

M4 Junction 18a Link Road, Strategic OBC

Quantitative Risk Assessment (QRA)

PREPARED FOR: HS
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PROJECT NUMBER:
REVISION NO.: Final QRA TN 2018 03 05

Introduction

A Quantitative Risk Assessment (QRA) was undertaken as part of the M4 Junction 18a Link Road Strategic Outline Business Case study. The purpose of the study is to develop and assess scheme options for link between the M4 and the A4174 Ring Road. This technical memorandum briefly outlines the risk identification (development of a risk register) and the QRA processes, and presents the QRA outputs.

The main purpose of the QRA is to support the scheme costing by predicting the level of risk contribution, having a defined level of confidence, to cover the construction of the scheme. QRA allows for uncertainty in unplanned additional cost items that cannot be included in the project costs.

A typical QRA process involves four steps.

Step 1 is the identification of all risks affecting the project, achieved through risk workshops and risk reviews resulting in a Risk Register. The Risk Register will be continually reviewed and updated.

Step 2 is analysis of the various risks by defining their distributions in terms of probabilities, impacts and knock-on effects. This information is also gathered through workshops and other interactions.

Step 3 is undertaking the risk modelling using Monte Carlo simulation. In this task CH2M standard methodology was followed which uses @Risk® software. The QRA model used standard CH2M templates and uses Microsoft Excel and @Risk® software packages. The model used the Monte-Carlo simulation theory by replicating 10,000 iterations of likely project risk scenarios. Confidence levels relating to the cost of the scheme are obtained from the distribution of the averaged results produced by the simulations.

Step 4 is analysing the results against required contingency needs for the project. At this stage a range of risk percentile values (p(x) values) are provided to enable an informed decision, with consideration given to any stakeholder requirements (e.g. DfT).

Risk Model Inputs

Risk Identification and Categorisation

The Risk Register (included in Appendix 2) was developed through a risk workshop. Quantitative risk assessments were made based on Highways England's standard risk matrices; these are shown below.

RIP Schemes >£200M (5% = Very High)

Rating	1	2	3	4	5
	Very Low	Low	Medium	High	Very High
Probability (%)	<5	5-20	21-50	51-75	>75
Cost (£)	<400K	400-1.9M	2-5M	5.1-20M	>20M
Time (wk)	<8	8-19	20-31	32-40	>40

Probability	Opportunities					Threats				
Very High 5	25	20	15	10	5	5	10	15	20	25
High 4	20	16	12	8	4	4	8	12	16	20
Medium 3	15	12	9	6	3	3	6	9	12	15
Low 2	10	8	6	4	2	2	4	6	8	10
Very Low 1	5	4	3	2	1	1	2	3	4	5
	5	4	3	2	1	1	2	3	4	5
	Very High	High	Medium	Low	Very Low	Very Low	Low	Medium	High	Very High
	Impact									

	Critical Opportunity
	High Opportunity
	Medium Opportunity
	Low Opportunity
	Critical Threat
	High Threat
	Medium Threat
	Low Threat

The risks that are input into the QRA are taken directly from the Risk Register. A total of 43 risks were initially identified, and reviewed through a risk workshop that identified 17 risks to include in the QRA. Each risk was assessed for its Financial Risk and Delay Risk as follows. The Highways England standard risk matrices shown above were considered in quantifying risks to use in the Monte Carlo Simulation.

Risk Quantification

The QRA was undertaken on the general Link Road project at a high level, without differentiating Western and Eastern options.

During the risk workshop, individual risks were quantified in terms of their distributions, likelihood/probabilities, impacts and knock-on effects, etc. For each risk, the key inputs recorded to use in the QRA model are; Cost Impact Estimate (Minimum, Maximum, and Likely), Delay Impact Estimate in months (Minimum, Maximum, and Likely), and Likelihood (in broad categories of Almost Certain, Likely, Possible, Unlikely, or Rare).

The cost of delay to construction programme is assumed £560,000 per month, irrespective of the preferred option (Western or Eastern), which has not been selected yet. This is an indicative cost of delay based on likely total preliminaries value of schemes of this scale. This value will be reviewed in further QRA reviews, and the confidence of this value will improve as the project progresses (i.e. option selection, investigations, design, etc.).

These values were then used in the model to determine a Mean Outcome and a Risk Exposure for each risk and for each iteration. The Monte Carlo simulation used 10,000 iterations, and this is expected to cover all (or most of all) possible risk outcomes that the project could result in. Confidence levels for total risk (percentile values) are obtained from the distribution of these results.

Risk Model Outputs

Risk Value

The table below shows the Grand Total Risk value (Financial + Delay) for the project; a screenshot of the @Risk output is included in Appendix 1.

Various Percentile risk values (i.e. P(x) values) are shown in the table below. Department for Transport WebTAG requirement is p(50), which was calculated as £37M.

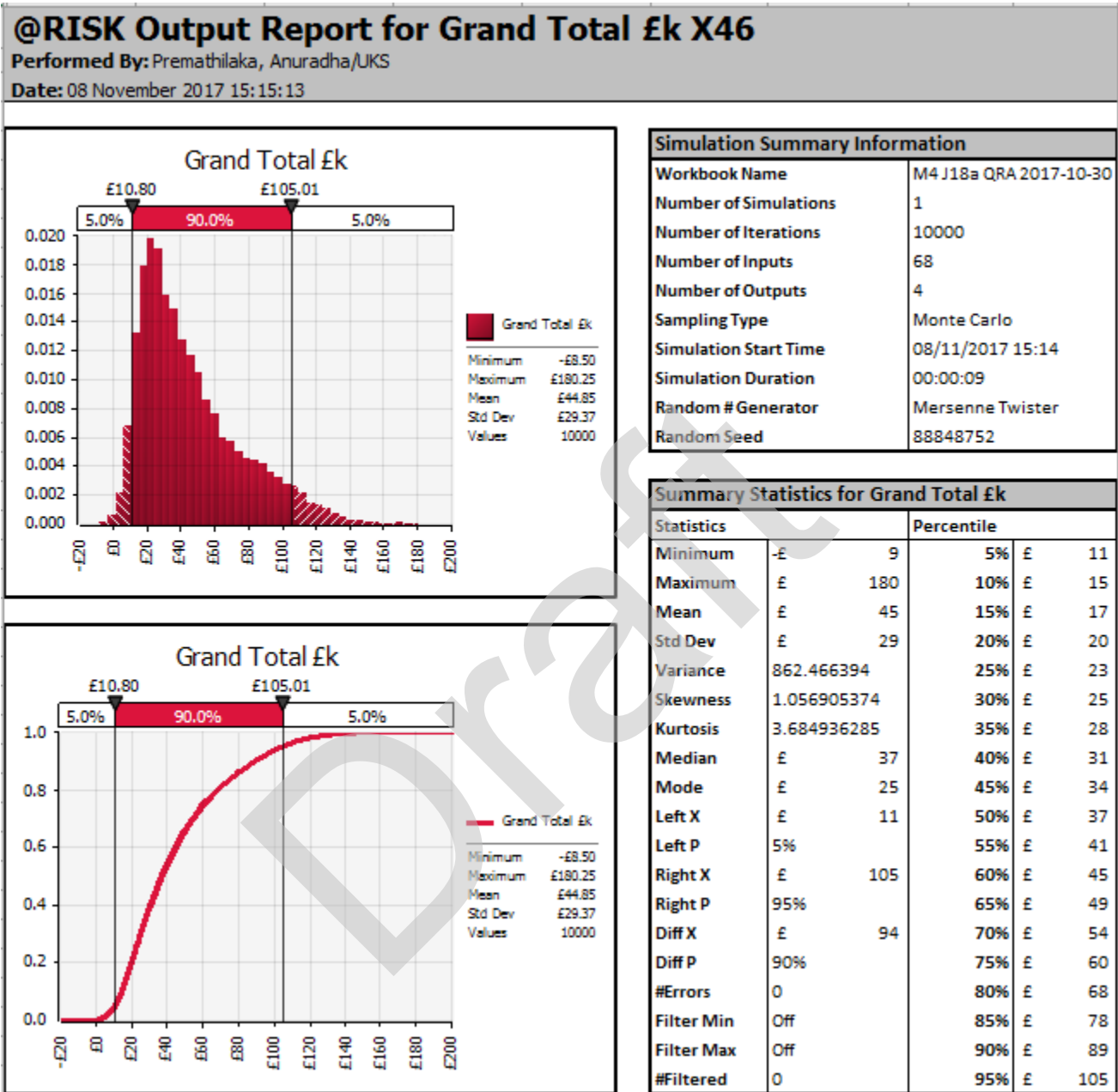
	P(30)	P(50)	P(80)	P(95)
Grand Total Risk (Financial + Delay)	£25M	£37M	£68M	£105M

Top 5 Risks

Out of the 17 risks quantified, the top 5 risks (Grand Total Risk for Financial + Delay) identified by the sensitivity testing are listed below.

Rank	Risk Ref	Description
1	Risk 17	Wider area impacts of the scheme exceed current modelled impacts and require additional improvements
2	Risk 36	Environmental legislation changes requiring significant design amendments
3	Risk 06	Risk of construction inflation being higher or lower than estimated value
4	Risk 05	Cost of statutory undertakers' diversions higher or lower than anticipated
5	Risk 26	Lack of resources (people, material, expertise, not funding) to progress the scheme

Appendix 1 – @Risk Output



Appendix 2 – Risk Register

Draft

Risk Register for M4 J18a Link Road Study

Rev: **DRAFT V0.1 - 10/2017**
 Scheme: M4 J18a Link Road Study
 Milestone: Strategic Outline Business Case
 Works Cost: To be determined

QRA Ref	Description	Category	Impact Commentary	Consequence to objectives "which would lead to"	Mitigation owner	Support	Risk Assessment					Proximity (date)	Approach Avoid, Accept, Reduce, Transfer	Mitigation Measures and Actions	DATE OF UPDATE	STATUS (Open/Closed/Not Active)	Residual Risk				
							Impact			Prob. Rating	Overall Threat Level						Cost	Time	Perf	Prob. Rating	Overall Threat Level
							Cost	Time	Perf												
Risk 05	Cost of statutory undertakers diversions higher or lower than anticipated	COSTS / FUNDING	Cost and delay caused by impact on major services (e.g. gas/oil pipelines)	Cost and time	Project Team		4	3	2	2	6.00		Avoid	Full engagement with major stats undertakers during design programme	01/03/2017	Open	3	2	2	2	4.00
Risk 06	Risk of Construction inflation being higher or lower than estimated value	COSTS / FUNDING	Additional costs		Project Team		5	1	2	4	12.00		Accept	Accept	01/03/2017	Open	5	1	2	4	12.00
Risk 07	Land inflation	COSTS / FUNDING	Additional costs		Project Team		4	1	2	3	6.00		Accept	Accept	01/03/2017	Open	4	1	2	3	6.00
Risk 17	Wider area impacts of the scheme exceeds current modelled impacts and require additional improvements	STRATEGIC / POLITICAL	Cost and delay		Project Team		5	3	5	3	12.00		Accept	Detailed technical design during full business case	01/03/2017	Open	3	2	4	2	6.00
Risk 20	Risk of delay to the DCO negotiations	ACCEPTABILITY / OBJECTION	Not going to secure all the land	Cost and time	Project Team		3	5	2	4	12.00		Reduce	Proactive engagement strategies developed to address land issues. Ensure resources are available.	01/03/2017	Open	2	2	2	2	4.00
Risk 21	Lack of stakeholder acceptance of Strategic OBC	ACCEPTABILITY / OBJECTION	Delay to project	Cost and time	Project Team		1	5	2	3	9.00		Reduce	Robust technical defence of proposals	01/03/2017	Open	1	3	2	2	4.00
Risk 22	Objection to scheme from environmental or other groups prior to DCO lead to delays and additional costs	ACCEPTABILITY / OBJECTION	Delay to project	Cost and time	Project Team		2	5	3	3	9.00		Reduce	Stakeholder engagement plan	01/03/2017	Open	2	5	2	2	6.00
Risk 26	Lack of resources (people, material, expertise, not funding) to progress the scheme	PROJECT MANAGEMENT	Additional costs		Project Team		4	3	4	2	8.00		Reduce	Programme management	01/03/2017	Open	4	2	2	2	6.00
Risk 28	Cost of drainage exceeds scheme cost allowance	DESIGN / CONSTRUCTION	Cost		Project Team		4	2	2	3	9.00		Accept	Detailed design phase will confirm drainage design	01/03/2017	Open	4	2	2	2	6.00
Risk 29	Risk of Part 1 and Part 2 Claims higher or lower than anticipated	DESIGN / CONSTRUCTION	Impact on cost		Project Team		4	1	2	3	6.00		Reduce	Put enhanced scheme designs in areas that are significantly impacted	01/03/2017	Open	4	1	1	3	6.00
Risk 30	Potential for direct action during construction	DESIGN / CONSTRUCTION	Cost and delay		Project Team		3	5	2	3	9.00		Avoid	Proactive security on all contracts, and early engagement	01/03/2017	Open	3	3	2	2	6.00
Risk 34	Contaminated land identified in key parts of route	ENVIRONMENT	Additional cost and delay		Project Team		4	5	2	3	12.00		Accept	Carry out full GI surveys along route to confirm/unconfirm contamination	01/03/2017	Open	2	2	2	2	4.00
Risk 35	Additional environmental mitigation required	ENVIRONMENT	Cost and delay		Project Team		4	5	2	3	12.00		Reduce	Timely environmental surveys and liaison with statutory bodies	01/03/2017	Open	3	5	2	2	6.00
Risk 36	Environmental legislation changes requiring significant design amendments	ENVIRONMENT	Cost and delay		Project Team		5	5	5	2	10.00		Accept	Accept	01/03/2017	Open	5	5	5	2	10.00
Risk 37	Potential of archaeological surveys (and finds), impacting on time, cost, route option	ENVIRONMENT	Cost and delay		Project Team		2	5	4	3	12.00		Accept	Carry out pre-screening where appropriate	01/03/2017	Open	2	5	4	2	8.00
Risk 38	Unforeseen ground conditions (e.g. unsurveyed mine workings)	ENVIRONMENT	Cost and delay		Project Team		3	3	3	3	9.00		Accept	Carry out full GI surveys along route to determine ground conditions, geo-physical / radar surveys	01/03/2017	Open	2	2	2	2	4.00
Risk 39	Additional costs due to discovery of UXO (unexploded ordnance)	ENVIRONMENT	Cost and delay		Project Team		3	3	3	3	9.00		Accept	Accept	01/03/2017	Open	3	3	3	3	9.00

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	5	4	3	2	1	5	4	3	2	1
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	Very High	High	Medium	Low	Very Low	Very Low	Low	Medium	High	Very High

Very High	Critical Opportunity
High	High Opportunity
Medium	Medium Opportunity
Low	Low Opportunity

Very High	Critical Threat
High	High Threat
Medium	Medium Threat
Low	Low Threat