risk impact varying greatly.

Risk evaluation uses the understanding and agreement of risks obtained during risk analysis to make decisions about future actions.

In some instances, the risk evaluation process can lead to making a decision to undertake further analysis, because the cost of the risk treatment outweighs the risk impact, or the probability of risk eventuating is negligible. In such circumstances, it is economical not to treat the risk and maintain the existing controls.

Information gathered during the risk evaluation process should be incorporated into the risk register, together with the assessment results (consequence, likelihood, risk treatments, risk owner, completion dates, reporting schedule and so on), as well as a target level which includes the level of risk acceptance or the retained level.

Different organisations have their own risk evaluation criteria: however, following are the commonly used criteria in the department:

- policies and directives that set standards or guidelines
- laws or regulations in the organisation, and
- expectations set by project owners or other project stakeholders.

After the risk evaluation, the project team collectively makes a determination on:

- do nothing option
- treating some risks
- using existing controls to manage some risks, if time and resources permit (some risks may not require further investigation), and/or
- reconsidering the project objectives if the risks are above and beyond the risk appetite.

There are two broad ways to analyse project risks: these are using qualitative and quantitative methods. Based on the context and complexity of the project, risk managers will determine which risk analysis method is most appropriate for the project.

7.4.1 Qualitative risk analysis

The qualitative risk analysis approach is usually a rapid and cost-effective way of establishing priorities for risk treatment, which lays the foundation for the quantitative risk analysis process.

The outcomes from this analysis are used as inputs to the quantitative risk analysis. Once project risks are identified and subjected to appropriate treatment, the base estimate is prepared with compensation for residual risks. To develop the total cost estimates, residual risks are modelled on an elemental basis of the project. This process leads to the quantitative aspect of the risk assessment.

The qualitative risk assessment process is mostly applicable at the early stages of the project's life cycle (for example, initiation or strategic assessment), acknowledging that there may be insufficient information, resources, or time available to undertake a more detailed risk analysis. Application of this method is only suitable for Type 3 or low risk projects in QTRIP.

Qualitative risk analysis is undertaken using the department's *Risk Assessment and Ratings Matrix* as shown in Annexure B of this manual.

7.4.2 Quantitative risk analysis

The quantitative risk analysis approach is performed on risks that were prioritised through the qualitative risk analysis process. Quantitative risk analysis is the process of identifying and analysing critical project risks within a defined set of costs, schedules and constraints. This process assists the project manager to balance the consequences of failing to achieve a particular outcome.

The purpose of the quantitative risk analysis approach is to capture uncertainty using available information and to go from a deterministic point estimate to a probabilistic estimate.

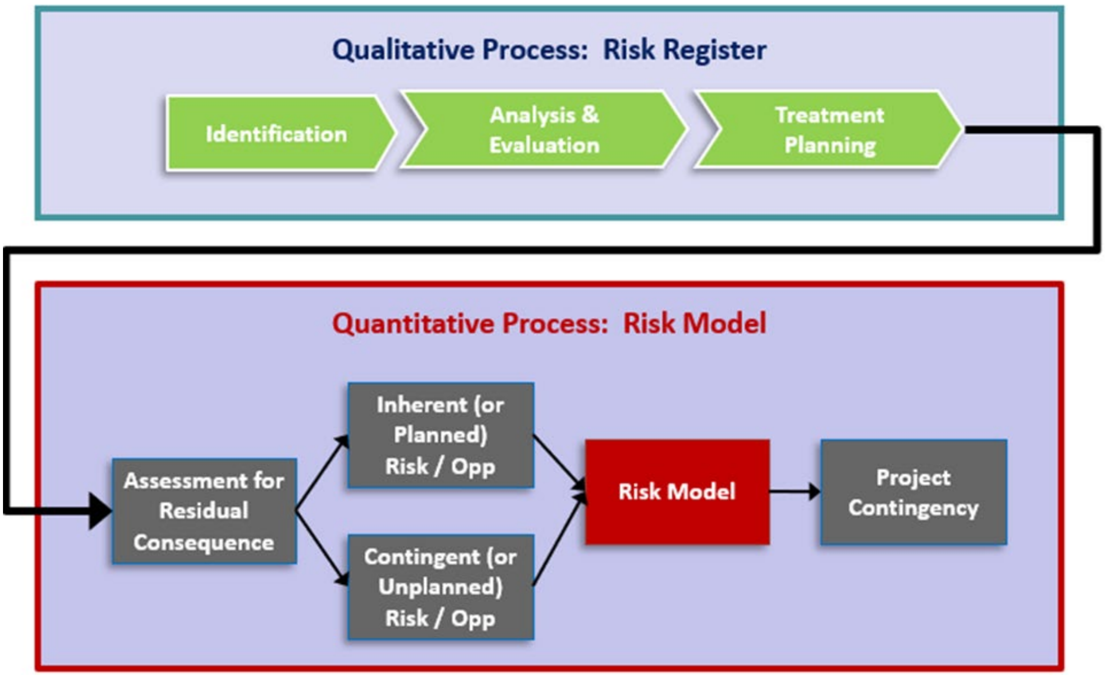
Generally, the quantitative approach employs probabilistic tools, techniques, templates and specialist software such as @Risk for risk evaluation and to develop contingency. The probabilistic simulation, also known as the Monte Carlo simulation, allows risks to be accounted for in quantitative risk analysis and decision making.

To provide greater levels of certainty and confidence, quantitative risk analysis requires a range of possible values of each input variable, namely lowest likely, most likely, or highest likely values, which are based around modelling individual risks.

The department's estimating policy mandates that all project estimates, beyond the business case milestone, have a P90 confidence level. P90 estimates are generally developed using a quantitative approach to evaluate project risks and using probabilistic risk evaluation software such as @Risk.

The process flow diagram for risk evaluation is shown at Figure 7.4.2.

Figure 7.4.2 – Process flow diagram for qualitative and quantitative risk evaluation



7.5 Treat risks

Risk treatment involves developing a range of options for mitigating risks, assessing those options, and then preparing and implementing action plans. The highest rated risks should be addressed as a priority.

Selecting the most appropriate risk treatment means balancing the costs of implementing each activity against the benefits derived. In general, the cost of managing risks needs to be commensurate with the benefits obtained. When making cost versus benefit judgements, the wider context should be considered.

Depending on the type and nature of the risk, the following risk treatment options are available.

7.5.1 Risk avoidance

One of the simplest and most effective ways to manage a risk is to avoid it by not starting or eliminating an activity or process that gives rise to the risk in the first instance. Where an activity has introduced an unacceptable risk, risk avoidance may be considered by choosing a more acceptable alternative or taking a different and less risky approach or process.

Some examples of risk avoidance are provided below:

- selecting alternative proposals, and
- adopting innovative design approaches and engineering changes.

7.5.2 Risk reduction

Risk avoidance and risk reduction are two strategies to manage project risks. Risk avoidance deals with eliminating any exposure to risk that poses a potential loss, while risk reduction deals with reducing the likelihood and severity of a possible loss.

Risk reduction is the process of implementing a strategy that is designed to reduce the likelihood or consequence of the risk to an acceptable level, where elimination is excessive in terms of time or expense.

7.5.2.1 Reduction in the likelihood of risks

Reducing the likelihood of a project risk involves implementing a strategy designed to reduce the likelihood to an acceptable level, where elimination is excessive in terms of time or cost. Reducing the likelihood usually means working to remove or reduce the source (cause) of the risk: for example, risks such as adverse weather events cannot be avoided, but careful planning of the construction program may enable avoidance of the risk to the construction, during those historically adverse weather patterns.

The mitigation measures in reducing the likelihood of risks include:

- undertaking contingency planning
- including contractual terms and conditions
- conducting inspections and checks to detect technical non-compliance
- implementing recovery programs, and
- designing for risks

7.5.2.2 Reduction in the consequence of risks

Reducing the consequence of a risk concerns removing or reducing the impact of a risk if it occurs. This involves implementing a strategy designed to reduce the consequence of the risk to an acceptable level, where elimination is excessive in terms of time or cost: for example, a project manager may decide to undertake extensive service potholing investigations for a road widening project to reduce the risk of damaging the underground services. The costs of service potholing investigation are negligible, compared to the potential costs of repairing damaged services.

The mitigation measures to reduce the consequences of risks include:

- undertaking quality procedures
- conducting regular audits and checks, and/or
- undertaking studies and investigations

7.5.2.3 Risk sharing

Risk sharing is the process of implementing a strategy that shares or transfers the risk between one or more parties, ideally based on who is in the best position to control the risk. Mechanisms for risk sharing include using special contract methods, insurance arrangements and/or implementing organisational structures such as partnerships and joint ventures to spread the risk responsibility.

Most common contract types, where risk sharing provisions are used in the department, are design and construction contracts and alliance contracts.

When sharing risks, project managers should ensure that the overall risk has been reduced and that flow-on implications are understood and managed.

Sharing risks with a contractor may create relationship tensions and flow-on implications for project performance: therefore, the risk sharing arrangement needs to be a well thought-out process from the outset.

7.5.2.4 Risk acceptance (retention)

Risk acceptance is making an informed decision that the risk is at an acceptable level, or that the cost of the treatment outweighs the benefit. This option may also be relevant in situations where a residual risk remains after other treatment options have been applied.

A risk may also be accepted (retained) if treatment options are not possible or are cost-prohibitive.

Retaining risks is not unusual in the project management context: however, it is critical to assess the potential cost of risks when estimating project contingency.

Once the project risks are accepted (retained), the project manager should make an appropriate allowance in the budget (or contingency) to manage residual risks if they eventuate. The probabilistic risk evaluation approach is applied to the residual risks that are determined for acceptance (or retention).

7.5.2.5 Risk treatment plan (strategy)

A risk treatment strategy is developed once the project's risks are subjected to identification, analysis, and evaluation processes. A risk management strategy can have several risk treatment actions that may be equally suitable but varying in cost. The selection of the final risk management strategy and actions must be made on an assessed-value basis.

The cost of treating risks should be equally commensurate and proportionate to the level of actual perceived benefits to be obtained from such actions; therefore, when developing a risk treatment strategy, the following information should be considered:

- provision of justification for the proposed risk treatment options, including a summary of the expected benefits to be gained from the treatment
- an outline of the approach to be used to treat the risk and any relationships or interdependencies with other risks highlighted in the risk register
- a clear definition of who is accountable for the treatment action and monitoring and reporting on progress of treatment plan implementation – where the treatment plan owner and risk owner are different, the risk owner has ultimate accountability for ensuring the agreed treatment plan is implemented
- specification of a target resolution date and scheduled milestones – where risk treatments have long lead times, developing interim measures should be considered (for example, it is unlikely to be acceptable for a residual risk to be rated high and to have a risk treatment with a resolution timeframe of two years), and
- identification of the resource requirements, including provision for contingencies.

Risk treatment plans should be integrated by appropriate management levels and made accessible to all appropriate stakeholders.

Decision makers and stakeholders should be made aware of the nature and extent of any residual risk following the risk treatment. Where appropriate, any residual or remaining risks should also be documented, and subjected to ongoing monitoring and review, to determine if the risk needs any further treatment.

7.5.2.6 Risk transfer

Risk transfer is a risk management and control strategy involve contractual shifting of a risk from one party to another. One example for risk transfer is purchasing an insurance policy, by which a specified risk of loss is passed from the contractor to the insurer.

As an organisational policy, the department mandates the use of Principal Arranged Insurance (PAI) for open bid contracts and when performing construction work as part of QTRIP. This cost of PAI must, therefore, form part of the cost estimate and must be separately identified as a Principal cost line item.

The PAI policy is designed to cover insurable risks, insofar as the insurance market will offer; construction risks of all projects works in the QTRIP Bulk program (<$100 million); and offer bespoke terms for most major projects (>$100 million). This provides insurance protection to the Principal, the contractor and some subcontractors. Professional Indemnity insurance is not typically extended to consultants engaged by contractors.

Contractual risk transfer is a non-insurance contract / agreement between two parties, whereby one party agrees to indemnify and hold another party harmless for specified actions, inactions, injuries or damages.

This risk transfer accomplishes objectives found in both risk financing (finding a source to fund the cost of a claim) and risk control (developing a means to avoid or lessen the cost of a loss).

Each contract contains terms which describe liability of cost for risks, should they eventuate.

7.6 Implementation, monitoring and review

Implementation, monitoring and review should be undertaken as a planned activity of the risk management process and as an ongoing and regular, periodic, or ad-hoc auditing or surveillance action.

Responsibilities for risk monitoring and review must be a clearly-defined process which encompasses all aspects of risk management to:

- ensure that controls are effective and efficient in both design and operational functionality
- allow obtaining further information to improve the overall risk assessment task
- allow analysis of lessons learnt from historic events, incidents, scope changes, trends, successes and/or failures, and
- help detect changes in scope or context, changes to risk criteria and changes to the risk itself, which can initiate or prompt an entire new review and revision of the risk.

The following are some suggested mechanisms for monitoring and reviewing project risks:

- Risk review meetings – In these meetings, the items for review include the risk register, assumptions, analysis, performance of risk treatments and changes to probability impact assessments.
- Risk practices self-assessment – The results from risk practices self-assessment should be reported and reviewed by the management team.
- Previous programs, historical data and lessons learnt – This activity should be undertaken to determine if there are actions, tools or techniques that can be applied to improve future projects.
- Monitor the environment – The project should be monitored for changes that could affect the direction or scope. Risk management should be an agenda item at all project status meetings.

Progress achieved, through implementing the risk management process, becomes a performance measure of project success. The results should be incorporated into the project's overall performance management and the project finalisation reporting.

Risk reporting should be a component of the regular project reporting cycle.

7.6.1 Risk management plan

A risk management plan is a document used by project managers to identify potential risks to the project, estimation of the likelihood and consequence and defining how to manage those risks. The project risk management plan, which includes risk treatments, describes how the selected treatments should be implemented. This plan should also identify who is responsible, when it is to be conducted, the expected outcomes, cost, performance measures and how / when the plan will be reviewed.

It is crucial to ensure that the project risk management plan is a living, dynamic document. At a minimum, it should be reviewed at the mandatory hold points between the phases of the project life cycle and when regular project reporting is undertaken.

An integral component of the plan is assigning responsibility to manage each risk. Continual monitoring and controls are required to ensure the risk treatments are appropriate and effective. The plan should assign the individual risks to a team member who is best suited to manage such risks.

To ensure that each team member assigned to managing a risk is progressing well, the project manager must periodically review the progress of each risk.

7.6.2 Determining risk control effectiveness

According to the *Project Management Body of Knowledge* (PMBOK) *Guide* Seventh Edition, monitoring is the process of monitoring the implementation of agreed risk response plans, tracking identified risks, identifying and analysing new risks and evaluating risk process effectiveness throughout the project.

Risk control is the measure or action such as policy, procedure, practice, process, technique, method, or device that controls or regulates the risk. Risk treatments become controls once they are implemented.

Since the objective of risk controls is to minimise exposure to risks, it is important to ensure controls remain effective.

The following is a rough guide to determining the rating of control effectiveness:

- Effective:
  - the implemented control design addresses the root cause(s) of the risk(s) that the control is intended to address, and
  - the control operates reliably (< 3% likelihood that the control fails to operate as designed).

In these circumstances, the project can continue to run in a business-as-usual manner, with the operation receiving ongoing monitoring.

- Largely effective:
  - the implemented control design addresses the root causes of the risk(s) that the control is intended to address, and
  - there are instances where there is a < 10% likelihood that the control fails to operate as designed.

If any control measure is in this rating, some actions must be taken to improve the reliability of the controls. Ongoing monitoring of the control's operation is necessary.

- Partially effective:
  - the control design addresses the root causes of the risk(s) that the control is intended to address, and
  - there are instances where there is a < 20% likelihood that the control fails to operate as designed.

If any control measure is in this rating, significant actions must be undertaken to improve the reliability of the control's operation. Ongoing monitoring of the control's operation becomes critical.

- Ineffective
  - the control design does not address the root causes of the risk(s) that the control is intended to address, and
  - although the control design addresses the root causes that the control is intended to address, there is a risk that the control may fail to operate (more than a 20% likelihood of control failure).

In such circumstances, the risk manager needs to re-assess the control's design, identify the root causes of the control failing to operate and take corrective actions.

7.7 Communication and consultation

Risk communication is the interactive exchange of risk information between the project manager, senior management, contractors, risk assessors and other stakeholders. Risk communication involves discussions around the existence, nature, form, severity, likelihood, or acceptability of risks.

Risks must be clearly communicated before, during and after a project, to ensure that stakeholder expectations and opinion are upheld. Ongoing communication and consultation are crucial throughout the project, to ensure the success of the risk management process.

Generally, individual stakeholders have different perceptions and opinions on risks, including the context, objectives, risk tolerance, risk control and effectiveness of the risk treatments. The communication and consultation process addresses any concerns the stakeholders may have about the process.

Project managers are often held responsible for communicating and consulting with stakeholders, but they should not be the only line of communication. A successful risk management process requires all project team member involvement, especially with subject matter experts (SMEs) who are experts in critical risk areas. Consultation with SMEs provides relevant and vital information to effectively manage project risks.

7.7.1 Recording and reporting the risk management process

The purpose of risk recording and reporting is to ensure that relevant stakeholders have a shared understanding of risks and risk management activities. Risk reporting is an integral part of the department's project governance, which is also aimed at enhancing project learning opportunities.

Project monthly progress reports should include a specific risk and contingency section where the output from the project risk and contingency management assessment will be presented. Regular reporting on the status of project contingency to the program manager is important to enable wider program implications.

It is important that the risk management process be recorded and that all decisions relating to managing retained records is considered, including:

- the project or organisation's needs for continuous learning and improvement
- the benefits gained in re-using information for management purposes
- the legislative, regulatory and operational needs for keeping and maintaining records
- the appropriate methods and methodologies associated with gaining access to and the future storage and preservation of media
- the records retention period provided by the legislation, and
- the sensitivity of all or part of the information being stored.

Recording project risks ensures that departmental records concerning vital historical, fiscal and legal value are identified and preserved, according to established guidelines and legislation.

The department's preferred method of recording project risks is through capturing risk registers in 3PCM. Transport and Main Roads aims to progressively implement the capturing of the risk registers for QTRIP projects into 3PCM, with the exception of asset maintenance projects (see Section 7.1.2.3 for more details).

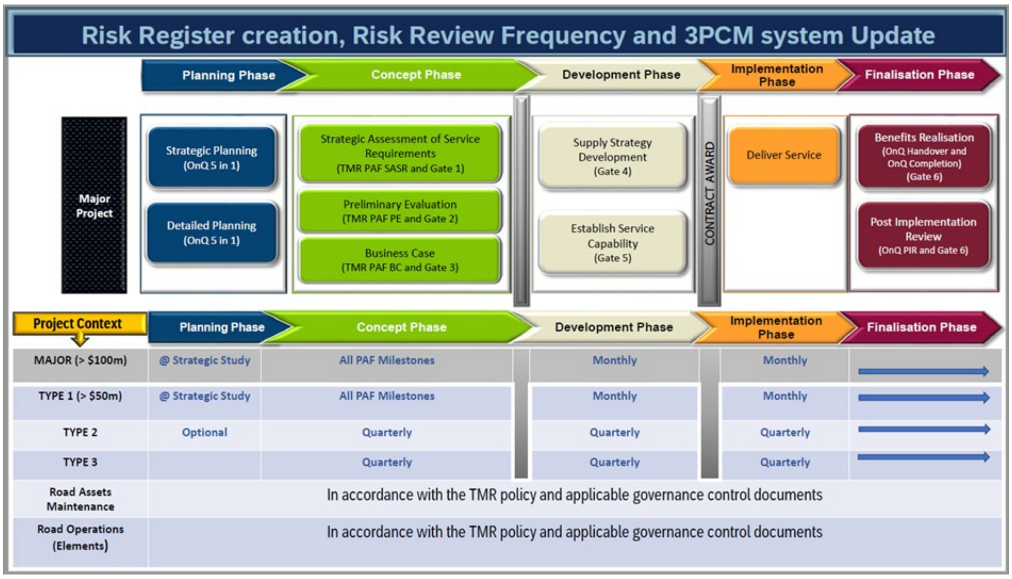
By capturing project risks in 3PCM, this enables the asset owner's visibility of information once the project managers moved on to deliver other projects.

7.7.2 Project risk review, record and reporting frequency

Project managers must ensure that the project risks are reviewed, recorded and reporting at regular intervals as the project evolves through the project lifecycle.

Once the project risks are reviewed and updated in the risk register, the updated risk registers must be imported into the 3PCM risk component, noting requirements in Section 7.1.2.3. The project manager should identify the risk review frequency by referencing Figure 7.7.2, depending on the project type and project stage.

Figure 7.7.2 – Process flow diagram for risk register creation, risk review and record



8 Categorisation of project risks

In the risk management process, it can be helpful to categorise risks into 'bundles' based on common features, and work through each category to minimise the chances of risks being overlooked. Risk categories help identify risks and enable the risk management process to become robust and practical at the same time.

There are many ways to categorise project risks: however, to streamline the risk modelling process, project risks are categorised into two major groups: namely, planned and unplanned risks. In practice, the demarcation between the planned and unplanned risks may be blurred.

8.1 Planned (inherent) risks

Planned risks relate to measured items: that is, those items specifically identified within the various components of the base estimate and which contribute to project cost. These risks remain uncertain, as the accuracy of the amount in the base estimate and the rate can vary over time.

The risk evaluation process can be applied independently to the quantity measured and the rate used for each measured cost component, or simply applied to both the quantity and rate combined.

An inherent risk is applied not only to measured items in direct costs, but also to measured items in indirect costs, margin and clients' costs: for example, the price of a particular mix of concrete varies between \$200–\$250 / m^3.

The exact quantity of concrete required, may not be known until a final measurement is performed, but is expected to be between 75 m^3 and 100 m^3.

The variability in the cost of the concrete and the quantity required are both inherent risks and should be assessed separately as planned risks.

Work items with no information, but which are known to be required, should be included as allowances in the base estimate, so that risk managers do not have to rely upon the contingent risk assessment process to make up the differences.

8.2 Unplanned (contingent) risks

Contingent risks relate to the risk attached to unmeasured items (that is, those items not listed in the base estimate, because they are unknown, or loosely identified and they may not occur and, thus, may, or may not, contribute to project cost). Typical contingent risks include adverse weather impacts, industrial issues, safety, planning approval conditions, changes during design development, changes to design standards, client requirements, unknown geotechnical conditions and potential claims from contractors.

These items are generally not included in the base estimate, as they will artificially inflate the total cost estimate or be accidentally double-counted somewhere further along within the estimate.

Contingent risks are, in some instances, often ignored, due to difficulties arising from the risk identification process and the potential impacts which they may have; however, their identification and assessment are critical, as an adequately provided for allowance within the contingency sum – for example:

- an adverse weather event may cause flooding around the project area, which causes rework or stop work for a period – while the rain event, which is an inherent (planned) risk causes delays, any delay caused by flooding due to the adverse weather event becomes a contingent (unplanned) risk, or
- due to changes in environmental policy (unforeseen / contingent risk), a project may have to absorb the Principal's costs incurred for the redesign and modification of existing works.

The risk register generally captures unplanned risks, which is subsequently used for a probabilistic modelling process.

Based on historical data, there are several major risk categories causing cost change in major projects in the department. These categories may be relied upon as a standard management tool to identify regular issues that cause change to estimated costs and help find ways of managing them on future projects.

8.2.1 Design development change risk

Cost estimates are prepared at early project stages with the level of project information available at the time. As the project advances through the project life cycle, changes may be required to address the previously unidentified performance requirements in the scope, including the advancement of the design. Design development change risks often occur through the lack of investigation (for example, geotechnical, pavement design, environmental) and are typified by the term 'scope creep'.

The department's historical data suggest this design development risk category can be 3%–8% of the estimated construction costs per design stage (that is, 3%–8% from business case stage to completion of development phase stage 1 design estimate (S1D), then another 3%–8% from S1D to development phase stage 2 design estimate (S2D); therefore, cost estimators are required to factor in appropriate risk allowance in the early cost estimates, to cater for changes to the design at development and delivery stages of the project.

8.2.2 Standards and policy change risk

The specific policies or standards that may change during development, delivery and finalisation phases could be unknown during the project's early stages; therefore, designers and estimators should remain vigilant to pending standards or policy changes, so the project meets current standards before moving the project through to implementation and finalisation stages.

This risk category focuses on the changes that may be required in the design standards by the policies imposed by state or federal governments at later project stages. These changes are a result of continuous improvement based on ongoing research and evaluation.

The department publishes updates to Technical Specifications three times a year or, rarely, by exception, some of which incur changes to existing conditions, or impose additional requirements during project delivery phases.

One of the most critical policy changes that can have significant cost implications relates to environmental offsets and emissions trading. Project managers should liaise with environmental planners about these changes throughout the project life.

Historical data suggest that the impact of this cost category could be in the order of 5%–7.5% of the construction and Principal's costs per annum.

8.2.3 Third-party influence risks

The costs and time required to investigate and relocate third-party assets (utility adjustments) can sometimes be a significant portion of the project. It is imperative that as much information as possible is obtained as early as possible in the project life cycle for inclusion into the relevant cost estimates.

In some circumstances, care must be taken to ensure that the correct scope of utility adjustments is developed and encompassed within the main construction contract.

It is often difficult to ascertain the potential costs of adjusting existing utilities in early project stages. It is desirable that, at the strategic stage, the existence of utilities be investigated by visiting the site, noting evidence of services and contacting the utility authorities to confirm site observations, or obtain information that could not have been established during a site visit.

From the business case through to design stages of S1D and S2D, details of the utilities must be fully investigated and, where required, an estimate for relocations must be obtained from the relevant utility authority. Even if such estimates are obtained, there can be a risk that such costs can vary considerably at the time of implementation: for example, a utility authority may not agree to meet the relocation costs of a utility that was not supposed to be in the vicinity. Appropriate contingency allowances should be made to address such situations, particularly in the early stages of a project in metropolitan areas.

Utility adjustment risks are not limited to power poles, cables, service pits and pipes: they also include tunnels or buildings where utilities are housed.

8.2.4 Revised functionality risks

This risk category accounts for scope change that results in revised project benefits (either increased or reduced) at development and/or implementation phases of the project.

These changes are caused by social, economic and safety reasons, such as varied requirements for traffic capacity, axle loadings, access points, or design speed compared to that originally described at project definition. A cost-benefit analysis will determine if these changes are warranted and justifiable.

To address this risk category, substantial changes may be required in the design already completed or, alternatively, a redesign of the entire project. The appropriate allowance must be determined by the estimator, in consultation with the project manager, to cater for this risk category and included in the contingency.

8.2.5 Principal's costs risk

The Principal's costs comprise the expenditure the Principal incurs when planning, conceptualising, developing, delivering and finalising a project. These costs apply to non-construction activities and may occur in more than one phase.

Often, the Principal's cost component is found to be underestimated in the project budgets. Generally, the Principal's costs are required to be estimated using the first principles methodologies for QTRIP projects: however, if the Principal's costs are estimated as a percentage of construction costs during early project phases, it is highly likely that such costs can change over time – therefore, a sufficient contingency allowance should be allowed for in the estimate, to reflect the risk and uncertainty in the overall project cost.

Historical data from previous projects suggest that the impact of this risk category is 30% of the unspent portion in the early stages of the project, depending on the project's complexity.

8.2.6 Project delay risk

Project delays can occur at any stage of the project's life cycle. The most common delays occur from difficulties in securing funding, election caretaker periods, impact of adjacent projects, reprioritisation of project components, staff turnover, environmental issues and unforeseen natural events such as flooding and pandemic (for example, COVID-19) and so on.

Project delay risks can also be caused by changes required by the Principal at later stages, such as delays in preparing and approving design drawings, underestimation of project complexity and unrealistic construction duration imposed on the project. While the project delay risks associated with the resources most likely arise in the implementation phase, stakeholder and process-related risks are more often distributed along the project phases.

Research work undertaken in the United Kingdom (Flyvbjerg, 2004) found that projects, on average, are delayed by 20% from the date announced in the business case, to the actual practical completion date.

Project delays can cause significant impact on project budgets: for example, a $100 million project that is scheduled to be completed in five years from the business case to completion, may add over $10 million to the project cost if it is completed in six years. In outturn dollars, this may increase the costs to $17 million (based on current escalation rates at the time of this manual’s publication)

This risk category is difficult to assess, so project managers and estimators should use historic data and experience to determine the appropriate contingency amount in the estimate.

8.2.7 Changes during the implementation phase

A project can undergo unplanned changes during its implementation and finalisation phases. These changes are due to a change in tools, technologies, processes, reporting structures and resources. These changes may also result from the requests made by the Principal and the contractor.

The department's investigation of past projects delivered, using various delivery methods, shows that the average cost increase, during implementation phase, was 11% of the estimate for comparison of tender (EFCT) prepared at the time of tender award.

There is no information available on whether it was due to scope creep, contractor's claims, quantity increases, or cost escalation; however, these results are consistent with cost increases reported in the recent QTRIP publication, so the cost estimators and risk managers should make reasonable contingency allowance to cater for this risk.

8.2.8 Property acquisition

Identifying the risks associated with property acquisition is a complex process which is generally unknown in the early estimating stages. Due to this uncertainty, an appropriate level of contingency must be allowed in the estimate to cater for the risks associated with property acquisitions.

The risks in property acquisition may include likelihood of the value of land increasing, prolonged legal costs, time required to acquire the land changing and exceptional hardship costs.

Apart from the direct costs associated with the land to be acquired for project purposes, there can be other costs in the land acquisition process which are:

- compensation paid to landowners due to project impacts on their land
- the residual value of land temporarily acquired, or made available by demolishing existing infrastructure replaced by the project works, and
- adjustments to property access, footpaths, fences and so on.

Once each property is purchased or accommodation works finalised, the risks associated with this cost category may be removed.

8.2.9 Unmeasured / unidentified item risks

Despite the best efforts made to prepare P90 cost estimates at the budget setting stages of the project, there can be missing work items which were not identified or measured during strategic planning, concept and development phases; therefore, it is recommended a contingency allowance be included in the cost estimate to cater for this risk as follows:

- S2D – allow 1% to 3% of total construction cost
- business case estimate – allow 3% to 5% of total construction cost, and
- strategic estimate – allow 5% to 7% of total construction cost.

These contingency allowances account for any unidentified or unmeasured items in the work schedule, which enable the estimate to reach the required confidence level. The level of acceptable risk is dictated by the type of risk, the project and the overarching divisional risk profile.

8.2.10 Project-specific risk items

In addition to these main risk categories, project managers may also need to focus on any project-specific risks impacting project delivery. Project-specific risks are specific to a project and, therefore, the impacts of these risks may differ from one project to another.

Measures for these risks are generally not known at early project stages. The link between project-specific risks and cost impacts is more easily understood than systemic risk and can make it easier to estimate the impact of these risks on specific items or activities. These risks are amenable to individual understanding and quantification, using expected value or simulation techniques; for example, it may be possible to estimate the impact of adverse wet weather on earthworks activities reasonably accurately.

Typical project-specific risks may include:

- site subsurface conditions
- delivery delays
- constructability
- resource availability issues, and
- contract conditions – limits of accuracy, latent condition, rise and fall, and so on.

There may be instances where the project site is located on an environmentally-sensitive area or adjacent to a major railway line. In such circumstances, there can be restrictions for work operations and/or additional works may be required to satisfy the authorities' requirements.

9 Contingency development

The uncertainty inherent in estimating processes means that it is highly misleading to represent an estimate as a single number. Instead, it should be considered as a range of possible outcomes. The distribution of possible outcomes for a particular project is defined by the estimate's probability distribution that is calculated, or simulated, through the application of probability and statistics.

Contingency is an integral component of the overall risk assessment and budget setting process, prior to an investment decision, and a key aspect of sound project management across the project life cycle.

Contingencies allocated to a project costing must be consistent with the residual risk in the risk register, adequate to cover the cost of unplanned activities or risks that are necessary to deliver project outcomes, and commensurate with the overall project objectives.

The importance of active contingency management by the project manager is to ensure there is sufficient contingency for the remainder of the project to allow decisions, such as project rescoping or descoping, to be made early enough so the project can still be delivered within the overall project budget.

A contingency allowance in cost estimates is normally expressed as a 'P' or probability value, or its deterministic approximation. The department requires cost estimates for QTRIP projects to be presented with P50 and P90 confidence levels as follows:

- P50 – represents the project cost with a most likely estimate and a 50% likelihood (or confidence) of not being exceeded for budget setting purposes, and
- P90 – represents the project cost with an 'unlikely to be exceeded' at a 90% confidence level estimate to provide confidence in project priority, affordability and strategic fit.

Methods for establishing contingency for cost estimates are generally divided into two groups: deterministic methods and probabilistic methods. These two methods are distinctly different and should be chosen based on the criteria developed by the department.

9.1 Deterministic approach for contingency development

The deterministic method is a simple approach that often involves applying a flat-rate percentage of construction to the base estimate to allow for risk: however, this simplistic approach is not recommended by the department or projects funded by the Australian Government.

The deterministic contingency development approach treats all input risk parameters as constants, whereby it manually applies a percentage to either individual work items (item-based approach), or to the aggregate cost estimate (factor-based) to cater for risks.

When using the deterministic approach for contingency development, contingency amounts are derived through the linear multiplication of the risk severity value and the likelihood of actual risk occurrence. These methods do not encompass the conditional nature of risk occurrences and can potentially deliver very inaccurate contingency provisions.

Australian road and rail agencies use both deterministic and probabilistic methods to develop contingencies: however, using deterministic methods is deemed acceptable only under certain circumstances.

Strictly speaking, a true 'P' value can only be derived through a probabilistic risk assessment: however, for the purposes of meeting the requirements for federal funding submissions, approximations to 50% and 90% confidence values may be estimated using a deterministic method, as explained previously, for projects with a total anticipated risk adjusted outturn cost of less than $25 million.

The deterministic contingency calculation tool at Annexure A of this manual provides an example used by the department in determining the P50 and P90 contingency components for road projects, using the deterministic approach (refer to Guidance Note 3B – *Deterministic Contingency Estimation* issued by the Australian Government for updated figures and further details).

9.2 Probabilistic approach for contingency development

A probabilistic cost estimation approach is a form of quantitative risk analysis which uses the Monte Carlo simulation to develop a contingency component to account for residual risks. This simulation process is a technique that allows cost estimators to account for risks using a quantitative risk analysis approach.

The rationale behind the probabilistic approach is the project's final costs are better depicted by a range of values with associated probability, rather than a single deterministic value, due to potential risks.

The Monte Carlo simulation is a statistical sampling technique which generates many possible outcomes of a model, all of which are feasible.

The likelihood of outcomes in each range is determined by the probability density functions of the inputs and the likelihood of an outcome in that range.

When provided with an appropriate input variable for cost items in the form of probability distributions for a project, the Monte Carlo simulation produces a sample of possible outcome values of the total project cost.

The Australian Government requires a probabilistic contingency development approach to be used for all projects greater than $25 million and for which federal funding assistance is sought.

9.2.1 Probabilistic risk assessment model

A probabilistic risk assessment is a systematic and comprehensive methodology to evaluate risks associated with every life cycle aspect of a complex project.

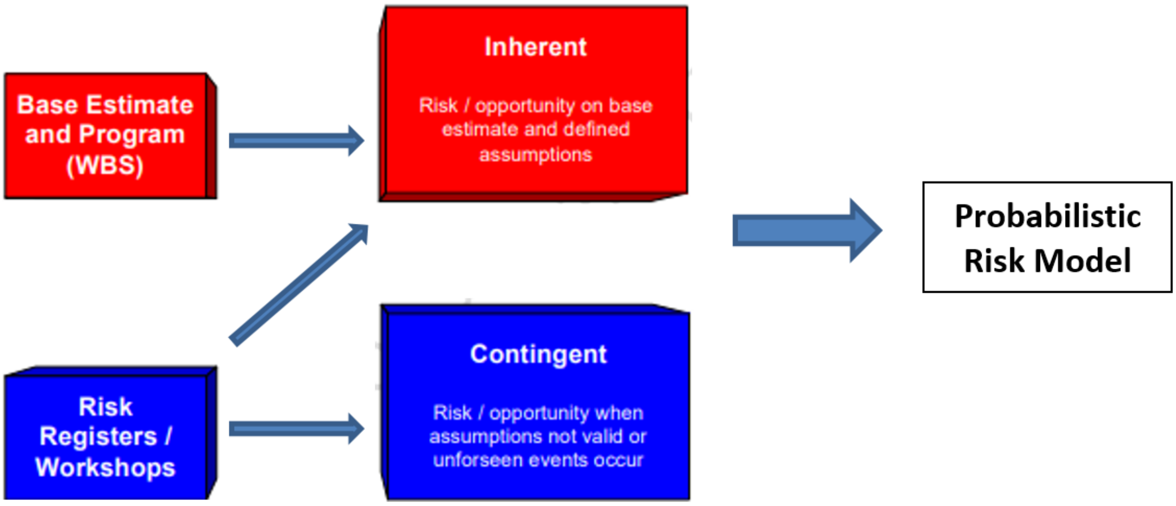
One of the shortcomings of the deterministic risk assessment approach is that it does not usually calculate the contingency amounts for both planned (inherent) and unplanned (contingent) risks individually, but a combined contingency allowance.

It is important to note that the line between planned and unplanned risks may be blurred. While it is not necessary for the categorisation of risks to be strictly applied, it is important that all risks (whether inherent or contingent) be accounted for in the risk assessment.

In contrast, consequences are expressed numerically (for example, the cost to repair flood damage) and their likelihoods expressed as probabilities or frequencies (that is, likelihood of one in 100 years) in probabilistic risk assessment models.

The probabilistic risk assessment process is shown in Figure 9.2.1.

Figure 9.2.1 – Probabilistic risk assessment outline



The typical sequence for the project's probabilistic risk assessment is as follows:

1. Prepare the base estimate and associated risk register, including key assumptions.
2. Prepare the planned (inherent) risk model using the individual line items in the base estimate. It is necessary to determine the range that each cost element (quantity and the rate) can vary, given the project phase or the project stage where the risk assessment is applied for. These are generally presented as lowest likely, most likely (base estimate) and highest likely values.
3. Identify the model and relationships between different elements in the inherent risk model. The relationships are modelled using correlation matrices that are based on the strength of relationship between elements.
4. Prepare the unplanned (contingent) risk model for individual, unplanned risks in the risk register, including the Principal's costs, and determine the residual impact and likelihood of each risk.
5. Conduct the risk workshop with key stakeholders to:
   a) review and validate the assumptions and inclusions / exclusions in the base estimate
   b) review and validate the ranges used for planned risks (rate and quantity), and
   c) review and validate the likelihood and consequence (dollar value) of the unplanned risks.
6. Update the risk register with risk dimensions that were agreed at the risk workshop.
7. Run the risk model through the Monte Carlo simulation.

It may be necessary to present the probabilistic model outcomes to the risk workshop attendees again to get agreement on the final risk approach.

9.2.2 Monte Carlo simulation

The probabilistic risk evaluation, commonly known as the Monte Carlo simulation, runs several iterations, with different cost combinations for each cost element, to build up a probability distribution for the overall project cost.

Monte Carlo simulations provide the following advantages, compared to the deterministic risk analysis:

- probabilistic results show not only what could happen, but how likely each outcome is to occur
- the graphical results generated by the model for different outcomes and their likelihood are a great tool to communicate project risks with other stakeholders
- sensitivity analysis provides a tool to rank inputs which are likely to have the biggest impact on the bottom-line result – in a single-point estimate developed using deterministic models, it is impossible to check which variable could have the biggest impact on the project, and
- in deterministic models, it is difficult to model different combinations of values for different inputs to see the effects of different scenarios. Monte Carlo simulations addresses this issue.

Prior to applying the Monte Carlo model for risk evaluation process, appropriate cost variation ranges for all risk elements must be defined. There is no set theory for determining these ranges: however, the project manager, based on their experience, is expected to provide guidance on the most appropriate ranges to be used, the project stage and the likelihood of the risk eventuating.

By applying probabilistic risk analysis, a realistic, whole-of-project risk profile can be developed which, in turn, will assist in the risk treatment process and determine the adequate contingency component of the project reaching the P90 (and P50) confidence level.

Wherever practical, the department encourages internal and external cost estimators to use the probabilistic risk evaluation process. There are instances where the use of the probabilistic risk evaluation process is mandated, which are:

- a professional judgement suggests that a more robust risk evaluation approach is warranted
- a qualitative approach is found to be inadequate to assess significant risks, given the project size
- the activities are complex or have a high impact on departmental business such as prolonged service disruption, and
- the project is deemed to be of high risk and/or of high value (that is, state projects with a value of greater than $10 million and federal projects greater than $25 million).

The Australian Government has mandated the use of a probabilistic contingency development approach for all projects greater than $25 million and for which federal funding assistance is sought.

9.2.3 Application of @Risk for probabilistic risk evaluation

The department's estimating policy mandates that all project estimates, beyond the business case milestone, must have a P90 confidence level.

The Australian Government also requires that PPR funding submissions have P90 and P50 cost estimates for all projects greater than $25 million when applying for federal funding assistance, using probabilistic risk evaluation approaches.

P90 and P50 cost estimates are generally prepared using a probabilistic risk evaluation approach and specialist probabilistic risk evaluation software such as @Risk.

The @Risk software is the department's recommended tool for a probabilistic risk evaluation for high risk and/or high value projects. External providers undertaking project cost estimates for Transport and Main Roads must provide a file format that is compatible with the department's recommended tool. Similarly, the Australian Government requires file format compatible with their requirements, such as @RISK, for federal funding applications being prepared for Transport and Main Roads.

The @RISK software performs Monte Carlo risk simulations to develop multiple scenarios of consequence outcomes and how likely they are to occur. These outcomes provide a plethora of valuable data for decision makers to consider most appropriate risk profiles for their project.

The adopted probability distribution must be based on historical records, industry performance, technical capabilities and other relevant performance information and must also be chosen to represent the variance of the estimated value in a probabilistic model of the estimate.

9.2.4 Choice of probability distribution

A probability distribution represents that the likelihood of an uncertain quantity, taking on values within the range, can arise. There is no objective basis for choosing one distribution shape to represent an assessment of the uncertainty in part of a project's cost.

The probabilistic risk evaluation software, such as @Risk, provides a substantial number of probability distributions: however, the most common probability distribution types used to model project risks are Uniform, Triangular, Program Evaluation and Review Technique (PERT) and Discrete.

Generally, continuous probability distributions (such as triangular and PERT) are used when any value within the variables range in the model can occur. The continuous probability distribution includes the linear distribution where each value, within the specified range, is equally likely.

The estimated quantities and rates of an estimate schedule can vary independently and, therefore, continuous probability distribution must be used to model uncertainty and possible variation in their quantitative values.

A discrete probability distribution (such as Bernoulli, Binomial, Discrete) is used when a finite number of values can occur because it models whether an event occurs or not.

In contrast to planned risks, unplanned risks are two-dimensional. One dimension is the risk severity and the other dimension is the likelihood. Each dimension can act independently of the other and can have a significant impact on the overall costs; therefore, unplanned risks are modelled using discrete functions such as Bernoulli, Binomial, Discrete.

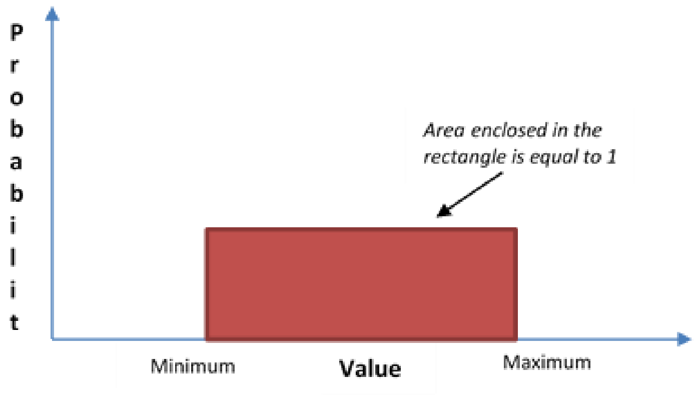
The extent of the variance is presented by a probabilistic distribution after determining the appropriate range of possibilities. To do so, the estimator establishes the most reasonable range for each cost element (quantity and the rate). These values can be presented as lowest likely, most likely (base estimate) and highest likely outcomes and appropriate cost probability distribution to be assigned for each cost element.

9.2.4.1 Uniform distribution

Uniform distribution (continuous) is one of the simplest probability distributions in statistics. It is a continuous distribution: this means that it takes values within a specified range, for example, between 0 and one.

Uniform distribution uses a first-guess approach for quantities believed to be randomly varying equally between a maximum and a minimum, which can be used when actual knowledge of the probable cost is not known with any confidence, but the range of the possible costs is reasonably determined: for example items, lump sums and so on.

Figure 9.2.4.1 – Uniform distribution

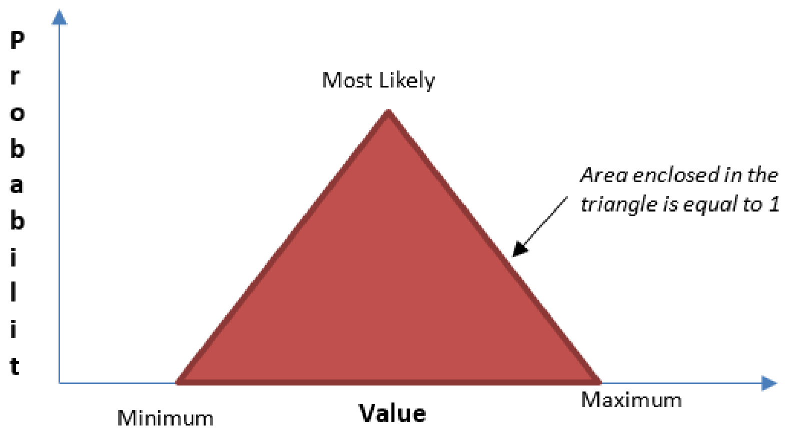


9.2.4.2 Triangular distribution

A triangular distribution is a continuous probability distribution with a probability density function shaped like a triangle. It is defined by three values: namely, the minimum value, the maximum value and the most likely value. The most likely value is the value adopted in the base estimate.

This distribution can be used when there is reasonable confidence in the rate or the quantity adopted but there is a possibility that this figure could vary between two extremes: for example, rates for work items, quantities with a possible error in measurement and so on.

Figure 9.2.4.2 – Triangular distribution



9.2.4.3 Program Evaluation and Review Techniques distribution

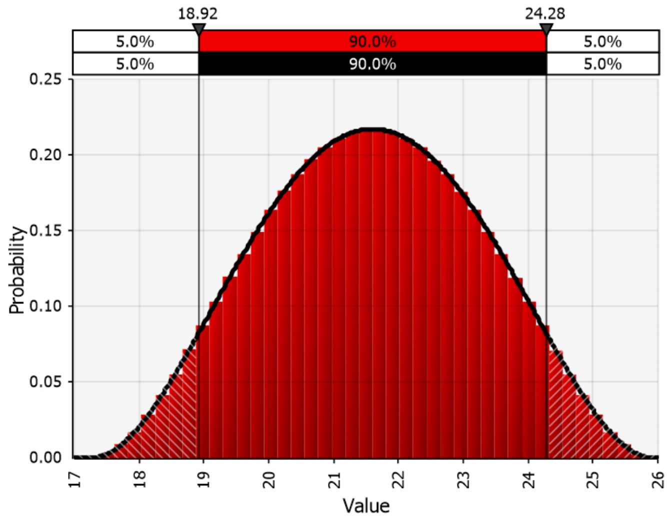
PERT distributions are essentially bell-shaped, triangular distributions which are commonly used for modelling planned risks.

The PERT distribution constructs a smooth curve which places progressively more emphasis on values around (near) the most likely value, at the expense of values towards the tails.

In practice, this means that the estimate for the most likely value is trustworthy, with a larger percentage of values being closer to the most likely estimate.

There will be some differences between the use of PERT and triangular in a project. Ultimately, the impact may not be as significant as it would be at the level of each of the activities in the absence of correlations.

Figure 9.2.4.3 – Program Evaluation and Review Techniques distribution



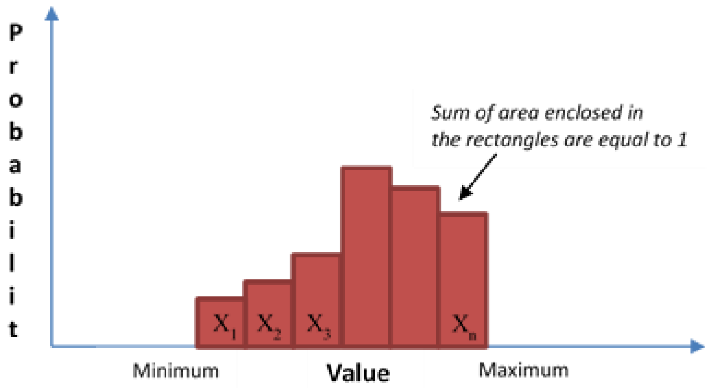
9.2.4.4 Discrete distribution

Discrete distribution is a statistical function that is used to show all possible values and likelihoods of a random variable in a specific range. The range would be bound by maximum and minimum values, but the actual value would depend on numerous factors.

This approach generally answers the question of 'how frequently does this event occur?' This is due to the value for a probability being attached to each possible value.

This distribution can be used when historical records exist, or when an analysis of the possibility of occurrence has been undertaken. Generally, unplanned risks are modelled using discrete distributions.

Figure 9.2.4.4 – Discrete distribution



9.2.5 Selection of the range for probability distributions

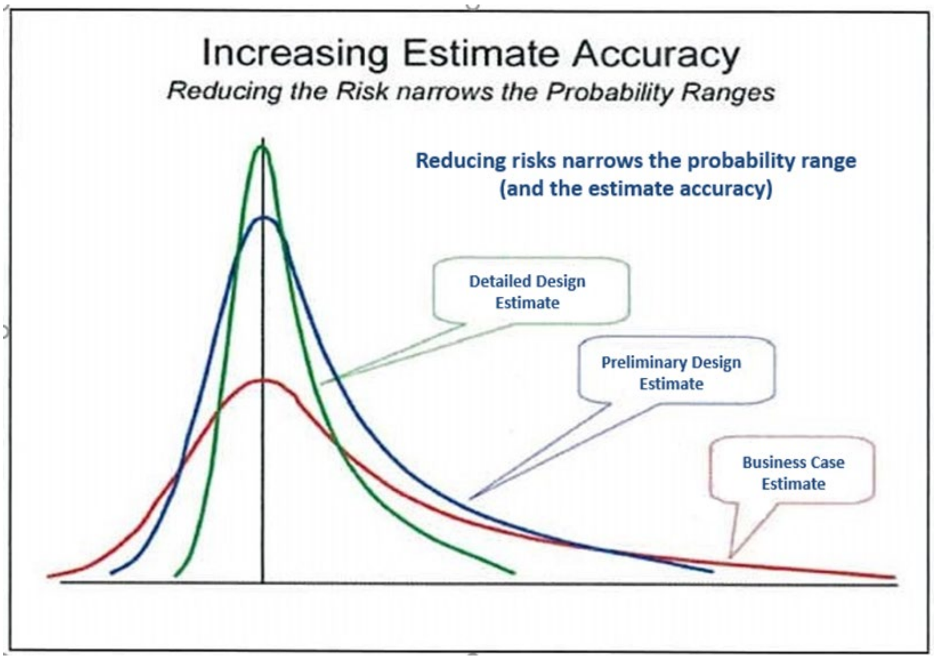
Prior to applying a probabilistic model for risk evaluation, estimators are required to define appropriate cost variation ranges for each risk element. This range can vary from one cost element to another and from one estimate to another, depending on the stage where the estimate is prepared.

There is no set theory for determining the ranges for the cost model, however, the project manager should use their experience to select the most appropriate range, based on their understanding of the project stage and the likelihood of the risk eventuating.

As part of general practice, the following indicative ranges are used to model the planned risks at the business case milestone of the project in QTRIP:

- most likely quantity / rate = the design quantity / rate
- lowest likely quantity / rate = 80% of the design quantity / rate
- highest likely quantity / rate = 120% of the design quantity / rate

Figure 9.2.5 – Selection of probability ranges for risk inputs



As shown in Figure 9.2.5, the ranges applied to planned risks must be narrower when the project is advancing through the project's life cycle. This means that, when the project reaches the S2D stage, the quantities and rates of the cost items converge towards the most likely values.

9.2.6 Number of iterations

There is no definitive figure for the number of iterations to be used during the probabilistic evaluation of project risks. If too few iterations are used, the model will fail to sample a representative number of outcomes, often indicated by output histograms that are lumpy, and result in inaccurate conclusions being drawn from the outputs.

If too large a number of iterations is used, the model will take time to process every time it runs the model.

As a rule of thumb, 10,000 iterations would be sufficient to provide a good representation of possible outcomes. Use of higher numbers of iterations would be acceptable, ideally giving rise to a smooth S-curve. With the use of existing software such as @Risk, it would take only a matter of seconds to simulate possible outcomes.

9.2.7 Correlation

Correlation refers to the presence of relationships (or dependencies) between different line items in the risk model. Failure to account for this relationship between line items will result in an underestimation of project risks in the model.

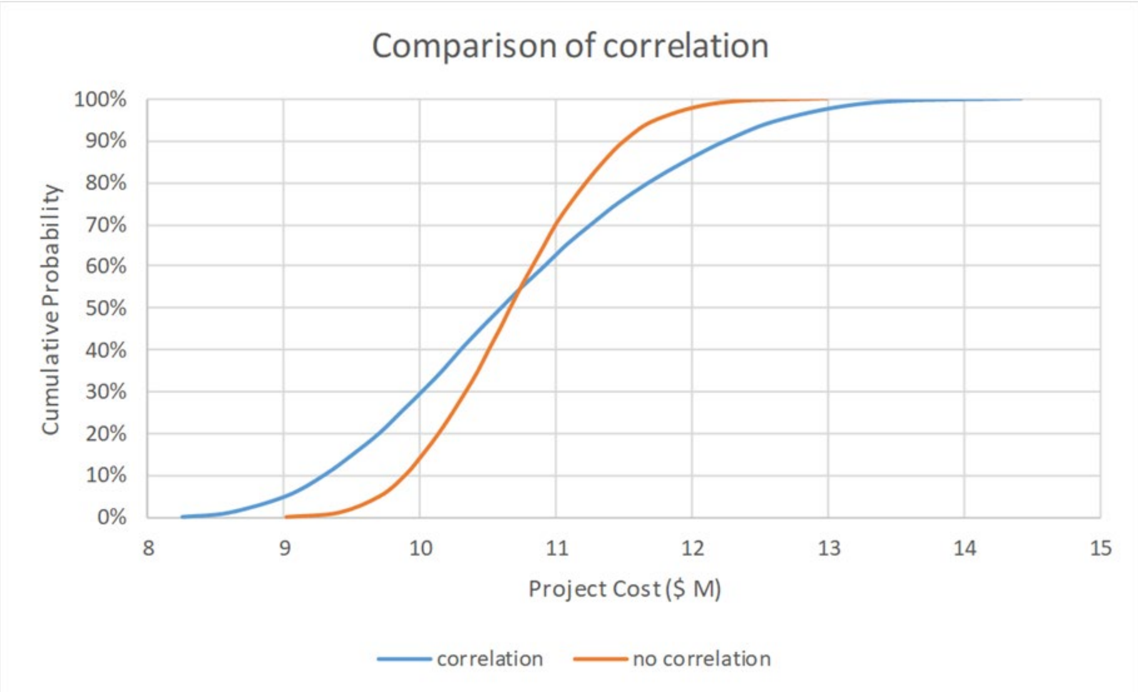
It is often found that many undesirable things happen at the same time (usually from sharing the same root cause) rather than being fully independent. Ignoring this tendency will likely result in an underestimation of contingency required to cover risk; therefore, the risk modellers must identify the items that correlate and build a correlation matrix within the risk model.

Correlations can have a large impact on the percentiles of cost probability distributions, and assuming no correlation can result in a large understatement of risk.

Many cost components in a project are generally linked, because there is a common cause or driver that affects each in the same way. Usually this dependence, or correlation, will be positive. It is rare that an increase in costs in one cost element will be offset by corresponding benefits in another cost element because of a common underlying influence. Such offsets do happen by chance of course, when two costs are uncorrelated so that one might rise as the other falls but systematically.

Figure 9.2.7 shows the S-curves for a project with and without correlation. As shown in Figure 9.2.7, the probability graph skews to the left once applied, the correlation to two components that were assumed to have interdependency.

Figure 9.2.7 – Comparison of correlation



If the interdependency of these two components is not modelled, the joint probabilities of the various combinations of these two parameters will be incorrect.

The correlation can be applied to a risk model in two ways:

- correlation by aggregating inputs and assessing the risk register: this approach is useful where several elements are similar in nature (for example, if concrete pipe culvert components were to be sourced from the same supplier, the unit cost for a 450 mm diameter pipe and 600 mm diameter pipe may be expected to move in tandem – they are strongly positively correlated: if the price of one goes up or down, so will the other), or
- using a correlation matrix which accounts for the correlation by using a matrix of related inputs with a correlation that defines the strength and the direction of their relationships.

Correlation is usually measured as a number between -1 and 1 and, as the correlation between two or more items trends towards 1 /-1, the correlation becomes stronger.

9.2.8 Stress analysis

Stress analysis enables the users to model risk elements that are at the high end of the project cost estimate. This is done by selecting several risk elements, stressing them and simultaneously running the simulations.

Once completed, the model provides a collection of reports and graphs useful to analyse the effects of stressing certain elements:

- Stress Low Values specifies a low range, bounded at the low end (say 5%) by the distribution and only allows values between 0% and the 5th percentile of the distribution to be modelled, and
- Stress High Values specifies a high range to sample, bounded at the high end (say 95%) by the distribution and only allows values above the 95th percentile to be modelled.

9.2.9 Sensitivity analysis

Sensitivity analysis allows users to run trial simulations that vary across a specified range on a selected distribution in the model. This analysis runs simulations at each input variable in the model, tracking the overall simulation results at each value.

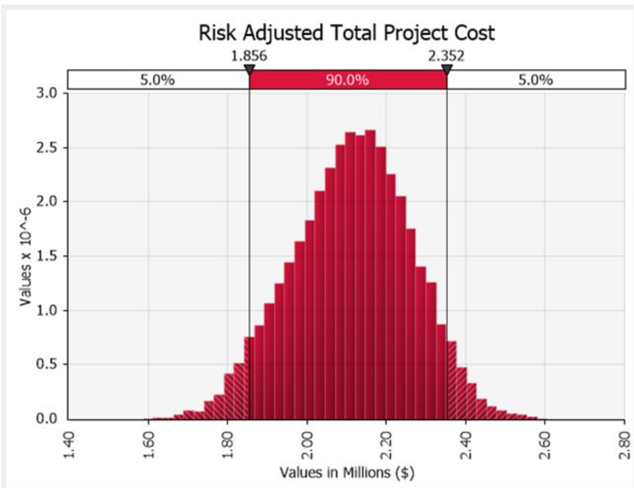
These results then show how simulation results change as the selected input variables are changed. This is an effective way to check impacts of Pareto risks on the project if they are going to vary.

9.2.10 Interpreting probabilistic outputs

Histogram

The results of a model can be presented either as graphs or numbers. It is common to make as much use of graphs as possible as they provide a quick and intuitive way of understanding the information. The purpose of risk modelling is to provide a basis for establishing contingency, so results should be presented to help decision makers set appropriate and realistic project budgets. As shown in Figure 9.2.10(a), the histogram is one of the key outputs in the probabilistic risk evaluation process.

Figure 9.2.10(a) – Sample histogram for a project



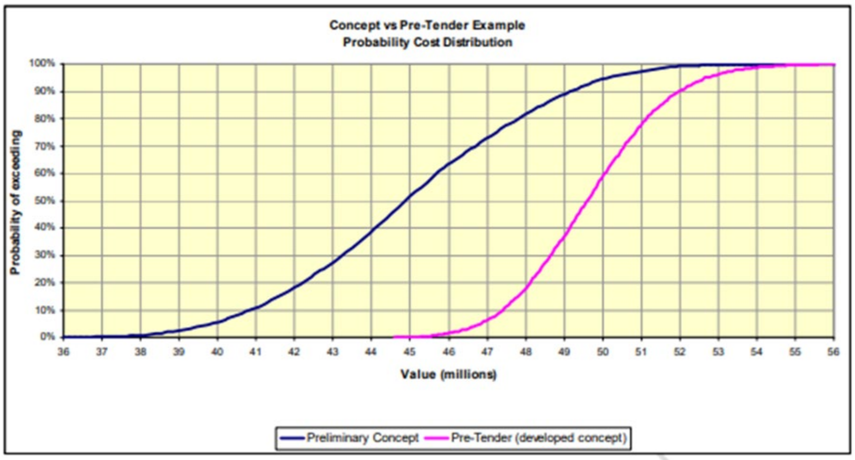
Statistics	Risk Adjusted Total Proj...
Dif. P	90.0%
1%	$1,769,776.27
2.5%	$1,814,775.58
5%	$1,856,011.81
10%	$1,913,267.03
20%	$1,985,654.13
25%	$2,014,193.73
30%	$2,037,936.11
35%	$2,059,940.39
40%	$2,080,211.80
45%	$2,099,689.83
50%	$2,119,183.78
55%	$2,137,791.82
60%	$2,157,852.60
65%	$2,176,648.86
70%	$2,195,966.66
75%	$2,217,603.68
80%	$2,241,243.83
90%	$2,303,693.61
95%	$2,352,254.65
97.5%	$2,391,510.88
99%	$2,438,357.85

'S'-curves

The probabilistic assessment output can also present as a cumulative probability distribution graph also known as an S-curve. The S-curve graphs the final costs against probability of occurrence.

The shape of the S-curve is the graphical depiction of the number of risks in the project. A project with a lot of risks usually has a flat S-curve. The more risks within a project, the more uncertainty there is in the final costs and the wider the range of final costs. Conversely, a project with a small number of risks has a steep S-curve. This can be better illustrated by Figure 9.2.10(b).

Figure 9.2.10(b) – Concept vs pre-tender S-curves



The S-curve allows direct selection of a budgetary figure based on the confidence level (P50 or P90). It is essentially the area under the cost probability distribution curve and, hence, the probability that the project cost will be less than, or equal to, the applicable cost at that point.

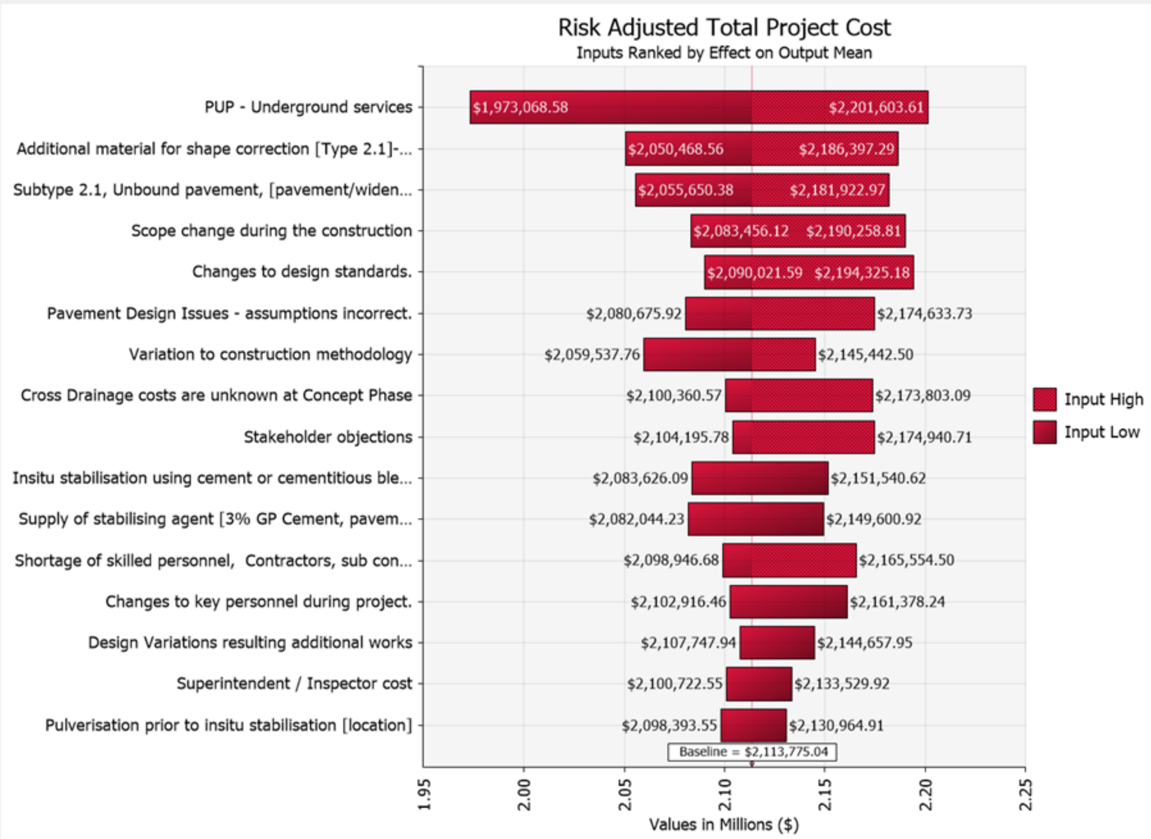
From the S-curve, P50 and P90 costs can be read, which are respectively the cost for which there is a 50% and 90% probability (or confidence level) that the actual project cost will not exceed that cost.

Tornado graphs

A tornado graph is another typical output of @Risk modelling software. It provides a ranking of the inputs with the greatest regression sensitivity. In simple terms, this graph shows which risks have the greatest effect on the variability in the output. Tornado graphs show not only the risk elements with the greatest value but also consider the likelihood that it occurs.

The whole purpose of a tornado graph is to identify the most influential model parameters; for example, Figure 9.2.10(c) is intended to communicate to a manager that the contingency on this hypothetical project is very sensitive to *PUP – Underground Services*, less so to risk factors such as *Superintendent / Inspector cost*.

Figure 9.2.10(c) – Sample tornado diagram



The Pareto analysis suggests that 80% of project cost overruns are attributable to around 20% of the causes (risks). Resources are often stretched in every project, so project managers will focus only on key risks, not every risk. As illustrated in Figure 9.2.10(c), the most critical risks (by both likelihood and consequence) are ranked by the tornado graph.

Staff who are assigned to manage project risks are required to identify Pareto risks (or 80:20 rule) so that project manager can manage the project effectively. The tornado graph is useful in prioritising risks in the order of both likelihood and the impact: however, this outcome should be used to verify that what the @Risk model is calculating as the greatest risks meets with reasonable expectations.

10 Contingency management

Contingency management is characterised by the appropriate level of governance and control applied to funding allocations for projects and programs. This control is applicable to projects and programs in QTRIP, with budgets exceeding a certain threshold.

11 Contingency reporting

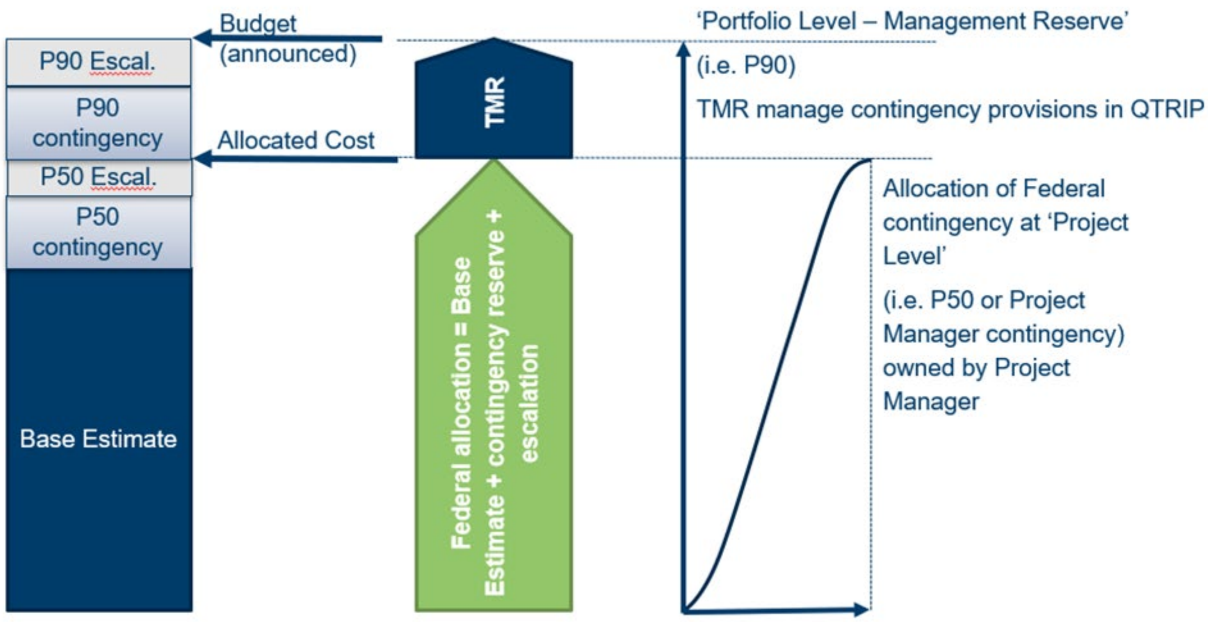
The are several benefits to the project to regularly undertake a contingency management assessment, such as:

1. enabling the project team to control the contingency usage during project lifecycle
2. forecasting that prevents overspend of contingency and overall project budget
3. rescoping or descoping project tasks or activities early enough so the overall project budget will not be exceeded, and
4. identifying potential shortfalls for contingency during the lifecycle of the project.

Key items for reporting are:

- contingency expenditure to date, plus forecasted future expenditure against original contingency demand baseline
- remaining contingency and unallocated contingency
- opportunity value offsetting contingency demand (forecasted expenditure)
- issues or ineffective treatments requiring ownership and remedial attention, and/or
- a statement on project risk and overall contingency health to the completion of the project.

Figure 11(a) – Federal approach in funding departmental projects



Source: Risk Engineering Society's draft guideline (for consultation)

Contingency management is a living process along the project life cycle as required in all QTRIP projects with the exception of asset maintenance projects (such as Road Maintenance Performance Contracts) and the projects in the MPE and RO elements. During each phase of the project and, as the project risk profile changes, the contingency must be assessed and adjusted.

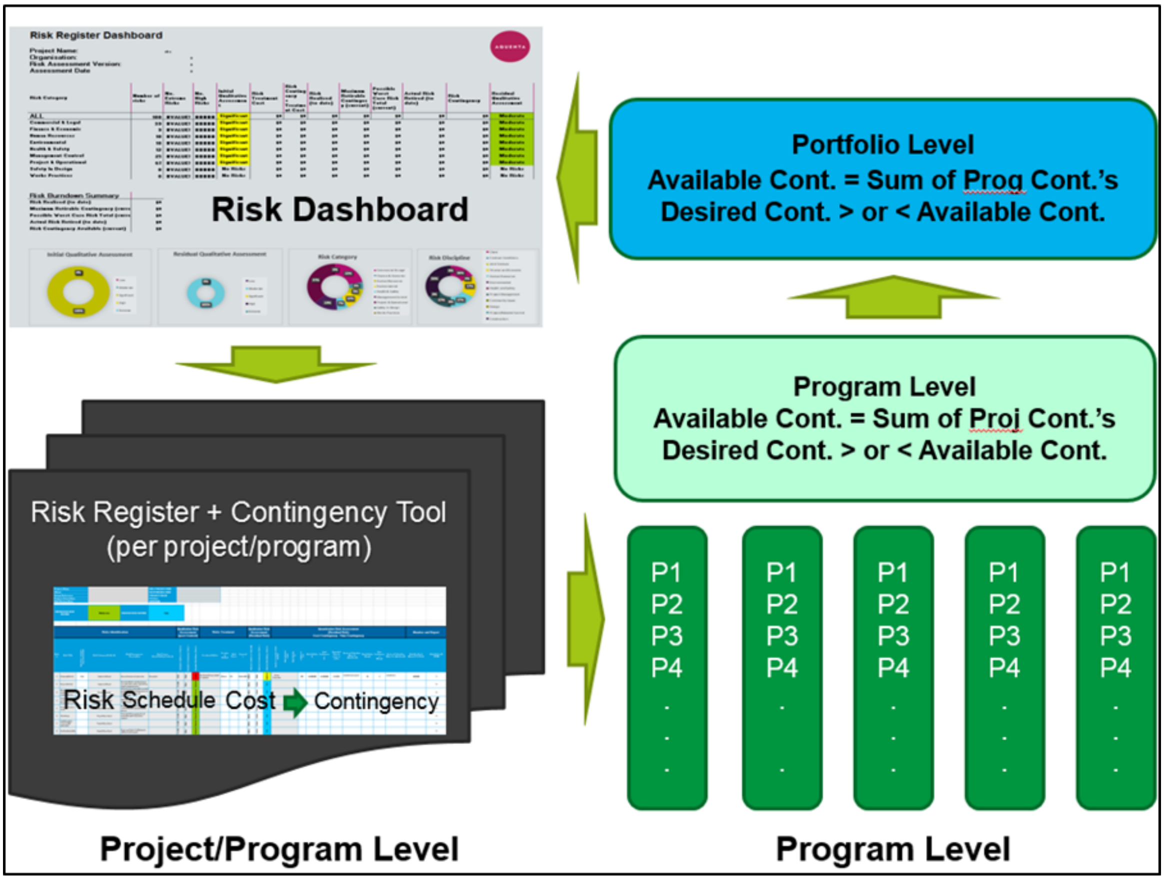
As shown in Figure 11(a), project managers are provided with a contingency reserve of up to P50 levels, with the difference between P90 and P50 contingency provisions being kept at portfolio levels.

Contingency management at project level is most often focused on individual risks that, should they occur, will need a contingency. At program level, this will enable a comparison of risks and reduce the required contingency by identifying interdependencies between risks across the program.

The portfolio will establish common frameworks and standards for risk management and a contingency management approach which will be cascaded to projects and programs to ensure a common approach and reporting structure. This should ensure that the portfolio does not expose the department to too much risk.

An example of an overall contingency management process from projects to programs and then portfolio is shown in Figure 11(b). The total value (sum) of the contingency allowance to be included in a project cost estimate depends upon how much risk is catered for within the estimate.

Figure 11(b) – Contingency management at project, program and portfolio levels



The Approved Project Delivery Value (APDV) process is established to manage contingencies at project level to the program level and then consolidation into the portfolio level for effective decision making.

11.1 Approved project delivery value

The QTRIP *Savings Management Policy* (available on request via email to PIP_Publication_and_Governance@tmr.qld.gov.au) outlines the overarching policy and decision making framework for the management, reporting and reallocation of project savings for QTRIP projects, with a total budget of $10 million or greater and must be referred to whenever there are identified project savings affecting the project's total budget.

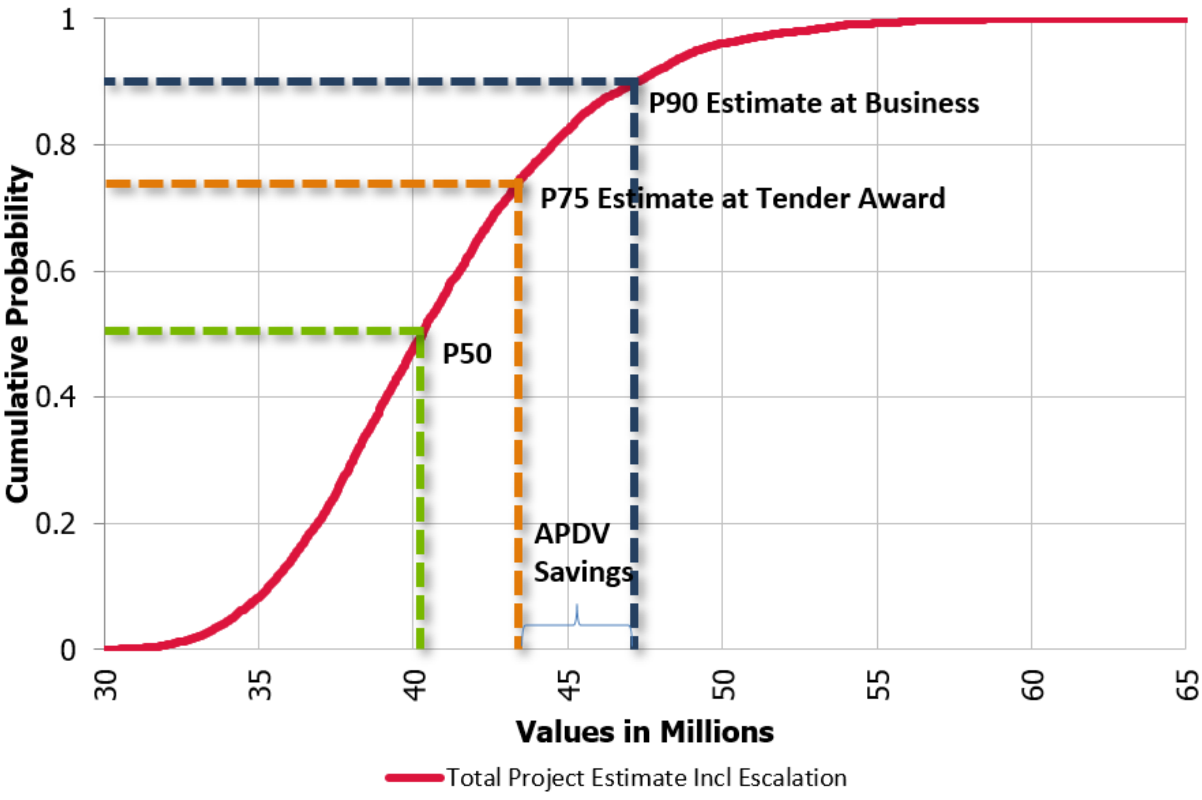
The APDV process reviews and validates the costs required to deliver the project to its agreed scope. It also considers the remaining risks and associated contingency and escalation to enable successful delivery. The APDV process is conducted at the time of awarding the main contract and at all significant milestones for long duration projects.

Once the APDV process is complete, it assists by identifying any potential savings on the approved budget. Such monies should be returned to the program budget for reinvestment.

The APDV process applies to all projects greater than $25 million, except the projects that are funded under the following investment programs:

- local government grants
- corridor preservation
- MPE
- RO
- Natural Disaster Program, and
- Transport System Planning Program.

Figure 11(c) – Approved Project Delivery Value process in contingency savings



The project savings identified through this process, are the difference between business case funding (P90) and the APDV at the tender award (P75) as shown in Figure 11(c).

As the project flows through development phase, three other key estimates are created as follows:

- S1D
- S2D, and
- EFCT.

The key outputs of the development phase are the S2D estimate and tender documents.

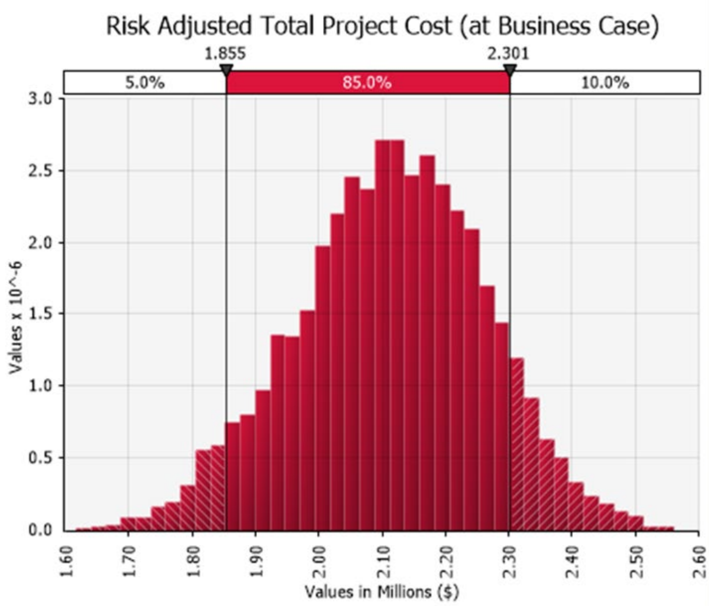
The EFCT, upon acceptance of a tender, informs the construction estimate. Once the EFCT is prepared, it needs running through the Monte Carlo model again to calculate the P75 value at the tender stage. The P75 value will then be compared with the P90 cost estimate prepared at the concept phase to develop the business case budget.

The difference of these two estimates is reported as project savings.

To understand the APDV savings calculation process, refer to the following example.

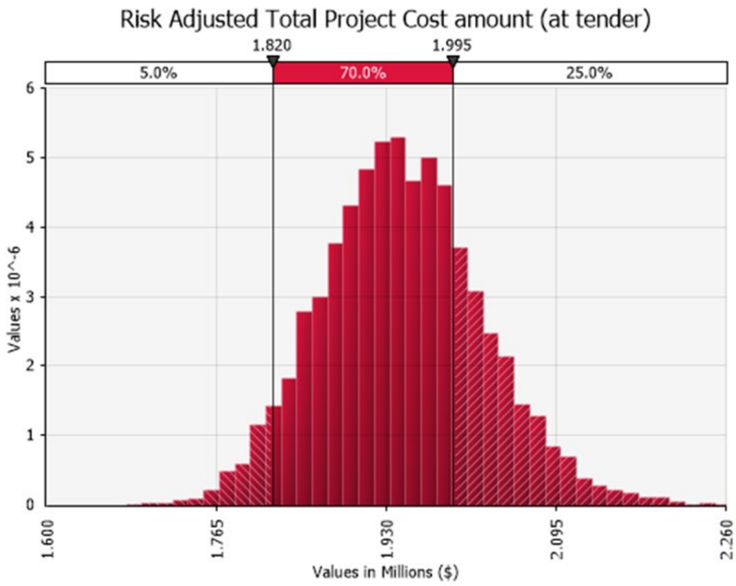
> Figure 11(d) and Figure 11(e) show two outputs created from the Monte Carlo model, run for the same project at business case and the tender award stages. Both model outputs provide histograms for estimate values at 5% confidence levels from 5% to 95%.
>
> In Figure 11(d), the P90 value, at the business case milestone, is calculated by the Monte Carlo model at $2,301,268.
>
> Figure 11(e) is the Monte Carlo model output values for the same project at the tender award stage.
>
> Note that the project evolved through the project life cycle when it reached the tender award stage: hence, the model inputs also get updated at this stage.

Figure 11(d) – Risk adjusted P90 estimate at business case milestone



Statistics	Risk Adjusted Total ...
5%	$1,854,769.24
10%	$1,916,015.42
20%	$1,990,444.15
25%	$2,016,176.26
30%	$2,038,921.01
35%	$2,059,481.17
40%	$2,079,938.07
45%	$2,099,928.04
50%	$2,117,280.16
55%	$2,136,325.97
60%	$2,157,410.18
65%	$2,176,360.40
70%	$2,195,894.96
75%	$2,217,482.78
80%	$2,240,685.70
90%	$2,301,268.08
95%	$2,349,417.94
97.5%	$2,391,926.80
99%	$2,444,028.50

Figure 11(e) – Risk adjusted P75 estimate at tender award



Statistics	Risk Adjusted Total ...
5%	$1,820,057.21
10%	$1,847,649.84
20%	$1,879,724.56
25%	$1,892,118.10
30%	$1,904,066.35
35%	$1,914,128.48
40%	$1,924,707.79
45%	$1,933,713.48
50%	$1,942,846.13
55%	$1,952,675.95
60%	$1,963,889.09
65%	$1,973,973.49
70%	$1,984,123.56
75%	$1,995,444.65
80%	$2,008,977.68
90%	$2,046,484.80
95%	$2,079,073.00
97.5%	$2,106,580.02
99%	$2,143,334.66

The P75 value is calculated by the model on the EFCT at the tender award stage, is $1,995,444: hence, the APDV savings for this project example is $2,301,268 - $1,995,444 = $305,824.

Further information about the APDV process can be obtained from the department's Program Control, Analysis and Reporting Contact Manager (Program Controls) team (email PCAR_Team@tmr.qld.gov.au).

12 Glossary of terms

Term	Definition
Activity	An element of work performed during a project. An activity normally has an expected duration, cost and resource requirement. Activities can be subdivided into tasks.
Approved project delivery value (APDV)	An APDV is the revised project budget at contract award.
Base estimate	The base estimate is the estimator's best prediction in terms of the quantities and current rates which are likely to be associated with the delivery of a given scope of work, prior to the addition of inherent and contingent risk values or escalation allowances.
Budget	The budget is the approved amount of funding for a project. This may be different to the estimates throughout the project's life cycle.
Business case estimate	An estimate prepared during the concept phase of a project to support the project's business case.
Component	A definable part of a project, including stages of planning, design and construction that contribute to the total project cost.
Construction estimate	An estimate produced after acceptance of the successful tenderer just prior to the implementation phase.
Contingency	A financial reserve, included in the project's estimate, to offset uncertain or unpredictable factors relating to the delivery of project objectives. The amount of funds, budget, or time needed above the estimate to reduce the risk of overruns of project objectives to a level acceptable to the organisation. Budget within the cost baseline or performance measurement baseline that is allocated for identified risks that are accepted and for which contingent or mitigating responses are developed.
Correlation	Correlation is the parameter (or statistic) used to describe the degree to which two variables are related, or the degree to which one variable's probability distribution is related to another.
Cost estimating	The process of estimating the cost of the resources needed to complete project activities.
Development phase Stage 1 Design estimate (S1D)	The estimate of all components of a project prepared based on advanced design. It provides a check of the alignment between the project estimate and the approved scope / budget. It occurs immediately prior to S2D and is expressed in outturn dollars (formerly preliminary design).
Development phase Stage 2 design estimate (S2D)	The estimate of all components of a project prepared prior to calling of tenders for construction and based on final designs, construction specifications and project documentation. It is expressed in outturn dollars (formerly detailed design).
Detailed design estimate	See development phase Stage 2 design estimate.
Escalation	The anticipated increase in project costs over time as a result of various factors such as inflation, market conditions, supply constraints and project complexity.

Term	Definition
Estimate	A document that records the calculated cost prediction to undertake a specific amount of work. It is prepared in a systematic manner appropriate to the size and complexity of the work and to a level of accuracy commensurate with available information and the intended use of the information developed. It may include some prior expenditure.
Estimated final cost	The estimated cost to deliver a project in current dollars
Estimate for comparison with tenders (EFCT)	The estimate prepared at the tender stage to assess tender bids. This estimate only considers contract scope, not the whole project.
Estimate probability	Ensuring that estimates have been prepared as prescribed and in accordance with the requirements and appropriate ranges for the different project phases and stages – being P50, P75 or P90.
Estimated cost	The total project cost is the sum of the base estimate, plus contingency, plus escalation, expressed in P90 values. This is also referred to as the total outturn cost. See also total project cost.
Indirect costs	These are costs not directly attributable to work items. For construction activities, these costs include onsite overheads (such as site supervision) and offsite overheads (contractor's corporate / business costs). They are exclusive of the contractor's contingency and profit.
Margin (contractor)	An allowance that includes the contractor's corporate overheads and profit.
OnQ	The department's project management framework that provides direction and guidance for effective management and delivery of projects.
3PCM	Portfolio, Program, Project and Contract Management System (3PCM) is the system used by the department and is based on the Oracle Primavera suite of products, which incorporates Oracle Primavera Portfolio Management (OPPM), Oracle Primavera Unifier (Unifier) and Oracle Primavera P6 – EPPM (P6).
P50 estimate	An estimate with a 50% confidence level of not being exceeded at project completion, while not being overly conservative.
P90 estimate	An estimate with a 90% confidence level of not being exceeded at project completion, while not being overly conservative.
Pareto principle	Pareto principle, also known as the 80 / 20 rule, is a theory maintaining that 80% of the output from a given situation or system, is determined by 20% of the input.
Preliminary design estimate	See development phase Stage 1 design estimate.
Principal arranged insurance (PAI)	Principal arranged insurance, is insurance arranged by an agency representing a Principal to cover the agency, Principal, contractors, subcontractors and other service providers in respect of risks under contracts awarded by the Principal. The premiums are paid by the agency arranging the insurance.
Principal's costs	Principal's costs are those costs which the department incurs to conceptualise, develop, deliver and finalise a project. These may include community consultation, environmental assessment, design planning, services relocation, resumptions, accommodation, site investigations, Principal-supplied material and so on.
Probabilistic estimating	A method of generating estimates which takes into consideration that quantities measured (or allowed for) can change, rates assumed can vary and risk with a probable outcome can materialise.

Term	Definition
Program	A group of related projects managed in a coordinated way to obtain benefits and control and not available from managing them individually.
Program manager	The person responsible for leading and managing a group of projects. The program manager interacts with each project manager to provide support and guidance on individual projects.
Program of works	The planned durations for performing activities and the planned dates for reaching milestones.
Project	A temporary endeavour undertaken to create a unique product, service, or result. Projects have a clearly-defined scope, start and end time, a structured set of activities and tasks, a budget and a specified business case.
Project manager	The person responsible for managing a project and achieving its objectives. Manages all activities necessary to deliver the project, or services, to the required quality standard and within time and cost constraints.
Project life cycle	All the activities necessary for a project throughout its life, from beginning to end, normally dissected into several sequential phases. The generic project life cycle has five stages: they are, planning, concept, development, implementation and finalisation.
Qualitative risk analysis	The process of prioritising risk for subsequent analysis or action by assessing and combining probability of likelihood and impact. In regard to estimating and risk assessment, this approach draws upon the softer skills such as experience, asking stakeholders the right questions, decision making, problem solving and adopting a common-sense review by appropriate personnel and is more reliant on the project team's experience.
Quantitative risk analysis	The process of numerically analysing the effect on project objectives of identified risk. In regard to estimating and risk assessment, this approach draws upon the use of tools, techniques, templates, software, and the use of specialist risk estimating software, such as @Risk.
Queensland Transport and Roads Investment Program (QTRIP)	The program of works that the department produces and plans to deliver, over the upcoming four years.
Risk	A project risk is the effect of uncertainty on project objectives; the chance of something happening that will have an impact upon project objectives. Risk is measured in terms of consequences and likelihood.
Scope	Scope is the work that must be undertaken to deliver a product, service, or result with specified features and functions.
Scope creep	Increase in project scope not anticipated at the start of the project.
Stage	A logical construct to describe the division of work within a project phase.
Strategic estimate	A high-level estimate that supports the department's strategic road network planning processes and presented in current dollars.
Total project cost (current dollars)	The estimated total completion cost.
Uncertainty	Uncertainty represents unknown or ill-defined variables causing a loss or profit. The point is that the agency causing the loss or profit cannot be named.
Variation	Approved change to the scope of work

Annexure A – Deterministic contingency calculation tool

For an estimate with a 90% confidence level of not being exceeded on a road project					
Factor influencing the estimate	**Available information on which the scoping estimate is based**	**Confidence and reliability level**			**Adopted contingency (example only)**
		Highly confident & reliable	**Reasonably confident & reliable**	**Not confident & not reliable**	
Project scope	A set of well-defined project objectives and related performance criteria A design report (with all underlying assumptions and exclusions noted) A set of concept drawings (covering all physical scope and staging)	6%	7%	9%	7%
Risk identification	Identified significant risks (political, community, technical, financial) A detailed risk analysis A project delivery method	6%	7%	9%	9%
Constructability	A constructability, staging and construction access review A construction timetable (with appropriate start up and handover periods)	3%	4%	5%	4%
Key dates	A set of project dates (to enable outturn cost to be assessed) Timing of the construction phase (for escalation assessment)	1%	2%	3%	2%
Site specific information	Sufficient and documented investigation for concept design (geotechnical, heritage, environmental, technical, hydraulic) Enabling works (adequately identified and allowed in the estimate)	5%	6%	9%	9%
Project interfaces	External interfaces (identified and defined in terms of scope, access and risk) Project assessment (extended or short site and greenfield / brownfield)	3%	4%	5%	4%
Total contingency percentage to be adopted for an estimate with a 90% confidence level of not being exceeded.					35%
Total contingency percentage to be adopted for an estimate with a 50% confidence level of not being exceeded (assessed to be 40% of the contingency percentage for a 90% confidence level of not being exceeded).					14%

Annexure B – Example Transport and Main Roads risk assessment and ratings matrix

CONSEQUENCE LEVELS	RISK DIMENSIONS									LIKELIHOOD LEVELS AND RISK RATINGS				
	Workplace Health and Safety	Time or Schedule Delay	Legal and Compliance	Assets, Operations and Services	Performance and Capability	Historical and Indigenous Heritage	Environmental	Media and Reputation	Financial	Rare	Unlikely	Possible	Likely	Almost Certain
										0-5%	6-30%	31-60%	61-90%	>91%
										This event may have happened previously in TMR or 'like' organisations. Not expected to occur in TMR in the foreseeable future.	The event has occurred infrequently in TMR or 'like' organisations. Occurrence in TMR would be considered highly unusual.	This event may have occurred occasionally in TMR or 'like' organisations. Distinct possibility of occurrence.	This event may have occurred in TMR or 'like' organisations on a regular basis. Occurrence within the financial year.	This event occurs frequently within TMR.
										WH&S - Once in five to ten years. The event may occur only in very exceptional circumstances.	WH&S - Once in one to five years. The event could occur at some time but unlikely.	WH&S - Once per month to one year. The event will probably occur in some circumstances.	WH&S - Once per week to one month. The event will probably occur in most circumstances.	WH&S - Once per day to one week. The event is expected to occur in most circumstances.
Severe	Safety Fatality, or significant disabling injury/illness to one or more persons Health Significant prolonged health issues	> 20% delay	Significant litigation activities and fines with whole of department or government impacts May involve class actions Major breach (non-compliance) with regulation/legislation that requires parliamentary inquiry	Multiple system failure/damage resulting in prolonged service disruption. Significant/critical infrastructure assets are destroyed/are unusable for extended period Critical impact to transport system users over a wide geographic area with major effects lasting more than a month. Disruption to operations and product delivery for an indeterminate period	Multiple critical business services cannot be delivered Inability to source resources	Irreversible impact to heritage Significant breach of historical or indigenous cultural heritage legislation resulting in prosecution Breach of stop order, injunction or protection declaration resulting in significant financial and/or legal penalties. Potential for inquiry and widespread high level public concern Ministerial Intervention	Irreversible impact on the environment including ecosystems and air quality or community health impact that covers a wide area, or is of high intensity, and/or is difficult to contain. Irreversible impact to conservation areas or Endangered Vulnerable and Near Threatened species. Significant breach of legislation resulting in prosecution Potential for inquiry and widespread high level public concern Ministerial Intervention	Significant and prolonged adverse community impact (months) Prolonged negative media attention (months) Campaign for change through media Irreparable loss of community confidence in the organisation Cabinet/ Executive level/ Whole of Government/ Ministerial intervention	> 5% variance of budget or amounts in excess of $10 million Not recoverable for several years	**HIGH** (Workplace health and safety) **MEDIUM**	**HIGH**	**HIGH**	**EXTREME**	**EXTREME**
Major	<u>Safety</u> 1 Considerable irreversible injury/illness to one or more persons 2 Serious reversible injury/illness to one or more persons <u>Health</u> Progressive chronic condition, serious health issues	11% - 20% delay	Litigation and undertakings requiring significant dedicated time by legal counsel to address liability and consequences Litigation or policy that may set a precedent or adversely impact reputation Major breach (non-compliance) with legislation, regulation, policy, or contract/agreement	Multiple system failure/damage Significant/critical assets are destroyed/are unusable for a determinate period, possibly weeks or months Significant impact to transport system users over a wide geographic area with major effects lasting a week or more. Disruption to operations and product delivery is able to be rectified but may take up to 6 months	Critical business service cannot be delivered Major changes in activities and resource allocation	Major breach of stop order injunction or protection declaration Notification of application for state ministerial stop order injunction or similar Significant decline in stakeholder relationship which results in requests for mediation (e.g. traditional owners) or DG intervention Major non-compliance with indigenous cultural heritage process and legislation	Medium to long-term impact on the environment including ecosystems and air quality or community health impact that requires specific specialist actions to contain Major breach of environmental legislation (including restoration orders) Potential for high level public concern in a regional area D-G Intervention	Considerable adverse community impact and concerns (weeks) Significant negative media attention (weeks) Significant loss of community confidence in the organisation	3% - 5% variance of budget or amounts in excess of $5 million Not recoverable within current or next financial year	**MEDIUM**	**MEDIUM**	**HIGH**	**HIGH**	**EXTREME**
Moderate	<u>Safety</u> 1. Moderate irreversible injury/illness to one or more persons 2. Reversible injury/illness to one or more persons resulting in time lost and/or restricted duties <u>Health</u> Acute short term health issues	6% - 10% delay	Serious issue requiring investigation and advice into legal liability and impacts Litigation requiring moderate dedicated time by legal counsel with limited adverse impact Non-compliance with legislation, regulation, policy or contract/agreement	Equipment replacement/repair Non-critical assets are destroyed/ unusable for a determinate period, possibly days or weeks Assets stolen or destroyed Disruption to operations and product delivery can be rectified over a 3 month period Moderate impact to transport system users over a wide geographic area with effects lasting up to a day or major impacts to specific users for prolonged periods	Multiple business services cannot be delivered. Requires hiring external or building internal capability	Formal interview regarding a breach and / or formal / informal investigation by external authorities Decline in stakeholder relationship (e.g. traditional owners)	Temporary impact on the environment where the impacts are on a medium scale Breach of or non-compliance with environmental legislation Potential for moderate public concern	Widespread community impacts and concerns (days) Significant negative media attention (days) Loss of community confidence in the organisation The impact will be of major interest to a number of external groups	1% < 3% variance of budget or amounts in excess of $1million Not recoverable within the current financial year	**LOW**	**MEDIUM**	**MEDIUM**	**HIGH**	**HIGH**
Minor	**Safety** Reversible injury/illness to one or more persons requiring medical treatment, but does not result in time lost or restricted duties **Health** Unresolved minor health issues	1% - 5% delay	Legal issues are able to be managed with legal advice Minor non-compliance with legislation, regulation, policy, or contract/agreement	Component level replacement or repair Non-critical assets are unavailable or unusable for a short period, possibly hours or days Moderate impact to transport system users over a restricted geographic area with effects lasting up to a day or moderate impacts to specific users for prolonged periods. Disruption to operations and product delivery can be rectified within one month with existing staff	Business service delivery impacted Can be rectified with existing staff and by review of existing procedures	Minor non-compliance with cultural or historical heritage process Unresolved breach of Cultural Heritage Management Plan or the TMR Cultural Heritage Process Manual which result in requests for mediation or compensation	Short-term impact on the environment limited to a small area and can be rectified using an existing process Non-compliance with environmental legislation not resulting in environmental harm but with minor potential environmental impact e.g. environmental nuisance	Local community impacts and concerns Occasional once off negative media attention Loss of confidence in organisation is easily restored The impact will be of interest to small localised external groups	0.5% <1% variance of budget Recoverable within current financial year	**LOW**	**LOW**	**MEDIUM**	**MEDIUM**	**MEDIUM**
Insignificant	<u>Safety</u> Injury/illness requiring first-aid treatment at most <u>Health</u> Treatable health issues	< 1% delay	Issues are able to be managed by routine procedures Does not affect compliance with legislation, regulation, policy, or contract/agreement	Minimal damage Non-critical assets are unavailable/unusable but can be replaced within acceptable timeframes Minimal impact to transport system users over a restricted geographic area with effects lasting up to a few hours or minimal impacts to specific users for prolonged periods. Minimal impact on operations or product delivery	Minimal impact on business service delivery Can be rectified with existing staff	Minimal or reversible effect on historical or indigenous cultural heritage. Minimal action required for management or containment Administrative breach of legislation that could not be anticipated or prevented with no harm to historical or indigenous cultural heritage.	Minimal short-term effect on the environment Minor to no action required for management or containment Administrative breach of legislation that could not be anticipated or prevented with no environmental harm	Individual concerns Minimal media attention No interest to external groups	< 0.5% variance of budget Recoverable within current quarter or month	**LOW**	**LOW**	**LOW**	**MEDIUM**	**MEDIUM**

Please note: Inputs to the risk matrix (likelihood and consequence) and resulting output (risk rating) require subjective interpretation. If a calculated risk rating appears to be too high or too low, you should exercise your local knowledge and discretion.

Annexure C – A typical risk workshop agenda format

Pre-workshop

- establish and agree on workshop objectives
- determine if external facilitator is required
- undertake a pre-workshop risk analysis
- identify key stakeholder participants (construction, environmental, public utility plant, design teams and so on)
- prepare and issue the workshop agenda to the stakeholders, and
- allow ample time to go through entire risk register.

Risk workshop structure

- introduction
- key requirements, project scope and objectives
- project cost estimate, key assumptions and exclusions, and
- project schedule, key dates.

Outline of the brainstorming process and expected deliverables

- generic risks
- planned risks / unplanned risks
- risk owners, and
- review of risks and elimination of duplicate or insignificant risks.

Risk ranking and quantifying

- agree on risk ranking methodology and how to score risks
- ranking of risks
- identify 'Red' risks, and
- determine 'Pareto Risks' on large projects.

Agree on treatment options and costs

- develop options and agree for treatment of 'Red' risks
- develop options and agree on options for treatment of other risks
- identify timescales and short-term action required for treatment, and
- add risk treatment costs in the cost estimate.

Annexure D – Example: An extract from *the Notes on Administration for Land Transport Infrastructure Projects 2019–2024*

J. ATTACHMENTS

This section is where information that was used to help complete the PPR will be attached as Appendices.

If a Business Case (including strategic or preliminary Business Cases) or Options Analysis was undertaken on the Project the Department requires a copy be attached to the PPR.

J1 Supporting Information

Supporting information should only include documents that have been referred to in the body of the PPR, for example:

- *GIS data;*
- *Photographs;*
- *Locality and/or topographical plans and maps;*
- *Demand forecasts;*
- *Safety audits;*
- *Historical crash statistics;*
- *Engineering plans;*
- *Environmental, cultural and social studies;*
- *Risk assessment reports;*
- *Other descriptive information.*

Documents in relation to cost estimates that must be provided include:

- *Completed Project Cost Breakdown spreadsheet;*
- *Cost Estimate Report explaining how the cost estimate was developed, which must include:*
  - *background and context for the Project;*
  - *outline scope for the Project;*
  - *details of the risk workshop/s undertaken, and subject matter experts consulted;*
  - *copy of the Risk Register underpinning the contingency included in the Project costings (where a probabilistic cost estimation process has been used this will be the source of much of the Cost Estimation Tool risk input data);*
  - *details of the person/firm preparing the cost estimate; and*
  - *evidence that Project costs have been comprehensively reviewed and authorised in accordance with the Proponent's published guidelines.*

For projects equal to or over $25 million in total Outturn Cost or where a probabilistic cost estimation process has been used, the following information must be provided:

- *Cost Estimation Tool (for example, @RISK and Crystal Ball) Output Report files, which must at a minimum include charts showing the non-Outturned Project Cost probability distribution and associated cumulative probability distribution ('S' Curve), Simulation Summary Details (that is, sampling type, number of iterations, Random Number Generator a Tornado diagram and accompanying Regression and Rank Information Table, and Summary Statistics for the Project Cost, including the Project cost estimate (unescalated) at 5 per cent intervals from 5 per cent to 95 per cent confidence).*
- *Cost Estimation Tool input data files in spreadsheet format that includes sufficient information to permit the Department or its contractors to re-run the probabilistic cost estimation simulation.*
- *Bibliography of all documents consulted by the cost estimator in preparing the cost estimate (including version number/date, proper title, document format and author). Note: It is a requirement that the Proponent maintains a digital library of all documents consulted in preparing the cost estimate.*

  Projects with cost estimates prepared using a deterministic estimation process must provide, when requested:

- *Underpinning documentation explaining the derivation of the Base Estimate and the approximate P50 and P90 values (both Non-Outturned and Outturned).*