AMS – Victorian Electricity Transmission Network

Risk Management (PUBLIC VERSION)

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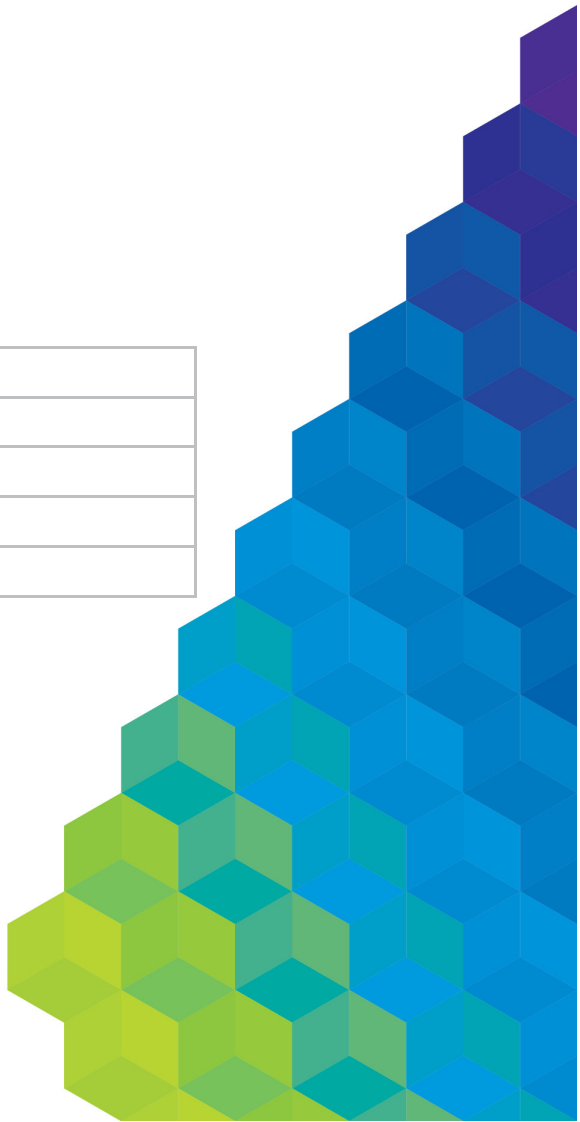

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1 Executive Summary

AusNet Services uses a range of techniques to assess risk and thus determine the replacement requirements for each asset class. The overall transmission network risk profile is the collection of risks posed by failures in the main transmission network components. Asset management strategies are aimed at stabilising the risks associated with the electricity transmission network. The proposed expenditure over the next regulatory period is estimated to maintain current levels of risk as shown in Table 1.

Asset Type	Program	Risk Assessment
Tower	Reinforce 48 towers and install fall arrest systems on approximately 3,300 towers	Risk reduction obtained by strengthening towers and reducing the likelihood and consequence of a fall as less than a quarter of towers remain without fall arrest systems.
Conductor and Ground Wire	Replace approximately 150 km of standard ground wire and 70 km of OPGW.	Marginal increase in conductor risk but maintains risk of ground-wire population.
Circuit Breaker	Replace approximately 150 circuit breakers through proposed station rebuilds and targeted programs.	Maintains Risk
Instrument Transformer	Replace approximately 100 instrument transformers through proposed station rebuilds and targeted programs.	Maintains Risk
Disconnectors and Earth Switches	Replace / refurbish approximately 300 deteriorated Disconnectors and Earth Switches.	Maintains Risk
Power Transformer	Replace 10 power transformers, 22 bushings and complete various asset management activities to extend the life of 37 transformers.	Maintains Risk

Table 1 – Asset Type Risk Assessment

1.1 Strategies

The following are the key improvement strategies for risk management:

- Development of effects tables based on economic evaluations in network planning reports.
- Development of asset criticality rankings.
- Development of optimised maintenance plans based on quantified levels of risks.
- Development of asset replacement and asset refurbishment plans based on quantified levels of risks.

2 Introduction

This document discusses the identification, analysis and quantification of risks that are associated with assets forming the Victorian electricity transmission network.

This document summarises the assessment of electricity transmission network business risks using the AusNet Services Risk Management Framework. It also references the assessment of network safety risks undertaken using the AusNet Services Risk Management Framework as part of the establishment and maintenance of an accepted Electricity Safety Management Scheme (ESMS).

The main component of this document is the assessment of asset failure risks by individual asset or asset class using reliability centred maintenance (RCM) techniques including Availability Work Bench (AWB) software models such as RCMCost and AVSim.

2.1 Risk Analysis

Risk analysis is undertaken in varying degrees of detail dependent upon the criticality of the event, the purpose of analysis and the available information and data. Analysis may be qualitative, semi-quantitative, quantitative or a combination of the three.

In practice, qualitative analysis is often used first to provide a general indication of the level of risk associated with an event or asset class, and to reveal the major risk parameters. Subsequently, more specific quantitative analysis is undertaken on the major risk parameters.

2.2 Semi-Quantitative Risk Technique (SQRT)

AusNet Services uses SQRT to assess overall network risk and specific high-level risks such as reliability, availability, health and safety, environmental, physical security and regulatory compliance. In the analysis of high-level risk situations where there are large numbers of contributing factors and influencing controls the AusNet Services Risk Management Framework is employed.

SQRT is more objective than qualitative analysis techniques and consumes less time and resources than quantitative analysis. As much as is reasonably practical, efforts are made to quantify individual contributing factors and influencing controls. This is done to achieve an objective overall assessment. Where AusNet Services' data is insufficient, industry data is used with caution.

2.3 Quantitative Risk Analysis (QRA)

QRA is the most objective risk analysis technique. Where accurate and reliable data, covering significant periods is available, AusNet Services uses this fully quantitative approach to assess both network performance and asset failure risks. The QRA approach is based on FMEA (failure mode effects analysis) and FMECA (failure mode, effects and criticality analysis) techniques and often employs software based regression simulations.

3 Network Business Risks

AusNet Services operates a corporate Risk Management Framework[1] based on ISO 31000:2009 "Risk management – Principles and guidelines. Corporate risks and control measures are registered using AusNet Services' Enterprise Risk Management Information System, CURA. The Enterprise Risk Team, a unit of the Risk and Assurance Division, supports the business in the implementation of risk management practices.

The registered risks that relate to the transmission network are summarised below in Table 2. These risks are regularly reviewed and the actions required to manage them are implemented in specified timeframes. CURA provides a monitoring and reporting capability to ensure these risks are managed in accordance with their priority level.

Risk Name	Residual Risk Rating	Target Risk Rating
Major transmission network failure / failure to provide adequate capacity	Level II	Level II
AusNet Services' assets cause a bushfire	Level II	Level II
Failure to achieve a satisfactory regulatory revenue determination	Level II	Level II
Changes in network regulations impacts on business value	Level II	Level II
Electric or magnetic fields being found to be harmful	Level II	Level II
BTS Project Z709 fails to meet business objectives or unplanned impacts result	Level II	Level III
RTS Project XA09 fails to meet business objectives or unplanned impacts result	Level II	Level III
WMTS Project XA14 fails to meet business objectives or unplanned impacts result	Level II	Level III
Physical effects of climate change on capacity and performance of network	Level II	Level III
Failure to meet network performance	Level II	Level III
Easements become encroached	Level III	Level III
Workplace exposure to Asbestos Containing Materials (ACM)	Level III	Level III
Failure to adequately manage greenhouse gas output	Level III	Level III
Failure to effectively manage changes to technical regulations	Level III	Level III
Reduction in CBD supply security	Level III	Level III
Failure to implement the recommendations from the Victorian Bushfire Royal Commission	Level III	Level IV

Table 2 – Transmission (and Transmission related) Network Risks Registered in CURA as at October 2015

At a minimum, a formal review is conducted on each risk annually. This includes assessing the causes, impacts and risk rating, as well as the status and effectiveness of treatment activities. This regular monitoring ensures emerging risks are quickly identified and assessed to aid in effective treatment and promote continuous improvement[2].

Risks are encouraged to be identified at all levels, however, the Executive Leadership Team (ELT) are responsible for ensuring AusNet Services' material risks are appropriately managed. On behalf of the Board, The Audit and Risk Management Committee (ARMC) provides oversight of the enterprise's material business risks and provides assurance of the adequacy and effectiveness of AusNet Services' risk management practices. Accountabilities for risks are allocated to responsible managers or executives depending on the residual risk ratings. General Managers and Managers receive monthly reports on the top business risks and their performance against risk review schedules.

[1] RM 001-2006 Risk Management Framework

[2] Refer "Risk Management Policy", "Risk Management Framework" and "Regulatory Compliance and Framework" for further information.

4 Network Safety Risks

As part of the ESMS, a Formal Safety Assessment (FSA) is carried out consistent with the Electricity Safety Act and the Electricity Safety (Management) Regulations in order to assess risks associated with the electricity transmission system. FSA process facilitates the identification of those risks which can be further reduced through the cost effective implementation of additional control measures.

Risk identification is used to generate a comprehensive list of safety risks based on those events and circumstances that might enhance, prevent, degrade or delay the achievement of objectives. Risks are typically identified at each level in the organisation through workshops, one-on-one interviews, change-management, control self-assessment or actual experience within the business or industry.

A structured safety risk assessment is then carried out[3]. Based on an assessment of residual risk, a consequence rating is chosen on the basis of the most likely impact on the AusNet Services and its stakeholders. The likelihood of the risk occurring is then derived by determining the chance that AusNet Services or its stakeholders will be affected at the chosen level of consequence. The risk matrix is used to determine the relative level of risks following the completion of the risk analysis.

The outcomes of the risk assessments are recorded in Risk Register Templates. Key risks are also registered in CURA. Once risks have been identified, assessed and evaluated, they are managed in a number of ways:

- Controls and action plans;
- Asset management strategies;
- Monitoring and review;
- Risk management information system.

The Formal Safety Assessment identified over 100 risks. Of these, there were none which were assessed as having a residual risk level of I. There were six which were assessed as having a residual risk level of II and these are summarised in Table 3.

Risk Title	Risk Category	Relevant Asset Management Strategy (AMS)	
		Number	Title
Explosive failure of primary plant	Asset related	AMS 10-64 AMS 10-54 AMS 10-67 AMS 10-73	Instrument Transformers Circuit Breakers Power Transformers Surge Arresters
Incorrect protection and control settings	Work process, practice and procedures related	AMS 10-20 AMS 10-68	Process and Configuration Management Secondary Systems
Exposure to HV AC during testing	Work process, practice and procedures related	AMS 10-15	Health and Safety Management
Failure of ground-wire in terminal stations	Asset related	AMS 10-75	Transmission Lines
Hazards with aerial inspection of lines	Asset related	AMS 10-75 AMS 10-65	Transmission Lines Lines Easements
Exposure to fire	Work process, practice and procedures related	AMS 10-65	Lines Easements

Table 3 – Identified Level II Risks

The identified level II risks are managed through implementation of the strategies in relevant Asset Management Strategies.

[3] Refer ESMS 20-01, ESMS 20-02 & ESMS 20-03 for further information.

5 Asset Risks

The risks associated with main network assets are quantified through the application of Reliability Centred Maintenance (RCM) techniques.

RCM requires the assignment of functions and functional failures to individual network assets. Failure Mode, Effect and Criticality Analysis (FMECA) of historical asset failure data determines the root causes of functional failures and the effects these causes have on key performance measures including network safety, reliability and availability.

Asset condition data collected during scheduled maintenance tasks is used to determine the condition of each asset and hence the dynamic time based probability of failures and percentage of remaining service potential (RSP) of the asset in that lifecycle phase.

The criticality of failures is established by reference to past network events and base information such as energy at risk as quantified by AEMO in the Victorian Annual Planning report[4] and by distributors in the annual Transmission Connection Planning Report[5].

RCM models output risk profiles for each asset category is used in determining overall transmission network risk.

5.1 Risk Profile

The overall transmission network risk profile is the collection of risks posed by the main transmission network components. Asset management strategies are aimed at stabilising the risks associated with the electricity transmission network. The proposed expenditure over the next regulatory period is estimated to maintain current levels of risk as shown in Table 4.

Asset Type	Program	Risk Assessment
Tower	Reinforce 48 towers and install fall arrest systems on approximately 3,300 towers.	Risk reduction obtained by strengthening towers and reducing the likelihood and consequence of a fall as less than a quarter of towers remain without fall arrest systems
Conductor and Ground Wire	Replace approximately 150 km of standard ground wire and 70 km of OPGW.	Marginal increase in conductor risk but maintains risk of ground-wire population
Circuit Breaker	Replace approximately 150 circuit breakers through proposed station rebuilds and targeted programs.	Maintains Risk
Instrument Transformer	Replace approximately 100 instrument transformers through proposed station rebuilds and targeted programs.	Maintains Risk
Disconnectors and Earth Switches	Replace / refurbish approximately 300 deteriorated Disconnectors and Earth Switches.	Maintains Risk
Power Transformer	Replace 10 power transformers, 22 bushings and complete various asset management activities to extend the life of 37 transformers.	Maintains Risk

Table 4 – Asset Type Risk Assessment

[4] http://www.aemo.com.au/Gas/Planning/~/media/Files/Other/planning/2012_Victorian_Annual_Planning_Report.ashx

[5] http://www.sp-ausnet.com.au/CA2575630006F222/Lookup/Projects/$file/TCPR2012.pdf

5.2 Generic Control Measures

5.2.1 Asset Management Information System

Central to the identification and management of risks is the Asset Management Information System (AMIS). The results of regular and routine asset inspections and preventative maintenance routines are recorded in the AMIS database. This practice allows trends to be identified and provides the targets for increased surveillance or higher levels of intrusive inspection and maintenance should they be required in order to better manage risks.

An effective way to identify potential risks is through participation in benchmarking activities and technical forums where the experience of others can lead to early warning of impending problems. AusNet Services will continue to participate in both national and international forums. When problems are identified, they are investigated and remedial action is taken. Remedial action can range from continuing to monitor the equipment problem through to the replacement of the fleet. In each case, when an asset management decision is to be taken, the options are considered against safety, environmental, technical and economic criteria.

In cases when preventative measures are proving ineffective AusNet Services develops contingency arrangements while longer-term plans are produced to overcome the problem. An attempt has been made to develop risk-based criteria for assets. This is best achieved by proper condition assessment of the fleet. In regards to network assets, risk management principles should be applied in the areas discussed below.

5.2.2 Maintenance

Currently maintenance is predominantly based on time schedules and duty. Reviews of recurrent maintenance intervals are used to explore the extent to which risk can be used to determine the level of maintenance. Maintenance intervals may be varied depending on the station and asset criticality ranking, provided that health and safety, and environmental risks are adequately taken into account.

The scope of work in some instances may be varied depending on the system importance (or criticality) of the asset. Using condition monitoring instead of routine maintenance may be possible if risk is low or can be managed to an acceptable level by the use of condition monitoring.

Maintenance practices may also be changed depending on the system importance of the asset. For example, more formal risk assessments and checks may be put in place in some high-risk locations.

Also, staff skill and competency levels may be linked to the level of risks associated with certain assets. In these circumstances, field workers are required to attain certain skill and competency levels before being eligible to work on high-risk assets.

5.2.3 Condition Monitoring

One of the key inputs for the asset strategies, whether it is asset maintenance, refurbishment or replacement, is asset condition. AusNet Services utilises online and off-line condition monitoring[6] (CM) techniques to continuously improve levels of network reliability and safety. The asset condition information is critical for the optimisation of maintenance plans and prioritisation of asset replacement programs.

Asset condition data is one of the main inputs for the RCM risk analysis. Some risk models use condition data combined with asset age data for risk analysis. AusNet Services use following common categorisation in determining the asset condition with specific condition identification measures for each asset type. Table 5 summarise the condition scoring criteria.

[6] Refer AMS 10-13 for further information.

Condition Score	Likert Scale	Condition Description
C1	Very Good	Initial Service Condition
C2	Good	Better than normal for age or refurbished
C3	Average	Normal condition for age
C4	Poor	Advanced Deterioration
C5	Very Poor	Extreme deterioration approaching end of life

Table 5 – Condition score definition and recommended action

5.3 Modelling Major Asset Risks

AusNet Services uses a range of techniques to assess risk and thus determine the replacement requirements for each asset class. These include dependability management methodology and modelling, engineering review of condition assessment data, calculation of long run sustainability based on expected asset life and total population of assets, assessment of projects in progress and engineering knowledge of assets and the operational environment. The various techniques are applied depending on the asset type and the asset data available. The range of resulting risk assessments and replacement forecasts are compared, contrasted and brought together using engineering judgement to inform the management of risk and development of the replacement forecast.

Dependability management brings together asset condition data, asset failure rates and the cost impact of asset failure to determine economic replacements. The dependability management program employs Availability Workbench software to provide an economic analysis of major terminal station and line assets over a ten-year period. This methodology has been consistently applied for the following major asset classes.

- AMS 10-67 – Power Transformers;
- AMS 10-54 – Circuit Breakers;
- AMS 10-64 – Instrument Transformers; and
- AMS 10-79 – Line conductors and ground wires.

Transformers have been used in the following example to demonstrate the dependability management process. For further information, refer to the “Risk Assessment” section in each of the asset management strategy documents

5.3.1 Dependability Management

The reliability modelling of power transformers sums the probabilistic replacements and equivalent risk costs and identifies a criticality ranking and the economic replacements or refurbishments required to prudently maintain failure risks. This quantitative model simulates the safety, environmental, reliability, availability and business risks associated with major failures

Probabilities of failure are based on condition assessments of core and coils, tap changers, bushings, insulating oil, and tank, wiring, auxiliary components & cooling systems undertaken by AusNet Services’ engineers. These condition assessments have been used to determine the RSP of the asset to replicate the reductions in the capability of assets to provide the specified level of service for each condition grade. Percentage of RSP reflects scoring criteria used during condition assessments and remaining useful life for each condition phase. Useful life and remaining life values define the Weibull parameters used in RCM modelling. A two-step calibration process was applied against model inputs to ensure outputs reflect power transformer failure rates observed in recent history and levels of risk.

Event consequences are modelled on environmental damage, collateral equipment damage, unserved energy and unplanned procurement and replacement costs associated with a major failure that would require the transformer to be removed from service for an extended period.

Risk Management

One of the outputs through completing this model is the ability to risk rank the entire transformer fleet. Table 6 illustrates the highest 15 risk ranked transformers in the fleet with their condition, description, and provides the proposed action to address these transformers.

Rank	Condition	Description	Proposed Action
1	Condition 5	B1 220/66KV TRANS [C.I.C]	Approved, committed and estimated completion 2016
2	Condition 5	B2 220/66KV TRANS [C.I.C]	Approved, committed and estimated completion 2018
3	Condition 5	B2 220/66KV TRANS [C.I.C]	Approved, committed and estimated completion 2016
4	Condition 5	B1 220/66KV TRANS [C.I.C]	Approved, committed and estimated completion 2018
5	Condition 4	B2 220/66KV TRANS [C.I.C]	Approved, committed and estimated completion 2015
6	Condition 4	B1 220/66KV TRANS [C.I.C]	Proposed for replacement (major station project)
7	Condition 4	B3 220/66KV TRANS [C.I.C]	Proposed for replacement (major station project)
8	Condition 4	B4 220/66KV TRANS [C.I.C]	Approved, committed and estimated completion 2018
9	Condition 4	B1 220/66KV TRANS [C.I.C]	Proposed for replacement (major station project)
10	Condition 4	B2 220/66KV TRANS [C.I.C]	Proposed for replacement (major station project)
11	Condition 4	B3 220/66KV TRANS [C.I.C]	Proposed for replacement (major station project)
12	Condition 4	B2 220/66KV TRANS [C.I.C]	Proposed for replacement (major station project)
13	Condition 4	B4 220/66KV TRANS [C.I.C]	Proposed for replacement (major station project)
14	Condition 4	B3 220/66KV TRANS [C.I.C]	Due to proposed B4 replacement, the risk should reduce and defer replacement
15	Condition 4	B3 220/66KV TRANS [C.I.C]	Approved, committed and estimated completion 2016

Table 6 – Risk Ranking of Power Transformers

6 Strategies

The following are the key improvement strategies for risk management:

- Development of effects tables based on economic evaluations in network planning reports.
- Development of asset criticality rankings.
- Development of optimised maintenance plans based on quantified levels of risks.
- Development of asset replacement and asset refurbishment plans based on quantified levels of risks.