2018-22
POWERLINK QUEENSLAND REVENUE PROPOSAL

APPENDIX 5.08

AMCL
Review of Powerlink's Risk and Prioritisation Approach

Delivering better value

A Report for
Powerlink
from
AMCL Pty Ltd

Version: 0.3
24th December 2015

Review of Powerlink's Risk and Prioritisation Approach

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APPROVAL				
Version	Date	Compiled by	Reviewed by	Authorised by
0.3	24th December 2015	G R Fuller	B Marshall	B Marshall
AMCL Pty Ltd File Ref: 313.005				

DISTRIBUTION			
Name	Controlled Doc. No.	From (version)	To (version)
1 copy of document each to:- Powerlink AMCL File Uncontrolled copies distributed as required	1	0.3	C
C = Current version			

AMENDMENT HISTORY		
Version	Sections	Amendment Details
0.1	All	Draft Submitted for Client Review
0.2	All	Revised Draft Submitted for Client Exec Review
0.3	All	Final

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REVIEW OF POWERLINK'S RISK AND PRIORITISATION APPROACH

This report has been prepared for Powerlink as an independent review of its Risk and Prioritisation approach.

This report has relied upon information provided by Powerlink and discussions with its staff. This information has been accepted as correct. This review has reviewed the approach outlined by Powerlink, but has not reviewed the correctness of the risk assessments or the calculations contained with the calculations spreadsheets. AMCL is therefore not representing the accuracy or appropriateness of the risk assessment outputs.

AMCL is one of the world's leading Asset Management consultancies. We have been supporting organisations from all over the globe along their journey to improve their Asset Management capabilities. We have offices in New York, Sydney and London and work with asset intensive organisations across many industry sectors.

As Patrons and founding members of the Institute of Asset Management (IAM), we are at the fore-front of the latest industry thinking and development. Staff from AMCL helped to finalise the formal industry standards for Asset Management - BSI PAS 55 and ISO55001 - and it is our conceptual model that forms the basis of the industry's leading practice, training and models.

AMCL endeavours to provide independent advice that is in the best interests of our clients as we are independently owned and we specialise in the field of Asset Management. Additionally, since we do not provide any engineering or construction services, nor do we have partnerships with any such companies, this clearly enables us to maintain this independence of approach.

AMCL is an accredited assessor under the IAM Endorsed Assessor Scheme which endorsers our staff to provide independent advice in the field of Asset Management. For each client engagement we ensure any advice provided is done so following our principles of Objectivity, Independence and Impartiality.

Yours sincerely,

Brenton C Marshall

Brenton Marshall, Director AMCL Pty Ltd

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Executive Summary

Powerlink Queensland is a Transmission Network Service Provider (TNSP) in the National Electricity Market (NEM) and owns, develops, operates and maintains Queensland's high voltage electricity transmission network. As part of its planning responsibilities, Powerlink undertakes an annual planning review of the capability of its transmission network to meet the forecast electricity demands, and the condition and emerging risks associated with the existing asset base.

Powerlink has developed a risk assessment methodology using quantified risk scores that are used to build a prioritised list of projects. The list forms the starting point of future investment needs on the network across a 10 year outlook.

Powerlink has demonstrated significant progress in the development of the Risk and Prioritisation methodology that aligns with industry leading practice risk management. The development of the risk assessment process has been based on sound Asset Management fundamentals. Although it is recognised that the approach has yet to be fully embedded into the organisation, the concept and methodology used in the Risk Assessment and Prioritisation process is considered to align with good industry practice.

AMCL has identified a number of opportunities for improvements to the risk management framework and prioritisation methodology, which are outlined in this report.

1 Introduction

Powerlink Queensland is a Transmission Network Service Provider (TNSP) in the National Electricity Market (NEM) and owns, develops, operates and maintains Queensland's high voltage electricity transmission network. It has also been appointed by the Queensland Government as the Jurisdictional Planning Body (JPB) responsible for transmission network planning for the national grid within the State. As part of its planning responsibilities, Powerlink undertakes an annual planning review of the capability of its transmission network to meet the forecast electricity demands, and the condition and emerging risks associated with the existing asset base.

In March of 2015 Powerlink invited AMCL to discuss the progress of development of Powerlink's Risk and Prioritisation methodology which underpin the development of their Asset Management Plan. Discussions were held in workshops with key asset management staff. AMCL provided feedback on the day as to possible improvements that could be made to help Powerlink focus their efforts as well providing some advice in mapping out some short and long term actions.

AMCL returned to Powerlink's offices in October 2015 to provide a review of the Risk and Prioritisation approach. This report contains the results of the review with the objective of establishing the status of Powerlink's Risk and Prioritisation approach in relation to development of the Asset Management Plan. Powerlink outlined their project prioritisation and asset risk framework during the on-site visit, with some documentary evidence being provided to support the objective interpretations inferred within this report. AMCL undertook this in accordance with its Asset Management Assessment process, which is accredited under the Institute of Asset Management's (IAM's) Endorsed Assessor Scheme.

2 Review Focus and Scope

The scope of the review was as follows:

- Review of Powerlink's asset risk and project prioritisation framework within the Asset Management Plan;
- Feedback on whether the asset risk framework and reinvestment prioritisation process is appropriate and aligned with good industry practice; and
- Advice on longer term actions and roadmap for future development.

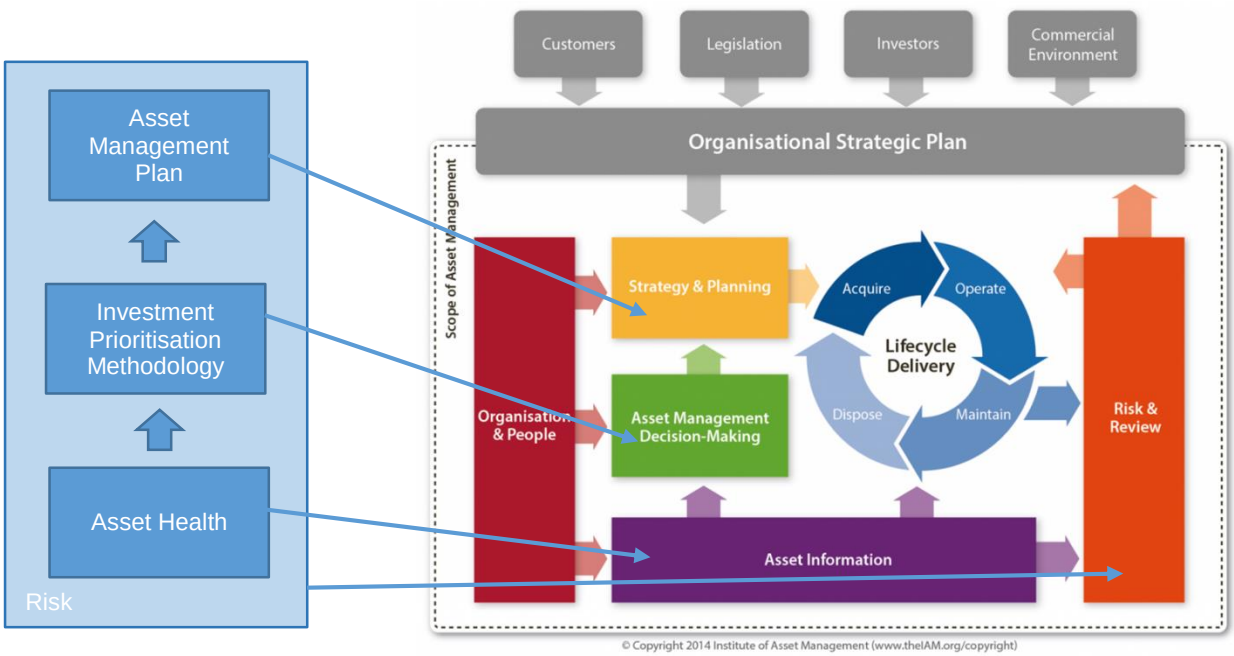
AMCL did not review any other aspects such as Powerlink's risk governance, asset management framework or investment approval processes.

This report was developed through discussions with key staff held on-site at Powerlink. Further analysis off-site was conducted to further review Powerlink's Risk and Prioritisation approach.

3 Assessment Overview

3.1 Context of review

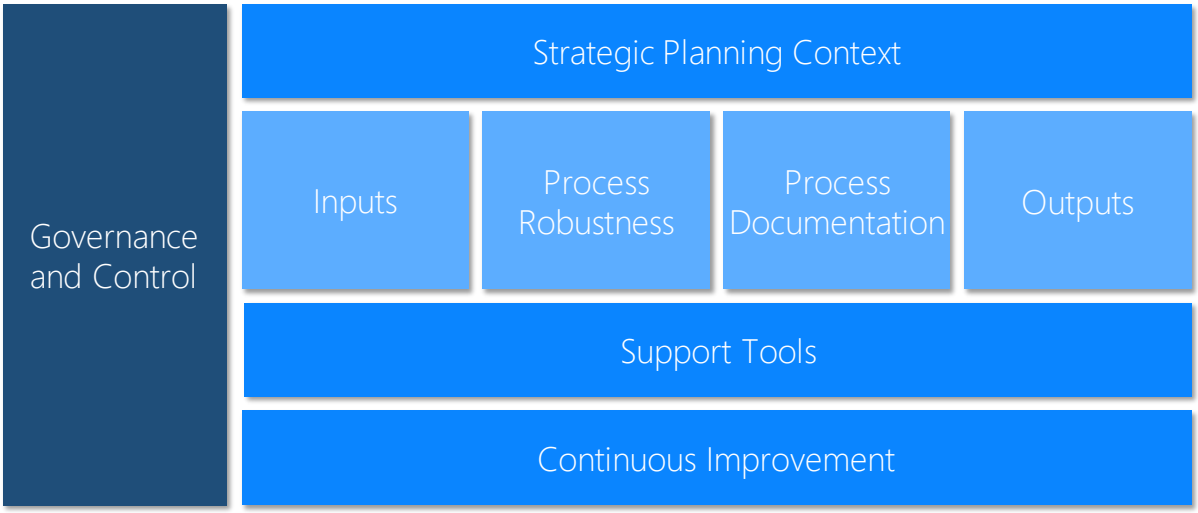
The focus of the review was to examine the bottom-up strategic planning process, which has a prioritised list of projects as an output captured in a 10 year Asset Management Plan (AMP). The process used for asset reinvestment is risk-based based on the health and condition of assets. It is noted that risk analysis was conducted on assets with a remaining life of less than 20% for primary plant, and 50% for secondary systems to establish the portfolio of projects.



The review was conducted using the Institute of Asset Management (IAM) 6 box model, ISO 31000 risk management principles as well as other leading practice Asset Management concepts and principles covered in the IAM Asset Management Anatomy, Global Forum for Maintenance and Asset Management (GFMAM) Landscape 39 Subjects, ISO 55001, PAS 55 and the International Infrastructure Management Manual (IIMM).

3.2 Assessment Framework

AMCL has used the following framework to assess Powerlink's Risk and Prioritisation approach to bottom-up development of the AMP.



As part of the assessment, discussion has been provided against each area of the Assessment Framework with a set of key maturity attributes being used as the basis of comments, refer to 3.2.3 .

3.2.1 Maturity Scale

The following 1- 6 maturity scale has been used to assess capability against the maturity attributes identified in the framework and to also assist in targeting improvement actions.

3.2.2 Powerlink's Approach to Risk Assessment

At the core of Powerlink's Risk and Prioritisation methodology is the following risk mechanism:

This mechanism is the key focus of this review. AMCL's understanding of the risk assessment mechanism used by Powerlink to develop the prioritised list of projects for input into the Asset Management Plan, is captured in the following statements:

- ***Risk Assessment Level*** - The level to which risks will be assessed are determined. For example, a sub-station is split into bays, and each bay is split into key components at which level the risk assessment is completed.
- ***Operating Context*** - Assessment and understanding of the operating context of the asset, the key failure mechanisms, their likelihood of occurring and their consequences
- ***Health Index*** - A health index for each asset / component based on a number of factors, including visual inspections, physical testing, failure history and age.
- ***Likelihood of Failure*** – Provides the probability that failure of an asset may occur within a given period of time.
- ***Exposure Factors*** – Probability that other co-incidental events or breakdown of controls occur that lead to the adverse consequence.
- ***Network Criticality*** - Consideration of the inbuilt redundancy in the network assets and its impact on reducing service delivery related failures. Consider both network and local redundancies (eg N-1 transformers).
- ***Controls*** - Consideration of local factors, including, availability of spares, ability to respond, presence of personal onsite, etc.
- ***Consequence of Failure*** - Method to measure the impacts of failures.
- ***Calculation of Risk*** - Combination of Probability of Failure, Likelihood of Consequence and the Consequence of Failure.
- ***Risk Evaluation*** - Determination of appropriate actions required in response to the determined risks.

These statements form the basis of the maturity attributes that have been used in this assessment of the risk assessment mechanism used by Powerlink.

3.2.3 Summary of Approach by Asset Class

The table below summaries the approach taken by Powerlink by Asset Class. It should be noted that this is a summary only and the Powerlink documentation should be read in conjunction with this report to fully understand that process applied.

Failure Modes	Asset Level	'Plain English' Risk Scenarios	Health Index Developed	PoF Curve Development	Event Tree Analysis (ETA)	Key Consequences Assessed	Exposure Factors
Transmission Lines							
Tower Collapse	Analysis by Span grouped by Built Section.	Documented (Identified key failure mechanisms at the component level)	No	Condition based Effective Age driven by Bolt Corrosion for 6 Corrosion Zones (A-F) and 2 tower types	No	• Safety risks within residential and public areas, and at road and rail crossings. • Network risks associated with potential loss of supply or impacts to the electricity market. • Stakeholder risks associated with negative media reports. • Financial impacts associated with replacement of fallen towers and emergency establishment of temporary structures.	• Location Based – Vehicular and Pedestrian Traffic • Network Criticality
Conductor Drop	Each span grouped by Built Section	Documented (Identified key failure mechanisms at the component level)	No	Condition based Effective Age driven by Insulator Pin Corrosion for 6 Corrosion Zones (A-F) and 3 insulator types	No	• Safety risks within residential and public areas, road and rail crossings, and possible bushfires.	• Location Based – Vehicular and Pedestrian Traffic • Network Criticality

Failure Modes	Asset Level	'Plain English' Risk Scenarios	Health Index Developed	PoF Curve Development	Event Tree Analysis (ETA)	Key Consequences Assessed	Exposure Factors
Earthwire Drop	Each span grouped by Built Section	Documented (Identified key failure mechanisms at the component level)	No	Condition based Effective Age driven wire corrosion for 6 Corrosion Zones (A-F)	No	• Safety risks within residential and public areas, and at road and rail crossings.	• Location Based – Vehicular and Pedestrian Traffic • Network Criticality
Substation Bays							
Current Transformer Failure (explosive & non-explosive)	For each CT and amalgamated for each bay	In progress	Yes	PoF vs Age – developed from cleansed real failure history for both explosive and non-explosive failure modes	Yes	• Safety risks associated with explosive failure of the CT. • Network risks associated with loss of supply or market impacts upon the occurrence of another fault, and loss of multiple items of plant under explosive failure cases. • Environmental risks associated with the release of SF6 into the environment. • Financial risks associated with damage to adjacent plant if the CT fails in an explosive manner.	• Likelihood of person(s) within the injury zone • Network Criticality

Failure Modes	Asset Level	'Plain English' Risk Scenarios	Health Index Developed	PoF Curve Development	Event Tree Analysis (ETA)	Key Consequences Assessed	Exposure Factors
Circuit Breaker Failure	For each CB and amalgamated for each bay	In progress	Yes	PoF vs Age – developed from cleansed real failure history for both explosive and non-explosive failure modes	In progress	• Safety risks associated with failure of the circuit breaker and backup CB under fault conditions. • Network risks associated with loss of supply or market impacts upon the occurrence of another fault. • Financial risks associated with emergency replacement of the circuit breaker, and advancing replacement of the CB.	• Likelihood of person(s) within the injury zone • Network Criticality
Bay Structure Collapse	For the bay structure and amalgamated for each bay	In progress	Yes	PoF vs Health Index developed from structural modelling/advice	In progress	• Safety risks associated with collapse of plant whilst field personnel are working. • Network risks associated with loss of supply or market impacts upon the occurrence of another fault.	• Likelihood of person(s) within the injury zone • Network Criticality

Failure Modes	Asset Level	'Plain English' Risk Scenarios	Health Index Developed	PoF Curve Development	Event Tree Analysis (ETA)	Key Consequences Assessed	Exposure Factors
Power Transformers	For each PT	In progress	Yes	PoF vs Effective Age	In progress	• Safety risks associated with failure of the transformer in an explosive manner. • Network risks associated with loss of supply or market impacts while the transformer is being replaced, and loss of multiple items of plant under explosive failure cases. • Financial risks associated with emergency replacement and advancing the replacement of the transformer. • Environmental risks associated with fire/smoke and oil clean-up when the transformer fails in an explosive manner.	• Likelihood of person(s) within the injury zone • Network Criticality
Secondary Systems							
Failure to Perform & Obsolescence	By Bay (Components grouped together)	In progress	Yes	PoF vs Health Index based on Powerlink's equipment failure rates	In progress	• Network risks associated with spurious tripping of aged relays causing loss of supply or market impacts under prior outage conditions. • Network risks due to the unavailability of spares and prolonged outage of plant resulting in potential loss of supply or impacts to the electricity market upon the occurrence of another fault.	• Network Criticality • Prior outages • Availability of spares

4 Findings

4.1 Strategic Planning Context

Area	Key Maturity Attributes	Maturity	Comments
Strategic Planning Context			
Alignment with Industry Practice	How well does the approach used align with industry practice strategic planning?		Powerlink has adopted a risk-based approach to strategic planning which is aligned with leading industry practice.
Alignment with Organisational Objectives	Can alignment with organisational objectives be demonstrated?		The use of the corporate risk framework demonstrates some alignment with the corporate objectives in terms of consequence. It is expected that the business drivers, such as decreasing demand and focusing on assets with <20%/50% remaining service underpins the Asset Management objectives which aligns with organisational objectives.

4.2 Process Robustness and Documentation

Area	Key Maturity Attributes	Maturity	Comments
Process Robustness			
Robustness of Risk Assessment Process	How robust is the process of assessment of risk based in the context of asset selection and scope?		The selection of assets that have been assessed using the risk framework are the core asset classes to which have key risks and those which have been assessed to have less than 20%/50% remaining life. These assets reflect the focus of reinvestment planning. Powerlink plans to extend to assessment over the next two years to include all the assets.
	How robust is the process of assessment using the proposed risk mechanism?	For maturity score refer to section 4.3.	For detailed comments on the mechanism refer to section 4.3.

Area	Key Maturity Attributes	Maturity	Comments
Understanding of Asset Risks	How well do the asset managers understand the risks associated with assets?		During the onsite discussions it was evident that asset managers have a good understanding of their assets and the risks associated, which have previously been captured using qualitative methods. The revised quantitative process has enabled the asset managers to further increase their understanding of the behaviour of the assets and to tweak the strategic management of them. This included a more in-depth understanding of the risk and how it links to real world consequences, which has altered the focus in the AMP.
Risk and alignment with ISO 31000	How well does the approach used align with good practice risk management?		The approach uses the good practice approaches for Risk Management and follows the requirements set out in ISO 31000 as well as leading industry practice of a quantified risk score in dollar terms.
Investment Decision - Making	How robust is the process of investment decision-making for the development of Asset Management Plans?		Previous risk assessment methods have been largely qualitative with investment decision making based on a mix of health indices and replacement indices. The current method of quantifying risk is a far superior approach providing better and clearer justification of investment needs. Further work is required to further embed the revised processes within end-to-end investment decision-making processes in the business, including options analysis, life cycle cost analysis and portfolio prioritisation and optimisation.
Consistency of Approach Between Asset Classes and Between Update Cycles	Is the approach used consistently applied across the asset classes as well as between update cycles?		The same framework has been applied for the risk assessment mechanism for each of the asset classes, which consisted of examining historical failure rate information, industry data, structural and corrosion modelling and published models to determine probability of failure curves, then carrying out a consequence analysis to determine various consequence paths post failure and finally by conducting a consequence loss analysis and applying various exposure factors depending on the nature of the consequence and combining the result as a total risk score. It is understood that the review cycle for risk assessments will be

Area	Key Maturity Attributes	Maturity	Comments
			conducted annually.
Completeness of Assessment of Risk Between Asset Classes	Have all failure modes been analysed for all asset classes, including consequences of asset failure impacting other asset classes?		The recent assessment was for key failure modes considered to drive asset reinvestments for the majority of asset types and classes. It is expected that remaining assets and other material failure modes will be reviewed at a later date.
Consistency and Reporting against Corporate Risk Framework	As an output to the risk assessment process how well are the risks reported against the corporate risk framework?		The corporate risk framework is used for mapping risks for reporting purposes as well as the quantified risk levels to help inform the business of risk exposure. It is expected that there is consistency of process when reporting risk.
CAPEX / OPEX trade-off capability	How well does the risk assessment and prioritisation methodology support the trade-off capability of CAPEX / OPEX?		The process does offer the capability of being able to trade off CAPEX against OPEX, and Powerlink has examined the use of operational projects to target pockets of high risk to defer major capital expenditure replacement or refurbishments. It is expected that as the methodology becomes embedded that Powerlink will start to more comprehensively optimise the balance between CAPEX versus OPEX to manage risk.
Use of Risk Framework	How embedded is the revised risk framework within the business and how well is it being used?		It is understood that a subset of assets have been through the risk assessment process and not all risk scenarios have been assessed. However, it is understood that all staff that are required to use the risk assessment process do so as appropriate.
Efficiency of the planning process	How efficient is the process of using the risk and prioritisation methodology to develop Asset Management Plans		Previously, the asset reinvestment needs were determined from a combination of health and replacement indices with detailed options analysis underpinning projects. The revised risk and prioritisation methodology is a new process that provides a strategic planning layer that sits in front of the business case development process using asset condition/health and failure consequence as the key driver for investment. As detailed options are not developed for each of the proposed projects, the prioritised list of projects is established in a shorter time frame. The list of project in its current state is a high-level timed asset interventions and the actual detail projects will be developed through the normal business case gating process. The real benefit of

Area	Key Maturity Attributes	Maturity	Comments
			the new process is that the 'first-cut' of the portfolio is prioritised so analysis of options for asset interventions can be undertaken only when required. At present the process is supported by an array of MS Excel spreadsheets and this is the first time the new process has been used. Also, there is limited documentation of the process at present. As these are each completed, and the process is further tested its efficiency will be further improved.
Calibration and Validation	Has the risk assessment model been calibrated and validated?		Where possible Powerlink's own historical failure information has been used to determine probabilities and where consequence data is available. Where information is not available statistical analysis and industry information has been used. It is understood that some asset classes do not have significant amount of failure information and industry rates and failure modelling have been used to determine the probability of failure.
Process Documentation			
Process Development and Documentation	How well has the development of the risk and prioritisation methodology been documented?		Powerlink has documented the process of development of the risk models by the use of 'Plain English Risk Statements' which discusses the technical aspects of the asset class which provide the justification of elements of the risk model including failure mode definition, likelihood of failure, exposure factors, consequence of failure, controls and risk levels. The overall end-to-end process is contained within spreadsheets at present. Powerlink is working towards the full documentation of the process to enable it to be easily communicated to internal and external stakeholders.

4.3 Risk Assessment Mechanism

Area	Key Maturity Attributes	Maturity	Comments
Risk Statement			
Risk Assessment Level	Are the assets being assessed at a level that enables changing risk along a linear asset to be assessed or enables sections or components to be replaced and not the entire asset?		The transmission lines have been assessed at a conductor span level in-lieu of built sections or the entire transmission line. This has enabled risks to be assessed along the length of the transmission line in order to pick up key risks based on changing likelihood and consequences of failure. Substations have been assessed at a component level that has enabled the level of redundancy to be assessed and understood at a system, facility, asset and component level.
	Is the level of assessment appropriate for decision-making?		The approach is appropriate for strategic decision-making. It is at a level that enables meaningful analysis to be undertaken in regards to asset renewal. The analysis has not been undertaken at a level where the asset managers get lost in the detail.
Asset Behaviour	Is there a standard approach for similar types of assets?		A standard approach has been used for each of the asset classes. This approach is being documented within each of the 'Plain English Risk Statements' for each of the main failure mechanisms.
	Are failure modes for each asset / component determined? Has a Fault Tree Analysis been undertaken for all asset classes, which has been used to determine the relevant failure modes?		The 'Plain English Risk Statements' identify the typical way that the assets have failed in the past and are likely to fail in the future. The most significant failure modes have been carried forward into the risk analysis. No Fault Tree Analysis (FTA) or Failure Mode Effects Analysis (FMEA) has been undertaken from a top-down or bottom-up perspective to fully develop all the failure modes at this stage. At this stage of maturity of assessment, this is considered appropriate, but in the future, a full analysis of all the failure modes would be in line with industry leading practice. Powerlink understands that there is further work to identify other failure modes with and across asset classes to complete the risk

			assessment for the entire scope of assets. The use of fault tree analysis to attain a comprehensive understanding of all failure modes and their respective likelihood and consequence of failures should be conducted in the future.
	Are individual failure modes assessed or are they assessed collectively?		For each of the failure modes that have been identified and carried through into the analysis they have had their consequences individually assessed, which is documented in the analysis spreadsheets.
	Has an Event Tree Analysis been undertaken for the Consequence of Failure?		An Event Tree Analysis (ETA) has been undertaken for some of the asset classes and this process is being progressively completed for all asset classes. The ETA has enabled Powerlink to increase its understanding of the direct and indirect consequences of failures and how they relate to each other. The ETA has been applied to the key failure modes that have been identified through the processes described above. Powerlink has also used the ETA to link each of the corporate consequences of failure categories to the consequences identified during this analysis.
Likelihood of Failure / Probability of Failure			
Health Index	Do the Health Indices exclude indicators that are not related to the renewal of the asset, for example, minor maintenance?		The current approach of strategic investment decision-making is based on using probability of failure as a function of asset health for most asset classes, while others are based directly of failure history data. Previous methods for investment decision-making were a mixture of replacement indices and health indices which had some condition basis as well as network criticality aspects. The rationalisation of the approach has helped minimise the subjectivity.
	Is a health index methodology established for each asset class or component?		Powerlink has established a health index or effective age equivalent approach for the majority of asset types.
	Is a health index determined for each asset / component?		For the asset classes where Powerlink has developed a health index these have been completed at either the asset or bay level, whichever one is considered appropriate for decision making.
Likelihood of	Is there a consistent method for the		At a high level the approach is consistent, however, for each asset

Failure	determination and estimation of LoF?		class a different approach is taken, which is specific to the factors driving the failure of that asset class, the available asset failure history and the level at which assets are managed.
	If a matrix approach is used, do the LoF ranges adequately represent the behaviour of the assets being assessed?		Powerlink does not use the matrix approach to determine LoF. However, a matrix approach is used to illustrate key risks associated with asset classes for not only internal reporting but as a supplement to the AMP.
	If a matrix approximation is not used (i.e. quantified LoF), are real LoF determined and directly used in the risk calculations, rather than a scaled range approach that can lead to a moderately inaccurate assessment (due to breadth of range)?		LoF is calculated based on a combination of real failure history or expert knowledge. The corporate LoF matrix is not used to calculate LoF. The LoF calculated values can be mapped back to the corporate LoF matrix if required for reporting purposes.
	Is evidence available that enables the correlation between the Health Index and Likelihood of Failure? Is this process documented?		'Plain English Risk Statements' have been developed for the purpose of enabling a more consistent approach, better documentation of understandings, transparency of calculations and assumptions as well as providing common understanding of risk events and failure impacts. Historical events have been used to inform the development of failure rates and LoF.
	Is LoF estimated on an annual period over a number of future years? For example for each of the next 10, 15 or 20 years?		Powerlink calculates LoF on an annual basis for each of the next 10 years, which is then used to determine the risk value for each of the next 10 years.
	Are all determined failure modes assessed or is it a subset? If some failure modes are not assessed, is this decision documented?		Only a subset of failure modes for key assets have been assessed. It is expected that the remainder of the asset classes will be assessed and comprehensive failure mode assessments completed at a future date. The selected failure modes are documented within the 'Plain English Risk Statements' and have been selected as they are considered the greatest threat to the assets.
	Have failure curves been developed that relate condition to PoF, age etc? Are these based on real data and have they been calibrated?		Where possible Powerlink's own historical failure information has been used to determine probabilities. Where information is not available, industry information or failure modelling has been used. It is understood that some asset classes do not have much failure information and these approaches have been used to determine the probability of failure.

	Is the LoF determined for each of the failure modes that is being assessed during the risk assessment? It is preferred for each failure mode to be assessed independently.		Each of the failure modes that have been chosen to be assessed have a LoF determined.
	How have the shape of the PoF curves been selected or calculated?		The process is dependent upon the asset class. For some asset classes is it based on actual failure history (for example CTs), while others have been estimated based on industry experience or expert modelling (eg structural failure).
Likelihood of Consequence (Network Redundancy and Controls)			
Network Criticality	Is it determined for different asset classes and how network redundancies should be considered?		Power system studies were conducted by Powerlink to determine the criticality of network assets along with power system contingency studies to understand the impact of asset failure for various contingency scenarios, for example, N-1, N-2, N-1-1 and N-2 – secure. Depending on the network configuration and operational boundaries with other network service providers (Energex and Ergon) the results of the analysis provide an assessment of the ability of the network to continue to supply after an asset failure. These included the ability to transfer loads or conduct network switching after the first contingency event. The analysis has taken into account that the redundant asset (N-1) may also be out of service at the time of the asset failure. An overview of this methodology was presented to AMCL during this review, and has not been assessed in detail. However, Powerlink should ensure that the methodology used for calculating LoF adjustments due to network redundancies be applied in a consistent manner across asset classes.
	Is the state of the network considered, for example, is it assumed that all other assets are operational at the time of a failure?		
	Is a network criticality process applied?		
	Has the LoC been considered and documented? For example, the CoF may be that someone is killed, but it may be very rare for someone to be onsite.		To cater for the variability in the cost of consequence a set of exposure factors have been used to modify the risk score therefore catering for the likelihood of consequence. These exposure factors have included the likelihood of both persons being near an asset and on-site during an explosive asset failure. A summary of the exposure factors used for each asset class is

			included in section 3.2.3.
Controls	Are the controls documented?		The assessment of all the controls applicable has not been fully assessed or documented at this time. The future development of both the FTA & ETA along with the documentation of the controls will enable this to occur. The analysis has assumed that planned and corrective maintenance is undertaken when required. In-built asset operational controls have been included in the exposure factors analysis.
	Has the LoF considerations been applied to the risk calculations?		Where the controls have been identified and included as part of the exposure factors, these have been included in the risk calculations.
Consequence of Failure			
Consequence of Failure	Is there a consistent method for the determination and estimation of CoF?		A consistent approach has been used to determine and estimate the consequence of failure, which is based on the corporate risk matrix. Not all the consequence categories have been considered in the recent risk assessments and therefore the entire set of consequences have not been quantified. Powerlink has selected the consequence categories that it considers are the most appropriate and represent the most significant consequences.
	Have all the consequences from the corporate risk matrix been considered?		
	Have consequences been quantified?		
	Have all the consequences from the event-tree been considered?		All the consequences from the event trees "Failure Flowchart" have been considered in the calculation of consequence, but the event tree analysis has not been completed for all asset classes.
	Have the determinate factors been identified that can be combined to calculate the CoF based on the operational context and to develop consistent estimation?		The CoF is determined from the corporate risk matrix and are not calculated based on determinate factors. Powerlink has the knowledge to determine these factors and has discussed the future potential to adopt this approach.
	If a matrix method has been adopted then, does a cross comparison of the consequence levels demonstrate that there is consistency between the interpretations of what each of the levels mean?		It is understood that the assumption of the model is that consequences are "aligned" and "equivalent". A review should be carried out of the consequence categories as to how well they align with the current stated financial implications to represent actual reality, as some risks may be overstated or understated in terms of

	If a matrix method has been adopted is there appropriately granularity between the levels?		consequence value. There has been no recent revisions to the structure of the consequence table with Powerlink identifying the need to provide more granularity around each of the consequence levels, which has been considered as a long term improvement.
	If a matrix approach is used, do the CoF ranges mirror a logarithmic scale?		The corporate risk consequence matrix uses a logarithmic scale that ranges from 1 to 7 for the range of consequences.
	If consequences are quantified in dollars, have the estimates been validated or calibrated?		It is understood that some validation has been done for consequence values, however this has not been comprehensively undertaken for the entire set of consequences.
	Is it clearly defined which CoFs link to which failure mode?		It is not directly apparent in the risk assessment spreadsheets, which consequences relate to which failure mode. The 'Plain English Risk Statement' and the completed ETA's provide some insight into the failure modes and their respective consequences, however, it is not comprehensive across every asset class.
	Do the CoF estimates reflect realistic estimates and therefore be defended if required?		It is understood that the consequence of failure estimates are to be reviewed, however, the assessment have been based on the 'Plain English Risk Statements' which have been designed to ground the risk assessments on real events, thereby increasing the accuracy of the risk values.
Risk Assessment			
Calculate Risk	Is it clearly documented how LoF, LoC and CoF are combined to calculate risk?		The process for producing a risk score using likelihood of failure, likelihood of consequence (exposure factors) and the cost of consequence is clearly defined and asset managers are aware of and use this method. These are currently documented within the asset risk framework and technical guidelines, however responsibilities have not been formalised within business processes and procedures. The summary table contained within section 3.2.3 was developed primarily by AMCL for this report. It would be beneficial for Powerlink to further expand this table and include as a reference within the AMP.
	Is it clear which are the dominant CoFs, or are		It is not directly apparent which are the dominant consequences of

	they 'lost' within a combined calculated index or score? This avoids the potential to miss a key risk and vital actions may be missed.		failure, without following the risk score aggregation process in the risk assessment spreadsheets and referring to the 'Plain English Risk Statement'. It is expected that as part of the development of Asset Management Strategies and plans that this information would be captured clearly to support future options analysis for the development of business cases for future programs of work. Safety has been analysed both as part of the overall risk approach and separately (part of the SFAIRP) assessment, which provides a degree of confidence that key safety risks should not be lost in the risk calculations.
	Have the risk estimates been calibrated or validated?		It is understood the final risk score output from the model has yet to be calibrated and validated with historical events, such as actual financial business impact due to a historical failure event. Where practical failure rates have been calibrated at a high level with historical events. The elements of the risk estimates have been developed based on the combination of likelihood of failure, likelihood of consequence and cost of consequence of which are built on Powerlink data and information or industry information where data gaps may exist. This is somewhat of a proxy for calibration and validation and more detailed assessments should be carried out at a later date.
	Have risk measures been developed and assessed, for example, risk of deferral or annualised risk? Is it clearly defined how the measures will be used in the evaluation of the risks?		Powerlink has developed risk metrics that assess the risks from the perspective of changing risks over time, which asset renewals would provide the greatest benefit/cost, and which projects are required to meet SFAIRP obligations.
	Are risk estimates calculated both for the current period and future periods?		The risk profile of the assets has also been estimated over the next 10 years based on the completion of the required projects. This demonstrates the expenditure required to maintain current levels of risk over time.

	Is there a method that defines how to combine the risk assessments for asset components and roll them up to a higher level, for example, how will the risks from a sub-stations bays components be combined into the overall assessment for the bay or even the substation?		The risk process assesses risks at component levels for some assets, and combines them together where required, for example, at the bay level for primary substation plant. The way in which components have been rolled up can be assessed from the risk calculation spreadsheets, but this has not been described in detail within the AMP.
Risk Evaluation			
Risk Evaluation	Clearly defined risk evaluation criteria?		The calculated risk values for each of the assets are used to categorise each of the assets into the corporate risk evaluation table to enable the assessment against the stated risk appetite of the business. Additional risk levels have been added to the table to enable this process to work in an effective and practical manner.
	Are the risk evaluation criteria relevant for physical assets?		The evaluation table is quite granular, but is a practical way of being able to assess the risks against the business risk appetite. Further refinement of the risk appetite may enable this process to be refined and made more applicable to asset risk assessments.
	Has the corporate risk appetite been defined and is it appropriate for application to assets?		The corporate risk appetite has been defined and the Powerlink process aligns and utilises this appetite level. Further refinements of the appetite levels would potentially enable this process to be further refined.
	Are the risk estimates mapped back against the corporate risk matrix to enable the risks to be appropriately managed in accordance with the corporate risk appetite?		The Powerlink process is aligned to this approach.

4.4 Inputs and Outputs

Area	Key Maturity Attributes	Maturity	Comments
Inputs			
Robustness of Data (quality and availability)	What is the quality if the data and information used in the model? Is the data and information used in the model robust?		Powerlink recognises that quality of data and information can be improved in the business. Much of the information used for input into the model, in particular condition information, which may be data collected in the field, is dependent on the quality the data. When moving from a qualitative approach to a quantitative approach in risk modelling it is important to have a clear understanding of the quality of data used, to minimise errors, and compounding effects. A typical strategy that could be employed to test the robustness of model outputs is to conduct a sensitivity analysis where variables of the equation are held constant and the remainder of the equation analysed to determine which variables have the greatest influence on the result. This helps to target data where quality is important due to its influence on the final result. Data quality audits, data cleansing programs, sensitivity analysis, asset information strategies and data population plans will help improve data quality.
Data Collection and Validation Processes	Are the processes for collection of asset information consistent and are asset registers validated in the field?		
Asset Attributes	Are the asset information registers compete with all asset attribute information populated?		
Accessibility and Storage	Is the asset information stored in a manner that is accessible and in a useable format for analysis, or does the user have to draw information from different sources and make assumptions and interpretations reducing the levels of confidence in the analysis output?		
Condition (Defect Identification & Severity v Condition Scoring)	How robust is the process for identifying and classifying defects? Can the assessment of defects be applied in a consistent manner?		The specifics of identifying and classifying defects was not discussed as part of the assessment process, however, it is important to highlight that the use of objective analysis in the field and ensuring that staff are appropriately trained to identify and classify defects is very important as it is this information that underpins the health indices. It is assumed that an objective and robust process is in place for the identification and classification of defects and that it is applied consistently in a repeatable manner.

Area	Key Maturity Attributes	Maturity	Comments
Outputs			
Risk Register	Are risk registers populated for all assets? Have the controls been accepted and assigned to relevant staff with the residual risk values accepted by the business as part of the corporate risk appetite?		Only assets <20%/50% remaining service life have been risk assessed at this point in time. Powerlink has committed to complete the remainder of the risk assessments in the near future. It is assumed that as part of the risk assessment process risk registers will be updated and risk management processes applied. The risks identified during this process are progressively being added to an asset risk register. However, a review of the asset risk register was not carried out as part of the scope of works.

4.5 Enablers

Area	Key Maturity Attributes	Maturity	Comments
Support Tools			
Assessment & Analysis Tools	Are the assessment and analysis tools appropriate and function effectively to provide robust output given the inputs? Are the assessment and analysis tools user friendly, accurate, free from programming bugs and issues or otherwise that may impact on the accuracy or timeliness of output? Is information stored and used within the tools secure from being tampered? Are there automatic information transfer function that require process oversight and governance?		At present, MS Excel based spreadsheets have been used for the assessment and analysis. It is understood that Powerlink are considering a more sophisticated system to record to the risk assessments outcomes, however, MS Excel spreadsheets will still be used for the risk assessments.

Area	Key Maturity Attributes	Maturity	Comments
Governance and Controls			
Approvals	Is there a sign-off acceptance process for the inputs and outputs of the model?		No formal sign-off process was sighted during the review, it is assumed that a process is in place.
Changes to the model	Is there a formal process for making changes to the model?		No formal sign-off process was sighted during the review, it is assumed that a process is in place.

4.6 Continuous Improvement

Area	Key Maturity Attributes	Maturity	Comments
Continuous Improvement			
Continuous Improvement Strategy and Externals Reviews	Are external reviews used to review technical aspects of the model as well as process, data and information practices? Is a structured plan in place that includes continuous improvement targets and review cycle/periods?		Powerlink has used both consultant and industry peers to review the various aspects of the tool, methodology and the inputs. Powerlink maintains a data improvement register that is specific to the risk assessment process. Some continuous improvement actions have been tabled and are being followed, however, a formal register or a continuous improvement plan has not been provided by Powerlink.
Knowledge and Awareness in the industry	Does Powerlink utilise knowledge sharing with peer organisations and keep up to date with industry knowledge.		Powerlink does utilise knowledge sharing to keep up to date in the industry. Powerlink regularly meets with its peers to discuss its risk assessment processes.
Embeddedness of risk and investment decision-making process	Is the process for risk and investment decision making fully embedded in the organisation.		The development of the risk and prioritisation methodology for the purpose of generating AMPs is relatively recent and is yet to be fully embedded in the organisation as a business as usual practice.

5 Conclusions

The following conclusions have been observed as a result of this assessment.

1) Powerlink has demonstrated significant progress in the development of the Risk and Asset Reinvestment Prioritisation methodology, and has adopted a continuous improvement culture to further improve this process.
2) Powerlink has gone to considerable efforts to understand the processes adopted by other electricity transmission businesses and understand leading practice.
3) The Powerlink approach aligns with leading industry practice for electricity transmission networks. The development of the risk assessment process is based on sound Asset Management fundamentals.
4) Powerlink has developed a risk assessment methodology with quantified risk score in dollars that broadly reflects the real cost and likelihood of asset failures.
5) Further work is required to fully develop the process across all asset classes and embed it into the organisation.
6) Changing from a qualitative risk assessment process to a quantitative assessment process brings with it complications, particularly with data quality. Removing the subjective judgement of staff requires more reliance on data and information and management and control of that data and information.
7) The documentation of the end-to-end process and how it has been applied to each of the asset classes requires further development, to enable improved transparency and repeatability of the process.

6 Recommendations

To assist Powerlink to moving forward, the following proposed actions have been identified.

These recommendations are high level and do not capture all of the actions identified in Section 4 of this report. It is recommended that Powerlink develop an improvement roadmap based on the actions contained within Section 4, including a risk based prioritisation of these actions.

1. Document the end-to-end risk process and how it is applied to each of the asset classes.
2. Review the risk and prioritisation methodology in relation to implementation of the proposed risk assessment tool.
3. Integration with the Network Investment Strategy – further develop how the risk assessment process fits with the development of business cases, including the quantification of benefits alongside risk.
4. Define Roles & Responsibilities including the governance framework.
5. Assess the tools required to support the processes, including how the excel spreadsheets can be replaced with a corporate system.
6. Determine how the risk processes aligns with managing program volatility and deliverability.
7. Document and prioritise all improvement actions.

Appendix A AMCL Credentials

A.1.1 AMCL Company Profile

Asset Management is about realising the value from your assets.

At AMCL we have helped organisations across the globe on their journey towards excellence in Asset Management and we understand how and when that value can be achieved. Excellence in Asset Management is about realising the value of your organisation's physical assets. It means making the best decisions about the management of all of your physical assets, throughout your organisation, and throughout their entire life-cycle – it is about embedding the best processes and first-class systems to increase your assets efficiency, effectiveness and value. It is about moving beyond the accepted standards of BSI PAS 55 and ISO 55000, and truly realising the value that your assets can unlock.

At AMCL we know how to build the business case for this investment and deliver a cost-effective approach that manages risk and creates value for stakeholders. We work with clients worldwide to transform the organisation and achieve the benefits associated with Excellence in Asset Management through our coordinated suite of Asset Management support services.

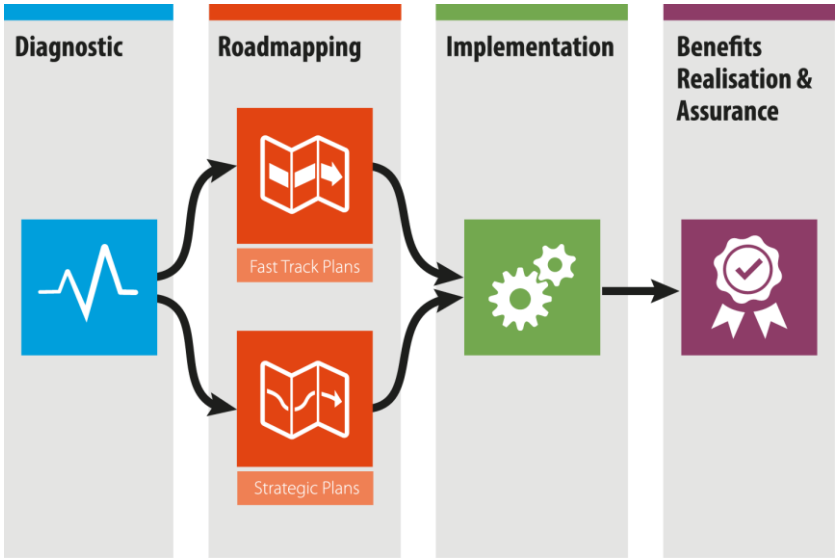


Diagram 1 Transforming Asset Management Organisations

Benefits realisation and assurance of our transformational approach include:

- IAM endorsed PAS55 Gap Analysis and Certification;
- IAM endorsed ISO55001 Gap Analysis;
- Monitoring and control of levels of Capex, Opex and Risk; and

- Benchmarking and Continuous Improvement.

AMCL is internationally recognised for its Asset Management assessment capability and experience and is ideally placed to provide Powerlink with a world class advice regarding Asset Management. AMCL is at the forefront of the thinking and practice of Asset Management, and our team includes founding members of the Institute of Asset Management (IAM) and the current President. We are also Patrons of the IAM (as well as IAM Endorsed Trainers and Assessors) and contributors and speakers at conferences held the world over.

AMCL was a key participant in the preparation of the original 2004 version of PAS 55, as well as its 2008 revision, and in the development of ISO 55001. The company was also heavily involved in the development of the Asset Management Landscape through its participation in the Global Forum on Maintenance and Asset Management.

AMCL is one of a few organisations worldwide to be an IAM Endorsed Assessor as well as an IAM Endorsed Provider of Asset Management training.

Diagram 2 AMCL's IAM Accreditation

AMCL offers a range of assessment and certification services based on our AMCL Asset Management Excellence Model™ (AMEM), which provides a framework to assess an organisation's capabilities against international best practice using a maturity assessment methodology developed in a cross section of industries over the last 15 years. The output of an AMEM assessment allows an organisation to compare themselves against peers within their own industry and against international best practice across all industries, including assessment against PAS 55 and the ISO 55001 standard.

A.1.2 Electricity Industry Experience

A.1.3 Reviewer Profiles

Brenton Marshall, BEng (Civil)(Hons), BCom– Director AMCL

Brenton has been responsible for creating strategies and implementation of Asset Management across multiple industries and countries.

He has a broad depth of Asset Management knowledge, including ISO 55001, life cycle processes and practices, asset management information systems, procurement strategies, organisational structures and asset management planning. In addition he experienced in long-term financial modelling and life cycle costing to maximise the life of existing assets and meet service delivery targets.

His wide range of experience has been gained in a diverse range of experience including; gas, electricity, hydro-electricity, water, wastewater, irrigation, parks and gardens, roads, rail and buildings projects in Australia, New Zealand, USA and Canada.

George Fuller, MBA, MApp Fin, BMEchEng – Senior Consultant

George is a Consultant with over 12 years professional experience spanning strategic asset management and engineering, having worked with an array of clients across the electricity, gas, rail, road, transportation and water sectors, in Australia and New Zealand.

He has provided clients with asset management consultancy services including business process assessment and business process re-engineering, covering key business aspects such as risk, governance and value underpinned by projects involving the implementation and adoption of best practice asset management principles and concepts such as management by objectives and organisational alignment.