Asset Management – Australian Utility Perspectives and Experiences

By

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Abstract

Asset Management is the ability to manage risk associated with delivering an optimised performance of any given asset. The purpose of an Electrical Network Asset Management Plan is to outline the level of resources and systems needed to manage the network and meet regulatory and business objectives. These are generally to provide safe, secure, affordable and reliable transmission or distribution electrical services to customers. The Plan would set out a forecast for asset replacement and maintenance expenditure to achieve the objectives and is typically developed within a strategic planning framework that includes taking direction from an organisational asset management policy and long term visions of how the network is to be developed. Network Service Providers (NSP's) apply risk-based approaches to decision making to achieve an efficient balance of maintaining safety, security and reliability of supply at an affordable cost.

In this paper the discussions centres on electrical assets with a life span in the order of 30 to 50 years and how a Network Service Provider can benefit from a proper understanding of the asset's historical data to make short and long term decisions. It also shows how that data can underpin the asset management plan and support the business operational, tactical and strategic decision making processes. It reviews some case studies where innovative asset management techniques have been employed and addresses some of the differences in asset management strategies between Transmission and Distribution Network Service Providers.

Introduction

Before the mid-1970s, most Australian electrical Network Service Providers (NSP's) had yearly operating budgets that were more than sufficient to cope with several small failures and an occasional large failure. Maintenance workers were largely disconnected from the budget processes and viewed their primary responsibility as repairing failures as quickly as possible with little regard for costs. Budgets for equipment maintenance were largely based on the prior years' performances, standard maintenance programs and the engineers' asset knowledge. After the mid-1970s, a competitive environment began to emerge and a level of regulatory compliance, safety and environmental obligations drew attention to the need for a more precise understanding of the management of network assets.

Since 1990, the world has seen a significant change in the electricity industry bought about by changes in regulatory requirements, market demands and operation, and the industry structure in general. The increase in private investment into NSP's changed the priorities of some utilities yet they still need to manage the needs of the regulators and their customers. At the time, it was perceived that competition, particularly among generators and retailers, would lead to greater efficiencies in the industry and result in lower prices to customers. This has not always been the case but does remain the main justification point for selling the utility. More recently private investment has been a way for governments to reduce debt and offset financial risks associated with upgrading and maintaining aging networks.

Despite the political influences, the power industry has rapidly moved to an asset management way of managing their networks. One reason is that asset management methods provide executives and financial managers with more visibility about where and how to more effectively spend the available budget. Additionally, it provides clear feedback with more accurate data management and asset condition to provide that visibility to financial decision makers and when implemented well within a business it can simultaneously increase profitability, reduce risk, and improve customer satisfaction.

Another reason asset management is now being implemented within businesses is that it has been only in the last decade or so that power systems and business technologies have permitted it to be economically applied to NSP's where their networks are geographically dispersed with interacting equipment, communication systems and resources. These days, automation and control systems, computerised mathematical engineering analysis tools and main frame or web-based information systems, are used as a more data-driven decision-making approach to asset management.

Taking the perspective of the asset, all that has happened is that one slow resource driven management system has been replaced with a more real-time data-based system. Yet, the asset still performs the same basic function albeit with new performance demands. Generally, the asset management and performance requirements, strategies and policies of electricity NSP's (private or public) vary in ways that may include:

- Differences in maintenance strategies and overall maintenance budgets;
- Variations across the management of asset condition data
- Differences in strategies and numbers of assets replaced annually;
- Variations in planned and unplanned outages per circuit per annum.
- Differences in failure rates across differing asset types
- Variations in capital expenditure on new infrastructure
- Variations in organisational structures and cultures that support asset management

These variations do not allow the NSP's to easily source standard data management systems that fit almost seamlessly into their mainframe systems and desired asset management methodologies. There are common elements in nearly all NSP's and apart from a some of the areas mentioned above, they broadly include:

- Identifying the optimal balance of risk and cost reduction and asset performance improvements
- The ability to compare the expected outcomes with actual results to identify and overcome the barriers to sustainable asset reliability levels.
- Applying lessons from the past to improve the asset management strategies and techniques for the future.
- Balancing resources against performance criteria and budget constraints.
- Optimising asset performance against regulatory requirements and customer demands

The biggest challenge for the NSP is to decide what type of asset management strategy it will adopt. Choosing between maintenance systems such as Condition Based Risk Management (CBRM), Time Based Maintenance (TBM), Condition Based Maintenance (CBM), and Reliability Centred Maintenance (RCM), can be somewhat confusing without an understanding of the relationship between the systems. Figure 1 below shows a typical interaction of some of these methods that can be employed by an asset manager. Here the Corrective Maintenance (CM) is performed generally where an asset fails or has a problem that can affect its in service performance. Where asset values are low and reliability is not critical this strategy can be very effective but it is rarely used in most larger NSP's.

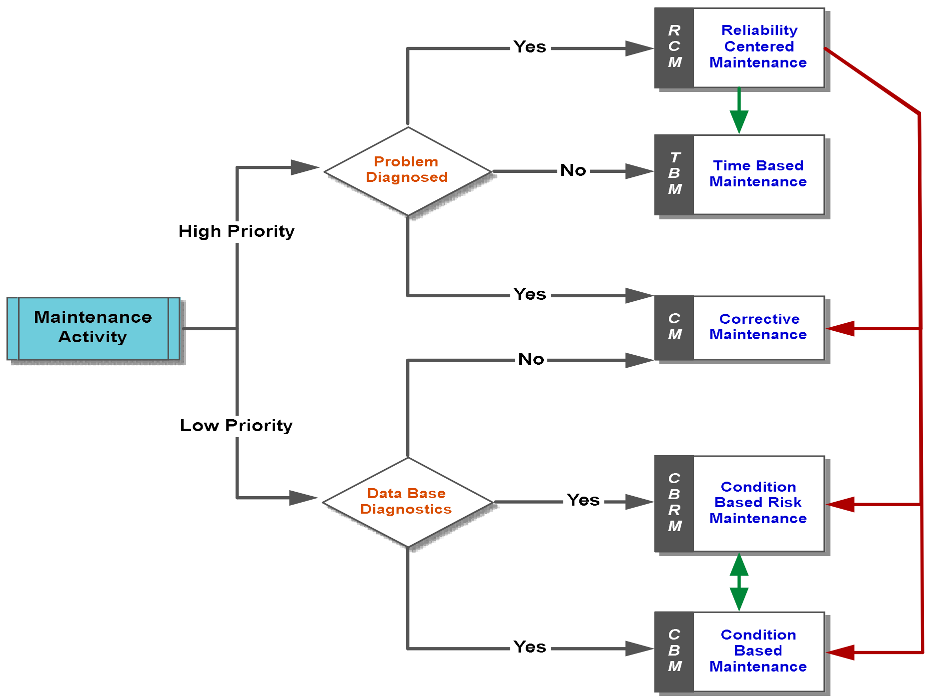


Figure 1
Typical Interactions of Maintenance Methods

The Time-Based Maintenance (TBM) uses a more traditional method, where components are replaced after a specified time or number of operations. Whilst the method produces satisfactory results and prevents many failures throughout the service life, it is not the most cost-effective option in all cases. Typically, all the assets of a specific type and age will be replaced as a batch and not remain in operation to the end of their effective service life.

Condition-Based Maintenance (CBM) is driven by the assessed condition of the asset. Under this approach, a good deal of condition monitoring and inspection data needs to be gathered to analyse and determine the asset condition. This requires investment into condition monitoring devices, test methods, data warehouses and diagnostic tools to ensure the best possible outcomes are achieved. This may not suit many utilities due to the level of investment and time to implement as the data gathered must be over long periods of time to be of substantial value. This is however, the direction that many NSP's have driven their businesses as those tools and systems become more readily available.

Reliability Centred Maintenance (RCM) uses the condition of an asset and the importance of that asset to the network to prioritise the maintenance. In this instance the strategy takes into account the importance of the asset to the network against the non-availability of supply. Recently more attention has been given to this approach as there are situations where it is not possible to identify the criticality and the condition of an asset, and the time-based maintenance is not an option, the only choice is to conduct corrective maintenance (CM). On the other hand, if the condition and criticality to the network are assessable, then a reliability-centred strategy (RCM) should be adapted.

Condition Based Risk Maintenance (CBRM) introduces the element of risk into the condition and reliability based strategies. This methodology has gained momentum over recent years as many utilities asses the level of risk associated with the asset performance. In some utilities, large volumes of asset condition data are fed into algorithms that determine the risk ranking and what assets should be maintained or replaced. They try to balance the risk against the condition based on failure rates, available condition data, criticality of the asset to the network and the budget. There is value in this method however, the algorithms tend to treat many assets types the same and work on the basis of a change in condition trend over a limited time. That is, the asset could be in very poor condition and near the end of life but as condition data has a very small rate of change the asset can be assessed as a medium to low risk and is pushed down the list of replacement priorities.

Knowing the Business and Knowing the Asset

When considering a NSP's business performance, a sound asset management strategy is one that can maximise that performance by applying strict data-driven strategies that consider the business profitability, risk tolerance, cash flow, regulatory requirements, reliability, environment, customer and staff satisfaction, and safety. In other words, the strategy is driven by the business objectives and goals which in turn directly drive the engineering and operating decisions (Figure 2). Asset management is conceptually and strategically, a business-driven paradigm, however, functionally it is based on known facts and is a data-driven process that requires more data than utilities have traditionally used for planning and operations. When used effectively it provides a comprehensive and rigorous decision-making tool that asset managers did not previously have access to. It is why good asset management strategies yield improved asset performance across the business compared with traditional methods.

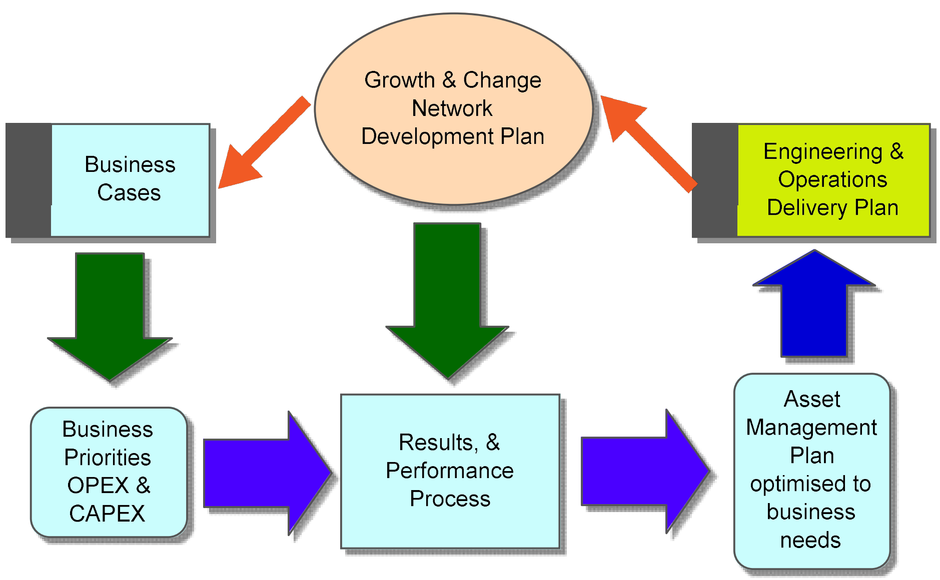


FIGURE 2

A Business-Driven approach to support Engineering and Operations

Asset management in the more mature NSP's is a business-driven methodology, in which many conflicting priorities, that generally interact, are balanced and leveraged to maximise the whole of business asset performance. Therefore, less mature utilities are now rapidly moving to asset management based strategies. When asset management is embedded in the business there are several clear benefits, some of which include:

- The provision of senior business managers with more precise data for better budgeting on exactly where and how available funds should be directed.
- It makes the utility's network needs more visible to financial decision makers, including a comparison of Substation vs Lines investments.
- It can and will increase the business profitability, reduce risk, and improve the customer experience.

At levels, closer to the field operations, asset managers need to have a clear vision of the business objectives and goals. They need to know their businesses from an asset point of view and can interpret these objectives and goals into an asset "fit for purpose intent". This means that if a business vision includes such objectives as delivering safe, affordable, reliable and secure, electricity supply customers then that asset manager needs to be able to understand how every available asset and resource contributes to achieving that objective. He must balance the asset performance against network risk, cost and supply availability so that the business stays committed to ensuring that supply is maintained safely, and the occurrence and duration of power interruptions is kept to a minimum for customers. In all he needs to know the business and know the assets.

How does Asset Performance Data assist in sound decision making?

Collecting volumes of asset performance data is meaningless unless it is turned into information that can assist in the decision-making process. It almost goes without saying that good asset decisions cannot be made without good supporting information. There is a distinction here between data and information. It is the gathering of asset data that when analysed and turned into information allows the asset manager to make the decision.

The information is crucial in deciding what is critical in the network and helping reduce the risk of missing a likely failure due to an emerging problem. When the correct information is available the rate at which failures are missed is significantly reduced. It can even help to reduce the rate at which false alarms are triggered or where a failure is indicated but there is no defect present. This is a clear cost benefit to the business as the reduction in the cost of these failures or false alarms will allow budget funds to be directed to other high priority projects within the network.

An example of gathering the data and analysing it is shown in Figures 3 to 6 inclusive. Here the utility has tracked the age of their transformers to understand the risk of failure and help develop a replacement plan for the oldest units. When the asset engineers looked closer at the data available and tracked the age profile of the HV bushings they soon discovered they had a situation where a wide range of bushing types with known failure modes existed in their network. Bushing manufacturers openly advise that Oil Impregnated Paper (OIP) bushings have a life span of around 25 years and the Resin Bonded Paper (RBP) bushings should be replaced after 30 years of service. Both types are at risk of failure when their designed operating life is reached. When reviewing the bushing ages, it was found that around 12% of the OIP bushings and almost 95% of RBP bushings were older than the recommended replacement age. This discovery changed the transformer risk profiles and whilst a replacement plan was still implemented and additional bushing replacement plan was developed. The utility had budget constraints that did not allow for intense

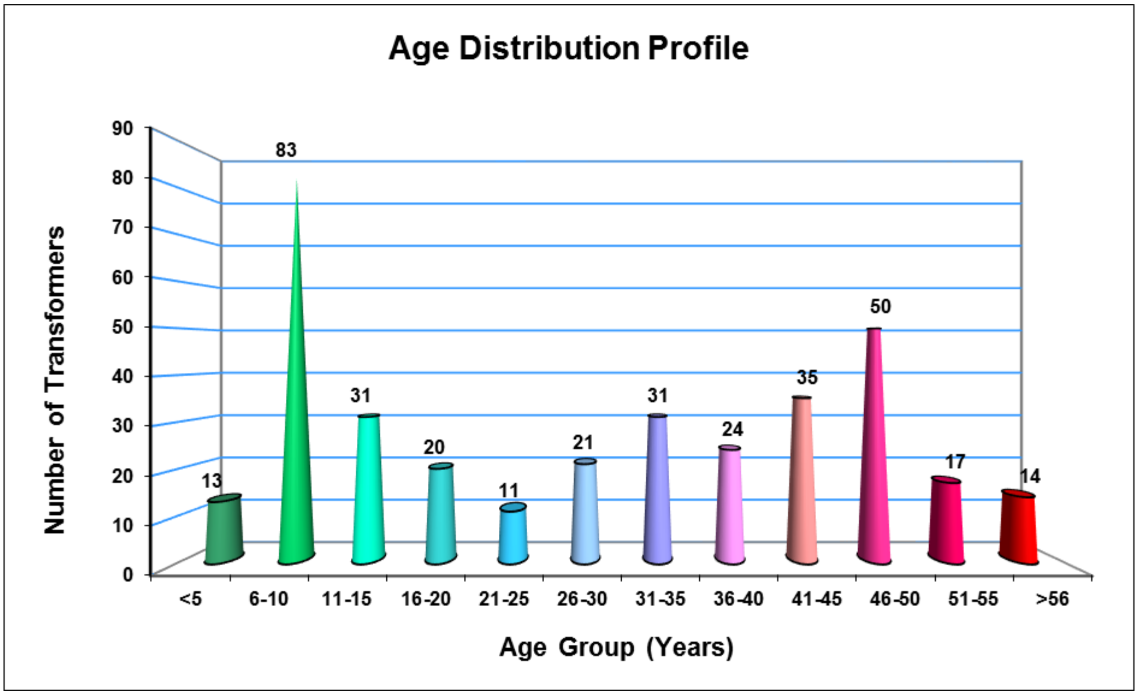
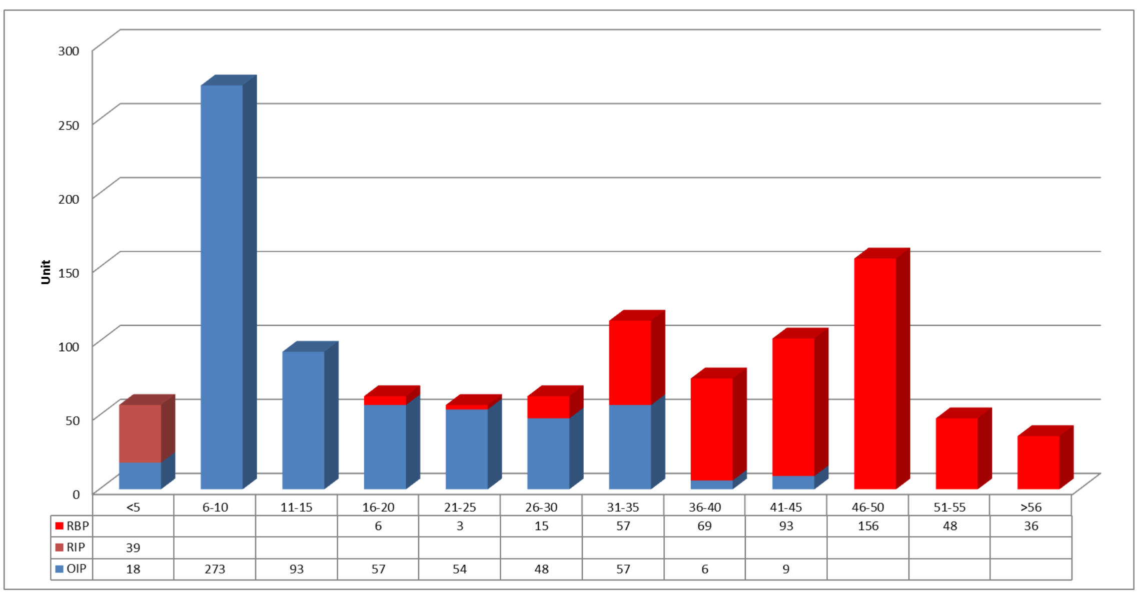


Figure 3
Transformer Age Profile for an Australian Network

replacement programs and so other options were needed to support the reduction of the risk of failure. The utility decided to implement an on-line bushing monitoring system on transformers that were low on the replacement program but had a high network criticality and aged bushings. This approach allowed engineers to monitor the bushing degradation and defer the replacement to a time that funds could be made available. The utility can now manage the risk of failure against available funds for replacement of both bushings and transformers.



	<5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	>56
RBP				6	3	15	57	69	93	156	48	36
RIP	39											
OIP	18	273	93	57	54	48	57	6	9			

Figure 4
Age Profile of all HV Bushings 66kV & above.

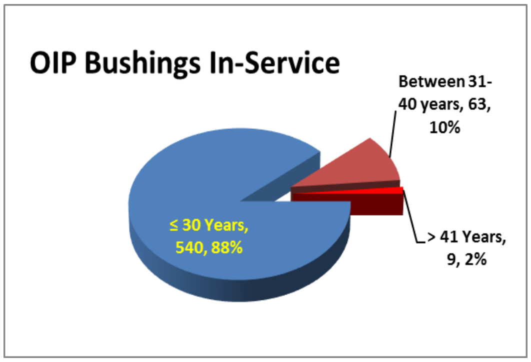


Figure 5
Breakdown of OIP Bushings Ages

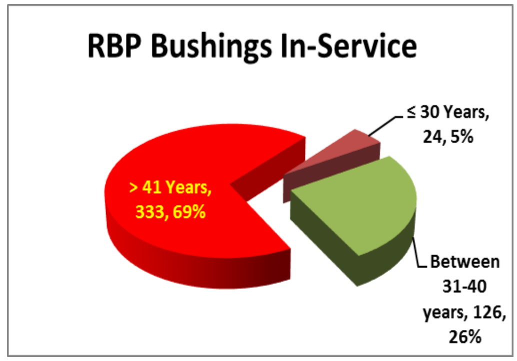


Figure 6
Breakdown of RBP Bushing Ages

Figure 7 is an asset aging model that shows the life cycle process needed for an asset that is well managed to its normal end of life. This model (and many like it) look at the assets as not failing prematurely, however in reality there is a small percentage of units each year that do fail unexpectantly. It may be lower than 0.5% per annum but they do happen and need to be managed. What this model is suggesting is that by adequately monitoring and collecting condition data from the asset those unexpected failures will reduce to a far lower level. Having said that, it can be deduced that by reducing the failure rates and doing only the necessary maintenance, the asset manager can then maximise the in-service performance life of the asset.

It should not be forgotten that the asset whole-of life is a cradle-to-grave process starting from the initial concept, through the design stage, manufacturing and into the operating life and continuing to the asset's end of life/disposal. Therefore, throughout the whole of life the asset data must be captured and presented in a way that the asset manager can assess its performance and condition with respect to the corporate objectives and all other network assets. To have a healthy asset it is imperative that it is monitored and its requirements are addressed during the life of the asset.

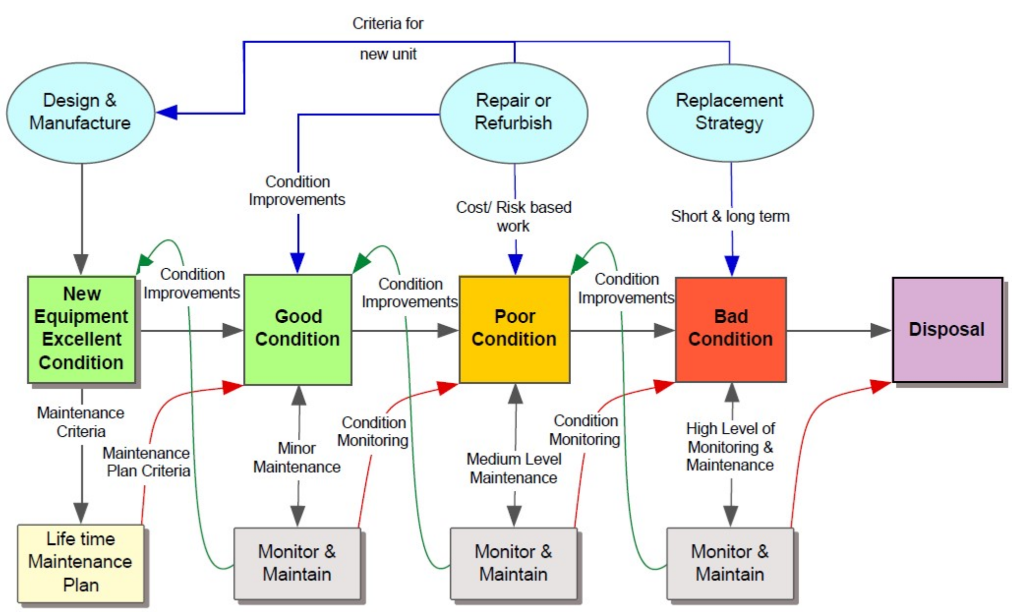


Figure 7
Typical Asset Life-Cycle Model

Just as in the case where the utility was managing their transformers and then bushings they could see the risks by applying whole of life strategies to the main transformer and then the components that cause failures.

Many asset managers use a form of health index to help turn the data into information and at the same time provide a quick way of comparing like assets across the network. It can help understand asset performance trends, failure rates, age profiles and maintenance cycles among other things. The subject of health indexes is too vast to discuss in this paper however, they are of value if developed in a way that is meaningful to the asset manager and aligns to the business objectives.

Asset managers and reliability engineers often describe the lifetime of a population of assets using a graphical representation called the bathtub curve (Figure 8). The bathtub curve consists of three periods: an infant mortality period with a decreasing failure rate followed by a normal life period (also known as the "useful life") with a low, relatively constant failure rate and concluding with a wear-out period that exhibits an increasing failure rate. Understanding the Whole of Life Cost (WOLC) of an in-service asset may seem complex at first but it really comes down to a few fundamental things. Knowing realistically where the problems helps and one way of doing this is to start listening to the asset.

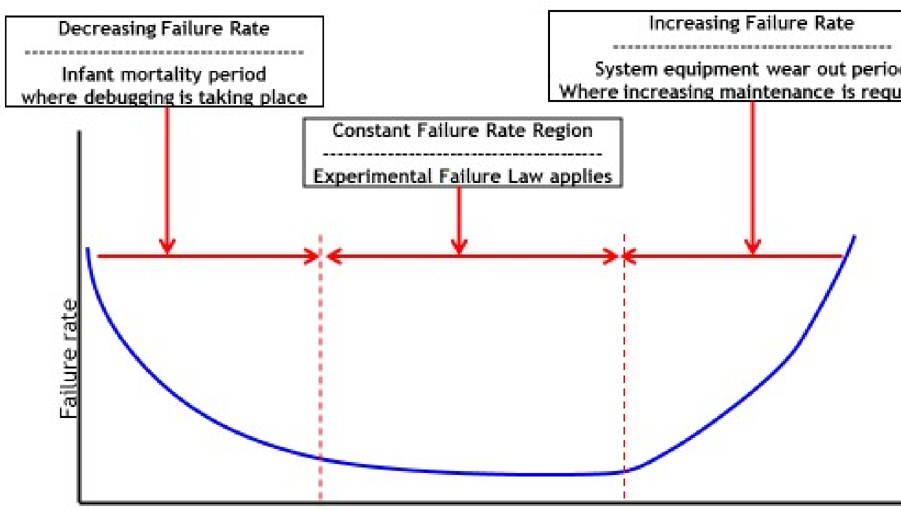


Figure 8
Bathtub Curve – Failure Rate vs Time

This means that we need to analyse the data fed back from the asset as this data is what the asset is saying about its condition. There is no such thing as a perfect data set however having the right types of data will help listen to the asset. The data will show trends in the condition and detect most abnormalities. This is where the asset is telling the asset manager there is a problem and it needs attention. All businesses are different and asset operating environments are different but there are similarities that can help with establishing a good foundation for analysing problems by data mining. Starting with what is immediately available and building on that can help the asset manager establish a very good view of what the asset condition is. It also helps to know what the unknowns are by performing a gap analysis on all data collected and comparing that with the lessons learnt from unexpected failures. By reviewing past lessons and failure trends the asset engineer can adjust his focus on the most appropriate data to collect and help prevent further failures.

Finally sharing information and learning for others' experiences across the organisation and with other organisations can support an understanding of where the emphasis on data collection and risk reduction will deliver the most benefits. In many utilities in Australia it is common practice to do failure investigations and some of the findings are shared between utilities who have similar assets that may be at risk. Sharing the information has its greatest value when the collective engineering minds can develop a solution that can be applied across all utilities. This has the added benefits of developing common practices, supporting replacement strategies for regulators and allowing the corporate asset risk profiles to be managed more effectively.

Total Cost of Ownership

Earlier in this paper it was mentioned that it is important for the asset manager to look at the whole of life cost of an asset, however, it is just as important to look at the Total Cost of Ownership (TCO) from a corporate perspective. All too often assets are purchased on the lowest priced item that fundamentally meets the specification. From an initial capital cost perspective, this is quite a sound approach however the lowest capital cost item may in fact be the most expensive to maintain. Therefore, the cost to operate the asset becomes excessive and funds allocated to other assets are impacted by the "money pit".

Figure 9 takes a pragmatic look at what the total cost of ownership (TOC) is. It resembles the iceberg where about 70% of the iceberg is hidden from view. This can hold true for the substation assets where the whole of life costs are generally not that visible to the organisation.

Figure 9
Analogy of the Total Cost of Ownership Model

Looking at the model one can see there is a very visible cost for buying the product however, below the surface there are all those costs that come with ownership. Those shown in this diagram relate mostly to the corporate issues and impacts on the organisation. There are other costs not shown and they include labour costs for maintenance, spare parts, loss of revenue due to outages and so on.

A key outcome here is that by developing a combined WOLC and TCO (whole of life and total cost of ownership) model for an organisation that is reflective of asset types then one can assess the true value of the asset to the organisation.

Is the Manufacturer to Blame?

This is an interesting question to ask about any high maintenance cost asset and the answer could well be yes. If a manufacturer is focused totally on developing a mass-produced product that can service any customer's specification they may not actually know how that product impacts the customer's network. This is a hard area to assess when performing a tender analysis and the manufacturer may well do some basic work that generates the appearance of knowing your network issues. Therefore, it is wise to do some reference checks to understand if the manufacturer has delivered on their promises and commitments to other utilities. It is also wise to follow what manufacturers in general are doing in the market place. That is, are they just selling product and displaying products at conferences or are they actively meeting with customers, discussing application issues and delivering case study papers at conferences and in journals. The difference here is that the latter is engaged in the industry and listening to the end users and how they use the asset and what problems they have throughout the life of the asset. This is where the greatest improvement in asset performance can be achieved. It is however, the area where price has an impact. The better performing and the high the quality of the asset the higher the price. Research and development combined with reliability and performance comes at a cost but that is where the cost must be off-set against the TOC and WLC model. When this is done effectively the higher initial cost products often become quite competitive.

The real answer to the initial questions is NO; the manufacturer is not to blame. What is to blame is the way the assessment of procuring an asset is performed and this is an organisational issue. The manufacturer is not to blame for an organisational deficit. The way to correct the issue is not an easy one as it requires significant data mining on asset types, then brands and components. Many academics and some economists have offered algorithms to try to resolve the problem but these do not fit all types of assets and the different brands and types within the asset group. Therefore, the only reliable method is to go back and "listen" to the asset. If assets are under stress in a specific location, then it may be that that asset is not the correct one for that application or it could be an asset defect or other issue. The asset engineer needs to understand why the asset is under stress and offer the asset manager a way that it can be effectively managed within the budgetary constraints. Again, this leads us back to the collection of data and turning that data into information upon which a decision can be made.

Change Management

Implementation of techniques in asset data acquisition processes requires changes in existing process, policies and responsibilities; and subsequently will necessitate managing the change and resistance to change by organisational individuals and teams. An organisation should aim to change the data collection and analysis process in a way that all relevant stakeholders cope with the change through involvement. This way there can be opportunities for stakeholders to raise their concerns in information, process change and lessons learnt sessions. It is important to have sessions which include communication among various field teams to understand the contributions they can make to make the asset management system. The way data is collected needs to be set at a standard or very consistent way or the data may ultimately be less meaningful to the end users. By taking this approach it will empower stakeholders to accept and embrace the changes through effective communication in relation to the reasons for the change and the realisation of the benefits for the business after the successful implementation of the asset acquisition process.

The change here is how data is captured and used as a way of making decisions on the asset from concept to disposal. It has an impact on the TCO and WOLC and if that data is used effectively within an organisation by not only engineers but also the accounting and commercial risk people then the asset management maturity level of that organisation with take a leap forward. By engaging all stakeholders, the asset manager is also listening to the business and implementing changes that ultimately can provide that safe and reliable network at a cost-effective price.

Conclusion

This paper has provided some insights into issues that have been faced by Network Service Providers not only in Australia but across the world. It has been stated that not every NSP is the same and not every asset performs the same but what is the same is the desire to maximise the performance and minimise the cost of the asset. Some ways of addressing this is to have a robust data acquisition system that takes asset data and provides information that can be used for decision making. It also goes to say that the asset must be correctly selected and to do this the data must be able to support that selection process. Every business struggles with articulating engineering data in terms of risk, cost and commercial impacts. Unfortunately, today this has become an absolute necessity and therefore the asset manager must collect the correct data to “listen” to the asset so he can tell the business what the impacts are on those economical, commercial, reputational, environmental, safety and supply reliability business concerns. By having a good a robust asset data collection and analysis the job of managing those assets does become easier as it underpins much of what a Network Service Provider business is about.

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Biography

Kerry is a registered and chartered professional electrical engineer with 40 years' experience in the industry and managers his own small consulting business. He has an extensive and diverse background in utility substation asset management, refurbishment, condition monitoring, maintenance and failure investigations. He is a member of Engineers Australia, The Asset Management Council, CIGRE and IEEE, and works with Australian Universities to support students and encourage research and innovation within the industry.