Overhead Conductor Condition Monitoring
ASTP/API Quarterly Progress Report (No.1 2019)

Prepared by:

Dr Lakshitha Naranpanawe, Dr Hui Ma and Professor Tapan Saha

Power & Energy Systems Research Group

School of Information Technology & Electrical Engineering

The University of Queensland

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THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

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Power & Energy Systems Research Group
Axon building (#47), Staff House Road, St. Lucia Campus
The University of Queensland
Brisbane, QLD 4072 Australia
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~~Srinivansan Chinnargan~~ (Energy Queensland) SCOTT MERILLO		09/05/2019
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Matthew Cupples (AusGrid)		09/05/2019
Peter Livingston (CitiPower/Powercor/United Energy)		
Tony Stevens (SA Power)		

Executive Summary

Energy Networks Association (ENA) member utilities have almost 800,000 kilometres of overhead conductor in service, valued at several billion dollars. Many of this critical infrastructure is ageing with some already reaching 70 years. This project investigates the effective ways of condition monitoring of overhead conductor in Australian distribution networks. The objectives are:

- Review of conductor failure modes, degradation mechanisms and ageing parameters and current Australian industry practices to asset manage overhead conductors.

- Define the criteria for quantifying conductor condition and its end-of-life, and determine the probability of conductor failure and estimate its remaining useful life.

- Identify the core areas of research and development for improving condition assessment of conductors in Australian Distribution Network Service Providers (DNSPs) networks.

- Survey state-of-the-art conductor condition monitoring techniques that could be used to monitor distribution conductor condition and assess the practicality and economics of applying these techniques in Australian networks.

This project was started on June 20, 2018. Having been working closely with project industry partners, the UQ team has successfully completed Milestone 1 tasks, including:

- A comprehensive review on the types, failures modes and geographical locales of conductors in Australian DNSPs' networks. The review was based on an extensive literature study on ENA 2015-2016 conductor survey and individual utility surveys, open source databases, IEEE, IEC and CIGRE standards and recommendations and other literature as well as discussions with industry experts.

- A comprehensive study to understand the conductor degradation mechanism and parameters that affect each type of degradation mechanism in Australian DNSPs' networks.

- After a survey of the current Australian DNSPs' practice on conductor asset management and their requirements for a proactive yet cost-effective conductor condition monitoring, the UQ team identified core areas of research and development for an improved condition assessment of conductors in Australian DNSPs' circuits.

The Milestone 1 report was submitted to ENA on December 20, 2018. Since the completion of Milestone 1, the UQ team has conducted a feasibility study on the implementation of conductor health index methodology in Australian DNSP’s networks. In the past four months (from January 1 to April 30 2019), the UQ team made the following progress:

- Conducted a feasibility study on the application of health index method to improve the condition assessment of bare overhead conductors in Australian distribution networks. After carefully reviewing two representative health index methods i.e. Canadian method and EA technology method, the UQ team found that the Canadian method may not be suitable for Australian distribution networks while the parameters and their weightages used in the EA technology method need to be further investigated.

- Developed a model using corrosion induced conductor failure data. The model can provide an estimation on the critical age, at which ACSR conductors in different geographical zones may fail due to corrosion.

- Developed a tool to estimate the remaining life of overhead conductors. The tool used a set of indices to determine the conductor age de-rating factors, including operating conditions, geographical locations, frequencies of fault occurrences, the number of mid-span joints and the repair history.

Several Australian DNSPs have been using commercial software tools for condition-based asset remaining life estimation. However, several issues are still not clear which impair the applicability of these tools, especially (1) what parameters are the most suitable as the inputs to the tools; (2) how to determine the weights to these parameters; and (3) how to obtain these parameters from in-service circuits. Within the period of Millstone 2, the UQ team will focus on the above three issues. In addition, the UQ team is planning to start the feasibility study of using drone to take high-resolution photos of conductors and then evaluate the conductor condition from these photos. This is the first task in Milestone 3 of the project proposal.

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1. Introduction

1.1 Background

ENA members have almost 800,000 circuit kilometres of overhead conductor in service. This represents an asset, which is conservatively valued over several billion dollars. Overhead conductor asset can be of different metal types, different sizes and capacities, and is employed in all climatic zones including tropical, temperate, arid, and highlands. Many conductor assets are ageing with some already reaching 70 years. Though many advancements in technology have been achieved throughout these years, approaches to cost-effectively monitor condition of bulk of conductors have not substantially changed. Existing conductor condition monitoring practices are still visual inspections and conductor replacement is usually driven by the frequency of conductor failures [1]. Reliable and cost-effective methods to assess the likelihood of a conductor failure have not yet been developed for the Australian distribution network service providers (DNSP) networks.

On June 20th 2018, ENA approved a research project proposal submitted by the University of Queensland team. The project is aimed at investigating how to effectively monitor and assess the condition of overhead conductor for an improved asset management of conductors in Australian distribution networks. The research works conducted in this project are:

1. An establishment of a knowledge base of overhead conductors in Australian distribution networks and subsequently the identification of the current core areas of research and development for an improved conductor condition assessment;

2. A methodology for quantifying conductor condition and estimating the remaining useful life of conductor; and

3. Identification of state-of-the-art commercially available conductor monitoring system and emerging smart sensor-based system and possibly evaluating a smart sensor with data collection methods.

The June 20th 2018, the project was formally started on June 20, 2018. Milestone 1 tasks were completed in December 2018 and Milestone 1 report was submitted to ENA on December 20, 2018. After that, the UQ team is working on the tasks of Milestone 2. This report is the project report for the period from January 1 to April 30, 2019.

1.2 Highlight of Project Progress

Having been working closely with project industry partners and two industry experts Colin Lee and Keith Callaghan, the UQ team made significant progress.

During the period of Milestone 1, the UQ team reviewed conductor population in Australian Distribution Network Service Providers (DNSPs) circuits including the types, failure modes and geographical locales of conductors [2]. The UQ team performed a comprehensive study to understand the conductor degradation mechanism and parameters that affect each type of degradation mechanism. Moreover, the UQ team reviewed the current Australian DNSP's practice on conductor asset management and their requirements for a proactive yet cost-effective conductor condition monitoring. The UQ team identified core areas of research and development for an improved condition assessment of conductors in Australian DNSPs' circuits.

During the period from January 1 to April 30 2019, the UQ team has conducted a feasibility study on the application of health index method to improve the condition assessment of bare overhead conductors in Australian distribution networks. The UQ team did a comprehensive review on two representative health index methods, i.e. Canadian method and EA technology method. Moreover, the UQ team developed a model, which was based on the dataset of conductor failure due to corrosion. The model can estimate the critical age, at which ACSR conductors in different geographical zones can fail due to corrosion. Furthermore, the UQ team developed a tool to estimate the remaining life of overhead conductors. The tool used a set of indices to determine the conductors' age de-rating factors, which includes conductor operating conditions, geographical locations, frequencies of fault occurrence, the number of mid span joints and the repair history.

Though some Australian DNSPs have been using commercial software tools for condition based asset remaining life estimation, several issues still exist impairing the applicability of these tools. These issues are: (1) what parameters are the most suitable inputs to the tools; (2) how to determine the weights assigned to these parameters; and (3) how to obtain these parameters from in-service circuits. The UQ is currently working on these issues and findings will be included in Milestone 2 report.

2. Industry and University Partners – Current

2.1 University team:

Tapan Saha

Hui Ma

Lakshitha Naranpanawe

University Lead: Tapan Saha

2.2 Industry:

Srinivansan Chinnargan (Energy Queensland),

Matthew Cupples (AusGrid),

Ayan Ghosal (Western Power),

Peter Livingston (CitiPower, Powercor, United Energy),

Tony Stevens (SA Power)

Industry Lead: Ayan Ghosal

3. Project Progress / Methodology

In the past four months (from January 1, 2019 to April 30, 2019), the UQ team has been working on Milestone 2, which objective is to investigate a methodology for quantifying conductor condition and estimating the remaining useful life of conductor. The key research and developed activities are:

1) Feasibility of developing condition assessment of conductor using health index methodology. Investigation of globally documented conductor ‘health index’ methods including the Canadian method (the health index is a weighted sum of conductor condition parameters, field inspection data, and service records, used to estimate the remaining useful life of conductor). Compare alternative Health index methods, assess suitability for Australian conditions and select the best to be trialled in the project.
2) A demonstration of health index method for condition assessment of a representative type conductor in Australia DNSPs’ lines. Demonstration of the selected ‘health index’ method on a representative type of distribution conductor for the participating ENA members, and benchmark the results against past investigation of conductor samples and metallurgical studies (such as those undertaken by Western Power and other ENA members). Trialling the Health index could be only possible provided the ENA member utility provides in-kind contribution for testing, validation, and access of previous measurements on selective conductor types.

This chapter of the report presents the methodologies, approaches, outcomes and discussions of the above research and developed activities. The UQ team has conducted a comprehensive review on two representative health index methods (Canadian method and EA technology method), which is detailed in Sections 3.1 and 3.2. With the help from industry experts Colin Lee and Keith Callaghan, the UQ team developed a method to estimate the remaining life of overhead conductors. This method is presented in Section 3.3. Further discussions on the advantages and limitations of the above three methods are provided in Section 3.4. To calculate conductor health index and estimate conductor remaining life, the input parameters and their weightages need to be properly defined. This can be achieved through statistical analysis of conductor failure data and condition monitoring, which are presented in Section 3.5. The UQ team has analysed conductor failure datasets from a number of Australian DNSPs. A summary of these datasets is presented in Section 3.6. By analysing the datasets of conductor failure due to corrosion, the UQ team has developed a methodology to extract conductor life information and estimate the critical age, at which conductors in different geographical zones can fail due to corrosion. The methodology is presented in Section 3.7.

3.1 A Brief Review of Canadian Methodology of Conductor Health Index Calculation

The conductor health index (HI) methodology presented in this section was developed by a team of Canadian researchers [3]. The health index was calculated using a set of condition parameters, which are related to the long-term degradation factors leading to the conductor's end of life. Firstly, a set of condition parameter scores (CPS) are calculated as

$$CPS = \frac{\sum_{n=1}^{\forall n} \beta_n (SCPS_n \times WSPC_n)}{\sum_{n=1}^{\forall n} \beta_n (SCPS_{n.\max} \times WSPC_n)} \tag{1.1}$$

Where,

SCPS - Sub-Condition Parameter Score

WSCP - Weight of Sub-Condition Parameter

$SCPS_{max}$ - Maximum Score for Sub-Condition Parameter

β_n - Data availability coefficient

DRF - De-Rating Factor

Then, the above CPSs are used to calculate the health index as

$$HI = \frac{\sum_{m=1}^{\forall m} \alpha_m (CPS_m \times WPC_m)}{\sum_{m=1}^{\forall m} \alpha_m (CPS_{m.\max} \times WPC_m)} \times DRF \tag{1.2}$$

Where,

CPS - Condition Parameter Score

WCP - Weight of Condition Parameter

CPS_{max} - Maximum Score for Condition Parameter

α_m - Data availability coefficient

In the Canadian method, the conductor's mechanical strength (torsional ductility and tension) was adopted as a critical parameter. Visual observations, service records, number of repairs/splices and the remaining tensile strength of the conductor samples were all used in health index calculation.

3.2 A Brief Review of EA Technology’s CBRM Methodology of Conductor Health Index Calculation

EA Technology’s Condition based risk management (CBRM 2.0) platform can calculate assets’ health indexes and the probability of failure [4-6]. The main reasons for investigating the EA technology’s CBRM method are: (1) the publically availability of the detailed information of the EA Technology’s CBRM methodology, procedures and implementations; and (2) Australian utility companies’ experience in using the EA technology’s CBRM tools

The EA Technology’s CBRM software is designed for the assessment, forecasting and reporting of Asset Risk. Its main objectives are:

- Comparative analysis of network asset performance between Distribution Service Providers over time.
- Assessment of the licensee's performance against the Network Asset Secondary Deliverables.
- Communication of information affecting the Network Asset Secondary Deliverables between the licensee, the Authority and, as appropriate, other interested parties in a transparent manner.

The key outputs of the EA Technology’s CBRM methodology is

- An evaluation of Probability of Failure (PoF), which is the likelihood of condition-based failure per annum for individual assets.
- An evaluation of the Cost of Failure (CoF) associated with condition-based failures for individual assets.

To calculate the PoF and CoF and eventually to obtain the risk matrix, the following input parameters are used (refer to Figure 1):

- Location Factors - factors relating to aspects of the environment, in which the asset is installed and may have impact on the asset’s expected life.
- Duty Factors – factors relating to the usage of the asset at its specific location that may have impact on the asset’s expected life.

- Observed Condition Inputs - factors relating to the observed condition of the asset.

- Measured Condition Inputs – factors relating to the condition/health of the asset determined by measurements, tests or functional checks.

- Reliability Modifier - a factor relating to generic reliability issues associated with the individual make and type of an asset.

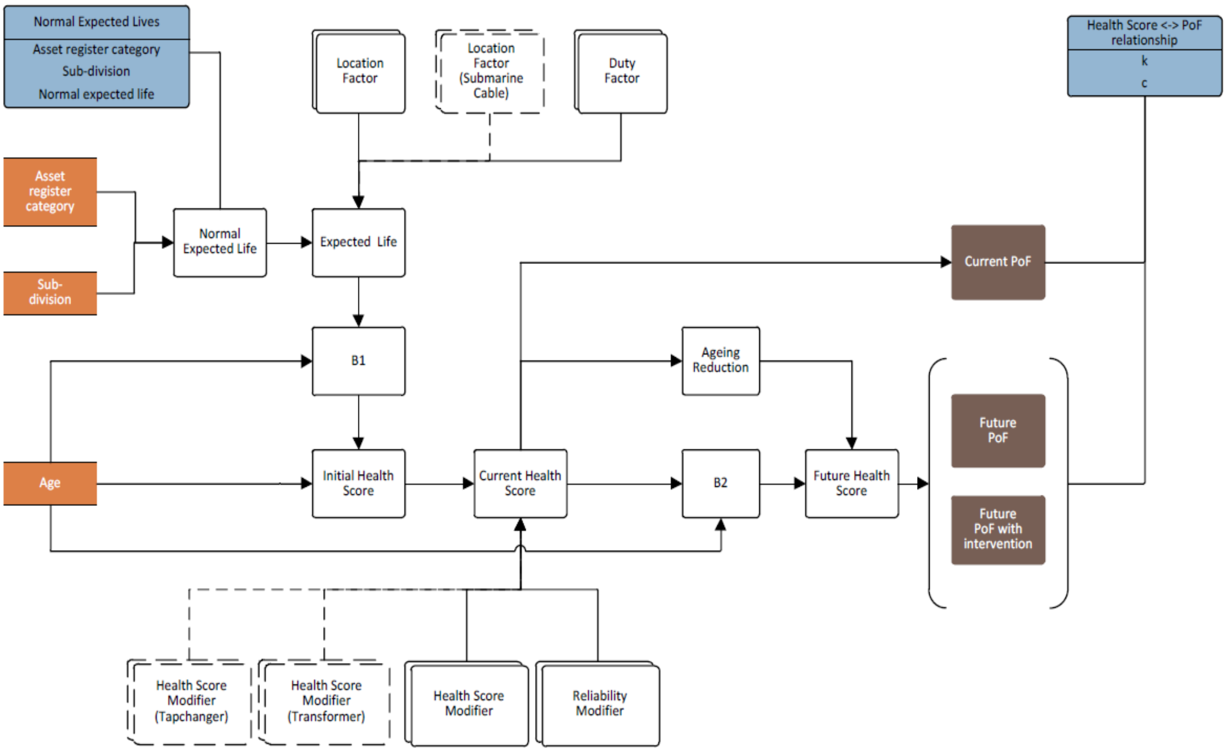


Figure 1 Methodology for calculating the probability of failure [2]

The factors such as Location Factor, Duty Factor, Health Score Modifier and Reliability modifier in Figure 1 are calculated using the methodologies as summarized in Table 1. Limitation of this method is described in section 3.4.

Table 1 Parameters used to calculate PoF and CoF modifiers

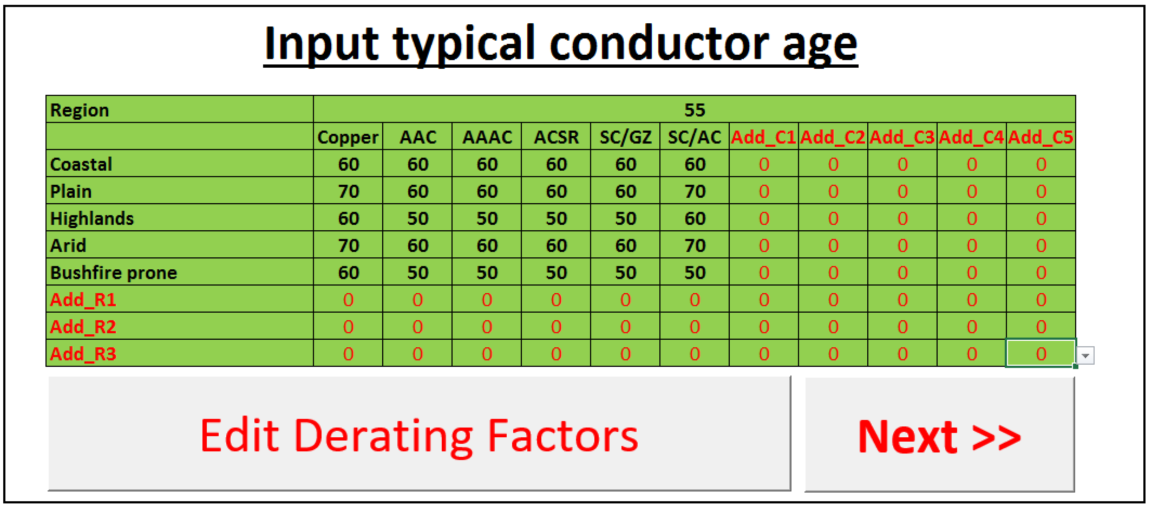
Modifier	Required Parameters
Location Factor	Distance from the coast Altitude Corrosion category Indoor/Outdoor
Duty Factor	Asset category Factors that introduce additional ageing due to the way the asset is being used
Health Score Modifier	Observed condition modifier (defined as follows) Measured condition modifier (defined as follows)
Observed Condition Modifier	Condition inputs from observations
Measured Condition Modifier	Condition inputs from measurement
Reliability Modifier	Based on the industry experience and available conductor condition data

3.3 A Brief Introduction of the UQ Team's Methodology of Estimating Remaining Life of Conductors

The UQ teams' conductor remaining life estimation methodology uses a set of input parameters including

1. Conductor data (Type, Age, Climate zone and Conductor operating conditions)
2. Conductor operating conditions are
    a. Whether the conductor is a distribution conductor
    b. Whether the conductor is operating in a costal location
    c. Does the conductor has high fault history
    d. Level of tension in the conductor (high or low)
    e. Whether the conductor span is above 300 m or not
    f. Whether the conductor already has multiple repairs and mid span joints

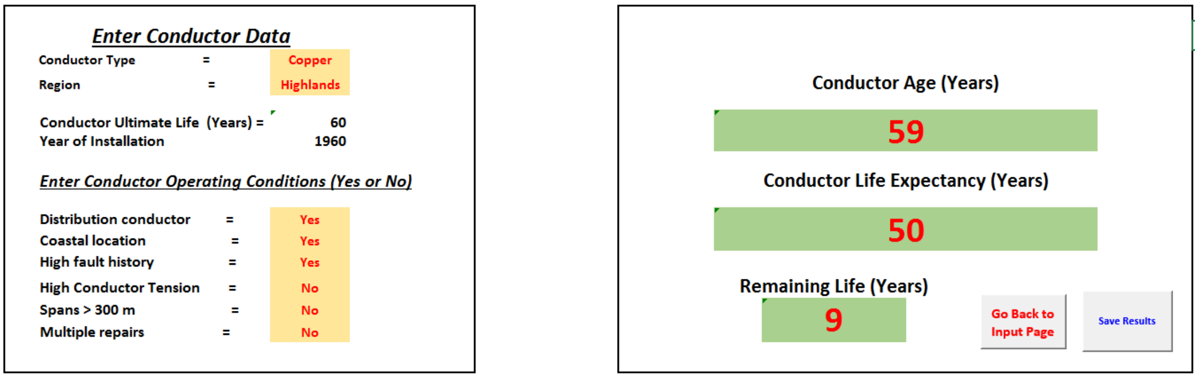
Each of the above parameters is assigned a de-rating factor. The de-rating factors are used to compute the remaining life of the conductors. The UQ team's software tool is implemented in Microsoft Excel. Several screen shots of the current version of the UQ team's software are shown below.



Input typical conductor age

Region	55										
	Copper	AAC	AAAC	ACSR	SC/GZ	SC/AC	Add_C1	Add_C2	Add_C3	Add_C4	Add_C5
Coastal	60	60	60	60	60	60	0	0	0	0	0
Plain	70	60	60	60	60	70	0	0	0	0	0
Highlands	60	50	50	50	50	60	0	0	0	0	0
Arid	70	60	60	60	60	70	0	0	0	0	0
Bushfire prone	60	50	50	50	50	50	0	0	0	0	0
Add_R1	0	0	0	0	0	0	0	0	0	0	0
Add_R2	0	0	0	0	0	0	0	0	0	0	0
Add_R3	0	0	0	0	0	0	0	0	0	0	0

Figure 2 The GUI of the UQ team developed software: Typical conductor life



Enter Conductor Data

Conductor Type = Copper
Region = Highlands

Conductor Ultimate Life (Years) = 60
Year of Installation 1960

Enter Conductor Operating Conditions (Yes or No)

Distribution conductor = Yes
Coastal location = Yes
High fault history = Yes
High Conductor Tension = No
Spans > 300 m = No
Multiple repairs = No

Conductor Age (Years)
59
Conductor Life Expectancy (Years)
50
Remaining Life (Years)
9

Figure 3 The calculated results of the UQ team developed software: Conductor data input and estimated data

It should be noted that UQ team is currently working with industry experts towards refining the de-rating factors correspond to each conductor operating condition for improving the performance of the above software tool.

3.4 Further Discussions on the Canadian and EA Technology Methods of Calculating Conductor Health Index

According the existing literature, the Canadian health index methodology has shown promising results [3]. However, after a feasibility study the UQ team found that,

- The Canadian method was developed mainly for transmission networks, on which various sensors can be installed.
- Canadian climate conditions are significantly different from that of Australia.
- The detailed information of the input parameters used in the Canadian method is not disclosed.

Based on the above facts, the UQ team has concluded that the Canadian method may not be suitable to the Australian distribution network.

The EA Technology's CBRM method provides a well-defined platform that can be used to calculate the health indices of various power system assets. However, the standard CBRM method is not tuned to produce an accurate health index of distribution overhead conductors. For example, the standard CBRM method only uses visual condition and Mid-span joints as the input parameter to derive the observed condition modifier of conductors (please refer to Figure 1). However, according to the existing literature and experts' knowledge, only visual condition and Mid-span joints alone do not reflect the true condition of the conductor. Therefore, one can suggest that the CBRM method needs to be refined by incorporating more observed conditions and test data for accurately calculating the health indices of distribution conductors. A number of Australian DNSPs have already used the EA Technology's CBRM methodology to determine health indices of their conductors. Hence, there is a timely requirement of focusing our research on selecting the most suitable input parameters and determining their weightages, which can be used as inputs of the EA Technology's CBRM method.

3.5 Input Parameters Proposed as Inputs for Calculating Conductor Health Index

To accurately calculate the health index for conductors in Australian distribution networks, it is necessary to select a set of parameters that can accurately reflect the true condition of the conductors under investigation. However, according to the UQ teams findings, the information on how to select these parameters are still insufficient. The UQ team has started working on identifying: (1) what parameters are the most suitable as the inputs to the tools; (2) how to determine the weights to these parameters; and (3) how to obtain these parameters from in-service circuits.

The input parameters the UQ team has identified so far are:

1. Maximum conductor operating temperature
2. Loss of cross section from lightning and fault current

3. Loss of cross section due to conductor clashing (phase to phase faults and high winds)
4. Conductor location (i.e. the distance to the coast)
5. Loss of cross section from corrosion
6. Loss of galvanizing layer (ACSR and SC/GZ conductors)
7. Loss of cross section from galvanic corrosion (ACSR conductors)
8. Line has long spans in open area (greater than 200 m)
9. Loss of cross section from fatigue (at clamps and damper positions)
10. Loss of cross section due to vegetation impact
11. Number of repair sleeves
12. Condition of repair sleeves and adjacent conductor
13. Visual inspections records

Among the above input parameters, only items 11, 12 and 13 are considered in the EA Technology's CBRM methodology. The UQ team is currently working on refining the above list and identifying the weighting factors for each of these parameters.

As the first step of the parameter identification process, the UQ team has started analysing the conductor failure data collected from a number of Australian DNSPs.

3.6 Conductor Failure Data of Australian Distribution Networks

The conductor failure data received from Australian DNSPs are listed in Table 2. From the table, it can be seen that all the data consist of conductor population, cause of failure and voltage level. Except for the data provided by SA Power Networks, all data comprise sufficient information for linking the cause of failure to the type of the conductor.

One vital information required for the statistical analysis of conductor failure data is the conductor age when fail. Such information are available only in the data provided by Western Power and Citipower/Powercor. The UQ team is conducting a Weibull analysis on conductor failure data provided by Western Power.

Table 2 Information of conductor failure data received form Australian DNSPs

Data source	Content of the failure data received
Energy Queensland	• Conductor type • Cause of failure • Voltage level • Maintenance crews' notes
Citipower/Powercor	• Conductor population/ Year Installed/ Climate Zone • Conductor failure data ○ Conductor type ○ Cause of failure ○ Voltage level ○ Conductor age when fail
Western Power	• Conductor age profile • Conductor failure data ○ Conductor type ○ Cause of failure ○ Voltage level ○ Conductor age when fail ○ Climate Zone
SA Power Networks	• Conductor population • Cause of failure/ Voltage level – Conductor type unknown
Ausgrid	• Conductor Age Profile • Failure cause, Number of failures per year (2014 – 2018)
TasNetworks	• Conductor population • Distance from coastline • Conductor age profile • Length of conductors installed per year (1952 - 2014) • Age based conductor replacement cost • Conductor failure data (# of failures per year 2006 – 2017) • Conductor failure data ○ Conductor type ○ Cause of failure ○ Voltage level • Maintenance crews' notes

3.7 Weibull Analysis for Extracting Conductor Life Information Data

Weibull analysis (also called "life data analysis") is a statistical method used to make predictions on the life of assets in the population [7, 8]. This is achieved by fitting a statistical distribution to data samples. The UQ team has conducting Weibull analysis on a data set provided by Western power. The data set comprises of conductor type, climate zone, cause of failure and conductor age at the time of failure.

Figure 4 and 5 illustrate the Weibull plots and conductor age distribution Steel, ACSR and Aluminium conductors in various climate zones of Western Power distribution network respectively.

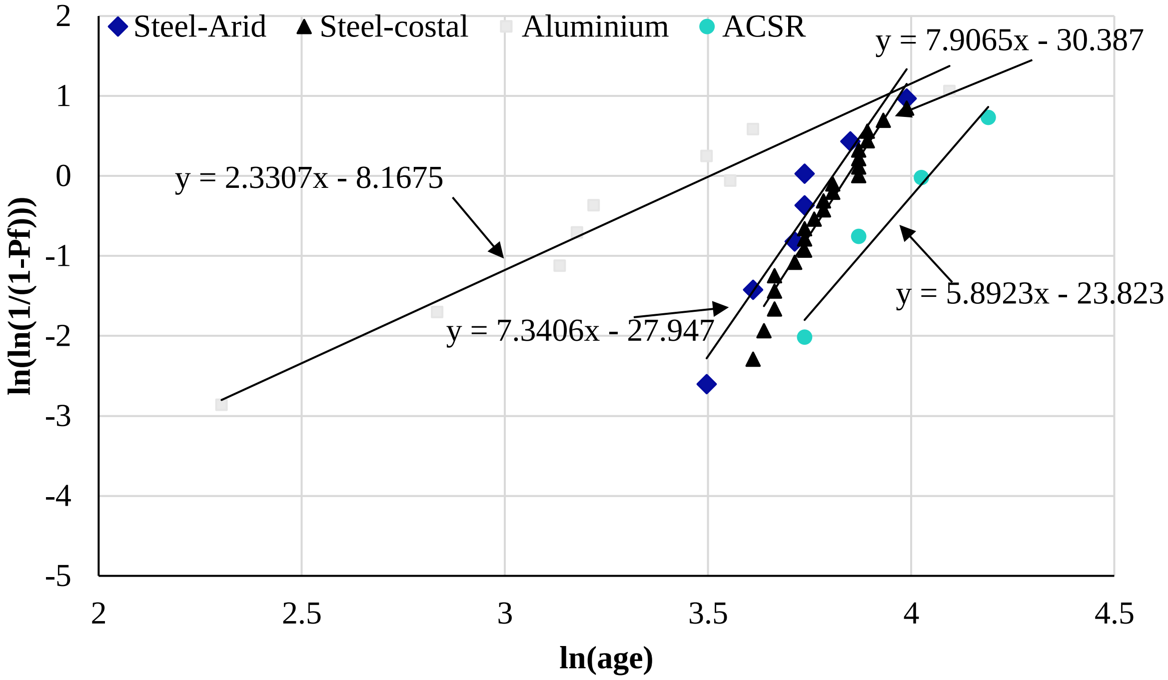


Figure 4 Weibull plots correspond to Steel, Aluminium and ACSR conductors failed due to corrosion in Western Power DN

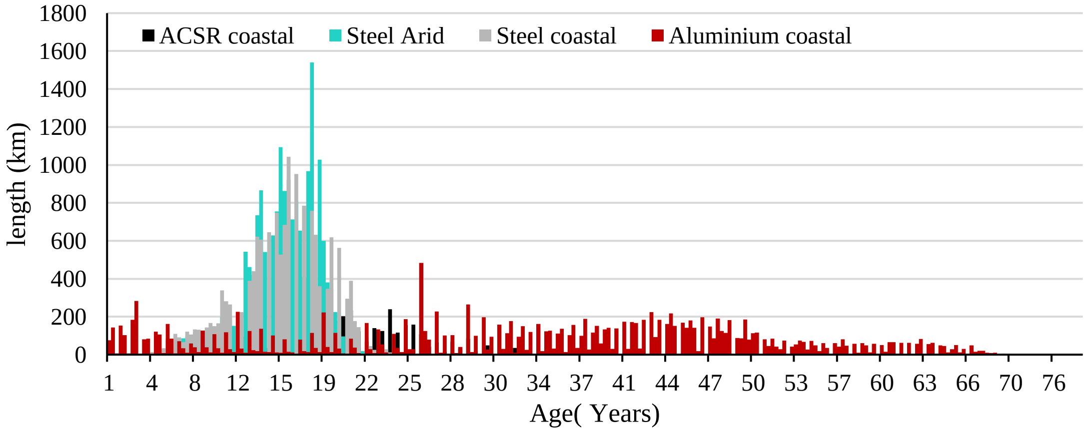


Figure 5 Conductor age distribution in Western Power DN

The Weibull plots in Figures 4 used to calculate two statistical parameters, namely β and η. β corresponds to the shape of the Weibull plot while η is a scale parameter representing the characteristic life of the conductor. Values of these two parameters corresponding to Western Power data are calculated and listed in Table 3.

Table 3 Statistical parameters calculated using Weibull modelling

	β	Characteristic life η **(years)**	Mean time to failure (MTTF) (years)
Steel - Arid	7.3406	45	42
Steel - Costal	7.9065	45	43
Aluminium	2.3307	33	29
ACSR	5.8923	57	52

From Figure 4, Figure 5 and the values of β and η, it can be concluded that:

- **Steel-Arid:** The length of steel conductors in Arid is 17,897 km. According to the data, the average conductor age is 31.3 years. However, according to the Weibull modelling, the characteristic life[1] of the steel conductors in arid is 45 years. Further, β is 7.341 hence the failure data represent a wear-out failure of steel conductor due to corrosion. As β = 7.341, the mean time to failure[2] is 42 years.

- **Steel-Coastal:** The length of steel conductors in coastal is 15,076 km. According to the data, average conductor age is 44 years. However, according to the Weibull modelling, the characteristic life of steel conductors in coastal areas is 45 years. Further, the β is 7.9, which implies failure data represent wear-out failure of steel conductors in coastal areas. However, the mean time to failure is 43 years.

- **Aluminium:** The length of aluminium conductors in coastal is 16,113 km. According to the data, the average conductor age is 38.48 years. According to Weibull analysis, β is 2.3307 and characteristic life is 33 years. This implies that the failure data represent a wear-out failure of aluminium conductor due to corrosion. The mean time to failure is 29 years.

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[1] Characteristic life (η)- the time at which 63.2% of the units will fail

[2]– Mean time to failure describes the expected time to failure for a non-repairable system

- **ACSR:** The length of ACSR conductors is 3,156 km. According to the data, the average conductor age is 40 years. The β is 5.8923 and the characteristic life is 57 years. This implies that the failure data represent a wear-out failure of steel conductors. The mean time to failure is 52 years.

Based on above results, it can be seen that there is a difference between the conductor end-of-life estimated using simple statistical parameters (i.e. mean value) and that obtained from the Weibull analysis. Further, the Weibull analysis results are in a good agreement with the conductor end of life figures typically use by Australian DNSPs. Therefore, the Weibull analysis can be used to analyse conductor failure data. However, it should be noted that, conductor failure data collected from DNSPs may not always contain the information required to conduct a Weibull analysis.

4. Future Works

- To conduct a detailed investigation of the parameters that Australian DNSPs should use as the input parameters to their in-house condition-based asset management tools.

- To investigate the methods of obtaining, calculating and estimating the above input parameters.

- To identify the weighting factors for each of the input parameters.

- To incorporate the refined input parameters with suitable weighting coefficients and provide to one of project partners to use in their in-house condition-based asset management tool on a selected type of conductors (given that the UQ team is granted the access to the tool by the project partner).

- A feasibility study of using drone to take high-resolution photos of conductors and then evaluate the conductor condition from these photos. This is the part of the first task in Milestone 3 of the project proposal.

5. Conclusions and Recommendations

The following conclusions and recommendations are made:

- The Canadian method was developed for transmission networks, on which various sensors can be installed. However, Canadian climate conditions are significantly different from that of Australia. Moreover, the detailed information of the input parameters used in the Canadian method are not disclosed. As a result, the Canadian method may not be suitable to the Australian distribution network.

- Some of Australian DNSPs in-house asset management software tools can provide health index calculation and predict the probability of failure of overhead conductors in distribution networks. However, there is still lack of understanding of input parameter selection. Hence, the accuracy of these software tool cannot be guaranteed. To deal with such difficulties, the UQ team has been investigating the input parameters, which can reflect the condition of the conductors more accurately.
- The UQ team found that the conductor failure data collected from Australian DNSPs do not always contain sufficient information, which may impair the accuracy of calculating conductors' health index and estimating conductors' remaining useful life.
- The UQ team is currently working towards improving the accuracy of existing conductor health index calculation techniques.

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7. Appendix

7.1 Risks

- Insufficient information contained in the conductor failure data provided by the industry partners.

- Inaccuracy of some type of data provided by the industry partners.

- The UQ team is not given the access to the industry partners in –house asset management tools.

7.2 Gantt Chart/ Project Plan

Task	Time (months)				
	1-6	7-10	11-12	13-14	15-18
Milestone 1					
Review, literature study, analysis and writing report	🟩				
Milestone 2					
Collecting conductor failure data modelling and analysing	🟩	🟩	🟨		
Determining feasibility of developing condition assessment of conductor using health index methodology		🟩			
Study of DNSPs in-house assert management software tools		🟩			
Identifying input parameters		🟩	🟨		
Identifying weighting factors for the input parameters			🟨		
A demonstration of health index method for condition assessment of a representative type conductor in Australia DNSPs' lines			🟨	🟨	
Milestone 3					
Survey state-of-the-art conductor condition monitoring techniques					🟨
Evaluating prospective emerging smart sensor-based conductor monitoring systems and provide some recommendations					🟨

🟩 - Completed tasks

🟨 - In-Progress Tasks

7.3 Financial statement

	2018										
Consolidated	**Carry Fwd**	**Aug - Dec**	**Adjustments**	**YTD Actuals**	**Carry Forward**	**Jan**	**Feb**	**Mar**	**Apr**	**Adjustments**	**YTD Actuals**
Revenue											
External Revenue											
Research Income	0.00	0.00	0.00	0.00	0.00	90,000.00	0.00	0.00	0.00	0.00	90,000.00
Total External Revenue	0.00	0.00	0.00	0.00	0.00	90,000.00	0.00	0.00	0.00	0.00	90,000.00
Internal Transfers											
UQ Wide Transfers Expense	0.00	0.00	0.00	0.00	0.00	(13,163.56)	0.00	0.00	0.00	0.00	(13,163.56)
Total Internal Transfers	0.00	0.00	0.00	0.00	0.00	(13,163.56)	0.00	0.00	0.00	0.00	(13,163.56)
TOTAL REVENUE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**76,836.44**	**0.00**	**0.00**	**0.00**	**0.00**	**76,836.44**
Expenditure											
Academic Salaries											
Salaries - Academic Non Casual	0.00	47,026.59	0.00	47,026.59	0.00	9,299.73	8,780.37	9,223.64	9,053.24	0.00	36,356.98
Total Academic Salaries	0.00	47,026.59	0.00	47,026.59	0.00	9,299.73	8,780.37	9,223.64	9,053.24	0.00	36,356.98
General Salaries											
Salaries - General Casual	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total General Salaries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Expenditure											
General Operating Expenses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consultant Professional & Oth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Travel	0.00	0.00	0.00	0.00	0.00	32.28	0.00	0.00	0.00	0.00	32.28
Total Other Expenditure	0.00	0.00	0.00	0.00	0.00	32.28	0.00	0.00	0.00	0.00	32.28
TOTAL EXPENDITURE	**0.00**	**47,026.59**	**0.00**	**47,026.59**	**0.00**	**9,332.01**	**8,780.37**	**9,223.64**	**9,053.24**	**0.00**	**36,389.26**
Operating Surplus/(Deficit)	**0.00**	**(47,026.59)**	**0.00**	**(47,026.59)**	**0.00**	**67,504.43**	**(8,780.37)**	**(9,223.64)**	**(9,053.24)**	**0.00**	**40,447.18**
Carry Forward	0.00		0.00	0.00	(47,026.59)	0.00	0.00	0.00	0.00	0.00	(47,026.59)
Accumulated Position				**(47,026.59)**							**(6,579.41)**

* Currently the project is in deficit by $6,579.41.