Appendix 8J

Risk Assessment

December 2010

METROLINX

An agency of the Government of Ontario

APPENDIX 8J

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EXECUTIVE SUMMARY

The assessment of risk for the electrification study has been carried out as a parallel activity which has provided a process into which the stakeholders, client and team members have been able to raise relevant issues as a direct consequence of the projects' evolution or from prior experiences.

The collation and management of risks has been carried out over the course of the study period and has been regarded as a live project process. The risks that have been identified have been added or merged into a project risk matrix and scored and ranked in terms of likelihood of occurrence and consequence /impact. The purpose of this is to highlight a prioritisation of risks with the eventual goal of closing risks by providing reasonable mitigation /contingency or the transfer of the risk to another owner.

The identification of the risks within the project was carried out using a formal and proven process based on best practices and the experience of the joint venture team.

While mainly formal, the risk process was flexible to assist in guiding the project team in their decision making processes, encouraging traceability and ownership. The process not only acted as a catalyst for determining any hidden risks, but also helped in the elaboration, questioning and provision of answers as part of the mitigation process.

An added benefit of the formality was to encourage cross discipline understanding and wider effects of the risk allowing more immediate pinpointing of the highest priority risks associated with the project.

The final risk matrix allows auditors and future users an easier understanding of the issues and mitigations at the time of the study from which they can make further judgements, should circumstances alter or be revised.

The key objective was to provide Metrolinx, stakeholders and the public some degree of assurance that fundamental issues have been addressed and assessed, that there was an understanding of risk consequences and that there are suitable mitigations in place to minimise the impact o f the risks.

The final risk matrix has closed all risks with the exception of risks relating to capacity analysis and ongoing negotiations with stakeholders.

1. RISK PROCESS FOR ELECTRIFICATION STUDY

1.1. General

In any project there is always a degree of risk and while the key objective is to reduce these no project can fully eliminate all risks. However, with careful assessment the risk can be reduced from unacceptable to tolerable levels taking into account the effects of socio-economic factors. This type of risk reduction is more commonly identified with the acronym ALARA (As low as Reasonably Achievable).

It is important to note that there is no one specific technique of risk assessment that fits all types of projects, however the process of risk assessment utilised the concepts of Chapman and Wards 'SHAMPU' Shape Harness and Manage Project Uncertainty to provide some confidence of an accepted evaluation process.

1.2. Definition

The ability of an internal or external influence to bring about a degree of uncertainty into the performance of the project or its intended outcome.

1.3. Objectives

A broad set of objectives were formalized to guide the risk assessment for the Electrification Study:

- To minimise risks to Metrolinx.
- Elaborate the major risks associated with electrification.
- Provide mitigation, knowledge of risks and/or minimisation.
- Prioritise future planning.
- Provide traceable records of decisions and actions.
- Provide a basis for continued risk assessment leading to project implementation.

1.4. Process

The identification of risk within the Electrification Study project has been carried out using a formal process based on best practices and our collective team experience. Figure 1 provides a graphical representation of the process flow.

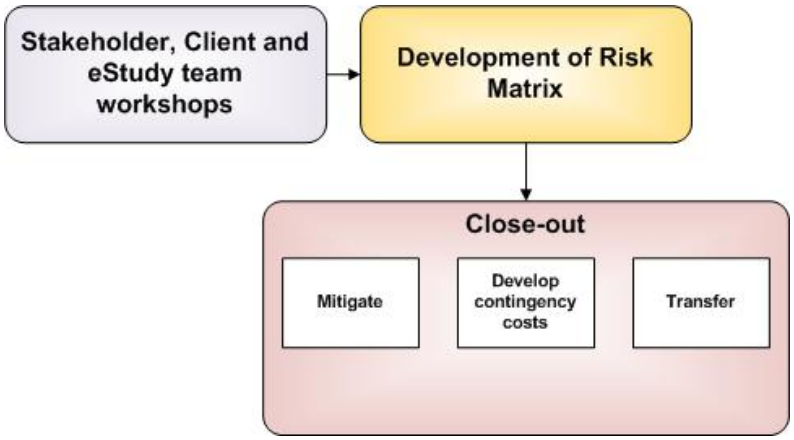

Figure 1 - Project Risk Process

The risk assessment broke down the study into a set of key elements and assessed the potential for minimising, transferring, reducing or removing risk to the Electrification Study. Along with ongoing input from team members, the study conducted a number of Risk workshops that allowed collective opinions to be recorded from the team, client and stakeholders.

Scope

While a number of internal Electrification Study project management risks (related to the study) were identified at the beginning of the risk assessment process, these were removed and mitigated as part of the internal JV team processes. The populated risk matrix represents risk associated with the implementation of an electrification scheme in the GTHA.

1.5. Methodology

Level 1 Categorization

In order to manage risks these are first sorted into a set of generic categories. While the categorization of risks can be contentious with some of the risks span two or more categories, the primary objective is to ensure that most risks are captured regardless of the categorization. If an incorrect becomes more obvious as the risk is elaborated then it can be modified to suit.

The initial risk categorization was structured under the following categories.

- Infrastructure
- Power
- Operations
- Government
- Human/Social
- Financial
- Safety
- Project
- Technical
- Vehicle

- Stakeholder
- Image and reputation

Each of the risks under the category headings shall be assessed with a score representing the probability of likelihood /occurrence and the magnitude of consequence /impact as shown below. Five being 'Almost certain' or 'Catastrophic' and one being 'rare' or 'insignificant':

Probability of Likelihood/ Occurance		
	Almost certain	5
	Likely	4
	Possible	3
	Unlikely	2
	Rare	1
Magnitude of consequence /impact		
	Catastrophic	5
	Major	4
	Moderate	3
	Minor	2
	Insignificant	1

Table 1 - Likelihood / Impact scores

The product of the likelihood and consequence scores provides a value whose magnitude allowed the risk assessment to rank and prioritise risks.

For example: A risk whose likelihood/occurrence was almost certain and the magnitude of consequence/impact was catastrophic would score 25 on the table below. This scoring of 25 would rank the risk as Extreme (see table 2) and would require action to reduce its likelihood or impact to the study.

	Severity				
Likelihood	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

	Severity				
Likelihood	1	2	3	4	5
5	Medium	High	High	Extreme	Extreme
4	Medium	Medium	High	Extreme	Extreme
3	Low	Medium	High	High	High
2	Low	Medium	Medium	Medium	High
1	Low	Low	Low	Medium	Medium

Table 2 - Scoring Matrix

As guidance to assist risk management the following sub categories were provided to the Level 1 categories to further breakdown the risks.

Level 2 Categorization

This list was not intentionally exhaustive but served to illustrate the level of detail necessary to understand the potential degree of complexity associated with the Level 1 categories.

Infrastructure

- Stations
- Track
- Bridges
- Signalling
- Maintenance and storage facility
- Crossings

Power

- Capacity
- Availability
- Redundancy
- Consumption
- Energy source

Operations

- Management structure
- Capability
- Maintenance
- Adaptability
- Complexity
- Adoption
- Training
- Personnel

Government

- Policy
- Personalities
- Regulatory
- Law and legal

Human /Social

- Noise
- Vibration
- Light
- Electromagnetic
- Contamination
- Natural habitats
- Archaeological

Financial

- Funding
- Cost

Safety

- Process
- Regulatory
- Emergency planning

Project

- Adoption
- Risk Management
- Stakeholders

Technical

- Feasibility
- Timescale
- Fit for purpose
- Interaction
- Adoption

Vehicle

- Diesel Locomotive
- Electric Locomotive
- FRA compliancy
- ARL Vehicle

Image and reputation

- Other study integration
- Public awareness
- Communication

Stakeholders

- CN
- CP
- Metrolinx
- Emergency services
- Metrolinx
- Hydro
- OPG
- Public
- VIA

2. DISTRIBUTION OF RISKS

Over the course of the Electrification Study, the risk matrix has been populated with a number of different risks associated with the proposed electrification scheme.

Figure 2 below provides a quick representation of the distribution of risks by category. The percentages do not imply any particular bias but merely indicate the nature of the risks identified as the Electrification Study evolved. However, the number of risks attached to a particular category may assist further in carrying out targeted analyses to supplement the risk data generated by the Electrification Study.

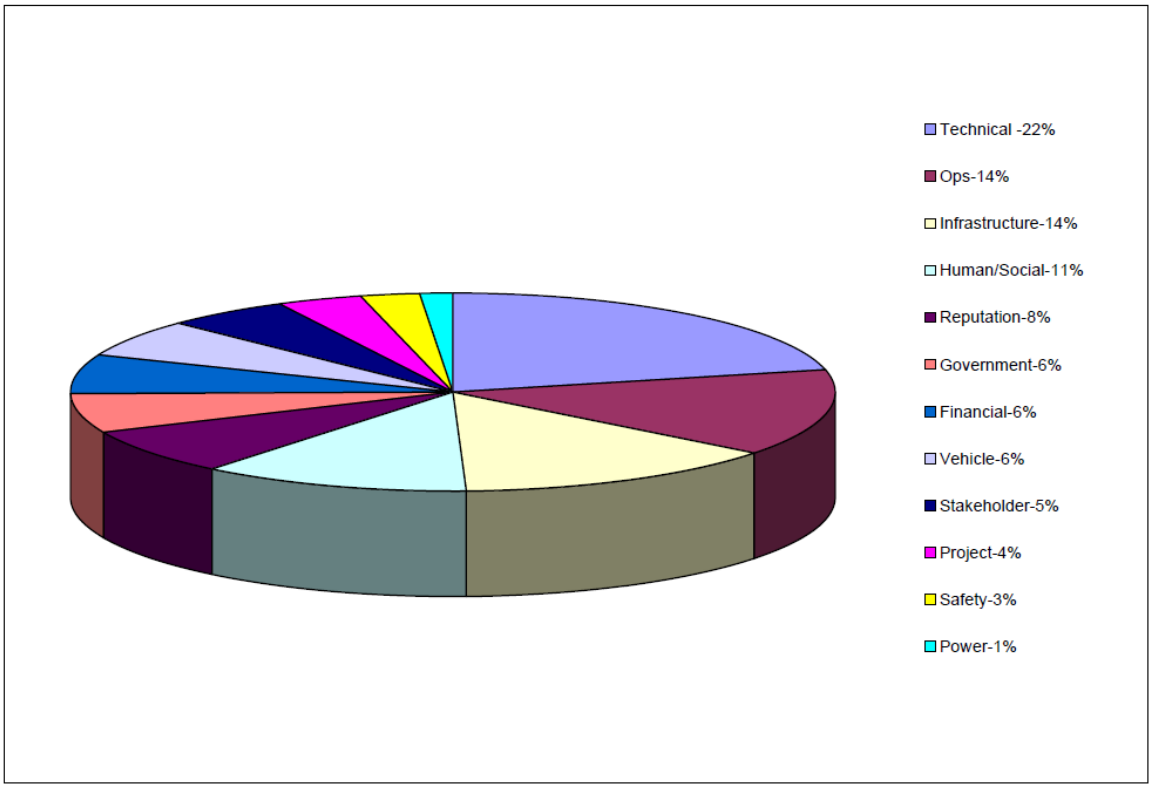

Figure 2 - Distribution of Risks

The risk matrix provides a chronological list of risks as they were identified. A number of risks have been marked N/A (not applicable). These have been marked as such in places where duplicate risks have eventually been identified or they have been more applicable to the Electrification Study internal project process which has been handled by the Electrification Study quality system. So as not to resequence the risk I.D's, the rows have been maintained in the matrix.

Figure 3 below provides a visual interpretation of the risk factors calculated for the perceived risks.

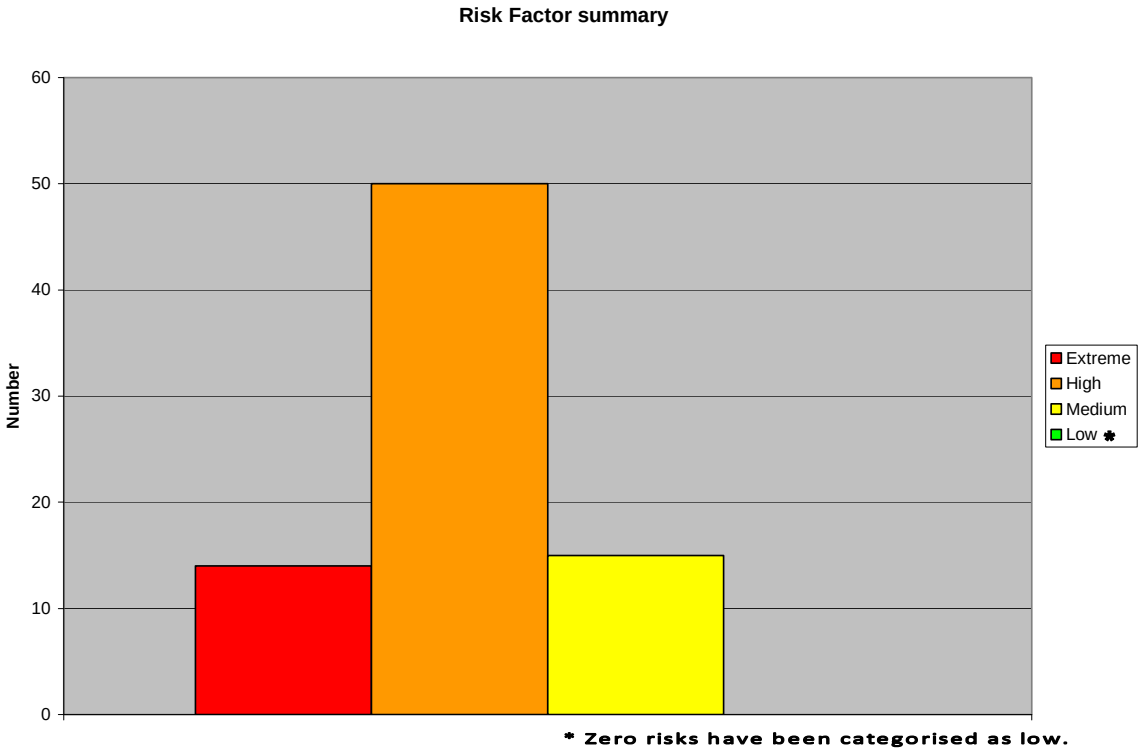

Figure 3 - Risk Factor Grouping

3. RISKS THAT REQUIRE MITIGATION OUTSIDE THE STUDY

Of the total risks identified there are a number which require mitigation outside of the Electrification Study:

3.1. Capacity Analysis Related Risks

Three risks will require to be transferred to the ongoing capacity analysis, as these are more applicable to variations in the capacity scenarios.

These are:

- **RSK_ID_026 – Capacity is beyond the limit of existing infrastructure**. Capacity analysis study will be required to determine the network bottlenecks and capacity limitations.
- **RSK_ID_061 – Assumptions that reference case is operable/ deliverable are not valid.** The Electrification Study has assumed capacity for reference case is deliverable, however the evaluation of the Union station rail corridor will require to be carried out to confirm.
- **RSK_ID_072 – Future population /employment areas change**. The long term capacity needs of each corridor will be as a direct result of local planning opportunities and the promotion of growth centres. The capacity study will

need to assess maximum corridor capacity needs and correlate the findings with the conclusions of this study.

3.2. Risks Related to Ongoing Negotiations with Stakeholders

Two risks are specific to discussions with stakeholders which will require ongoing negotiations:

- **RSK_ID_080 – Height clearance unacceptable to CN/CP**; Metrolinx will require to conduct discussions with CN/CP over agreements for height clearances along the chosen corridors.
- **RSK_ID_042 – East-West Lakeshore shared with high speed rail affects network design and power consumption**; Ongoing consultation between Metrolinx and the Ontario Ministry of Transportation (MTO) will be required to ascertain the scope of the high speed rail project.

3.3. Risks Related to Future Considerations

Four major risks have been identified, which are dealt with separately under 'Future considerations' later in this section, while these are considered closed their outcome may impact future decision making.

These are listed and described below.

- RSK_ID_038 – Choice of Technology does not stimulate ridership.
- RSK_ID_042 – East-West lakeshore shared with high speed rail affects network design and power consumption.
- RSK_ID_045 – Few if any 'Big Move' objectives are attained.
- RSK_ID_057 – Accuracy of demand forecasts.

(RSK_ID_038) – Choice of Technology does not stimulate ridership

There is little evidence that a particular type of rail technology is a primary factor in stimulating ridership. Anecdotal evidence suggests that electric vehicles may be more acceptable to passengers over diesel. However there are certainly secondary factors which have a large contribution to commuter acceptance and the ability to stimulate ridership all of which could be adequately provided, in varying degrees, by both forms of propulsion:

- Reliability;
- Frequency of operation and timeliness;
- Accessibility;
- Fares;
- Customer Information;
- Customer care and ambience;
- Comfort ; and
- Safety and Security.

Unlike other new railways which tend to have completely new corridors and vehicles. The GO corridors are already established and GTHA passengers of the GO network have already accepted travel within double-decker coaches. In essence the commuters will only experience significant changes in the type of locomotive used and which is perceived to provide improved journey times and reliability.

(RSK_ID_042) – East-West lakeshore shared with high speed rail affects network design and power consumption

At the time of writing the high speed rail study conceptual document was not available for analysis. The high speed rail study has the potential of impacting some of the existing GO transit corridors particularly Lakeshore- East and Lakeshore-West. To reduce the potential impact we have made certain assumptions in advance of the high speed rail study data becoming available.

The data is currently not adequate to perceive any impact of the operation of high speed trains in these corridors on the findings of the Electrification Study findings. Conceptually it is possible that the proposed new high speed trains will share the tracks with some of the GO Transit corridors, possibly Lakeshore East and Lakeshore West into and out of Union Station. This has the potential of increasing the electrical power demand depending upon the number and type of high speed trains and in particular if the new trains will travel in the peak time traffic, or off-peak traffic. If the new high speed trains operate outside of the peak time, the power requirements may be less. It should be noted that there is some additional power capability along the Lakeshore, but will require to be verified when the new high speed train data is published.

The maximum 'track' limit of the GO corridor is considered to be 125mph (201 km/h). The design speed of the catenary for the GO corridor has some additional design margin and is based on the standard designs followed by DeutscheBahn where the Re 200 train design is considered suitable for speeds up to 143mph (230 km/h).

Due to lack of data, the Electrification Study has not modelled the additional high speed rail traffic in the GO corridors and this should be a further work task. The Electrification Study has assumed that any high speed trains will not be permitted to go very fast alongside the Lakeshore corridor when the vehicles intermingle with the slower GO trains, this has a benefit of reducing overall power demand of the high speed train to that comparable to the GO electric locomotive.

(RSK_ID_045) – Few if any 'Big Move' objectives are attained

The Electrification Study has considered a number of 'Big Move' objectives in its decision making. As the 'Big Move' objectives are more encompassing strategic targets for Metrolinx the options presented for the electrification of the corridors are just one facet of a much broader strategy within the GTHA. As such some but not all objectives have been met by the available corridor options.

(RSK_ID_057) – Accuracy of demand forecasts

The ridership forecasts are a fundamental component of the transportation impact analysis because electric trains offer journey time benefits to passengers, and the more passengers who use the service, the greater the transportation benefits. This in turn affects the transportation Benefit Cost Ratio, a key measure for cost effectiveness of electrification.

The Reference Case ridership forecasts were provided to the Study team by Metrolinx and are based on a number of assumptions that represent the transit environment in the next 20 years, including land use and population changes, the provision of the public transit network and other factors which influence the use of private automobiles. Clearly there will be uncertainties in forecasting future ridership. However, given that the current levels of ridership are fairly well established, the likely range of forecasts would be less than, say, a brand new rail line.

Within the Study, sensitivity tests have been undertaken to illustrate the change in BCR's for each option if the ridership demand range was +/-20% of the forecasts employed in the main evaluation so that the key impacts on cost effectiveness can be understood.

In addition, there are steps that Metrolinx could take to manage the risk of having insufficient riders to deliver the level of transit benefits estimated in the Study. These could include:

- A commercial (fare) strategy which promotes the use of transit, particularly during off-peak periods where capacity is ample;
- The improvement of access to GO Rail stations (such as timetable co-ordinated bus feeder services, additional park and ride capacity); or
- Marketing or Smarter choice initiatives, which aim to inform the local communities the advantages of GO Transit.

3.4. Specific Corridor Risks

Of the remainder, with the exception of (**RSK_ID_076**) **– 'The width restrictions for the Richmond Hill line'** and (**RSK_ID_089) – 'Conversion of ARL DMU to EMU disrupts service and schedule'**, all risks were generic and equally applicable to all corridors at this level of study. Appendix 8J-1 provides the risk matrix which details further explanation of the risk mitigation, transfers and close-out.

3.5. Additional Detailed Risk Discussion

In addition some further explanation has been added to a small number of risks which are more pertinent to the public interface and which could not be addressed by single line entries in the risk matrix.

3.5.1. (RSK_ID_010) Increased risk of electrocution and (RSK_ID_011) - Dewirement at road /rail interface and public areas

Electrocution through contact

Electrocution through deliberate or accidental contact is an obvious risk associated with electrification. The planned high potentials of the catenary wire can cause high levels of current to pass through a body to ground, resulting in potential injury to human health. The close proximity of the infrastructure to public places will require attention to segregation and, where necessary, improvements for minimising potential contact.

Full or partial electrification brings increased exposure alongside the line and may emanate from two key areas that are not easily mitigated:

- Deliberate contact – Climbing of portals and live catenaries.
- Accidental contact – Encroachment in close proximity to wire (i.e. on top of high-sided trucks), movement of ladders, flying of kites and holding helium-filled metallised balloons in station areas.

Electrocution through equipment failure

Two further areas of electrocution which have mitigation but which are still prevalent on a working electrified line:

- Failed infrastructure – A live conductor falling to ground, protected by circuit breaker but requires detection and public awareness if a circuit breaker does not trip.
- Electrical breakdown – A gradual degradation of equipment insulation which can permit stray currents to flow in conductive material and is normally mitigated by a thorough maintenance and testing scheme.

These new risks therefore place increased responsibilities on Metrolinx to ensure that the:

- Public are warned of the higher risks involved.
- Public are knowledgeable of who to contact and what procedures to follow in the event of an emergency.
- The emergency services are trained and can respond in an appropriate manner.
- The public are informed of how their conduct around the line must be modified to compensate for the higher risks associated with electrification.
- Staff and maintainers are educated to deal with any emergencies.
- Staff and maintainers are educated with the increased safety and maintenance awareness associated with electrification.

Prevention of electrocution through the limitation of accessibility

- ***Fencing and prevention of intrusion***

Grounded fencing in proximity to the track provides a two-fold barrier of protection, in that it serves to prevent unlawful intrusion into the track area, but also as the fencing is grounded it also serves as a method of providing a fault circuit back to the traction supply breaker to assist in tripping the supply should the catenary fail and touch or come in close proximity to the fence.

Fencing also acts as a deterrent for the public who may use the track as an unofficial path and who would be subjected to increased risk of higher speed and more frequent trains running in the corridor. The placement of fencing is fairly extensive in the GTHA corridors and the suburbs are likely to be the only areas where strategic segregation from public areas is required. Moreover if the track bed is placed in a cutting or on a raised embankment these tend not to require extensive fencing as the geography already provide some degree of segregation. However each situation must be judged on its merit and potential risks to the public.

- ***Un-official paths***

The residents in the GTHA currently have the benefit of a number of unofficial paths across the track. With fencing installed these paths will no longer be accessible and will cause some frustration to the path user. Experiences in Europe tend to require additional laws and penalties and their enforcement to ensure the unofficial paths are not re-instated and to maximise public safety.

- ***Official paths***

Official paths such as pedestrian and road crossings can be areas in which the public have a greater degree of exposure to risk; this is more likely to be at a road crossing where a high-sided vehicle could contact the catenary. The use of CCTV in both cases may help to provide early detection of infrastructure failure.

3.5.2. (RSK_ID_012)- Power failure and redundancy, Recovery of unpowered vehicles and (RSK_ID_027) -Single point power failure on rail network

A power failure may occur from four possible system scenarios:

- Pantograph to contact wire failure.
- Traction power substation transformer failure.
- Contact wire failure.
- Vehicle system failure.

Pantograph to contact wire failure

Despite the Pantograph being a well proven device, its location and exposure to elements outside of the vehicle body result in a harsh operational environment. In some instances poor maintenance or stray branches from nearby trees can cause premature failure or poor operation resulting in loss of current from the contact wire, which in turn leads to the vehicle becoming stranded. In the event of using a single locomotive, its is normal practice to support a dual redundant pantograph which under normal operational duty remains retracted and which can be deployed in situations where the working pantograph becomes inoperable. Figure 4 below shows a typical dual redundant pantograph system.

Figure 4 - Electric Locomotive

Traction power substation transformer failure

The conceptual design has utilised dual redundant AC Transformers in the traction power substation to provide mitigation in the event of a single AC supply failure. In the event a single transformer or subsystems fail the design detects the failure and can switch to the redundant transformer. Each Traction power substation will be designed with redundant incoming HV feeds, such that in the event of a main supply feed to the dual redundant transformers an alternative high voltage supply can be maintained.

Contact wire failure

The contact wire is considered the weaker link of the power transmission system. Its exposure to high and low temperatures, continuous wear and the possibility of being in contact with other

items requires that the catenary is continually inspected and maintained to ensure maximum operational reliability.

In the event the wire fails either through breakage or associated mounting failure, the locomotive will remain stranded and unpowered in the failed electrical section. To mitigate this, a recovery plan will require to be created which requires that:

- A response team to isolate the electrical system /vehicle and make safe.
- A diesel switcher is available to tow or push the stranded vehicle into a powered electrical section, or if possible another electric locomotive; providing power can be maintained.
- Additional fleet capacity to support a spare vehicle and coaches if de-training of passengers is required.
- A track design which can accommodate bi-directional running and crossovers to gain access to the stranded vehicles and access to powered sections if electrical locomotives are to be used for recovery.

Vehicle system failure

A suitable mitigation for vehicle failure is regular maintenance with strategic replacement of parts at predefined service intervals. In the event of vehicle failure, normal recovery principles should apply with the use of alternative Locomotive or switcher to remove the failed vehicle from service. In circumstances where passengers are potentially exposed to extreme high and low temperatures with no climate control, the recovery plan should ensure that the vehicle removal is rapid and as efficient as possible to ensure that passengers are not exposed to injurious internal temperature changes.

3.5.3. (RSK_ID_022) - Electromagnetic radiation disturbs non-railway equipment in close proximity to line and (RSK_ID_025) - EMI/EMF affects human health

Disturbance to non-railway equipment

Equipment which is placed in close proximity to the track areas and overhead lines is vulnerable to the effects of Electro Magnetic Interference (EMI) as a direct result of the high level of traction current within the overhead power infrastructure and vehicles.

These risks generally emanate from:

- Harmonics due to inverter switching.
- Broadband noise due to arcing at the contact wire /pantograph interface.
- Large magnetic fields.
- Harmonics caused in the incoming AC supply.
- Large electric and magnetic fields at 60Hz.

The new electrification scheme may also utilise new equipment and subsystems which can introduce a new set of risks, mainly from:

- Communications systems, cable and radio-based equipment.
- Revised signalling equipment.
- New train-borne equipment.
- Power control systems /SCADA.

The conceptual design report elaborates on the types of electromagnetic coupling and the methodologies of managing this. However while trackside equipment is easily accessible and available to be modified to improve EMC, an additional risk is the proximity of commercial and residential equipment to the new electrified line; which is harder to modify , but also determine the mechanism and complexity of potential interference sources.

The conceptual design has therefore been based on proven electrification design practices and is known to have minimal impact at the trackside and surrounding environment. Nevertheless to mitigate any potential neighbourhood conflicts, it is suggested that an early local analysis of the surrounding electromagnetic environment and frequency spectrum would provide a basis of comparison and a minimisation of risk in advance of the installation of the electrification system onto the corridors.

EMI/EMF affects Health

The electromagnetic field surrounding high voltage wires is a known physical phenomenon; the conceptual design report provides a detailed summary on known limits of exposure and acceptability. Similar to the intensity of light, the physical properties of the electromagnetic field diminishes at a rate determined by the inverse square law such that the height and horizontal distance between the overhead lines and objects located in close proximity, serve to reduce the field strengths and potential human exposure. With respect to the coaches, while passengers and Metrolinx personnel within the car body can be located closer to the high voltage equipment, they also have the benefit of a grounded metallic enclosure which serves to attenuate higher electric fields to acceptable exposure limits. These too can be measured and appropriate design accommodations can be made.

Other areas of potential exposure are the traction power supplies and HV feeders. At this conceptual stage the placement of supplies has considered the locality to neighbourhoods and has provided as great a distance from potentially sensitive areas. The HV supply will either be fed from underground wires or overhead pylon in accordance with municipal, provincial and national electrical codes.

APPENDIX 8J-1 RISK MATRIX

Identity	Category Description	Date raised	Raised by	Comment	Contingency /Mitigation	Probability of Likelihood/ Occurance	Magnitude of consequence /impact	Probability/ likelihood	Severity/ Impact	Risk Factor	Action Y/N	Closed /Contingency
RSK_ID_001	Government	04/01/2010	GW (Delcan)	Project direction altered by government change or involvement	Regular briefing of government stakeholders	Unlikely	Moderate	2	3	6	N	Closed - High level briefings conducted by Metrolinx
RSK_ID_002	Government	04/01/2010	GW (Delcan)	Changes to federal, provincial and municipal law regarding environment	Evaluate forthcoming provincial and federal obligations and determine timelines	Possible	Moderate	3	3	9	N	Closed - Bill 150 (Clean energy act) has the biggest impact but has improved the EA process.
RSK_ID_003	Operations	04/01/2010	GW (Delcan)	Commuter, Freight, ARL and VIA traffic cannot be mixed if not designed to FRA standards	Ensure that vehicles are designed to FRA crashworthiness, lines can be fully segregated, temporally separated or use PTC system.	Unlikely	Major	2	4	8	N	Closed- Also applicable to reference case also.
RSK_ID_004	Stakeholder	21/07/2010	Metrolinx	Negotiations with stakeholders inconclusive or no decision reached.	Establish meeting venues and timescales	Likely	Major	4	4	16	N	Closed- Stakeholders and public have been consulted and comments duly noted.
RSK_ID_005	Vehicle	21/07/2010	Metrolinx	Tier 4 Rolling stock unavailable	Confidence from Manufacturers of Tier 4 Research and development	Possible	Major	3	4	12	N	performance evaluated as part of reference case.Tier 4 will be available.
RSK_ID_006	Human/ Social	21/07/2010	Metrolinx	Human health impacted	Evaluate WHO guidelines, limits and levels	Unlikely	Major	2	4	8	N	have been evaluated in study next to corridors
RSK_ID_007	Infrastructure	21/07/2010	Metrolinx	Land Acquisition required	Detail land areas and difficulty of acquisition	Possible	Moderate	3	3	9	N	Closed - Land acquisition figures and indicative figures provided in report.
RSK_ID_008	Technical	21/07/2010	Metrolinx	Widespread Signalling immunisation required	Determine the ElectroMagnetic Compatibility (EMC) risks	Possible	Moderate	3	3	9	N	Closed - This has been vvaluated as part of conceptual design report and appropriate cost contingency added.
RSK_ID_009	Safety	21/07/2010	Metrolinx	Increased risk of collisions at R.O.W.s and crossings	Determine quantity, location and impact.	Possible	Catastrophic	3	5	15	N	Closed - Risk not dependent on electrification and is the same as that of the reference case.

Identity	Category Description	Date raised	Raised by	Comment	Contingency /Mitigation	Probability of Likelihood/ Occurance	Magnitude of consequence /impact	Probability/ likelihood	Severity/ Impact	Risk Factor	Action Y/N	Closed /Contingency
RSK_ID_010	Safety	21/07/2010	Metrolinx	Increased risk of electrocution	Determine strategy /methodology of minimising effects. Analyse Living areas.	Likely	Catastrophic	4	5	20	N	Closed - Public awareness campaign, signage, restriction of public access, training of personnel. Safety ethos change
RSK_ID_011	Operations	21/07/2010	Metrolinx	Dewirement of catenary at Road rail interface and public areas.	Determine O&M policy, training and public awareness campaign	Almost certain	Major	5	4	20	N	Closed - Public awareness campaign, signage, restriction of public access, training of personnel. Safety ethos change
RSK_ID_012	Power	21/07/2010	Metrolinx	Power failure and redundancy, recovery of unpowered vehicles.	Determine strategy /methodology of minimising effects. Assess fleet failure bottlenecks i.e Willowbrook and develop alternative vehicle stabling strategy.	Almost certain	Major	5	4	20	N	Closed - New operational policy will be required. Some diesel fleet required for recovery.
RSK_ID_013	Technical	04/01/2010	GW (Delcan)	Information unavailable□/inaccurate	Peer review with Metrolinx and confirm, accuracy	Possible	Moderate	3	3	9	N	Closed - Regular briefings and consultation with Metrolinx have taken place over the study period
RSK_ID_014	Reputation	04/01/2010	GW (Delcan)	Impact of E-Study decisions not communicated	Ensure accurate reporting to Lura, determine key issues and communication ideas	Unlikely	Minor	2	2	4	N	Closed- This has been through the public consultations provided in the study.
RSK_ID_015	Technical	21/07/2010	Metrolinx	Equipment cannot operate in climate	Ensure specification/choice/ performance of equipment can operate in extremes of temperature	Unlikely	Moderate	2	3	6	N	Closed- This will be dealt with by new operating policy and appropriate specification.
RSK_ID_016	Project	04/01/2010	GW (Delcan)	Entrenched ideas	Regular communications to stakeholders and Metrolinx	Possible	Moderate	3	3	9	N	Closed - Regular briefings and consultation with Metrolinx and stakeholders have taken place over the study period
RSK_ID_017				N/A	N/A					0	N	N/A
RSK_ID_018				N/A	N/A					0	N	N/A

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RSK_ID_019	Project	04/01/2010	GW (Delcan)	Poor risk management fails to detect major risk	Ensure regular meetings and close out. Continuous management and assessment	Possible	Moderate	3	3	9	N	Closed - Risk matrix is ongoing live document into which multiple parties have placed comments. Each risk requires suitable mitigation or transfer to close
RSK_ID_020	Technical	04/01/2010	GW (Delcan)	Cost/benefits not adequately determined	Ensure that costs and benefits can be quantified or qualified	Possible	Major	3	4	12	N	Closed - Cost benefit analysis included in final report
RSK_ID_021				N/A	N/A					0	N	N/A
RSK_ID_022	Technical	21/07/2010	Team	Electromagnetic radiation disturbs non-railway equipment in close proximity to line	Carry out EMC risk assessment and analysis of living areas	Likely	Minor	4	2	8	N	Closed - Risk assessment and costs evaluated. Appropriate contingencies added.
RSK_ID_023	Human/ Social	04/01/2010	GW (Delcan)	Choice of technology worsens environment	Ensure choices provide net benefits to environment	Possible	Moderate	3	3	9	N	Closed - Filtering process has selected technologies that have a overall net benefit.
RSK_ID_024	Human/ Social	04/01/2010	GW (Delcan)	Noise and vibration increased	Limits imposed on N&V in line with WHO and legislation	Possible	Moderate	3	3	9	N	Closed - Levels have been evaluated in study
RSK_ID_025	Human/ Social	04/01/2010	GW (Delcan)	EMI/EMF affects human health	Limits imposed on EMF in line with WHO and legislation. Assess potential exposure rates and health effects	Possible	Major	3	4	12	N	Closed - Levels have been evaluated in study
RSK_ID_026	Operations	04/01/2010	GW (Delcan)	Capacity required is beyond limit of infrastructure	Determine bottlenecks at early stage to assist analysis	Possible	Major	3	4	12	Y	Transfer to Capacity study analysis
RSK_ID_027	Operations	04/01/2010	GW (Delcan)	Single point power failure on rail network	System failure modes to be explored	Possible	Moderate	3	3	9	N	Closed - The Failure modes evaluated as part of conceptual electrical design and suitable redundancy built in.

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RSK_ID_028	Financial	04/01/2010	GW (Delcan)	Technology options do not provide desired economies	Ensure economic targets are evaluated	Possible	Moderate	3	3	9	N	Closed - Evaluated as part of the study filtering process
RSK_ID_029	Government	04/01/2010	GW (Delcan)	Environmental benefits not realised	All energy supply chain delivery analysed	Possible	Moderate	3	3	9	N	Closed - Evaluated as part of the study filtering process
RSK_ID_030	Financial	04/01/2010	GW (Delcan)	Significant energy price rise□/taxation	Analysis of fuel price sensitivity	Possible	Moderate	3	3	9	N	Closed - Evaluated as part of the conceptual design report.
RSK_ID_031				N/A	N/A					0	N	N/A
RSK_ID_032				N/A	N/A					0	N	N/A
RSK_ID_033	Operations	04/01/2010	GW (Delcan)	Inadequate power capacity	Assessment of power	Unlikely	Major	2	4	8	N	Closed - OPA have confirmed adequate capacity will be available.
RSK_ID_034	Operations	04/01/2010	GW (Delcan)	Inadequately trained staff	Resource availability	Likely	Major	4	4	16	N	Closed - Metrolinx aware of changes to operational needs.
RSK_ID_035	Operations	04/01/2010	GW (Delcan)	Operational requirements changes	New operation plans	Likely	Moderate	4	3	12	N	Closed - Metrolinx aware of changes to operational needs.
RSK_ID_036	Operations	04/01/2010	GW (Delcan)	Reluctance for safety ethos change	Revised training plan	Likely	Moderate	4	3	12	N	Closed - Metrolinx are aware of changes to operational needs and revised training schedule.
RSK_ID_037	Technical	04/01/2010	GW (Delcan)	Electrical clearances insufficient	Determine risk areas	Almost certain	Major	5	4	20	N	Closed - Risk of higher than assumed vertical clearance has been considered through Monte Carlo and contingency analyses.
RSK_ID_038	Government	04/01/2010	GW (Delcan)	Choice of technology does not stimulate ridership		Rare	Major	1	4	4	N	Closed- See Appendix 9-I
RSK_ID_039	Stakeholders	08/04/2012	GW (Delcan)	Union members affected	Liaise with Unions	Likely	Major	4	4	16	N	Closed - Metrolinx aware of required union negotiations.

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RSK_ID_040	Technical	08/04/2012	GW (Delcan)	Technology too complex	Filtering ensures viable technologies are selected	Possible	Major	3	4	12	N	Closed - Evaluated in study. Options have preferred trusted and mature approaches.
RSK_ID_041	Technical	13/04/2010	RW (Arup)	Grounding modifications to infrastructure	Assess modifications	Likely	Moderate	4	3	12	N	Closed - Modifications assessed and cost contingency added based on expected alterations to infrastructure
RSK_ID_042	Operations	13/04/2010	GW (Delcan)	East- West lakeshore shared with high speed rail and affects network design and power consumption	Consult with MTO	Possible	Major	3	4	12	Y	See Appendix 9-I- Transferred to Metrolinx as ongoing discussions
RSK_ID_043				N/A	N/A					0	N	N/A
RSK_ID_044	Technical	27/04/2010	RB (Delcan)	Vehicle kinematic envelope does not fit in existing alignment	Establish generic worst case envelope for vehicle	Possible	Major	3	4	12	N	Closed - GO standard vehicle envelope used as worst case
RSK_ID_045	Reputation	11/05/2010	GW (Delcan)	Few if any Big move objectives are attained	Ensure Key objectives are traced to the final report	Possible	Moderate	3	3	9	N	Closed - See Appendix 9-I
RSK_ID_046	Project	27/05/2010	AC (RWDI)	Stakeholder expectations regarding environmental assessments for air, quality noise, human health impacts are beyond the scope of this project.	Discuss with stakeholders the primary focus of the project.	Likely	Moderate	4	3	12	N	Closed - Analysis has determined limits for air quality, noise and human health
RSK_ID_047	Technical	18/05/2010	KKA (LTK)	Non-availability of Primary Power Supply	Consult with Electricty Supplier	Unlikely	Major	2	4	8	N	Closed - Backup capacity is adequate to provide power in the event of primary failure (Source OPA)
RSK_ID_048	Technical	18/05/2010	KKA (LTK)	Decrease in Availability of Electricity in Future	Consult with Electricty Supplier	Unlikely	Major	2	4	8	N	Closed - This is an unlikely scenario given the ongoing demand forecasts
RSK_ID_049	Technical	18/05/2010	KKA (LTK)	Electricity Cost May Go Up	Consult with Electricty Supplier	Likely	Minor	4	2	8	N	Closed - Sensitivity of the cost of electricity evaluated in study
RSK_ID_050	Technical	18/05/2010	KKA (LTK)	Use of Material likely to be prohibited, such as SF-6 gas for the switchgear	Equipment Selection and specification	Possible	Minor	3	2	6	N	Closed - SF6 not banned but alternatives exist.

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RSK_ID_051				N/A	N/A					0	N	N/A
RSK_ID_052	Financial	24/05/2010	JT (SDG)	Reliability issues with new rolling stock	Include reliability targets in the supplier contract and have financial incentives for the supplier to deliver a reliable train from the offset. Explore the possibility of a pre-series or prototype to test on the GO network in advance of constructing the main train order.	Possible	Moderate	3	3	9	N	Closed - Electrical vehicles provide improved reliability above reference case
RSK_ID_053	Financial	24/05/2010	JT (SDG)	Operating subsidy budget requirements	There is a risk that if the operating subsidy could not be met, the level of service may have to be reduced and the benefits of any new technology would be compromised.	Possible	Moderate	3	3	9	N	Closed - Evaluated within sensitivity and scenario tests
RSK_ID_054	Reputation	24/05/2010	JT (SDG)	Integration with other major Metrolinx studies; Study assumptions and objectives may not be consistent or coherent, undermining the value of the Study.	Cross-project communication facilitated by Metrolinx; where possible seek to incorporate issues in the final report as they emerge.	Possible	Minor	3	2	6	N	Closed - Metrolinx is acting as intermediary between parallel projects.
RSK_ID_055				N/A	N/A					0	N	N/A
RSK_ID_056				N/A	N/A					0	N	N/A
RSK_ID_057	Technical	24/05/2010	JT (SDG)	Accuracy of Demand Forecasts	Where different demand forecasts may influence the business case, we undertake "what-if" sensitivity tests (such as demand +/- 20%) on the demand levels to understand how the performance of each option may differ.	Possible	Moderate	3	3	9	Y	See Appendix 9-I
RSK_ID_058	Technical	24/05/2010	JT (SDG)	Cost Inflation Assumptions	Review inflation assumptions with Metrolinx and benchmark against other sources for energy cost inflation. Undertake sensitivity tests to explore the implications on the performance of each option.	Possible	Moderate	3	3	9	N	Closed - Rates of inflation applied to cost estimates

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RSK_ID_059	Technical	24/05/2010	JT (SDG)	Option Pre-Screening Criteria not comprehensive	Review screening criteria with Metrolinx and team, review options that have been screened out and apply sense checks to see if likely options have been included.	Possible	Major	3	4	12	N	Closed - Discussions with stakeholders, metrolinx and public have determined key criteria.
RSK_ID_060	Reputation	24/05/2010	JT (SDG)	Passenger Disruption During Construction	Provide a clear assessment on the likely passenger disbenefits during construction, and make recommendations to Metrolinx on how the disbenefits could be minimized through information provision and replacement bus services.	Likely	Major	4	4	16	N	Closed - This has been assessed as part of construction phasing
RSK_ID_061	Reputation	24/05/2010	JT (SDG)	Assumptions that Reference Case is Operable/Deliverable are not valid	Undertake a high level scenario test to examine the performance of the detailed options assuming that a lower level of service is operated on the GO network.	Possible	Major	3	4	12	Y	Study has assumed capacity for reference case can be delivered. Capacity analysis at USRC will be transferred to the Capacity study analysis
RSK_ID_062	Operations	21/07/2010	JT (SDG)	New technology introduction disrupts service	Develop phasing strategy that permits a degraded service with supplementary transit service	Likely	Major	4	4	16	N	Closed - This has been assessed as part of construction phasing
RSK_ID_063				N/A	N/A					0	N	N/A
RSK_ID_064	Human/Social	21/07/2010	Team	Use of Tier 4 diesels impacts health	Assess potential exposure rates and health effects	Likely	Moderate	4	3	12	N	Closed- Reference case emissions assessed
RSK_ID_065	Human/Social	21/07/2010	Team	Catenary has large visual impact in sensitive areas	Develop visual mitigation concepts	Likely	Moderate	4	3	12	N	Closed - Visual intrusion mitigated at preliminary design with techniques such as strategic tree planting.

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RSK_ID_066	Infrastructure	21/07/2010	Team	Electrification induces increased development which cannot be supported locally (parking requirements, local highway congestion etc)	Assess local planning impacts	Likely	Major	4	4	16	N	Closed - Development as a result of electrification will be managed as part of long term city planning and not part of the electrification study.
RSK_ID_067	Human/Social	21/07/2010	Team	Electrification requires increase in fares	Assess effects on fare costs	Possible	Moderate	3	3	9	N	Closed - Metrolinx are able to re-evaluate fares to compensate for any corridor improvements. The benefits of electrification; higher frequency of operation and faster journey times may assist in helping passengers accept a higher fare structure. The final report includes a commentary to this effect.
RSK_ID_068	Government	21/07/2010	Team	Low Canadian content in electrification solution	Assess manufacturers products.	Likely	Moderate	4	3	12	N	Closed - Concept design and vehicle technology choice does not preclude manufacturers.
RSK_ID_069	Reputation	21/07/2010	Team	Public awareness of health and safety issues inadequate	Educate and inform through Public meetings and campaigns	Unlikely	Major	2	4	8	Y	Closed - Metrolinx aware of responsibility of public health and safety.
RSK_ID_070	Human/Social	21/07/2010	Team	Electrification solution produces higher noise levels.	Assess likely noise levels.	Possible	Moderate	3	3	9	N	Closed - Noise evaluation limits detailed in report
RSK_ID_071	Infrastructure	21/07/2010	Team	Widespread constructional activity places high demand on workers and inflates wage costs	Assess workplace pool and qualifications	Likely	Major	4	4	16	N	Closed - Assessed as part of a Monte Carlo analysis.

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RSK_ID_072	Human/Social	21/07/2010	Team	Future population /employment areas change	Assess long term planning for region	Possible	Moderate	3	3	9	Y	Closed - Transferred to Capacity Study. The long term capacity needs of each corridor will be as a direct result of local planning opportunities and the promotion of growth centres. The capacity study will need to assess maximum corridor capacity needs and correlate the findings with the conclusions of this study.
RSK_ID_073	Operations	21/07/2010	Team	Service level cannot be achieved with Tier 4 diesels	Evaluate service level at early stage	Possible	Major	3	4	12	N	Closed- service level determined as part of the reference case
RSK_ID_074	Vehicle	21/07/2010	Team	Dual mode not available in Tier 4	Discuss with manufacturers	Possible	Major	3	4	12	N	Closed- Tier 4 engine will be developed as a specific contract and present little technical risk
RSK_ID_075	Vehicle	21/07/2010	Team	Dual mode Tier 4 performance insufficient	Discuss with manufacturers	Possible	Major	3	4	12	N	Closed - Tier 4 power output available.
RSK_ID_076	Infrastructure	21/07/2010	Team	Richmond Hill line has insufficient width clearance	Mitigated by evaluating line and apportioning costs to line improvements.	Almost certain	Moderate	5	3	15	N	Closed - Evaluated as part of Richmond Hill line and appropriate cost contingency added.
RSK_ID_077	Infrastructure	29/09/2010	DB (Metrolinx)	Buried services and utility relocation required	Evaluate major services and utlities in proximity to the track	Likely	Moderate	4	3	12	N	Closed - Contingency for utility relocation within cost estimate
RSK_ID_078	Infrastructure	29/09/2010	DB (Metrolinx)	Trackside equipment space insufficent	Evaluate spatial envelopes to the side of the track	Likely	Major	4	4	16	N	Closed - Cost added to estimate + assessment of land values. $1000 dollar per square metre included.

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RSK_ID_079	Infrastructure	29/09/2010	DB (Metrolinx)	Road Bridge Modifications unacceptable to authorities	Determine modification areas required and discuss with authorised bodies.	Likely	Major	4	4	16	N	Closed - Road bridge costs assume safe modifications and design can be accommodated.
RSK_ID_080	Infrastructure	29/09/2010	DB (Metrolinx)	Height clearance unacceptable to CN/CP	Discuss with CN/CP the importance of setting the parameters	Possible	Major	3	4	12	Y	Closed - Transferred to Metrolinx - Ongoing discussions with CN/CP. C
RSK_ID_081	Stakeholders	29/09/2010	DB (Metrolinx)	GO owned corridor agreements with CN/CP inconclusive	Generate memorandum of understanding	Possible	Major	3	4	12	N	Closed- selection criteria for corridor considers corridor ownership
RSK_ID_082	Stakeholders	20/10/2010	BP (Metrolinx)	CN/ CP owned corridors fail to reach agreement for electrification	Generate memorandum of understanding	Almost certain	Major	5	4	20	N	Closed- selection criteria for corridor considers corridor ownership
RSK_ID_083	Technical	26/10/2010	GW (Delcan)	AC and DC grounding systems incompatible	Assess similar systems	Unlikely	Major	2	4	8	N	Closed - Affects 1) The parallel line which accommodates the existing SRT and GO line between Kennedy and Ellesmere Stations on the Stouffville line. 2) The parallel lines of the TTC subway and GO line at Kipling station on the Milton Line. Similar systems are running in Boston and Washington metro.
RSK_ID_084	Vehicle	28/10/2010	GW (Delcan)	Few FRA compliant electric loco manufacturers - less competition	Assess manufacturer availability	Possible	Moderate	3	3	9	N	Closed - FRA electric locomotive has been factored in and are available. These will require either temporal or track segregation.

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RSK_ID_085	Infrastructure	28/10/2010	GW (Delcan)	Additional signalling infrastructure required to support non FRA compliant electric locos	Additional contingency required	Possible	Moderate	3	3	9	N	Closed - FRA compliant locos that require no immediate signalling upgrades have been considered so as to match reference case
RSK_ID_086	Financial	28/10/2010	GW (Delcan)	Variation of copper prices	Additional contingency required	Likely	Moderate	4	3	12	N	Closed - Copper price fluctuations may result in small variability in OCS costs but as these are a small percentage of the overall electrification scheme and that 2010 copper prices are at a high level compared with the low price of 2002, this represents a lower risk to the project
RSK_ID_087	Infrastructure	28/10/2010	GW (Delcan)	Signal pole sighting	Resighting of poles requires cost contingency	Likely	Moderate	4	3	12	N	Closed - Signal heads already have cost allocated for clearance
RSK_ID_088	Infrastructure	28/10/2010	GW (Delcan)	Site access restrictions	Location or access prohibitive	Possible	Moderate	3	3	9	N	Closed - Assessed as part of land acquisition/values. Large items like traction transformers have adequate space around selected areas.

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RSK_ID_089	Vehicle	09/11/2010	GW (Delcan)	Conversion of ARL DMU to EMU disrupts service and schedule	Determine contingencies required to either provide additional fleet during conversion of DMU to EMU or ensure the DMU's can be updated over a longer period of time.	Possible	Moderate	3	3	9	N	The 35% contingency allocated to the cost of the conversion of the vehicle will compensate for costs involved with the disruption of the service. Leasing of vehicles to fill a gap is a possible solution. Difficult to assess at this stage, the DMU could certainly be designed to incorporate mountings for both DMU and EMU equipment.