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ASSET MANAGEMENT COUNCIL

ASSET MANAGEMENT MATURITY

What Level of Maturity should our Organisation aim for?

Integrating ISO 55001: 2014 with other ISO Systems

Asset Management Maturity Model

Includes **AM Speak 2020 Supplement**

ERNST KRAUSS

EDITOR IN CHIEF

Asset Management Maturity – is it for us? This should never be a question. It is of course a sizeable investment to change an Organisation that manages Assets in to an Asset Management Organisation. And when all is done and achieved, how does the Organisation and importantly also the Stakeholder know what has been achieved? And that what has been achieved is working and embedded as the 'new culture'? When considering the Asset Management system as described in ISO 55001, it is clear that the whole organisation needs to be involved in Asset Management. It was refreshing to receive a 'lecture' in Asset Management form a Personnel Manager in an Organisation for which I had the privilege to assess their Asset Management Framework and processes.

The engagement from the leadership team right through to the work force on the shopfloor or front line can be sometimes short lived. An observation of Organisations that globally are requesting support to improve their Asset Management System leads me to the conclusion that there are many early adaptors of ISO 50001 or PAS 55 discovering that their processes require constant attention and improvement and have presently deteriorated from the earlier focus on an Asset Management. Of course, as Organisations evolve and mature there are many reasons why the focus shifts and changes. And then there is the natural change of personnel that occurs in every organisation and requires firmly embedded processes and procedures that make Asset Management sustainable within the Business.

As the whole organisation is involved in Asset Management, it is not sufficient to make sure that Policies and Plans are kept alive and are reviewed from time to time. Certification to ISO 55001 is also a sizeable investment and is not a one-off investment, but should be kept alive throughout the life of Asset Management processes. Stakeholders require assurance that Asset Management is functional and provides the best outcomes, based on efficient management of the Business and its assets. This is where a maturity assessment of the Asset Management System is important, as this provides these assurances about effectiveness of the Asset Management System.

Culture, Processes and Cross Functional engagement are the some of the focus areas of a good Asset Management System. Assessing Asset Management maturity, for instance through the Asset Management Council Maturity assessment process, is a vital step to provide continuous assurance. Why not consider basing your next improvement cycle of your Asset Management System on such a Maturity process? The benefits of a Maturity assessment are the structured evaluation against internationally proven criteria of the efficacy of your Asset Management System resulting in the identification of specific improvements required to retain effectiveness of cost, risk and performance. Such an assessment is also a very effective way to identify where best to start to implement an Asset Management System.

We trust you enjoy the articles provided and welcome, as always, your feedback.

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FROM MY DESK: CHAIRMAN'S LETTER

CHAIRMAN, DAVE DAINES

The ISO 5500x series of Standards were issued in 2014 and their existence has focussed many businesses and organisations to comply, conform or just use the Standards to develop, implement, maintain & improve an Asset Management System.

The standards by their nature state minimum requirements and the continual improvement process provides the vehicle to further develop and mature the system.

The Global Forum in Maintenance & Asset Management (GFMAM) defines Asset Management Maturity as "the extent to which the capabilities, performance and ongoing assurance of an organisation are fit for purpose to meet the current and future needs of its stakeholders, including the ability of an organisation to foresee and respond to its operating context."

As the interest in Asset Management continues to grow internationally there is an increasing level of consideration towards understanding and measuring the level of maturity. Asset management maturity requires that an organisation deliver outcomes such as customer service, profit, safety and assurance, with the assigned resources and within the requisite delivery period. Asset management maturity is dynamic and should be able to respond to both the changing business environment and changing stakeholder needs in a manner that aligns with the other functions of the organisation.

Many tools have been developed in order to try and measure maturity. The tools range from the simple that use the familiar scale of innocence to excellence to the more complex that provide a detailed insight into the organisation. The AM Council Asset Management Maturity Model (AMMM) has been developed by a cross section of industry and rigorously tested.

As you will see from this edition of the Journal, there are many ways in which organisations are focussing on Asset Management Maturity

David Daines
National Chairman, Asset Management Council.

ARTICLE 1 – What Level of Maturity should our Organisation aim for?

Roger Byrne

SUMMARY:

Many people are confused about the level of maturity required by their organisation on respect to managing their significant portfolio of assets?

The ISO 55000 / IIMM 2015 and GFMAM and other organisational guidelines talk about a basic / core, intermediate and advanced level while other guides and many consultants promote the idea of world's best practice / a very advanced approach.

This is a complex issue, but the following process outlines the approach that Roger has developed to assist organisations to understand the issues involved and the logic of an approach that can be taken, to develop a Best Appropriate Practice (BAP) level of maturity for the individual assets and their investment strategies.

The following are responses by Roger Byrne to questions from various managers, staff, and Elected Board Members on Advanced Asset Management.

Disclaimer: They are for general appreciation of the issues involved only and should not be applied without further assessment of your particular situation.

TECH 1

1 OVERVIEW/SUMMARY

The approach promoted by Roger is best explained by the following summary:

- The overall degree of maturity we need for good asset management is related to the asset portfolios we own, their condition / performance/ value and the criticality (business risk) they represent to your service delivery.
- Asset portfolios usually present a diverse set of assets and components that will be at different stages in their life cycle, and represent different business risk exposures in delivering their required / desired levels of service.
- The objective of sound asset management must be: "To make good decisions on how to manage these components, assets, facilities, systems and ultimately the services they need to deliver from an affordability perspective, which should include 'triple bottom line' assessments".
- In simple terms, we need to make decisions that have reached an appropriate level of confidence or Confidence Level Rating (CLR) . In simple terms we need to complete a maturity level of analysis (or quality) that that is commensurate with the value of the investment being justified.
- We need to meet an appropriate confidence level (or quality) rating (CLR) to match that investment and the complexity of the analysis necessary to reach a justifiable decision. Assuming that the CLR is identified by an assessment of the level of process sophistication followed and the quality of the data used in that process. This is dealt with in more detail by another manual namely: "Determining the Confidence Level Rating of your Decision Making".
- In all investment cases we should be doing life cycle cost analysis but varying the level (of sophistication) to suit the value of the investment being made or the risks associated or likely to result if the investment is not made.
- We also need to complete this investment analysis in a most cost effective way. Very few organisations have the financial resources to fully fund the costly analysis required and therefore we need a logical step by step process that filters and identifies those components and assets on which we should be completing this higher level (more sophisticated) economic analysis, or alternatively staging the level of analysis to meet the funds / resources the organisations can afford to make.
- It is also important to realise that the more complex projects do not require every life cycle element to be done at the higher analysis level, but by understanding the Business Value Chain (BVC) the investment represents we can adopt a suitable level of analysis of the parts of evaluation. But this is better explained by reading the relevant manual (as shown above).
- From my experience I believe it is necessary to have some 4 levels of AM maturity / sophistication to meet all the different analysis required, whereas the original ISO standards used more. See figure later in this FAQ.
- My premise is that a simple two levels of AM (basic or advanced) level doesn't really fit the bill, resulting in us doing either too little or far too much analysis and lacks a focus for cost effective implementation programs.
- Even small organisations with simple asset systems may have a single assessment (pipeline renewal strategy) that warrants a world class analytical approach, whereas many other component renewals can be undertaken using a core/ basic or intermediate level, e.g. simple failures.
- I believe that an organisation should grow to a level of maturity that applies to 85% of the asset portfolio decision making, and they should have the ability to know when they should import specialist skills for major asset issues / evaluations and strategies that require this higher level of analytical input. The following figure shows the relationship between the IIMM and the original ISO scale.
- In terms of process maturity we need to identify the critical analytical factors in the analysis and match the CLR assessment to suit in terms of process sophistication and data quality.

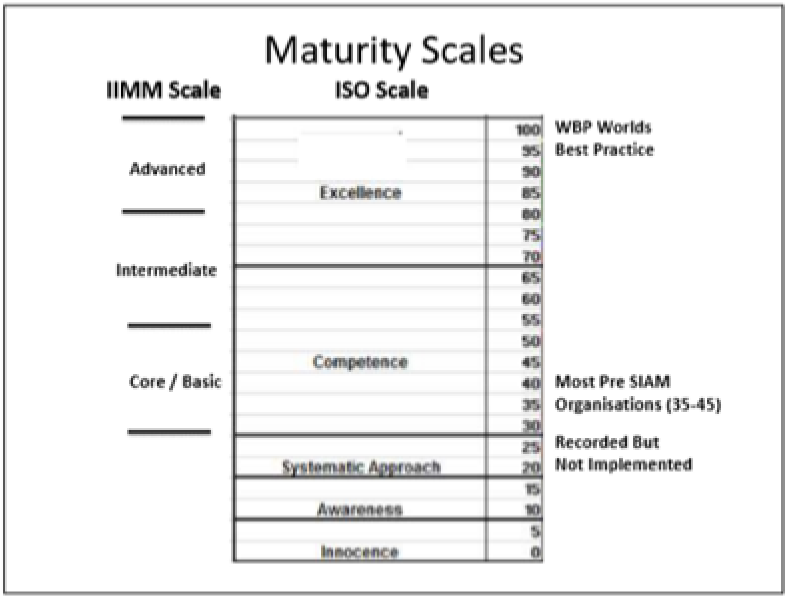


Figure 1

2. SO WHAT SHOULD YOU DO?

So let's start at the beginning. You have just decided to improve that way you are managing your assets.

You first assess your current levels of maturity (quality) against a respected asset management standard. TEAMQF

/ PAS 55 / IPWEA / and now the ISO 55000.

This will give you a good idea of your current maturity or quality level overall. However the key is to decide on what are the things you need to improve first. We have covered this in many 'Getting Started' manuals so I won't go into this here, but you should refer to these.

By understanding our organisations current level of maturity we can better understand the GAP we may have to this BAP level and can then plan our implementation program more effectively. See following figure. By using the step by step process (see later) we can understand which assets and which investments required more detailed analysis. However the first thing we need to do is to get a feeling about our asset portfolios in terms of getting a level 1 (AM1) or basic understanding of all our assets.

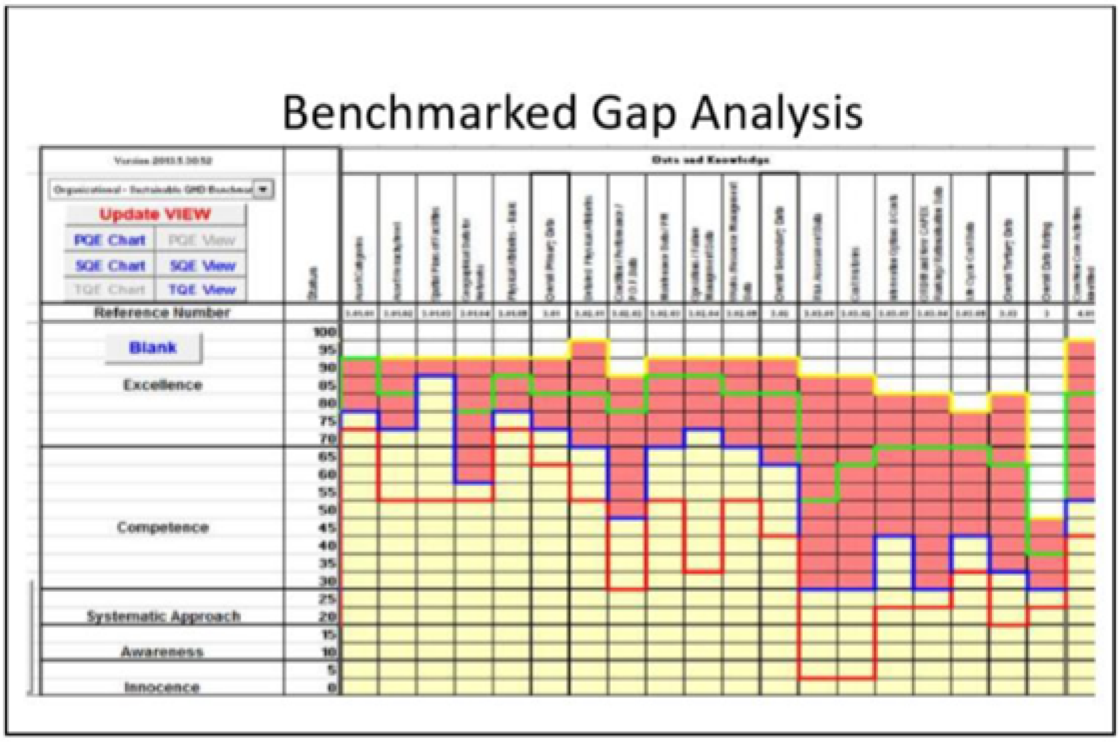


Figure 2

TECH 1

3. SO WHAT INFORMATION & OUTPUTS DO WE NEED TO KNOW?

From level 1 to level 4 we really need to be able to answer the following questions:

1. What assets do we own? Broken down into components using a suitable hierarchical level down to a maintenance managed item (MMI)
2. In what condition are they?
3. How well are they performing against their required (or design) level of service?
4. What is their residual physical life & % Life consumed? Don't worry about design life just focus and what life is left.
5. When will they need renewal (replacement or rehabilitation) & what will that cost? (End of physical life)
6. How are they currently utilised – and what is the demand for the asset?
7. What is their likely failure mode?
    a. Capacity will be exceeded and they need to be augmented / duplicated? Or is their demand far less than their capacity.
    b. Reliability / Level of Service failures?
    c. End of physical life?
    d. Annual Costs (LCCA) exceed other viable options?
8. What is the business risk exposure to our business if they fail?
9. What is the optimal maintenance program (planned and unplanned) on the assets to ensure they have the lowest life cycle cost? (Remaining life)
10. What is the lowest cost future strategy to manage these assets? And what is the Confidence Level Rating (CLR) of this strategy .
11. What will be the total cost of those strategies & what funds will be needed over time?
12. What is the likelihood that these funds will be made available? Willingness to pay.

If we know these outcomes for all assets, against the predicted demands, then we can fully understand the needs of the entire asset portfolios. We then have the predicted future levels of service and cost of service.

However it is the Confidence Level Rating (CLR) that we have in this data for individual assets and the derived expenditure predictions that is most important.

Armed with this information we can consult all stakeholders and determine to funds that can be provided and use these in the most optimal way having all the above information and knowledge. I have seen too many organisations happy to make large investments on very weak data and analytical processes.

What we really need is a cost effective process to identify the level of analysis that is warranted for the decisions required, aiming at getting adequate confidence level in the outcomes / strategies derived.

4. UNDERTAKING THE ANALYSIS USING DIFFERENT LEVELS OF PROCESS SOPHISTICATION

Every one of these outcomes / decisions can be undertaken with different levels of sophistication. In fact we have identified at least four levels all with substantially increasing costs.

For example we can look at the Condition Assessment Processes. CAP level 1: Can be a simple 1-5 or 1-10 assessment process

CAP level 2: Using a multi criteria analysis tool that provides scores from 0-200 / 400

CAP level 3: Using a variety of more sophisticated assessments: CCTV, X-Ray, Oil Analysis, infra-red thermography, ground penetrating radar etc.

Each of these levels provides the ultimate outcomes required, namely:

- The residual physical life
- The level of service (where condition is involved)

The data then used in these processes then produces the outcomes desired, e.g. the optimal capital, maintenance & operational strategies that relate to the individual assets and their components.

However the cost of this analysis increases significantly with each level. Therefore it is vital that we identify those assets that warrant a higher level of input and not just apply the Advanced Level 3 processes to every asset. See figure below.

This applies to all the analysis required to derive all the decisions / outcomes listed above. If we match these processes with the quality of the data available then we can get an idea of the CLR that has been derived. When we compare that with the value of the investments being considered we can set a process that justifies the level of sophistication required.

Other documents detail the different levels of sophistication for all the processes involved in sound life cycle asset management analysis including:

1. Condition assessment, (CAP) residual life & probability of failure.
2. Performance assessment, condition, reliability (RCM) and probability of failure (PoF)
3. Maintenance planning & analysis (MM)
4. Risk assessment (consequence & probability) and mitigating / management on TBL terms (BRE)
5. Life cycle cost analysis techniques (ORDM & LCCA)

Figure 3

Looking at the Cost of Data

DATA REQUIRED	AM Level 1	AM Level 2	AM Level 3
Methodology USE	DELPHI GROUPS	MCA	Full Analysis
CLR Derived (Ave)	50% approx	70% approx	85% approx
Asset Register	$10	$15	$30
Asset Attributes	$20	$100	$300
Asset Locations	$10	NA	$400
Condition Assessments	$15	$200	$500
Residual Life	$10	$100	$200
Performance	$10	$100	$200*
CRC Valuation	$40	$70	$100*
Capacity / Utilisation	$50	$500	$1000*
Maintenance History	$50	$200	$800*
Maintenance Plan	$100	$500	$1500
Renewal Strategy	$75	$400	$800
Risk Assessment	$60	$500	$2000
CIP Validation	$100	$500	$1000
	AM1 Delphi $560	AM 2 MCA $3600	AM3 Full $8900

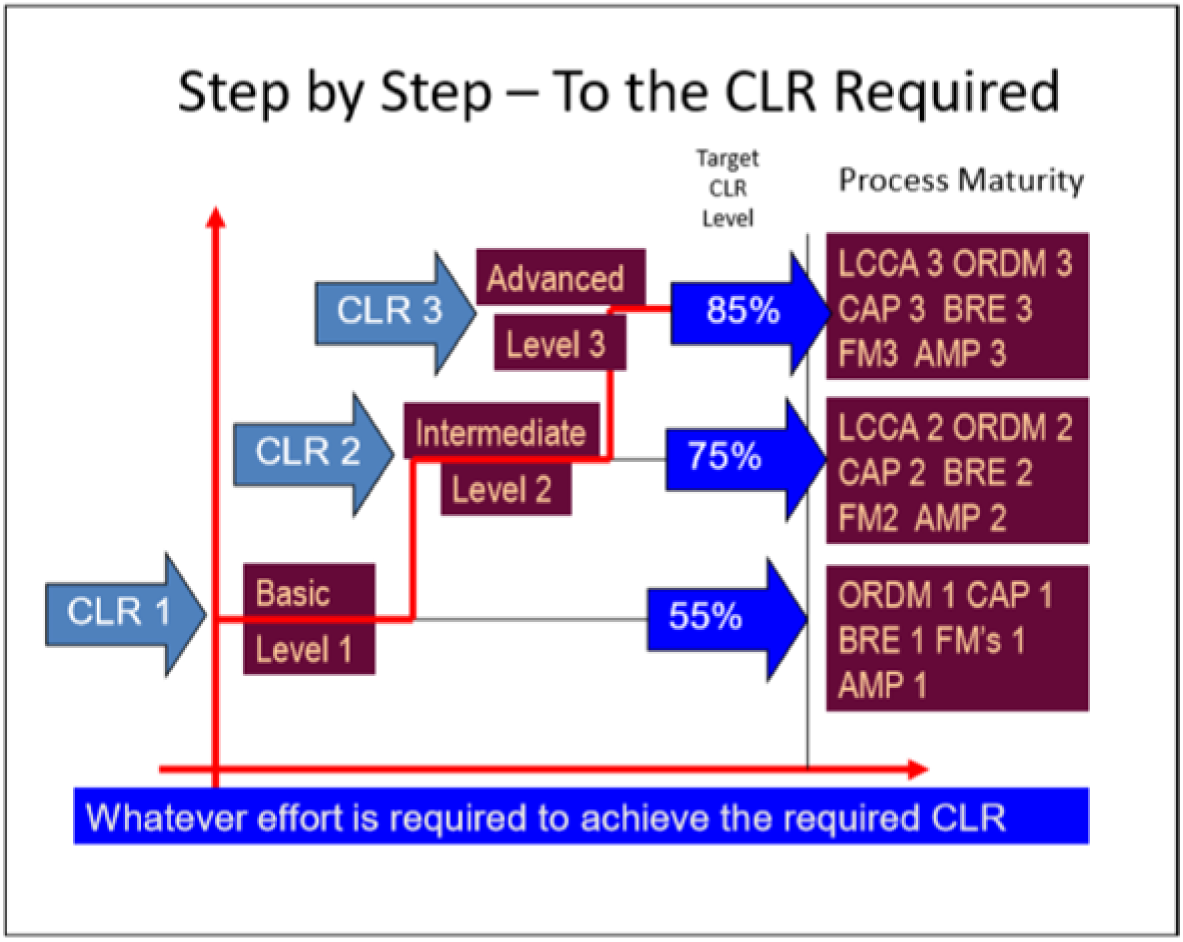


Figure 4

5. UNDERSTANDING THE CONFIDENCE LEVEL RATING OR QUALITY OF OUR DECISION MAKING

If we understand the quality of the process we have followed and have an assessment of the quality of the data we have used in that process, then we have an ability to understand the confidence level rating of the analytical evaluation outcomes or our strategic decisions.

We do this as a simple calculation:

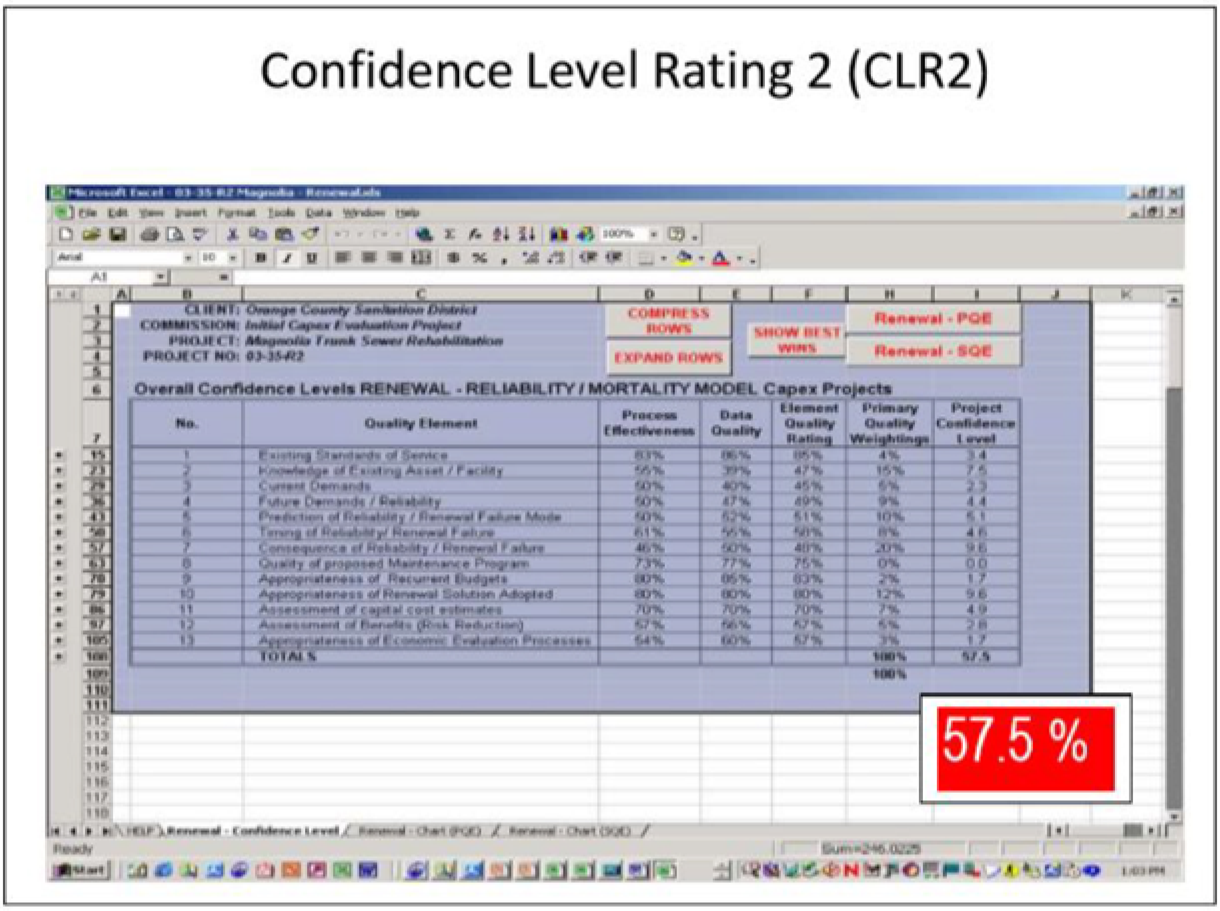
(Process Quality + Data Quality) / 2 X the business value chain of quality element.

It is hard to get your head around it initially, but makes sense as you see it in practice.

The CLR is then related to the value of the proposed investment. The greater the investment, the higher the CLR needs to be to get approval. E.g.

Up to $ 500,000 CLR 50 500,000 to $2 Million CLR 60 $2M to $10M CLR 70$10M to $50M CLR 80 Over $50M CLR 85

We start lower than these values and then increase the CLR as we get more advanced in our AM practices and thereby control the cost of the analysis required to suit our organisations capability to complete and fund / resource such analysis. It all grows together in a logical step by step process.



No.	Quality Element	Process Effectiveness	Data Quality	Element Quality Rating	Primary Quality Weightings	Project Confidence Level
1	Existing Standards of Service	83%	86%	85%	4%	3.4
2	Knowledge of Existing Asset / Facility	55%	39%	47%	15%	7.5
3	Current Demands	50%	40%	45%	6%	2.3
4	Future Demands / Reliability	50%	47%	49%	9%	4.4
5	Prediction of Reliability / Renewal Failure Mode	50%	52%	51%	10%	5.1
6	Timing of Reliability/ Renewal Failure	61%	55%	58%	8%	4.6
7	Consequence of Reliability / Renewal Failure	46%	50%	48%	20%	9.6
8	Quality of proposed Maintenance Program	73%	77%	75%	0%	0.0
9	Appropriateness of Recurrent Budgets	80%	85%	83%	2%	1.7
10	Appropriateness of Renewal Solution Adopted	80%	80%	80%	12%	9.6
11	Assessment of capital cost estimates	70%	70%	70%	7%	4.9
12	Assessment of Benefits (Risk Reduction)	57%	56%	57%	5%	2.8
13	Appropriateness of Economic Evaluation Processes	54%	60%	57%	3%	1.7
	TOTALS				100%	57.5
					100%	

Figure 5

6. APPLYING A LOGICAL / COST EFFECTIVE STEP BY STEP APPROACH

How should we complete this cost effectively? The process I believe is the most cost effective is as follows:

1. The organisation should complete their initial AM processes to Level 1 AM for ultimately all assets 100%.
   a. This can be staged by first completing the basic AM processes
   b. Collecting the initial data using a 'Delphi Group' approach. See separate manual.
   c. Concentrating initially on assets that are:
   i. In the last 20% of their effective lives.
   ii. Have poor performance records.
   iii. Have high unplanned maintenance costs.
   iv. Have a high consequence of failure
   d. However we should always complete the whole asset portfolio (100%) to this AM level 1 process & data sophistication.
2. Then using Level 1 BRE assessments for all assets we identify the top 5% of assets and take these up to

AM Level 2 processes & CLR 2 assessments. Eventually we will lift the top 15% to 20% of these assets to AM level 2 assessments.

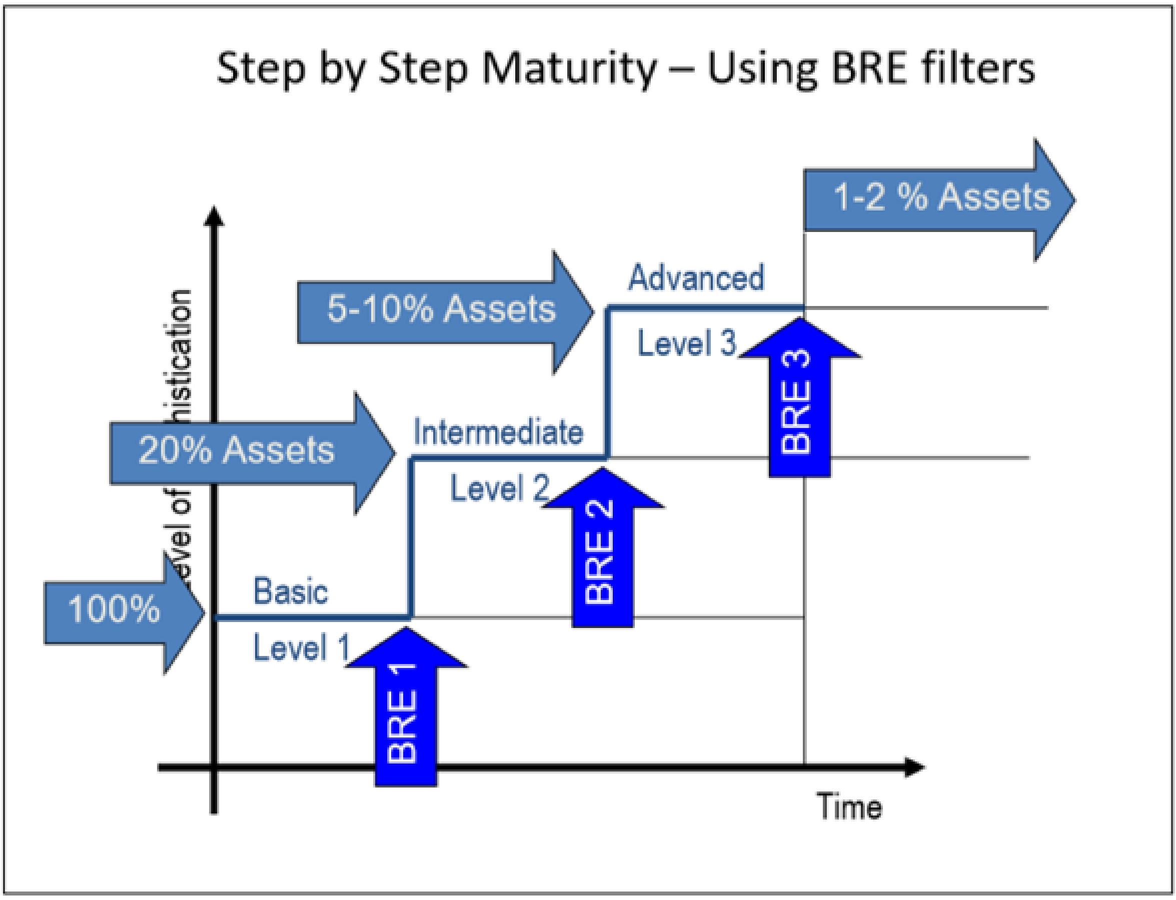


Figure 6

3. Then using Level 2 BRE assessments we identify the top 5% of these assets and take these up to AM Level 3 processes & CLR 3 assessments. If any projects are currently on a Capital Work Program we can do hindsight assessments to verify their validity.

This is best illustrated by the figure on the above:

By understanding the makeup of the CLR assessment, we can easily understand the weaknesses in our analysis, either in the level of process or the quality of data, easily allowing us to identify improvements (additional analysis or data collection) that can be used to justify the project.

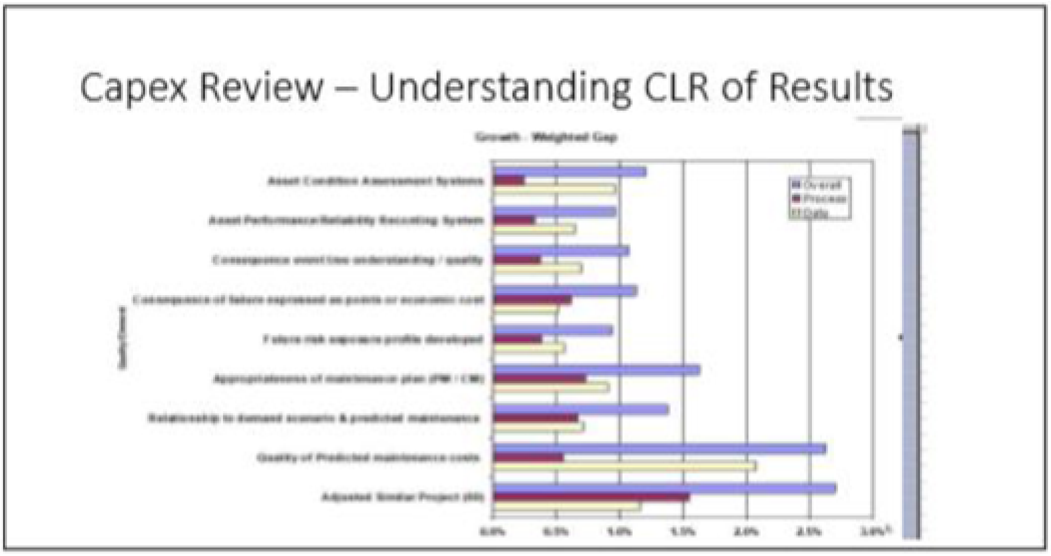


Figure 7

7. COMPLETING THE INDIVIDUAL PROJECTS DETAILED ANALYSIS COST EFFECTIVELY

By applying /using the Business Value Chain (BVC) approach we can ensure that we put our scarce resources into those parts of the life cycle analysis that represent the greatest benefit to the organisation.

This is best shown by the figure above.

8. CONCLUSION

The level of maturity / sophistication that an organisation needs to use to manage their assets cost effectively will vary with the types of assets they own, and their current performance and business risk that they represent. It needs to be varied to suit the complexity of the analysis required and the data available to feed that analysis.

It is evident that this type of approach is able to provide organisations with the flexibility to complete the necessary analysis to derive necessary outputs that can be logically justified and adjusted to suit the resources available to the organisation.

I believe that the approach outlined above represents a cost effective, best practice approach to this complex issue.

9. CASE STUDY

Recent major whole of metro city projects in the Republic of South Africa.

The eThekwini Municipality ETM (Durban) with a population of 4 million has reached level 1 for all assets in just over 5 years for less than 40% of the average resources and costs associated with other similar organisations who followed more typical asset management implementation methods / approaches.

These basic Level 1 approaches have given ETM full AMP's for all 17 business units. They understand the future expenditure models have an average CLR of almost 60% and they are currently implementing Step 2 using a good approach to Business Risk Assessment (BRE 1.5)

TECH 1

As stated previously, I believe that an organisation should grow to a level of maturity that applies to 85% of the asset portfolio decision making, and they should have the ability to know when they should import specialist skills for major asset issues / strategies that require this higher level of analytical input.

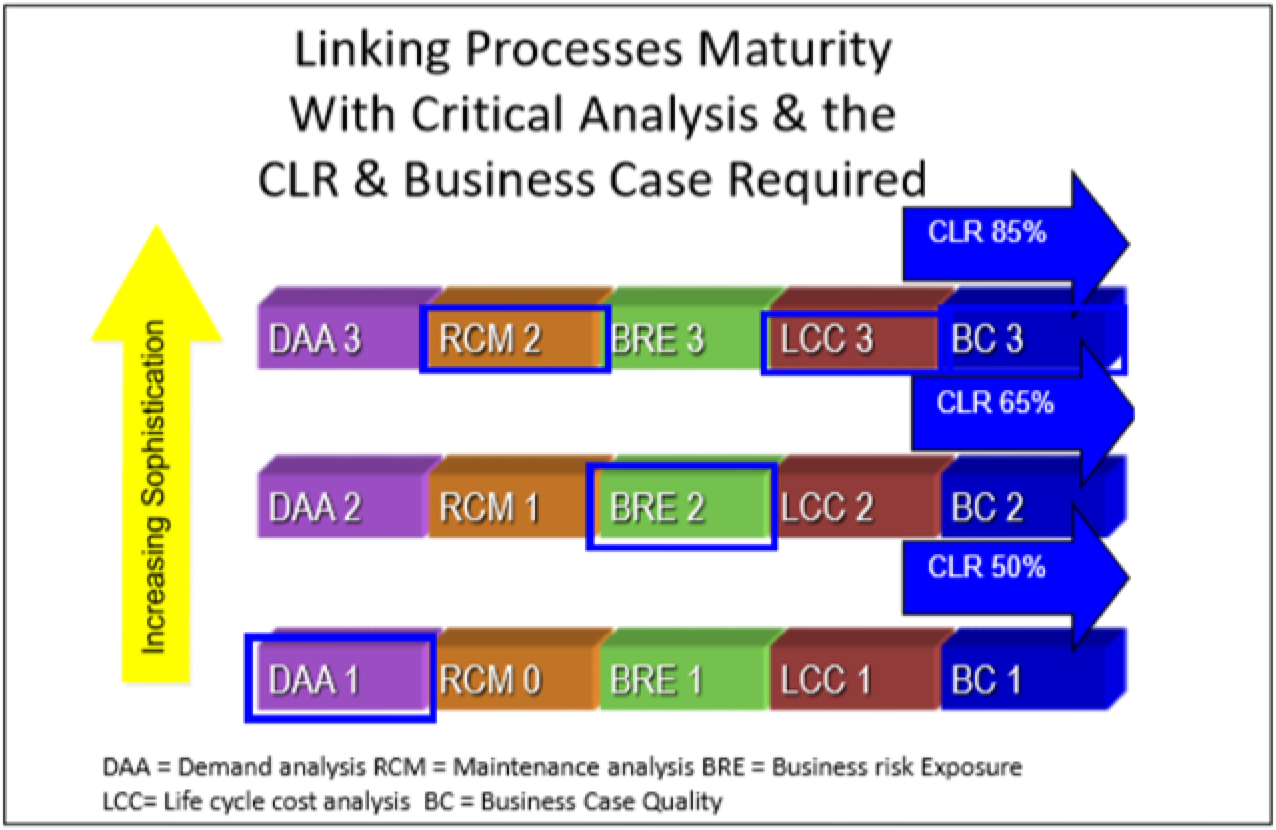
It is difficult to implement SIAM cost effectively.

This paper outlines the way this has been done most cost effectively, but it is hard to pick up by just reading this document. Feel free to contact me and I will provide you with other supporting materials.

I am delighted to watch the progressions in AM that have occurred since the global publication of the first National Asset Management Manual (IPWEA) in 1993.

We have come suck a long way. Good luck to all who go down this path, and push the boundaries as I see in many papers to this conference.

Figure 8



ARTICLE 2 – Integrating ISO 55001: 2014 with other ISO Systems

James Riddle

1. INTRODUCTION

The integration of ISO 55001:2017 with other ISO systems is on the surface very easily achieved as all standards have had to have the high level structure in place since 2013, however, integration using a clause by clause approach such as the high level structure (e.g. a system based on clauses 4.1 to 10.3.) does not fit the intent of the ISO standards with all of the most commonly used systems (quality, safety and environment) requiring a process approach to be used.

A clause approach is also often frustrated by a lack of alignment with the objectives, purpose and structure of the organisation and is normally poorly understood by the line workers.

To overcome this a search on the internet can find many different solutions to integration that does not a pure high- level structure. The advice seen ranges from electronic tools you can purchase to achieve the outcome to some generic advice. The take home message seems to be to develop a system that: "… integrates all of an organisation's systems and processes into one complete framework, enabling an organization to work as a single unit with unified objectives…" (The Integrated Standards Store, 2020).

As a part of its Royal Charter, BSI develops and publishes Publicly Available Standard (PAS). This is a process that captures best practice on a specific subject, both for the benefit of their industry and to help promote their expertise.

This does not use a consensus approach as typical with an ISO standard and the PAS is seen as occupying the intellectual space between in-house and national standards. It allows the standard for an entire industry to be developed (The British Standards Institution, 2020). A relevant example of a PAS is PAS 55-1:2003 – "Specification for the optimised management of physical infrastructure assets". This is the forerunner of ISO 55001:2014, similarly PAS 9 was the forerunner of ISO 9001 and PAS 14 was the forerunner of ISO 14001.

The high-level structure which has been adopted by ISO as the under lying architecture of all standards since approximately 2013 and this is based on PAS 99:2012. This has the reported benefits in the Introduction as:

a) improved business focus;

b) a more holistic approach to managing business risks;

c) less conflict between individual management systems;

d) reduced duplication and bureaucracy;

e) more effective and efficient audits both internally and externally;

f) easier facilitation of the requirements of any new MSS that the organization wishes to adopt." (The British Standards Institution, 2012, page iii)

The asset management system standard in ISO 55001 lists in section 2.2 the benefits of asset management as "…enables and organization to realize value from assets in the achievement of its organisational objectives…" (The British Standards Institution, 2014, section 2.2, page 1). This aligns with both PAS 99 and the home message gained from the integrated system searches. Therefore, an approach that uses the asset management system as a mechanism for guidance and integration will be examined based on case studies. All the cases are all drawn from the utility sector to reduce one of the variances that may be in place for integration.

In the cases below, two main approaches have been seen for the integration of quality, safety, environmental and asset (QSEA) management systems. One is based on the organisation's processes with the asset management system used as an input to the strategic planning and objectives and the other uses asset management to establish the annual budget through the strategic planning process. In this approach the asset management system is used to direct the annual budget and identify the long-term future requirements. Both approaches use the asset management system as the mechanism to achieve integration with the organisational other management systems.

Examples of these approaches are presented as case studies below. In addition, an integrated system that focuses on ISO 55001:2017 and ISO 27001:2013 (Information Technology Security Techniques) has also put forward as a case study to demonstrate that integration is not limited to QSEA management systems. This has also been shown to be based on the second approach.

The case studies below all have been visited by the author, all have varying degrees of system maturity and all have had operational systems in place for at least six years with most externally audited for at least three years. By request from the organisations, the name of the company cannot be divulged, but a brief background is provided to support the case.

2. CASE STUDY 1

The organisation is a water utility and it operates a safety (OHSAS 18001:2007, transitioning to ISO 450001:2018), Quality (ISO 9001:2015, limited to one activity), Environment (ISO 14001:2015) and an Asset system (ISO 55001:2014). It has approximately 850 staff and contractors. It is not fully integrated and is presented to demonstrate that system maturity and structural drives do have an influence on the level of integration.

The CAPEX for all systems is set by the Asset Management System, but this does not apply to Opex with each system responsible for their own Opex. The entire budget is a part of a regulatory submission and overall control in the review period is through this. The organisation also has a requirement that an annual Opex plan is produced based on achieving set objects that are alignment to the corporate strategy and this is subject to senior management review. The growth of the organisation along with some Government initiated activity changes has also led to some of the Opex decisions by the systems. The Opex requirements have led to a siloed reporting system based on individually set objectives.

From a system procedural point of view, each management-system is required to align with common organisation elements such as risk, and management of change. This is through alignment or adoption of the corporate driven procedures. Separate procedures on some clauses of the standards are in place with separate management review and corrective action systems are still in place. Learning from each system is achieved at an annual meeting with collaboration occurring, but some persistence of separate systems is still noted.

The management system in place is therefore not fully integrated but partially aligned with the main driver for non- alignment the objective setting based on the current Opex process. The regulator is helping to drive the organisation to adopt an integrated approach and an end to end process approach based on customer and stakeholder satisfaction is being implemented to help achieve this. This is expected to be in place by June 2021. In addition, the internal audits are conducted by an external team and are based on a process and risk approach. This is supported by a central team conducting system level audits. This has helped identify opportunities for integration.

In summary, the systems have repeated effort, that has led to some confusion at the line level on how to apply them and some loss of alignment as each system follows their own direction based on their own Opex drivers. The organisation is has recently taken an educative approach to the internal audits to help build a culture to overcome this.

From an asset point of view, the Capex is fully integrated and the adoption at the maintenance and operational level by the small teams at the operational sites is integrated through necessity. This integration does not always occur at the system level.

From a third-party auditing perspective, the current system leads to repeated effort and therefore time. The report is written as separate systems and as an example, the last one was 92 pages. This report also had similar findings for each system. The report was also littered with suggestion on what is being done well at each site or system and suggestions for coordination. It must be remembered that the system maturity is low compared to the other clients due to government drivers and the current Opex requirements, but the organisation is taking steps to address these concerns. It will be shown below that an integrated approach is possible and as noted above one of the two approaches is to be adopted.

3. CASE STUDY 2

This is a water utility organisation and it operates a Quality (ISO 9001:2015), Environment (ISO 14001:2015) and an Asset system (ISO 55001:2014) with some operational sites certified to safety (AS/NZS 4801:2001); all sites do consider safety. It has approximately 4400 staff and contractors. It operates an integrated system centred on the processes.

This organisation has been subject to a significant restructure in the last few years with the focus on ensuring the customer is at the heart of everything they do. This was aimed to gain cost reduction, improve service delivery and improve the perception of the organisation by the end customers. The solution to achieve these outcomes was for the organisation to restructure around its processes. This was done to remove duplication and ensure a team was either focussed on the delivery of an operational process or were part of the corporate and strategic setting process; they could not be both. This did lead to more clearly defined roles and responsibilities for each team. The process review aimed to ensure that there was no duplication of effort and as a result this did lead to some staff displacement. The process approach also changed the goal setting activity to be more centralised and less regionalised.

Asset management was one of the later process streams to be reviewed but it has been and continues to be one of the key contributors to the strategy. Maintenance and new asset or asset renewal activities have been delegated to process owners at a regional level. These activities are supported by the other systems through project plans, annual objectives and measurement through a dashboard portal which is also used as an input to the asset planning.

The system specialist provides regulatory and strategic direction advice with the asset team also ensuring future needs of the organisation are considered based on a whole lifecycle approach. All strategy must align with the five-year strategic planning cycle and the expected outcomes from the leadership team. All the management systems are seamlessly integrated through the process definitions. Objectives are aligned to the strategic planning and this sets the annual Capex and Opex budget. This has led to reduced role confusion and all system and teams having a strong alignment with customer needs whilst taking into consideration the risks and lifecycle needs of the assets.

The system maturity is relatively high and has been in place for at least three years. The approach on aligning team effort on either corporate (across all processes) or at a process area and no repeated or duplicated effort has led to this outcome. The processes are also often reviewed through different levels of audits to ensure the alignment is maintained based on change in legislation, direction or new activity.

From a third-party perspective this approach does need a mature auditor who can understand the structure and organisational context and the report "ignores" the clauses and is based purely on processes. This has led to a virtually seamless review between systems with the only decision on reporting being what system is best place to address any finding.

4. CASE STUDY 4

This is an energy utility organisation and it has an Information Technology Security Techniques (ISO 27001:2013) and an Asset Management System (ISO 55001:2014). It has approximately 2000 staff and contractors and is an integrated system through asset management and goal setting. The management system is now operated by one team with the Technology Security Techniques operated by a team who coordinate with the management system personnel. In the past these two systems reported to different departments. The common reporting has allowed an approach of integrating the objectives across the two areas.

On the surface these two systems do not naturally integrate as whist both standards follow the high-level structure, the system detailed requirements and risk models are very different. The Technology Security Techniques (ISO 27001:2013) risks focuses on IT security without regard to lifecycle or critical assets. None the less the systems have been coordinated by treating the Technology Security Techniques as a unique asset with their own risks associated with the lifecycle. This has led to the IT security being considered as an obsolesce issue in terms of physical asset management. This has allowed the integration of the cost, risk, opportunity model into this area and allows the goals and objectives to be aligned to the overall corporate plan in the same manner as the other assets. This is aided by a common reporting structure.

Currently management review, internal audits and corrective actions are treated separately, for each system, but work is progressing on integrating these by taking an annual coordinated approach with the day to day running left to each specialist area. This is the approach taken to the other physical assets being considered. The outputs from the specialist areas reviews and data analysis from them are a part of the annual review of the project opportunity model that aligns the strategic plans that sets the budget and objectives for the year.

The system maturity is at a coordinated level with plans to better integrate noted. Given a recent restructure has led to the common system reporting, process on this will be eagerly anticipated.

From third party perspective, despite both being based on the high-level structure, the requirements of the ISO standards are not well aligned and therefore it is difficult produce a report that captures the level of integration seen. However, the asset approach adopted by the organisation has allowed a reporting and system framework to be established. This has reduced auditing time and lead to reporting based on common improvements between the systems to occur.

5. SUMMARY

The aim of an integrated system to have all an organisation's systems and processes into one complete framework, enabling an organization to work as a single unit with unified objectives has been shown to be possible. The approach as seen in the cases is effectively two-fold; alignment of the strategic planning and annual plans around the asset needs or a second approach is a process alignment across the organisation. In both approaches asset management principals help establish the values and the objectives through the collection and consideration of all data sources including those from other systems. The collaboration between teams is paramount in the success of implementation.

The high-level structure inherent in all ISO standards since 2013 does assist in the system integration as it allows for a common approach between the systems to be realised. The common factor is for all successful approaches is a structure that has a central team who coordinated the system approach, and this is centred on the organisation's strategic outcomes. The only non-integrated case presented was shown to lead to inefficiencies and potentially higher costs.

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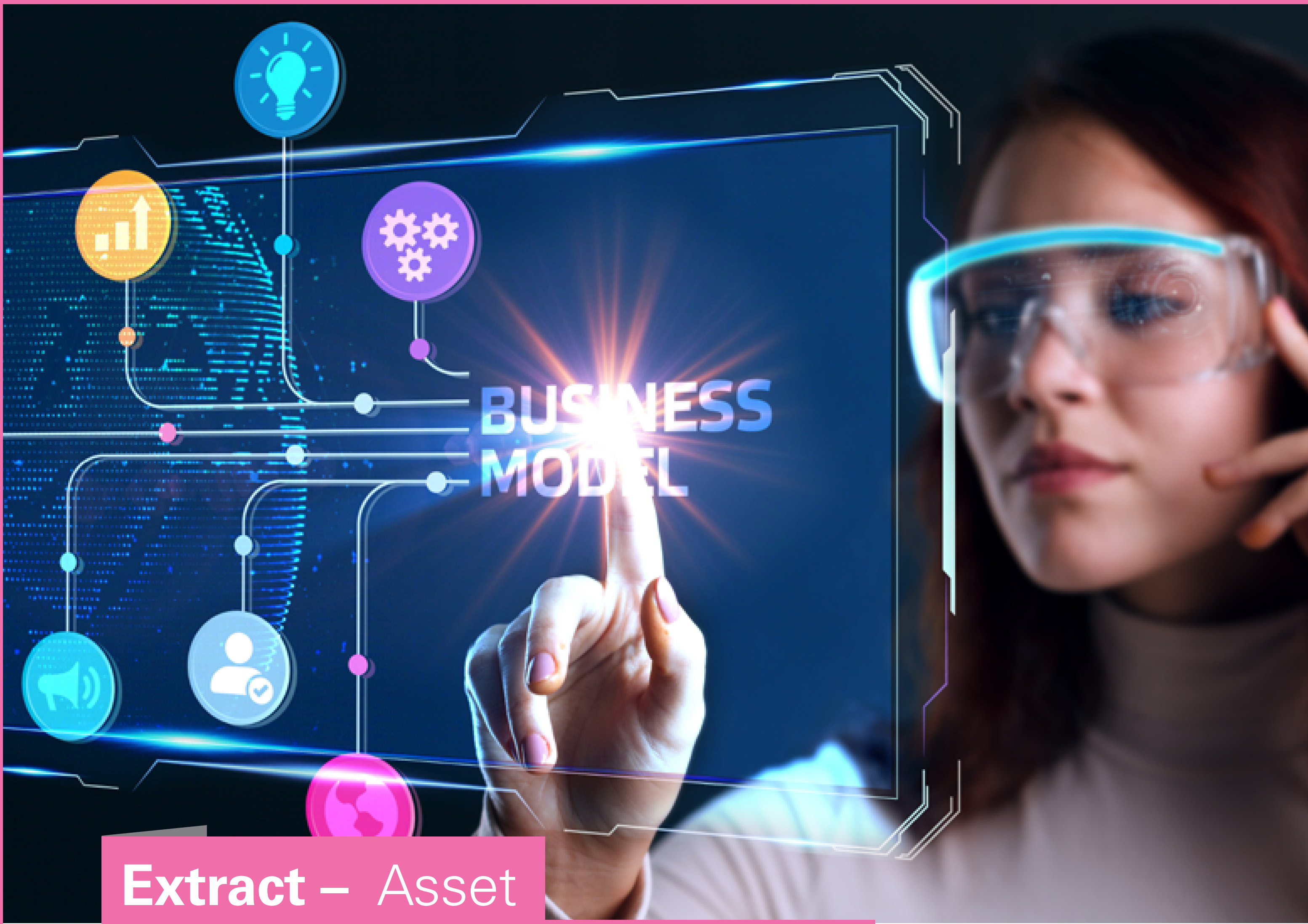


Extract – Asset Management Maturity Model

Reference: Framework for Asset Management by AMBoK Publication

1 .INTRODUCTION

Asset management maturity is defined by the Asset Management Council as "the ability of an organisation to foresee and respond to its environment through the management of its assets, while continuing to meet the needs of its stakeholders'.

Asset management maturity requires that an organisation deliver outcomes such as customer service, profit, safety and assurance, with the assigned resources and within the requisite delivery period. Asset management maturity is dynamic and should be able to respond to both the changing business environment and changing stakeholder needs in a manner that aligns with the other functions of the organisation (for more information on this, please see Sections 2 and 3, and especially Figure 2).

Asset management maturity can be considered as the extent to which asset management is aligned and integrated into an organisation.

Asset management maturity is described by:

- A set of Organisational Elements – Structuring, Governance, Structured and the Business Assets;
- A set of Maturity Lenses to focus on and analyse asset management across all four Organisational Elements. These Maturity Lenses are used to

Figure 22 – Asset Management Maturity Organisational Elements and Fundamentals

analyse important aspects of asset management; and

- A set of Qualities that provide a description of the essential nature of asset management maturity across the whole organisation.

2. ORGANISATIONAL ELEMENTS

There are four Organisational Elements. Each Element aligns with a Fundamental from ISO 55000, as they underpin implementation of asset management and the supporting asset management system. The four Organisational Elements are:

Structuring Element – This Element impacts on everything performed within asset management, but is generally the least understood Element.

The Structuring Element is focused on delivering the Leadership and Culture fundamental and is responsible for shaping the Structured Element, the Governance Element, and the way the business assets are regarded. The Structuring Element includes behaviour, emotions, human interactions and interfaces that produce cultural norms and power relations.

For decision making processes to be embodied in the organisation, all parts of the Structuring Element must be coherent and aligned, as they underpin the organisation's values and all other Organisational Elements.

Governance Element – This Element delivers the Assurance Fundamental and is responsible for providing a level of assurance to the stakeholders that the asset management system and asset management within the organisation remain fit-for-purpose and safe to use. The implementation of the asset management system is a good base for an audit program to provide assurance of the Structured Element.

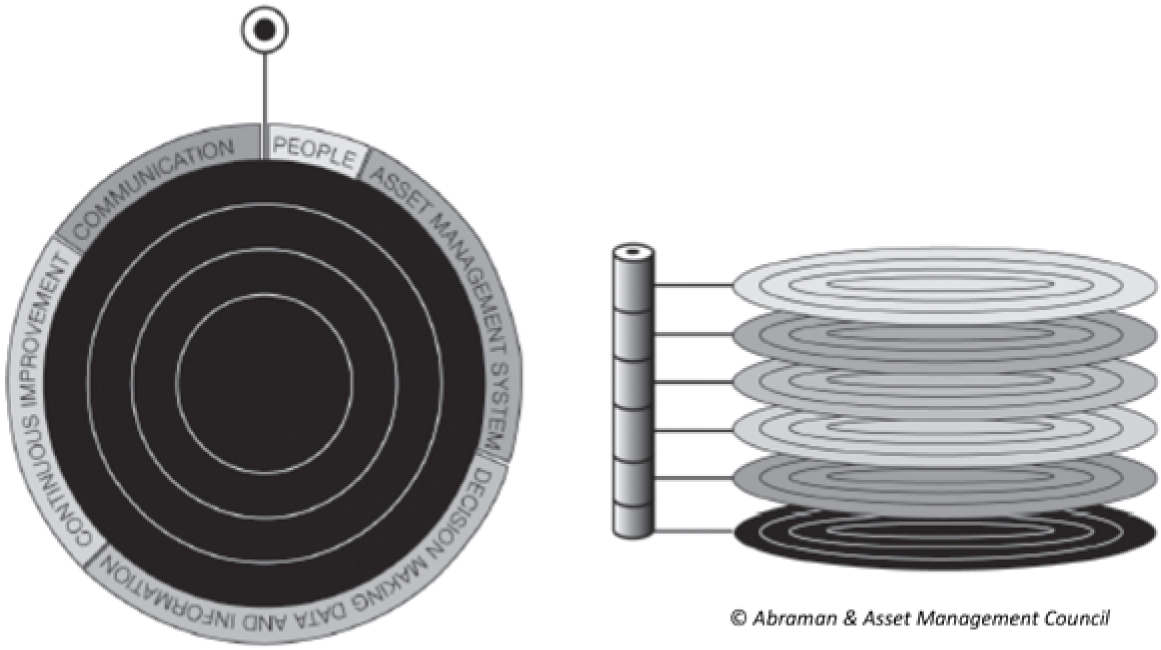


Figure 23 – Example of Asset Management Maturity Lenses; each lens provides information across all four Organisational Elements

Structured Element – This Element delivers the Alignment Fundamental. It encompasses developing and implementing processes, plans, activities and tasks as part of the asset management system. The Structured Element allows an organisation to develop an integrated approach to the delivery of organisational objectives through the use of the Business Asset Element.

Business Asset Element – This Element delivers the Value Fundamental and encompasses delivery of the organisation's objectives in relation to the use of assets including physical assets.

3 MATURITY LENSES

Asset Management can be viewed through a number of Maturity Lenses – each one provides information about features that span all four of the Organisational Elements and how the Organisational Elements are aligned and being conducted.

These Maturity Lenses may include:

application of the principles of continuous improvement;

use of, and access to, information to support asset management related decision making;

the degree to which asset management focusses on the organisation's objectives;

the degree to which asset management focusses upon a demonstrable balance of cost, risk and performance outcomes;

use of competent, capable, authorised and motivated people within asset management.

4. MATURITY QUALITIES

While the Organisational Elements describe the parts of asset management maturity from the perspective of asset management, asset management maturity also contains qualities that are universal across the organisation. Such qualities include:

- use of a "common language";

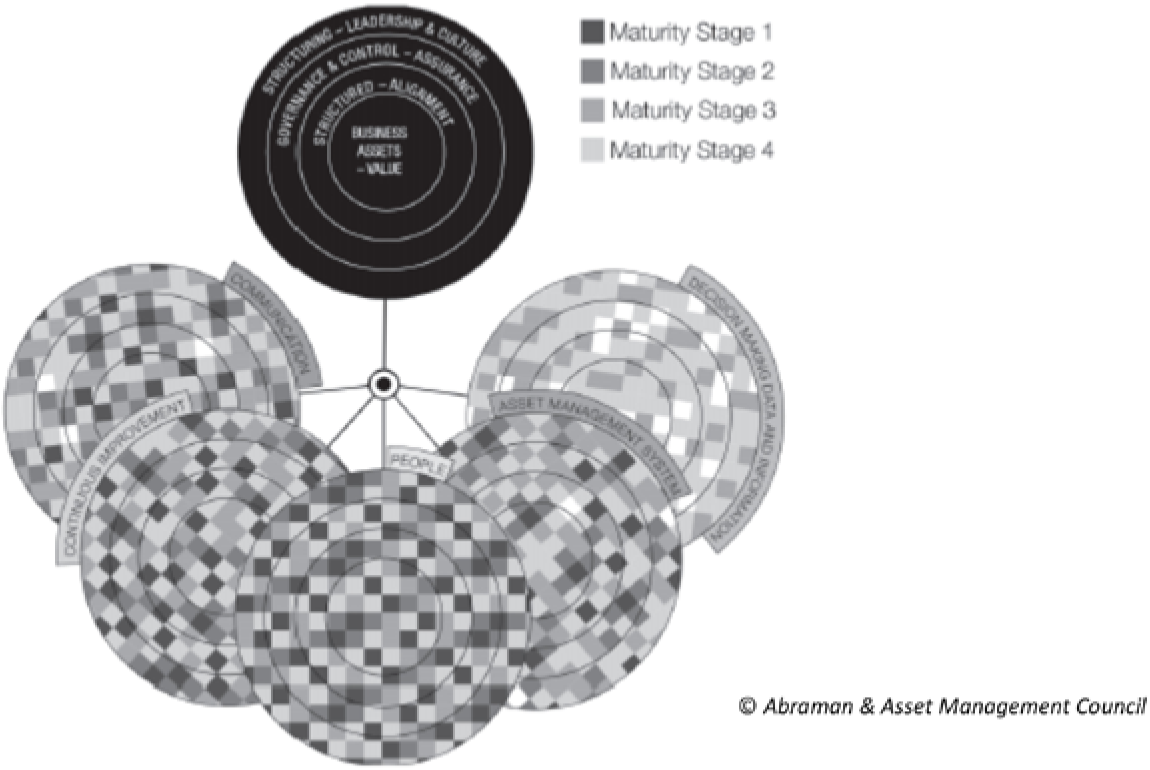


Figure 24 – Asset Management Maturity depicting the interrelation of Organisational Elements and Maturity Lenses assessed by Maturity Qualities

- evidence of a "shared purpose" and alignment;
- an "integrated approach" to the management of assets adopted by all business functions; and
- evidence of a strong asset management commitment by the organisation's people.

5. BUILDING ASSET MANAGEMENT MATURITY

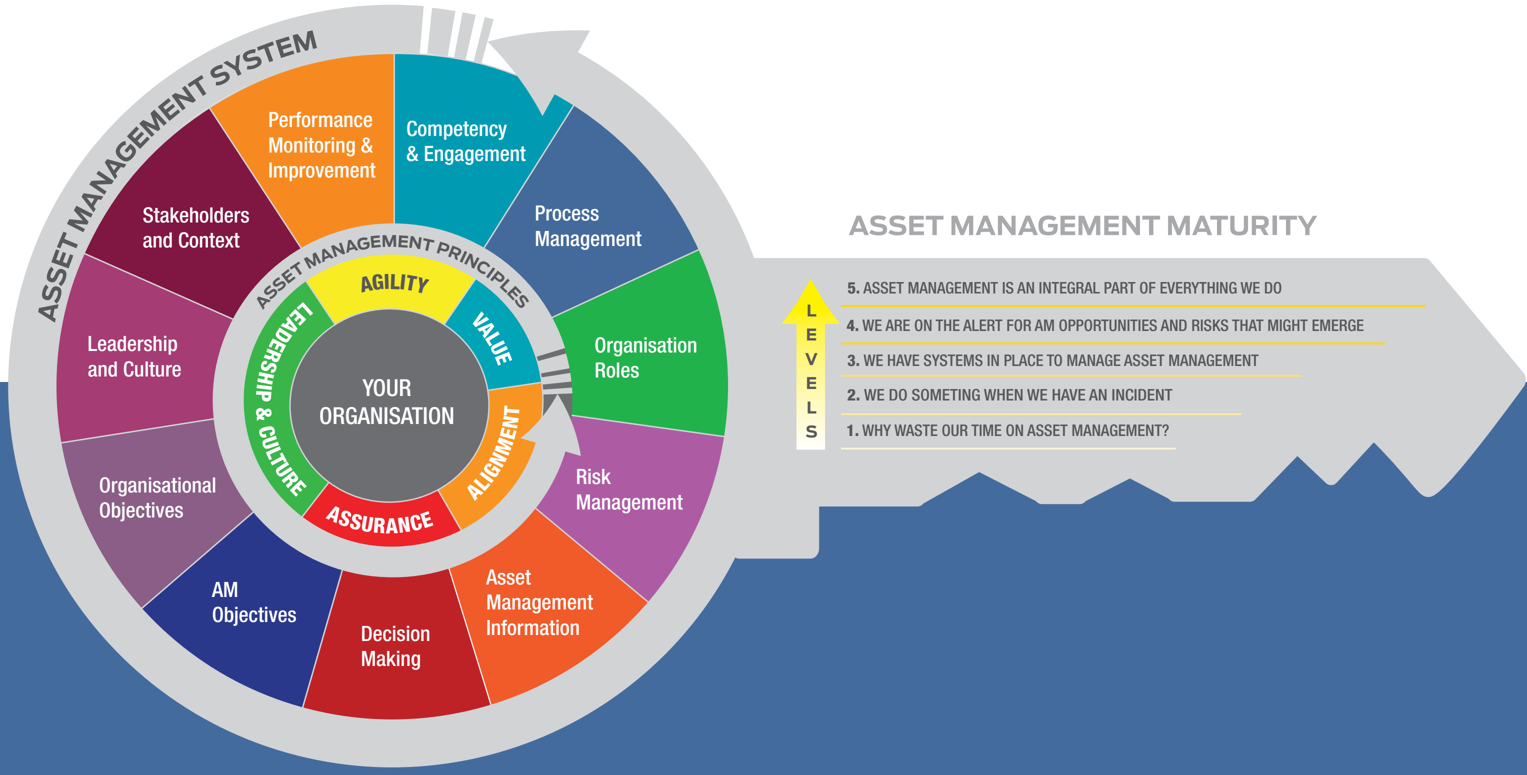
The Asset Management Maturity Model shown above depicts the Organisational Elements of asset management, the Lenses through which to view those Elements and finally, a set of Qualities that need to be present, to measure and develop asset management maturity. The concept of asset management maturity is complex. This is why a number of Lenses to focus on the organisation from different perspectives have been developed. Further, there are a number of universal Qualities to identify asset management maturity.

Asset management maturity is not about benchmarking, but is a tool to assess many factors such as culture, leadership, integration, organisational climate, principles and values and behaviours. It is from this assessment that root causes can be understood and strategies applied to improve performance.

Asset management maturity is dynamic. It is not steady-state. At some point even mature organisations may need to 'restart' from an immature stage again, after having achieved a high stage of asset management maturity. It depends on external environments, stakeholder needs and the organisation's commitment to continuous improvement.

Unlocking value in asset management

ASSET MANAGEMENT COUNCIL



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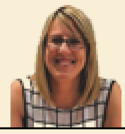

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Large-scale Asset Management? Tick!

Shane Day, Head of Asset and Data Management, Downer Group interviewed by Linda Kemp, Communications Specialist, Asset Management

I recently spent time with Shane Day, Head of the Asset and Data Management Office, Downer Group, and invite you to read on to learn more about asset management from the perspective of one of the Asset Management Council's member organisations.

Downer is an integrated services company that designs, builds and sustains assets, infrastructure and facilities. The company builds strong relationships of trust with customers, truly understanding and predicting their needs and bringing them world leading insights and solutions. Downer is an enormous and successful business; an employer of over 50,000 people across three main business groups: Australia, New Zealand, and Spotless.

As the head of the Asset and Data Management Office (ADMO), Shane's role is to connect the centres of excellence in asset management across Downer's business. In boasting a CAMA-qualified team Shane's department is striding towards that goal. The implementation of an ADMO Council, made up of senior management executives, operational staff and stakeholder framework, provides a roadmap for an aligned asset management approach within Downer. Monthly meetings with the council ensure that the asset management goals outlined in the roadmap are followed and kept within line-of-sight for leadership and operational staff. Shane notes this is the path that enables the team to make decisions that consistently impact in positive ways for the business.

Downer was the first business in Australia to receive certification through ISO 55001, and following that, re-certification; currently Downer holds four ISO 55001 certifications across four industry areas. In addressing the challenge of integrating asset management practice across long-term and short-term contracts, nine different industry sectors, and educating staff, ADMO has brought asset management into the Downer Standard: one approach, aligned with ISO 55001 that connects and governs the asset management approach in the business. In the ADMO team, Chris Wong as the Asset Management Frameworks Manager oversees and performs maturity assessments across the company's business units, with the aim to achieve alignment, continually improve and demonstrate best-in-class in asset management leadership. In the last eighteen months, the ADMO team has performed thirty maturity assessments in the company.

It's an exciting place to work, Shane notes.

I ask him to provide me with an example of Downer's most innovative solution, to which he quickly responds, 'The formation of this ADMO team'. While this is an integral component of the business and displays how asset management must be aligned with the overall business plan, he concedes that many readers may wish to hear an example that is more grass-roots asset management. Shane tells me about Downer's data analytics platform created for the rail sector, TrainDNA.

Built in collaboration with Microsoft, using the MS Azure platform and Downer's intellectual property regarding analytics and asset information, TrainDNA is currently deployed on Sydney's fleet of Waratah (A and B series) trains. TrainDNA allows the business to analyse the volumes of data that establish trends, understand the performance of the trains, predict failures and help inform and calculate the remaining life of the asset. It's a powerful example of data-driven decision-making in preventative maintenance, using sophisticated analytics.

Shane seamlessly provides additional examples of innovative solutions currently in operation within Downer. Reconomy repurposes soft plastics and glass to create materials for road surfaces. 'It's part of the circular economy, and highlights Downer's investment into sustainability,' Shane offers. He then mentions Downer's digital point cloud for monitoring road condition, a great long-term solution for the roads business. And with a final flourish, he notes the partnership with Keolis Downer, an international transport operations business that provides positive asset management practices across their multi-modal transport solutions.

I'm curious to discover Shane's thoughts on data's role within asset management, both in a general perspective, as well as at Downer. He responds by noting its importance and value to drive outcomes. Given Downer historically has been built by acquisitions, Shane's team is focussed on data as a path to standardisation; there are numerous systems and, he informs me, there can never just be one asset information system within Downer, in light of different engagement models, such as Public Private Partnerships (PPPs) and joint ventures (JVs). The team works to mandate the asset data information by extracting and collating it, to perform analytics across the entire business suite—while ensuring appropriate data privacy—in order to create a greater benefit from the Downer IP.

In terms of maintenance practices, Downer performs everything from work-order directed activities, fixed-period inspections to condition monitoring, reactive maintenance to preventative practices and sophisticated full-lifecycle management. The role played by data analytics as a maintenance tool varies according to the industry, contract type and asset type, and any pertinent industry regulations.

I ask Shane how the business creates value for their many customers. Shane declares that Downer's breadth of experience in asset management activities carried out strategically and cost effectively, supported by fact-based decision-making, enables value for their customers. Asset management is Downer's core business, and given their history of global best-practice, they are able to adapt asset management practices according to the client's needs, ultimately proving an efficient and valuable outcome for their customer. Downer has a sound awareness of the finer points of asset management; this knowledge intrinsically forms part of each contract.

The ADMO Council also provides worthwhile connections with other businesses that Downer leverage effectively for their clients, attending and presenting at the yearly AMPEAK conferences. Equally, the ADMO team educate colleagues on asset management practices that provide a whole-of-business culture change which organically flows on to the customers. One such example is the development of an asset management learning pathway that forms aspects of the on-boarding process for new staff. Downer is committed to asset management and providing best-in-class, cradle-to-grave understanding to their customer base: recently a number of staff undertook an in-house Asset Management Fundamentals course provided by the Asset Management Council. It all links to reinforce that asset management is critical, valued, and directed onto their customers.

It sounds as though Downer is all rose gardens and sunny skies, so I probe to discover where the storm clouds are. What are some of the challenges facing Shane and his team, and Downer more broadly, I enquire. After a chuckle, he acknowledges that the main challenge lies still, always, with raising a general awareness of what asset management truly is. He expounds: asset management has been around for a while, and has in recent years grown in awareness since the ISO standard in 2014. However, for Shane and asset managers more widely, the main challenge is still driving the understanding that it is a management standard. It is a framework that underscores how to manage a business overall, not simply a maintenance practice. It's coming together, Shane notes, it will just take time.

Another challenge that Shane initially hesitates to reveal lies within the 'digital cloud transformation hype'. It's not that he doesn't see value within it, more that it can distract from the work behind the scenes within the asset management field. He stresses that Downer is involved with digital solutions; the company has an AI team who integrate machine learning and robotic process analysis (RPA) solutions that generate extremely useful outcomes for the company and their customers. However, the current buzz of digital transformative options must be recognised as a solution.

Prior to learning the solution to any puzzle or equation, the problem—and in Shane's experience it is normally not just one problem—must first be deciphered. I find Shane's perspective interesting and he makes a valid point.

This dovetails succinctly into my asking Shane to disclose his top three advice statements for asset managers. Without hesitation, Shane responds by first stating an asset manager's role is to help leadership executives to develop asset management objectives that stem from the business objectives, this will illuminate the line-of-sight across the organisation. Secondly, Shane advises to communicate and educate those objectives within the business and maintain a strong focus on that. Thirdly, his advice lies with applying data standards early and consistently. Any business that collects data will reap benefits and find a natural progression follows: collating, leveraging and trusting the data.

Lastly, I'm interested to understand how Downer is retaining asset management knowledge. Shane reels off examples: the ADMO team issues news articles that promote business cases, store research, and offer a contact point to connect people; the roadmap used by the ADMO Council provides guidance and line-of-sight regarding the business's asset management framework; and the Downer Standard, the framework, templates and guides accessible to all staff that highlights the strategies favoured by Downer.

In support of those more formal avenues, knowledge is also shared in a more verbal and relaxed method. Through business champions, networks, various meetings and collaboration tools—such as MS Teams—knowledge is wheeled around like a morning tea trolley. After taking sustenance from the trolley, all staff feel sated and keen to perform their role, knowing that although the trolley is rolled away, it returns the following day.

Asset management at Downer is like that. Shane's ADMO team strive to pass on knowledge, provide support and information in ways that satiate employees and Downer's vast customer base. It's large-scale asset management, performed with a tick.

Linda Kemp wishes to thank Shane Day for his generosity in sharing his time and knowledge for this article.

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ASSET MANAGEMENT COUNCIL

CPAM STAR PROFILE – Yury Fedichkin

1. WHY ASSET MANAGEMENT?

For me, Asset Management (AM) is the way you do business whether it's a gas station or multibillion-dollar corporation.

As a successor of Operational Excellence (OE), I've noticed an interesting point that AM goes more on business high level: "The coordinated activity of an organization to realise value from assets", where OE goes deeper to its elements and describes what exactly needs to be done to achieve best asset performance.

It's an exciting opportunity when you can work in both disciplines!

2. How long have you been working in the Asset Management Sector?

My journey started with Norilsk Nickel Metal & Mining company, where I went through extensive training and project experience. I was absorbing what McKinsey company was conducting at a copper smelter plant; that was around 11.5 years back.

From that ride, my assignments have been from operation business process analysis and modelling to Enterprise Asset Management and Asset Performance Management software implementation for mining, metallurgical, oil and gas and petrochemical industries. And all of this is hard to assume if I was doing this not applying basic Plan-Do-Check-Act concept, which is the operating principle of ISO 5500x.

3. What is your speciality?

I have acquired bachelor's degree with a major in computing but have never practiced it.

Nevertheless, I was qualified to go straight to Mining company in Northern Siberia region of Russia, where tough people meet with harsh climate (-55 0C, "black blizzards", polar nights, etc.) Indeed, that type of environment has adversely affected my character and resilience no matter what.

Since that time, I've been employed with engineering consultancy, maintenance and reliability software and IT companies in the field like Operational Excellence, Asset Management, Asset Performance Management, Reliability and Maintenance.

Now, I'm currently working as a Senior Reliability Consultant at GE Transportation, a Wabtec Company providing reliability, maintenance, asset management and Asset Performance Management consulting, advisory, solution implementation, and training for asset-intensive companies in the Asia Pacific, Africa and Americas regions.

4. What drew you to explore more about this particular area?

I think it's more about whom I worked with or who have been inspiring me to do what I love to do.

Firstly, this refers to my journey and people I met on my way; it's obviously my father, who was working hard for 35 years at a copper smelter plant, my mentors, and world's famous reliability Gurus, whom I admire to.

Secondly, it's a privilege to collaborate with customers, work mates, and the sometime just be helpful for somebody or seeing appreciation from them.

5. What's the best career advice you've ever received and who gave it to you?

That was back in 2013, when I first had a pleasure to work with one of the Senior Consultants (Romel Soares) from Meridium, Inc. company, who later became my mentor and good friend too.

He was carrying a weight (and still does) of international Reliability and Maintenance experience and was willing to share it with me without hesitation.

"If you are going to do it, then do it right!", these words still go off in my head. This, so far, has been helping me to climb an Asset Management mountain.

6. What makes a great asset manager?

I have had an opportunity to work in six continents with people of different nationalities and company's cultures.

Having seen different leaders and managers in AM field, one comes clear that true Asset Manager is a versatile person, indeed.

This person must get boldness in its decision-making ability as well as business and engineering common sense at the same time.

If he (she) has industry experience and have seen how 'dirty work' is done, that would be an ideal 'one in a million' person. If not, he (she) must to catch up, having the right attitude and certain soft interpersonal skills.

7. What is the most exciting trend that you've noticed in asset management today?

Eventually, people started to talk about it in a greater scale. So, in my opinion, we are in 'conscious incompetence' phase, when we just starting to understand what we have missing.

Another good point is that companies realize that AM topic is the multi-disciplinary domain, where there is no existence of different industry's barriers anymore.

Some might ask me where's the technology piece in it. The reason why I'm not mentioning technology, simply because it is coming as a second last, even maybe the last item in my list of AM trends. AM goals cannot be achieved without organization discipline and consistency, first of all;

Remember Denzel Washington famous words that between the goals and its achievement is discipline and consistency!

They can't be acquired by technology per se.

8. What is the biggest challenge facing up-and-coming asset managers today?

From my little experience perspective, I see that the following three aspects still lacking in most of the parts of the world: not common professional language, discipline, and organization cultural aspect.

Challenge to speak in common AM language. Engineers struggling to understand organization's finance area and vice versa.

Technology driven or driving the technology is a big difference, you should not let decide technology for you.

Locked down to the human resource local market only is the cultural aspect.

In addition, some things can be improved in terms of how business conducted: how company objectives meet with its perspectives, objectives and KPIs.

But my personal time-to-time challenge is the slight drop of enthusiasm that makes you upset when it comes to the practical Asset Management reality in industries. Nevertheless, I still full of faith and passion about what I do.

9. What is your proudest career achievement?

I should be really thankful for chances I got through my career to work overseas, to learn from best companies and its Subject Matter Experts.

The main achievement for me is what I have already acquired down the road: Reliability, Maintenance, Operational Excellence and Asset Management real on-the-job training, skills and experience.

10. What's next for you?

I'm always eager to continue learning new things and sharpen my skills, where the Master of Maintenance and Reliability Engineering postgraduate master's degree from Federation University Australia could be the perfect new challenge in the nearest future.

11. When you're not busy at work, what do you enjoying doing to unwind/relax/explore?

My family is my safe harbour. I love to spend most of my free time with my wife and daughter. My little one is a quite spontaneous person; she helps me to look at the things under a different light, what can't not inspire me at my day-to-day work.

Moreover, running and swimming are my passion and life routine to keep me organized and stay fresh-minded.

Yury recently achieved his Certified Practitioner of Asset Management (CPAM). To find out more about our internationally recognised certification scheme, visit www.amcouncil.com.au/certification

CSAM STAR PROFILE – Atul Prasad

Why Asset Management?

Asset management involves defining what an asset/s must be able to do; how asset/s must perform; working out what we need to do to asset/s to achieve a positive outcome from them. Being a Trade qualified Fitter & Turner and Engineers Australia Fellow Registered Charted Professional Engineer, it is and always has been an enormous challenge to work with and convince people at all levels. It is much easier to convince them when the asset is about to fail or fails completely. To achieve the best outcome, I work with people and involve them because at the end of the day they are the ones who work with assets and encounter day to day problems with various assets. Majority of the problems related to assets can be solved there and then if we get the buy in of the right people. Our assets shall not be neglected at any time.

For example, if an asset is unreliable, it is critical to have the right qualifications, skills, knowledge and competence to solve the problems and this comes with life experience and learning about assets. In short, assets are like people, therefore, we need to look after our assets because with assets we can't run them to failure for a successful business.

How long have you been working in the Asset Management sector?

I have been working in the asset management sector since I began a fitting and machining apprenticeship at a hydro and diesel power station in Fiji at Fiji Electricity Authority (FEA). After completing my five-year apprenticeship, I worked as a fitter and turner for 2 years with FEA. I then migrated to Australia and since then, I have worked in various roles as a Fitter and Turner, and now as a Professional Engineer after completing my Bachelor of Engineering & Bachelor of Technology (Mechanical Manufacturing), MBA and Master of Engineering (Maintenance and Reliability Engineering). In summary, I have been working with asset/s for over 25 years.

What is your speciality?

My qualifications are in various areas such as Fitter & Machinist, Bachelor of Engineering and Bachelor of Technology together with Master of Engineering (maintenance and Reliability Engineering) and an MBA.

I also completed Advanced Diploma in OHS as well as OHSMS Lead Auditor with Exemplar Global as and a Certified Senior Practitioner in Asset Management and a Lead Investigator. In summary, the following are my specialities:

- Maintenance and reliability Engineering
- WHSE – Work, Health, Safety and Environment
- Process Engineering
- Production & Manufacturing
- Engineering & Management.

What drew you to explore more about this particular area?

During my working career with different companies and in different countries such as Europe, Korea, Pacific Islands, New Zealand and Australia, it gave me an opportunity to learn and understand different cultures and work ethics. This allowed me to become stronger and confident when facing challenges with asset safety, maintenance and reliability. I see problems with assets every day in my life and as a hands-on engineer, I have a genuine interest in fixing the problems. I talk to people on the work/shop floor to get their views, ideas and problem solve with them using techniques such as Fault Tree Analysis (FTA), 5 whys & how. My trade and professional engineering qualifications and life experience helps me to keep things simple so that it is easy for others to understand at every level.

What is the best career advice you've ever received and who gave it to you? What makes a Great Asset Manager?

There were a few people who gave me career advice during my career in asset management. One in particular, was by my manager when I was working as a Mechanical Service Engineer. The advice given was "don't be scared of taking the risks, if your instinct tells you that you can do it then do it, but don't guess'.

Listening to people, working with people, hands on experience, understanding asset management system tools and techniques together with qualifications, experience and competency can make a great asset manager, provided things are kept simple and not made complicated.

What is the most exciting trend that you have noticed in Asset Management today?

Some of the trends that I have noticed in asset management today are but not limited to:

Safety – to manage out physical assets, mitigate/eliminate risks, decrease whole-life costs and improve asset performance, reliability and uptime, as well as improve safety. We need to provide more than just the logical system and framework that is encouraged in ISO 55000.

I have experienced that organisations are now placing more emphasis on asset safety including assessing the risks and mitigating them.

Intelligent Diagnostic Indicator – it is now possible to target defects more quickly and gives a focus on better analysis.

Remotely supervise an entire group of machines – it is now possible to monitor for a vibration analysis from anywhere in the world. The dashboard provides an overview of the machines and will report which ones are problematic. There is also an emerging trend towards data analytics and digitalisation but still needs further development due to lack of understanding and getting peoples buy in.

What is the biggest challenge facing up-and-coming Asset Managers today? What advice would you give to an up-and-coming Asset Manager today?

Lack of meaningful data is one of the biggest challenges that an asset manager has to face with. There is either no data available or there is too much data available with no meaning. My advice is if you think available data may not correct then seek advice or start from scratch without wasting time. "Always be honest with data analysis", Figures don't lie, liars' figure"

What is the biggest challenge facing the Asset Management sector today/your particular field of asset management today?

I think the biggest challenge is:

- getting qualified, experienced and competent people;
- improving the organisational culture;
- working towards same goals;
- lack of preventative maintenance – planning & scheduling;
- documentation of day to day problems and data management;

What is your proudest career achievement?

There are a number of proud career achievements that I have accomplished during my working life. To name a few:

Achieving my Six Sigma green belt certification by:

- Completing Lean Six Sigma Project 1– gap saving of $614,900.00
- Completing Lean Six Sigma Project 2 – gap saving of 1.1 million dollars ($1,100,000.00).
- Completing Lean Six Sigma Project 3 – approximate saving of 75 million dollars ($75, 000,000.00).

This was a very proud moment for me as I added this value to their assets and achieving their goals and objectives for one of their state-of-the-art Cylinder maintenance Centre in Sydney.

STAR PROFILE – Atul Prasad

- Just recently for my current employer, I improved the reliability of tablet presses by re-designing the OEM concept to a much reliable and resilient design. This eliminated frequent jamming or rollers and causing significant loss in productivity.
- Becoming a Fellow Registered Chartered Professional Engineer (Engineers Australia) and CSAM (AMC), CertOHS Practitioner AIOHS) and CertOHSMS Lead Auditor (Exemplar Global).

What is next for you?

My next move is to become a certified machinery safety expert (CMSE) and help organisations to improve their asset safety particularly with machines within manufacturing and production. People lack expertise with asset safety and how to mitigate/eliminate hazards/risks associated with their assets. I am thinking of starting my own business focusing on asset safety, maintenance and reliability after my certification.

When you are not busy at work, what do you enjoy doing to unwind/relax/explore?

In the weekend, I go for my 10km run and sometimes I stretch it to 20km. During summer apart from my run, I enjoy swimming as well to relax my mind and body and just to keep myself fit and healthy.

I also enjoy going out for dinner and coffee with my wife on weekends and some weekdays and at the same time make time to have drinks and chill around with my 2 boys Jason and Aaron and talk about their Uni studies.

This year, my wife and I are celebrating our 30th wedding anniversary and we are going on a Europe tour for 5 weeks.

Atul recently achieved his Certified Senior Practitioner of Asset Management (CSAM). To find out more about our internationally recognised certification scheme, visit www.amcouncil.com.au/certification

CHAPTER **NEWS**

VIRTUAL CHAPTER CHATS

The AMCouncil is constantly seeking new ways to innovate and engage, especially during these unprecedented times where traditional networking events have been put on the back burner. Introducing Asset Management Council virtual chapter chats, your networking connection through the COVID-19 shutdown!

Our V-chats have proven popular as members have taken the opportunity to take a break, grab a cuppa and connect with other asset management professionals in a virtual environment.

Chapters have focused on various relevant topics such as managing assets with funding during the quick build; operational changes as a result of COVID-19 that organisations are planning to keep into the future; the impact of COVID-19 in the way we operate and maintain assets.

Each was a chance to join in discussion, meet other AMCouncil members, share one's own experiences and discover how other asset managers were tackling their current asset management challenges.

As you can see, some fruitful discussions were had with some common themes emerging.

CHAPTER WEBINARS

Keeping to the theme of converting traditional chapter events to the virtual world, our Brisbane and Sydney chapters have kept on track with their programme of events, broadcasting live in webinar format to their respective chapters and beyond.

Sydney's May technical event featured Mark Ragusa, a dedicated asset management professional recently provided a large webinar audience with an interesting presentation on decision making and risk management processes within Ausgrid.

ASSET MANAGEMENT COUNCIL

ASSET MANAGEMENT COUNCIL'S V-CHATS

Your networking connection through COVID-19 shutdown!

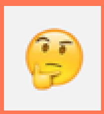
VIRTUAL NETWORKING

We are social beings. We thrive on connections with others, and in the work environment this is just as important. Through V-Chats, you can meet remotely with other asset management professionals, keep the networking wheel of your job spinning and your asset management brain switched on. To whet your appetite, let's look at some of the discussion matters raised by our local chapters.

CHALLENGES

Members from our Brisbane chapter spoke to challenges workplaces may face, including:

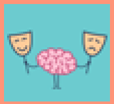
- travelling for work...how necessary is it and for which industries?
- impacts of knowledge-sharing and maintaining a robust network while working from home
- areas where virtual access works and doesn't work
- need for business to be flexible and adapt according to customer and stakeholder needs



NSW STIMULUS PACKAGE

Sydney chapter members raised these questions:

- Can new fast-tracked assets be sustained long-term?
- How robust are decision-making processes?
- What about maintenance and upgrading of assets?
- Is the stimulus hitting the right spots?
- How can we be better prepared for future crises?



COVID-19 IMPACTS

Our Perth chapter discussed issues arising from the pandemic:

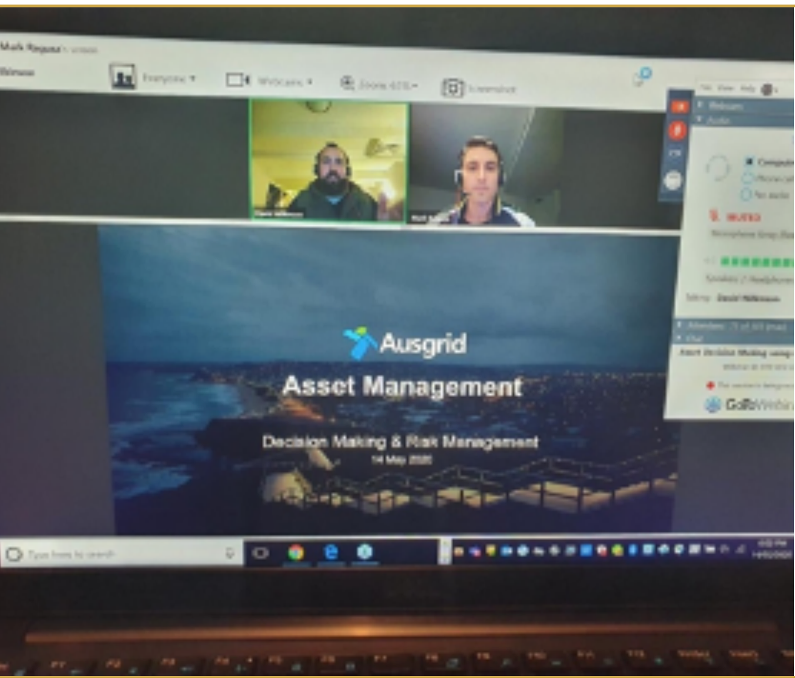
- The blurring of our public and private lives
- Mental health impact on society in light of redundancies and loss of social connections
- Lessons going forward in managing workforce safety
- Innovation key driver in future-proofing assets and business

WHAT'S CHANGED?

The Melbourne chapter discussed what has changed in workplaces:

- Operational impacts on assets, people and productivity
- The relevance of ISO55000 to asset managers against the 39 subjects by GFMAM
- Adjustments faced by businesses with return to work issues
- Wellbeing of staff: maintaining connections and communication during working from home

CHAPTER **NEWS**



Mark noted asset management must start with an understanding of the organisational objectives which are translated into asset management objectives. Creating this line of-sight will enable asset management decisions to align achieving organisational objectives. The basis for making asset management decisions must also be established so that decisions are consistent and appropriately supported.

At Ausgrid, risk management techniques have been adopted to guide the decision process. Quantitative analysis has been broadened to support maintenance and asset renewal decisions. Specifically, cost benefit analysis is being used to evaluate cost against the monetised risks and opportunities. Key performance indicators are then developed to monitor leading and lagging indicators which will inform whether the performance of asset management decisions achieve the organisational objectives.

Tuesday 31st March saw the Brisbane Chapter host a webinar on the subject of risk within asset management. This presentation saw Geoff Hales present on risk and criticality for optimised management of assets and Kim Adil speak about risk implications for RCM, equipment inspections and work execution.

It was interesting to see locations of the attendees taking up of the webinar not just across Australia but stretching as far as the USA, Europe, Middle East and even Moscow.

With such a great reception, the Brisbane Chapter decided to do it again. On Tuesday 12th May they hosted an internationally attended webinar of over 300 delegates on disruption in asset management. This informative session was provided by Denise Brown from Powerlink.

The presentation was in the context of current and future changes in the power transmission industry. The session reflected on the impact of internal drivers and regulatory influences. Denise's presentation also included the challenges of balancing external factors - e.g. renewable energy and large scale battery storage, and how these factors influenced the short and long term decision making in the organisation to support sustainable customer service.

All three of these webinars were recorded and are available for AMCouncil members viewing on our TV page at www.amcouncil.com.au/tv

ANNOUNCING 2020 WA CHAPTER COMMITTEE

The WA Chapter AGM was held on the 2nd April and a full strength committee elected including three new committee members. We are happy to announce the 2020 AMCouncil Perth committee line up is:

- Dr Carla Boehl (Chair)
- Carlos Fortuna (Vice-Chair)
- Jane Agnew
- Therese Brooks
- Ankur Maheshwari
- Graham Saunders
- Kecheng Shen
- Jakob Verhoef
- James Wright
- Tristan Velnoweth

We wish to put forth a huge thank you to outgoing chapter chair, Anselm Boehl, and to outgoing Vice Chair, James Tziros, for their hard work and committed efforts in leading the WA chapter. Get in touch with the Perth chapter through **chappert@amcouncil.com.au**

ANNOUNCING 2020 MELBOURNE CHAPTER COMMITTEE

Thank you to all who nominated to join the AMCouncil Melbourne Chapter Committee. We are delighted to announce the Melbourne Chapter Committee for 2020 as follows:

- Dave Alexander (Chair)
- Andrew Sarah (Deputy Chair)
- Sean Reeves (Secretary)

Thank you again for your nominations, and welcome on board.

If you are wanting to get in touch with the Melbourne chapter, please drop them a line to: **chapmelb@amcouncil.com.au**

ANNOUNCING 2020 NEW ZEALAND CHAPTER COMMITTEE

Thank you to outgoing chapter chair, Raymond Tan, for his hard work and commitment. We welcome Rex Harland, Andrew Gatland and Tracy Massam as current chapter chair, vice chair and secretary, respectively. The general committee includes: Peter Griffiths, Jack Crutzen. You can drop the committee a line at: **chapnewz@amcouncil.com.au**

ANNOUNCING 2020 CANBERRA CHAPTER COMMITTEE

We are pleased to announce the 2020 incoming committee. Stepping out of the chapter chair is Mike Schulzer and we wish to thank Mike for his dedicated efforts in the chapter over the previous years. Welcome, Ryan.

- Chair: Ryan Chenery
- Assistant Chair: Mike Schulzer
- General Committee members:
- Alex Wilson
- Wayne Francisco
- Solomon Ecundayo

The Canberra chapter can be contacted through **chapcanb@amcouncil.com.au**

CHAPTER **NEWS**

ANNOUNCING 2020 BRISBANE CHAPTER COMMITTEE

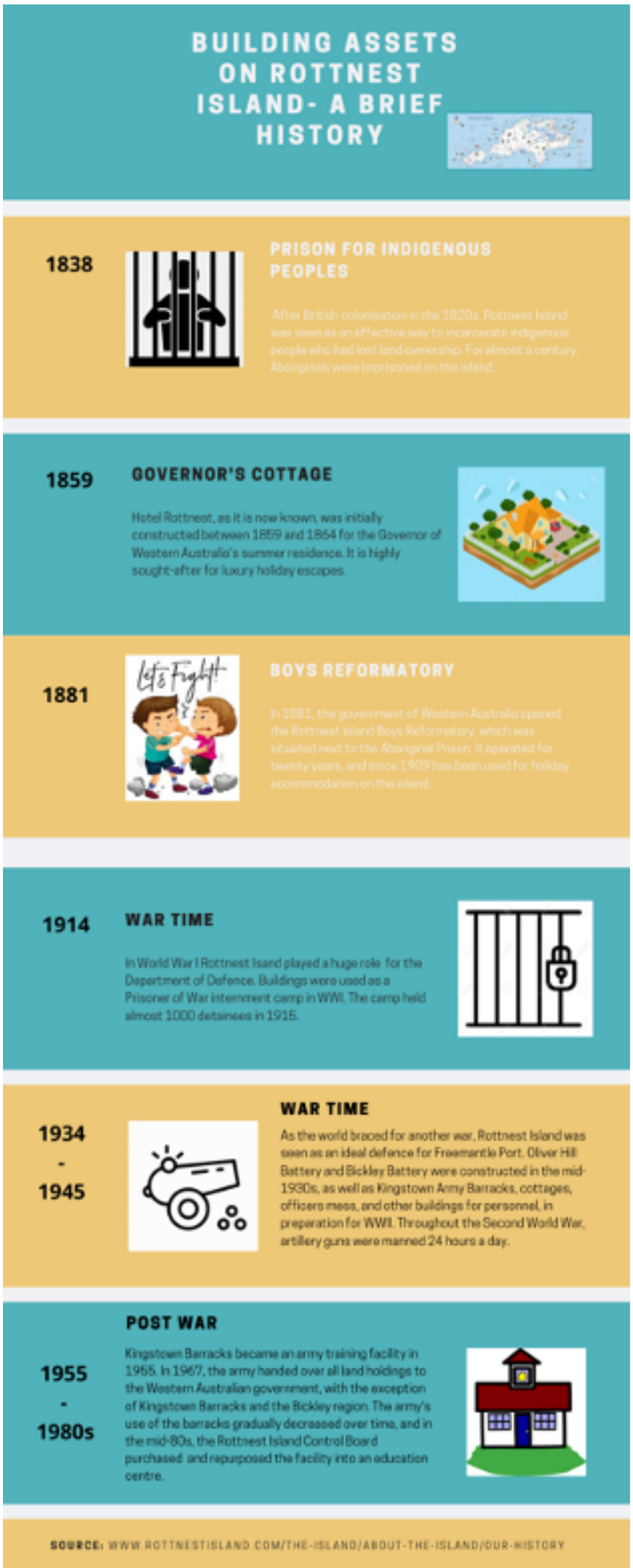
Thank you to all who nominated to join the AMCouncil Brisbane Chapter Committee. All nominations were accepted at the last Annual General Meeting. The re-elections of Keith Paintin as Chapter Chair and Peter Pennell as Chapter Vice Chair were also confirmed.

The new Brisbane Chapter Committee for 2020 is as follows:

- Keith Paintin (Chair)
- Peter Pennell (Vice Chair)
- Ella Hingston (Secretary)
- Ken Chapman (Assistant Secretary)
- Lalyn Bartram
- Alexandra Cohen (new committee member)
- Edwin Salazar (new committee member)
- Sparshy Saxena (new committee member)
- Stephen Walker
- Mick Windsor

Thank you again for your nominations, and welcome on board.

If you are wanting to get in touch with the Brisbane chapter, please drop them a line to: **chapbrissecretary@amcouncil.com.au**



BROADSPECTRUM

ferrovial services

CENTRE OF EXCELLENCE FOR ASSET MANAGEMENT

OPTIMISING SUSTAINABLE ASSET VALUE

COVID19 IMPACT ON ASSETS

A collection of every-day asset management news and views by Linda Kemp Communique

COVID-19 HELPS USHER IN POLICIES TO REDUCE EFFECTS OF CLIMATE CHANGE

Only last year, and in the first few months of 2020, many of us were focussed on the world's changing climate and its negative impact on the environment. And then, coronavirus swept across the globe and wholly took our attention. However, countries are awakening from the COVID coma and we are being urged to slowly, carefully, return to our lives. But you may notice, we are not being advised to return to our old ways. Take the United Kingdom for example, where in late May, local councils were directed by the government to increase spaces to allow for social distancing measures as people return to work and school.

The repurposing of assets in the UK includes making space available outside regional cities for parking, reclaiming current road space and altering it for use by cyclists. The Transport Secretary, Grant Shapps, said in a press conference held on 23rd May, 'For those who live too far to cycle and walk…we will repurpose parking places just outside town centres[1]'.Mr Shapps continued, adding the aim in introducing such measures was not to merely get past restrictions, but to 'permanently change the way we use transport[2]'.

Manchester City Council is seizing the opportunity created by COVID and is planning to permanently close roads and create diversions for bus routes. The council is planning this in collaboration with its framework on their five-year climate emergency plan[3].

This strategy from the UK government appears to be a two-pronged approach to make the lives of constituents safer by holding at bay the likelihood of a fresh spike in COVID patients, while also attempting to reverse the effects of greenhouse gases caused by vehicles as a preferred mode of transport. It additionally demonstrates the crucial need to repurpose assets as community needs change, either electively or by directives from government.

PREPARING ASSETS FOR COVID LIFE

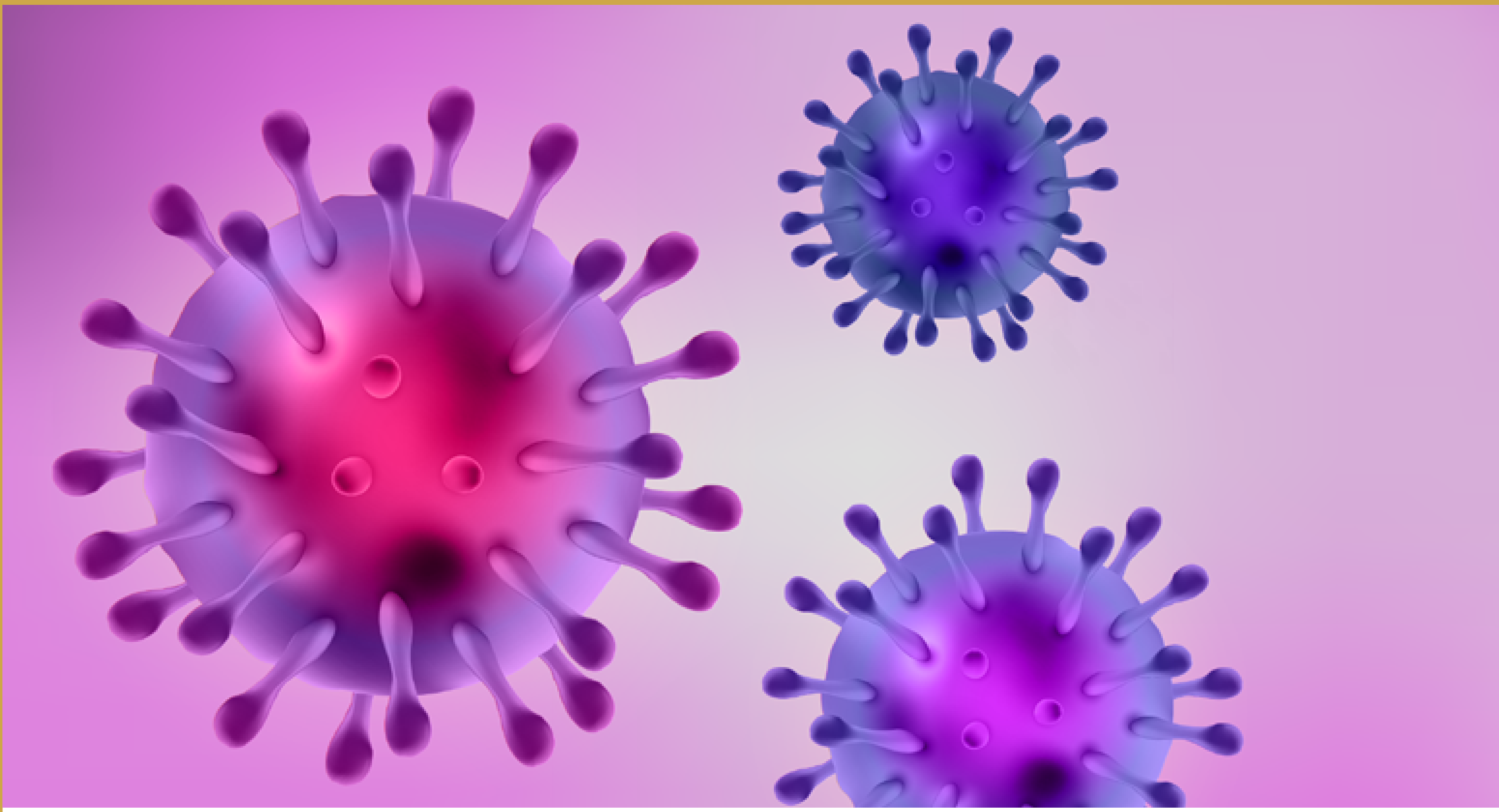
Most of the world is releasing its breath over the coronavirus pandemic. Restrictions are being relaxed, cautiously and optimistically, in many countries. Individuals are stepping out their homes and, while observing social distancing guidelines, greeting friends, neighbours and extended family members.

In Melbourne, Lord Mayor Sally Capp, is preparing the city for the return of workers, traders, shoppers and domestic tourists, while maintaining the suggested social distancing guidelines, by putting in place measures to widen the footpaths and bike lanes1. This will enable pedestrians and cyclists to roam the city streets, while keeping a safe distance from other individuals.

Yarra Trams is also undertaking preparatory measures for an increase in passenger numbers, once restrictions are relaxed in Victoria. Since late March, staff members have worked diligently to sanitise the trams and the company has offered a wider availability of PPE and cleaning products to drivers and inspectors. Physical barriers on board some trams were trialled and passenger access to the front row of seats were also restricted[2]; these are likely to be in place for the foreseeable future.

The adapting of these physical assets is a positive sign. However, asset managers and owners reading will know of the delicate balance in asset management. What is the balance to cost, risk and performance? How is the adapting of such assets commensurate with capability, delivery, business and consumer needs?

By adding to the width of one asset, such as footpaths, what is the impact on others, city roads for example. With traffic in the CBD prior to the shutdown jamming to gridlock, what hope do commuters hold for access once footpaths have eaten into streets and lanes. The trams were equally crammed prior to the pandemic, and the curbing of passenger access onto these assets will surely necessitate greater service provision to meet demand.



WHAT HAPPENS TO ASSETS NOW?

The coronavirus is doing its best to wreak destruction on a wide scale. We're in lockdown, advised to stay home to flatten the curve, and keep everyone as safe as possible. We're hearing lots of stories about businesses working hard to provide products to protect our frontline workers: health professionals, delivery drivers, supermarket staff and other essential enterprises.

The fact is we do not know what lies ahead with COVID-19. Our politicians are clear in their advice that the restrictions may be lengthened. Our future depends on what we don't know. And that is unsettling. But one thing we do know is your business still needs an asset management plan; probably now more than ever.

Asset reliability is paramount in these times. Whether you are running an essential business or if you're closing for the time being, make sure your assets are maintained and running in tip-top shape.

Preventative maintenance schedules ought to be still in place, to offset the safety and reliability of the assets, your business, and any staff that are working. Now more than ever, condition monitoring is applicable to ensure that the asset continues to work until the next examination. Check for vibration measurements, wear or misalignment of parts, cracks and depths in surface corrosion.

If necessary, perform corrective maintenance tasks immediately. Conduct repairs and renewals to ensure that the asset performs its function, thereby alleviating risk and improving safety measures. There is less risk to your business when your assets are fit-for-purpose. And in these times of great risk and uncertainty, having one less concern is surely a good thing.

MANUFACTURING BRINGS OPPORTUNITIES FOR ASSET MANAGEMENT

This virus too shall pass.

And when it does, the implications for the Australian manufacturing industry are vast, according to Mr Nev Power, the recently appointed chair of the National COVID-19 Coordination Commission4. The commission holds responsibility to advise the government on ways to mitigate and anticipate the risks arising from the virus.

Mr Power believes that the manufacturing industry will experience a boom post-COVID-19, and with the supply chain disrupted from all the nation's significant sources, we have the opportunity to overhaul our manufacturing industry. The potential to create more jobs, particularly within the asset management sector, is manifold. Mr Power notes that the industry could benefit from the pandemic and emerge stronger and more competitive. The commission is already working on short-term manufacturing possibilities to produce products urgently needed at this time, including Personal Protection Equipment (PPE) and medical supplies. But to remain competitive for the long-term a revamp of our manufacturing processes is needed[5].

As many readers will already know, the manufacturing industry needs the principles of asset management. With so many engineering assets, large and small, used to manufacture goods, experts in maintenance and reliability, data and other areas of asset management will be in high demand.

AN AUSSIE HOME FOR GROUNDED AIRCRAFT

There are sites, particularly in the US, that store decommissioned aircraft, colloquially known as aircraft graveyards, or boneyards. But some readers may not be aware that here in Australia, we have our own aircraft storage facility.

The Asia Pacific Aircraft Storage (APAS), situated outside the Alice Springs Airport, in the Northern Territory, is the first commercial aircraft storage and recycling facility in the region, built in 2011 after an agreement was reached between the Northern Territory Airports and APAS. The facility offers short-term or long-term storage for aircraft, including maintenance programs which meet the necessary regulatory certifications. APAS also provides a decommissioning service for aircraft beyond service life that includes the disposal of fuselage, recycling aluminium, and disposal of all non-recyclable components, managing environmental and waste matters[6].

Very recently, due to the pandemic caused by coronavirus, APAS has seen a steady flow of aircraft seeking rest in the outback home until the call to fly again is rung. But far from just being grounded these aircraft are receiving extensive maintenance by the dedicated staff. The aircraft currently at the facility range from Fokker 100s to Airbus A380s to Boeing 737 Max 8s. And, due to clever insightful leadership and business planning, the capacity to expand the facility to store additional aircraft is easily met. Expansion for an additional 100 aircraft is already underway, and expected to be operational by June 2020[7].

As the coronavirus decimates numerous industries, it can be helpful for us to see the ways in which some businesses are thriving. APAS provides a much-needed service to airlines and leasing companies, while also benefiting individuals now by providing current employment prospects, as well as future growth opportunities in areas like tourism and infrastructure.

COVID IMPACT ON UNIVERSITIES BUILDING ASSETS

Over the past decade and longer, many Australian universities have experienced exponential growth. The influx of international students, and a wider uptake in domestic students to both onsite and online learning facilities have seen universities increase their infrastructure assets, including the construction of new buildings.

Since early March, due to the coronavirus pandemic, universities have been closing most of their onsite learning facilities. Many offer places on campus for students to access computers, printing and remote learning options while maintaining the necessary social distancing rules.

But what about the building assets? The accommodation and cafes, gyms and purpose-built study nooks? Are they just modern relics of a recent past?

For the interim, extensive checklists undertaken before closedown and regular security patrols ensure that facilities remain closed off and safe. The buildings wait, as if on pause, until the worst of the pandemic is over, and learning can resume. However, once restrictions are relaxed, it's likely that international borders will remain closed for many months, putting stop to the flow of international students.

What is to be done with these enormous buildings if there are no students to fill them? How will a university bring students back on campus, when the world looks to be moving more and more online? Three major Australian universities, University of Sydney, Monash University and University of NSW[8] are working on a recovery strategy, post-pandemic. A postponement of new capital works forms part of this approach.

With each upcoming generation even more reliant and conversant with digital learning, it remains to be seen how the university sector will recover post-COVID and what will become of the building infrastructure.

There are no easy answers, but the economic damage caused by the coronavirus serves as a warning to over-capitalisation.

ASSETS UNDER PRESSURE

Due to the coronavirus pandemic, we are hearing much about repurposing of assets and businesses altering their usual production to fulfil an urgent need in the community. There are many examples that highlight fluidity in assets, as well as the ingenuity from leadership to quickly respond and adapt their business function.

These are good news stories. But what pressure might this be placing on the asset itself, particularly if the volume of production is increased exponentially.

It is true that many engineering assets can be used for a variety of applications. But it is also true that assets can have hidden failures. As the name suggests, the failure of the part, or the asset itself, is not evident to the operator and, in some cases, such a failure does not even stop operation. Hidden failures can lie dormant and only reveal themselves when the asset is put under undue or excessive pressure.

Engineering assets are fit-for-purpose, and our members will know of the criticality for organisations perform regular, planned asset maintenance procedures in order to remain so. In this time, when you may be considering altering your business's core function to respond to a need arising from COVID-19, it is crucial to remember that tangible assets still require rigorous maintenance procedures. Even more so, perhaps, especially if you are producing vast quantities. Let's remember the value of assets, and effective asset management builds greater value for your business.

Here are five examples of assets that have been repurposed to meet the changing needs of stakeholders:-

1. **Fluidity in Assets – 3D printers making respirator valves**

   It will come as no surprise to our well-read members that Italy is now the country with the most cases of coronavirus; the deaths alone number over 8000[9]. The pressure placed on the medical infrastructure and surrounding industries is beyond compare.

   And so, the Asset Management Council brings you the fourth in our Fluidity in Assets series. This time we're looking at an Italian-based engineering start-up that used 3D printers to create respirator valves.

   A hospital in Chiari, in northern Italy reached crisis point recently when they urgently needed valves for respirators to provide oxygen for patients experiencing breathing difficulties due to the coronavirus. However, the regular manufacturer of the valves was unable to produce in the volumes required to meet unprecedented demand.

   The CEO of Isinnova, Christian Fracassi, immediately jumped into action and volunteered to help. He was unable to obtain a 3D model of the part, known as a venturi valve. Undeterred, Fracassi set to work to reverse-engineer the design of the valve, creating a prototype within a six-hour period.
   The hospital confirmed after testing that part was able to be fitted to the respirator and was of good quality. Fracassi's business printed 100 more valves and donated them to the hospital by the next day[10].

   Fracassi's decision to involve his business in a crisis demonstrates both the fluidity of engineering assets and intuition in leadership – crucial elements in asset management.

2. **Fluidity in Assets - Couture brand makes surgical gowns**

   There are plenty of good news stories to rise out of this pandemic with fluidity of assets, and the ingenuity of leadership to reconfigure products and services to meet the changing needs of the community.

   Over in the United Kingdom, couture fashion house, Burberry—famous for trench coats and its registered check design—is retooling its trench coat factory in Yorkshire to make non-surgical gowns and masks for patients[11] during the COVID-19 outbreak. That's going to make for some very stylish and fancy patients! In addition, Burberry has made a significant donation to the University of Oxford to fast-track research into a single-dose vaccine[12].

   Burberry's attention to practical assistance during this crisis underpins its humble beginnings: the trench coat was originally designed for soldiers during WW1. With epaulettes on the shoulders to suspend equipment including whistles and gloves, D-rings to carry grenades and other armoury, a gun flap to provide additional protection, and the durable, weather-proof fabric to shield the soldiers from inclement weather, the trench coat soon became a staple for the military. After the war, the company continued to expand its production and line, and moving from wholesale to retail, has grown to become a world-leader in fashion for its focus on sustainability and the circular economy[13].

3. Fluidity in Assets – US Military helping to repurpose buildings

One of the purposes behind the Asset Management Council's series in Fluidity in Assets, is to share knowledge of how businesses are contributing to reducing the impact of COVID-19. But another purpose is to share good news stories from around the world. In this post, we head to the USA, where the US military is helping to convert disused buildings into hospitals.

Lieutenant-General Todd Semonite, commander of the US Army Corps of Engineers (USACE), spoke recently on converting disused buildings, hotels and universities into hospital facilities, in light of the significant deficit faced by the health industry due to COVID-19.

The Javits Center in New York State is already being converted into an alternate care facility.

Lt-Gen Semonite advised that USACE is working alongside the New York City's mayor and NY State governor's teams, as well as existing health infrastructure to place almost 3000 hospital-like rooms in the convention centre. Nurses stations are scattered throughout the converted facility, in order for health professionals to be able to see up to twenty patients from the station[14].

The commander of USACE also noted that this can be done across the country, providing a quick but reliable solution to the coronavirus pandemic and the stress it creates on the health industry.

4. Fluidity in Assets – Dyson from vacuums to ventilators

Traditionally the home of the bagless vacuum cleaner, Dyson the company has been asked by the UK government to supply ventilators, in this time of crisis due to COVID-19.

According to the BBC, the government health system in the UK, known as National Health Service (NHS) have 8000[15] ventilators, leaving them ill-prepared to meet the demand from those who have contracted coronavirus and need ventilating.

James Dyson, owner of Dyson, rose to the challenge set by the government and has already secured his team of engineers who are working around the clock to design and supply 15,000 ventilators.

The engineers have already designed the ventilator which is now undergoing stringent medical testing before being released to the NHS for operation.

This is another great example of an asset's diversity, coupled with a can-do culture from the leadership of a business. It is in times of crisis that we can truly stretch capabilities in our thoughts, our physical assets and our business.

5. Fluidity in Assets – Buildings

Many buildings are currently being repurposed to provide new ways to help the community during the coronavirus pandemic.

Let's head to Western Australia. Nineteen kilometres off the coast of Fremantle, lies Rottnest Island, famous as the home to Australia's cutest marsupial, the Quokka. However, the infographic gives a brief history of the building assets on the island, and how they have been constructed and repurposed over time.

And most recently, in light of the COVID-19 pandemic, the Western Australian prime minister is considering the option of Rottnest Island being a quarantine zone[16], highlighting again the fluidity of assets to meet stakeholder and community needs.

6. Fluidity in Assets – Alcohol Manufacturers

There are many innovate ways in which businesses are altering manufacturing and production by repurposing their assets to meet the new customer requirements of the COVid pandemic.

When the supermarket aisles recently became bare of hand sanitiser, Australian gin and rum manufacturers switched their business to produce medical-grade hand sanitiser. Gin company SevenZeroEight, owned by Shane Warne and named for the total number of wickets taken in his cricket career, advised that an agreement had been made to provide a continuous supply of 70% alcohol hand sanitiser at cost to two Western Australian hospitals[17].

Queensland based manufacturers, Bundaberg Rum Distillery and Beenleigh Rum Distillery also commenced supply of hand sanitiser, with a view to provide schools and healthcare workers with the much-needed product. Similarly, Archie Rose Distilling Co. in Sydney has also halted production of alcoholic consumables in favour of proliferating the market with hand sanitiser[18].

These companies highlight the fluidity of assets as well as ways that ingenuity in leadership can bring wider community benefits and greater value to businesses.

DATA SOARS AT HOMES AROUND AUSTRALIA

COVID-19 has brought challenges to many aspects of our lives. In the professional arena, many of us are now working from remotely and for those employed in the asset management sector, this fact can usher in a set of unique circumstances when managing asset portfolios. Completing inspection reports, presenting analysis and findings, and developing maintenance strategies all from the home office.

The infrastructure to support this in Australia is the National Broadband Network, better known as the NBN.

Even prior to #shutdown, people were increasingly relying on digital connections. But add in the working from home status of so many of us, online schooling for students, and accessing movies via the numerous streaming apps available, it's understandable that over the past three weeks the NBN has experienced an uptake in demand. Let's take a brief look at this uptake in demand. Data is measured across three timeframes: daytime business, early evening, and busy evening.

- In the week leading up to Easter 2020, peak upload throughput increased by over 100 percent.
- Wednesday 8th April was the busiest day for uptake across all three timeframes coinciding with the release of an update to the popular game, Call of Duty.
- Orders for higher-speed plans through internet providers increased during the same week.
- Reliable performance is critical for employees to connect via video-conferencing and those running their own business from home[19].

ZOOM GOES SECURITY

The coronavirus has caused an explosion in the use of social media platforms, and particularly software programs that have a videoconferencing option.

As more and more of us are remaining indoors, following advice to #stayhome, the way we connect with our work colleagues for critical business functions, as well as our friends and extended family members has been via these platforms.

But recently, Zoom has come under fire for breaches in security, as it struggles to keep up with the new demand. In March, users zoomed to 200 million a day, as opposed to 10 million a day in December 2019[20], and Zoom became the most downloaded free app on iTunes, ahead of the usual suspects of TikTok and Disney+[21]. As the use of Zoom has grown, unfortunately, so has the attraction of the darker side of technology: cyber hackers and trolls. The CEO of Zoom, Mr Eric Yuan, has had to think on his feet as he is faced with complaints from new users about harassment and unauthorised people accessing social catch-ups, children's birthday parties as well as business meetings.

The cyber wing of the Australian Strategic Policy Institute (ASPI), the International Cyber Policy Centre (ICPC), warns users should exercise caution when selecting videoconferencing platforms, particularly in light of the Australian Defence Force's decision to ban personnel from using Zoom[22].

It is important that such platforms don't leave users at risk of exploitation. And in our current global situation, we need these online connections more than ever.

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Application of Reliability Centred Maintenance for Formulation of Optimal Maintenance Strategies

Erik Van den berg & Gopinath Chattopadhyay

Summary: High Reliability, Availability and Maintainability (RAM) and lowest possible life-cycle costs (LCC) are goals of leading industries. Pre-emptive interventions, through Preventative Maintenance (PM) are worthwhile if they can balance the cost of maintenance with the restoration of degradation and elimination of failure mechanisms. PM activities themselves, if not performed properly, can introduce additional damage, and increase life-cycle costs. Inadequate PM could allow equipment to wear out faster, leading to reduced overall reliability and availability. Recommendations for maintenance, inspection and testing programs is improved using Reliability Centered Maintenance (RCM). The application of RCM to assets that have been operating for some time is of significant value to organisations, largely because there is knowledge and experience with operation of the assets. It provides insight that is generally not available at FEED or design phase. Other positive impacts of a good RCM are improvements in morale, teamwork and individual motivation. Failure Modes, Effects and Criticality (FMECA) and RCM analysis are implemented, followed by review and further improvement of maintenance support, spares and logistics strategies in line with ISO 60300 group of standards on dependability management. This paper discusses application of RCM to Liquefied Natural Gas (LNG) loading arms in INPEX Australia's operations, part of transformation to a 'high-reliability' organisation.

Keywords: Failure Modes, Events, and Criticality Analysis, FMECA, RCM, Reliability Centred Maintenance, Maintenance Optimization, Maintenance Strategy

1. INTRODUCTION

Ichthys onshore LNG processing facility in Australia includes marine loading arms (MLA's) at the end of jetties for loading of LNG, LPG and condensate tankers. The criticality, and availability requirements for these assets are high for meeting contract commitments to customers. The failure of one LNG liquid/hybrid arm can reduce loading from 12,000 m3 to 10,000 m3 per hour. The failure of further arms (leaving one vapor arm and one liquid arm operational) can further reduce loading to 5,000 m3 per hour. Considering business drivers, it was observed that the MLA's were a prime candidate for maintenance review, with opportunities to make improvements to the maintenance build, using RCM to optimize, with operational experience of the arms and associated equipment. Further to this, under the provision that reviews would be conducted in the operations phase, the OEM (Original Equipment Manufacturer) recommended maintenance regime was previously adopted during the design phase. An excessive and conservative approach at best. Not considering the specific usage parameters and environmental conditions unique to an installed location. Hard time based complete overhauls of the components and the arms, which required removal of the arms every 5 years using a floating barge-crane. All maintenance needs to be executed in the non-operational windows, around every 72-hour intervals. Typical turnaround time for loading from first line ashore to last line off is 29 hours including tidal restriction, with average fill time of 15 hours of an LNG carrier of 155,000 m3. The RCM (Moubray, 1997), (SAE International, 2011), (SAI Global, 2011), (United States Army, 2006), (United States Department of Defense, 1981), (International Atomic Energy Agency, 2008) methodology, originally developed for the aviation industry, has also been used effectively for this asset in conjunction FMECA, (Standards Australia, 2008), (US Department of Defense, 1980) for the analysis of reliability (Gonzalez, 2013), (Catelani, et al., 2015). RCM has been used with FMECA and/or Fault Tree Analysis (FTA) (Standards Australia, 2008) in the military, nuclear, oil and gas, and chemical processing industries, to reduce maintenance burden and support costs for preservation of a required state of readiness and/or operability. The goal is to optimize the use of resources for maintenance and to ensure the desired level of asset integrity and reliability are retained.

Fault Tree Analysis is used for determining failure mechanisms and considered in FMECA to determine the effects and criticality ranking of each failure. RPN (risk priority number), is mathematically expressed by RPN = (OR).(SR).(DR), where OR = occurrence ranking, SR = severity ranking, DR = detection ranking. The RPN is used to rank the failure modes, from those of the most concern to those of the least concern. This is conducted using a quantitative analysis where accurate relevant failure data is available or qualitative (subjective) analysis, using the experience of team members (United States Army, 2006) where data is not available.

Figure 1 – LNG arms connected to LNG tanker

A benefit of FMECA, is to get 'buy-in' to the maintenance program from operations personnel (Moubray, 1997). Once all the functional failures have had the RPN calculated, those with the highest score are evaluated first. The outputs should ensure the safe (non-hazardous) and economical operation and support of a system while maximizing its availability (United States Army, 2006). This is driven first by safety and then by economics. RCM decision logic tree is used to formulate recommendations for suitable maintenance strategies. It helps in avoidance of some common maintenance problems, including but not limited to insufficient proactive maintenance, frequent recurring problems, unnecessary or conservative PM, perfunctory rationale for PM strategies, lack of maintenance program traceability, blind acceptance of OEM recommendations and insufficient use of predictive maintenance technologies.

For an oil and gas company to be successful, it is essential that they understand the criticality of all maintenance actions, and the direct impact that maintenance has on reliability and availability of their systems and equipment (Carlucci & Tognarelli, 2015). Maintenance recommendations from OEM do not differ from lubrication recommendations, in the fact that they are, in most cases over conservative, to ensure performance under a wide range of operating conditions, without considering the specific equipment application and operating conditions. Maintenance recommendations can also be modified, providing skilled people following tested and proven methodologies exercise this, with caution. The OEM does not have the means to monitor MTBF (Mean time between failures) of equipment, as they are not always called upon for maintenance, and even when they are, they normally have no knowledge of the operational profile and environment the equipment may have been subjected to. Therefore, their recommendations reflect only their experience and judgment, combined with theoretical knowledge, and in some cases knowledge from destructive testing in controlled conditions, including simulating the harshest operating environments to accelerate degradation in run-to-failure tests (Feinberg, 2016). The vendor generally does not know or understand the specific details about how the organisation will use the equipment or the specific operating environment, including environmental conditions, temperature, vibration, UV exposure, presence of airborne contaminants, carbon, chloride, humidity, etc. It is also worth noting that an OEM would naturally be biased toward recommendations that yield a positive commercial benefit for them, such as aftersales support, parts sales and avoidance of warranty claims. It, by nature, tends to be over-conservative.

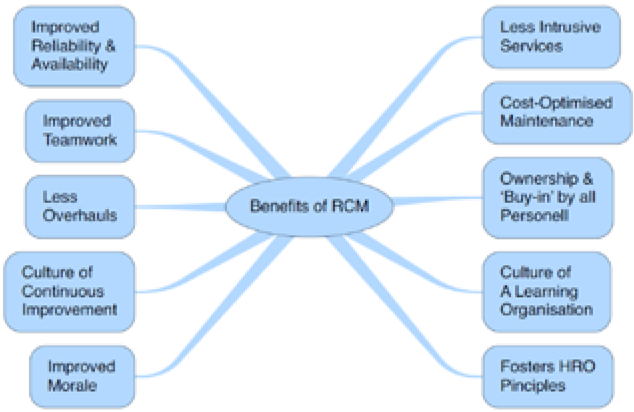

Figure 2 – Benefits of RCM

RCM enhanced team members' confidence and sense of ownership. For companies in the process industries, particularly operators of major hazard facilities, or 'high reliability organizations' (HRO's), RCM serves to reinforce focus on analysing root cause of failures, and subsequent revision of procedures (Andriulo, et al., 2015), fostering continual improvement. Involving maintenance personnel in the RCM process gives them an insight into the structured FMECA thinking and importance of accurate failure data recording. Despite the widespread belief that components or equipment follow the specific rule set when failing, exhibiting 'bathtub-curve' characteristics, where the 'burn-in' and 'wear-out' periods are the times where most failures occur, there is evidence that this is more often not the case. This means maintenance strategies should be predictive, condition-based methods wherever possible, to increase total availability and improve MTBF.

United Airlines analysed the databases of failure data which highlight that 89%-92% of failures did not follow age- related patterns (Zabawski, 2018). The results of the data collection efforts by United Airlines were a surprise to most people, as they are still today, when people are looking at the results for the first time. Important to note, is that only around 4% of the components followed the traditional bathtub curve. With only 11% showing signs of traditional age-based failure patterns, this means that the 89% remaining would not benefit from a limit on operating age or hard-time-based maintenance. This means that preventive time-based maintenance means waste of resources, with components retired early and an increased failure rate of some equipment.

Based on the knowledge of failure patterns, FMECA and RCM methods, it was proposed that INPEX adopt an RCM approach for revising current maintenance strategies, using the marine loading arms as the first system to develop a blueprint for the process. The key point of all the logic trees is to ask questions that guide engineer/s, to formulate economic maintenance strategies. For example, the tree from the United States Department of Defence (United States Army, 2006) prompts the lubrication or servicing tasks to prevent failures, inspection or functional testing to detect degradation, restoration/repair or if none of the options are effective, the logic prompts the mandatory redesign of a system. The decision logic must ensure economic strategy, considering predictive maintenance (PdM) and condition-based maintenance (CBM). A review was conducted and RCM logic shown in Figure 3 was proposed for the marine loading arms.

2. THE METHODS

RCM logic proposed was similar to that used by NASA. It helped to identify predictive type test and inspection strategies to detect impending failures before they lead to a functional failure. Using the decision logic tree, the engineer/s is/are able to evaluate each option for its technical feasibility and its impact on safety, environment, production, and cost. It is proposed to use non-destructive testing (NDT) methods to detect variables that predict impending failures before they happen, to allow the preventive maintenance to be scheduled to improve availability. For example, a bearing that will give adequate warning before it fails that could be picked up by vibration monitoring (Kondhalkar & Diwakar, 2019) could likely be a candidate for an on-condition strategy. Providing the random nature of timing for signs of impending failure does not disrupt production, for example in an N+1 arrangement, the simplest form of standby system, where one component is operating and a spare one is on standby. If lack of redundancy could cause production impact, then one needs to ask if the time before failure of the item is predictable and consistent. If so, then it may be more economic to implement time-based repair/restoration or complete replacement. For example, the overhaul of a non-spared, critical machine like an industrial gas turbine or compressor, may best be done on a time-based interval if the failure of such equipment can lead to unplanned rectification, with avoidable additional downtime and significant losses due to production stoppage, as opposed to planned shut downs, where proper planning and execution of in the shortest possible time can occur at the most suitable time window. For hidden failures, for example, a faulty gas or infrared fire detector, function tests at fixed intervals may be appropriate, and if the failure mode remains untreated then further analysis is required, with potential for a design change, if needed.

Once the criticality/RPN is determined for all failure modes in FMECA, maintenance tasks are mapped against each failure mode, for further analysis. For example, when the INPEX RCM decision logic, and QRCM (Quantitative RCM) decision algorithm are used to improve to optimise maintenance strategies (Smith, 2011), for a large structural bearing of the MLAs, this resulted in implementing effective lubrication, and condition monitoring, with removal of time-based replacement tasks.

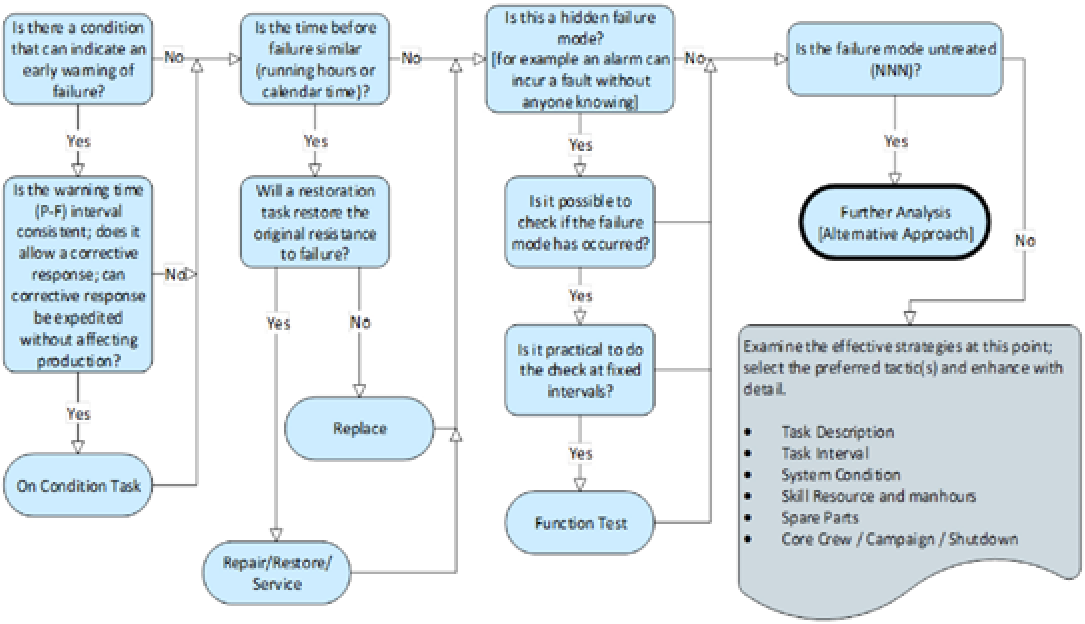

Figure 3 – RCM decision logic tree used for INPEX RCM

3. RESULTS

The FMECA analysis identified 17 functions, 29 functional failures, with 39 failure modes. For the key functions, the failure effects, mechanisms, and current controls were identified and RPN conducted. There was a significant reduction of OEM recommended hard-time-based overhauls, with an increase in lubrication and condition monitoring tasks, moving to a much more on-condition, PdM based strategy.

Figure 4 –Slide from MLA RCM update

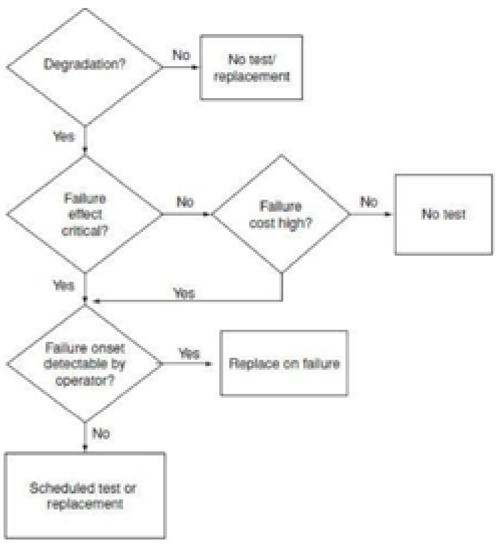

Figure 5 – A typical RCM decision logic tree

Explanation of key RCM outcomes as follows:

- Rigid time-based overhaul schedules are removed
- This represents ~70,000 hours of maintenance over the next 6 years, plus significant material & equipment cost savings

- Preventive maintenance (e.g. greasing) and predictive maintenance (e.g. condition monitoring) strategies are employed, with major components replaced with 'rotable' spares only if required.
- Major components requiring arm removal can now last 20+ years (slew, fulcrum and apex bearings) where they were previously replaced at 5 yearly per OEM recommendations.

The FMECA and RCM workshops have revealed that the only component failures that would necessitate the complete removal of the arm assemblies (task recommended every 5 years by the OEM) are that of the slow and intermittently moving slewing, fulcrum, and the apex bearings. The marine loading arm complete overhaul activity, which required removal of the arms, would be disruptive to the shipping schedule with the possibility of causing a production impact, and would also require a floating barge-mounted crane of significant size, and additional costs. There is redundancy, to continue loading with 3 of 4 arms operational, with relatively minimal disruption and cost. However, the slower loading rates impact shipping schedules, demurrage costs, and can lead to a total plant shut- down with significant financial impacts, of revenue losses. Benefits from this project are:

- Average saving of 13,000 hours per year
- Total hours over a 20-year period – 275,000 hours

Applying a norm of $250 AUD per hour, total saving of around ~$69M AUD (over 20 years)

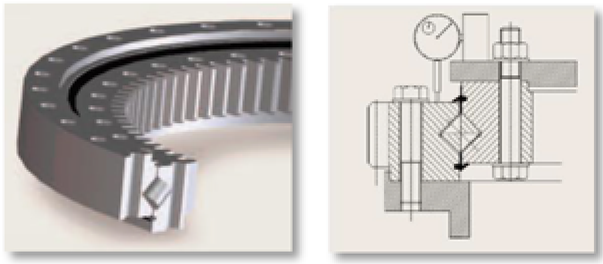

Figure 6 – Radial and 3D views of slew bearing

The mission profile consists of only sporadic movements when extending or retracting the arms to connect or disconnect with an LNG tanker. When connected, they are subject to only reasonably subtle and small incremental movements as the ship raises or lowers as a result of weight changes or tidal movements. Around 60% of the time, for the remainder of their operational cycle (United States Department of Defense, 1981), the bearings sit in a dormant mode. The complete overhaul of the entire arms at no more than 5 yearly intervals as reccomended by the original equipment manufacturer (OEM) is a conservative, costly and undesirable strategy.

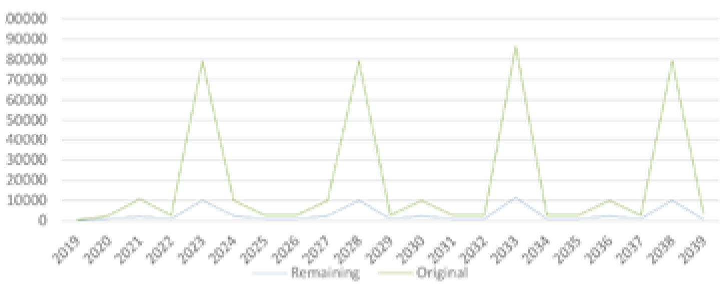

Figure 7 – PM maintenance work order hours before and after RCM

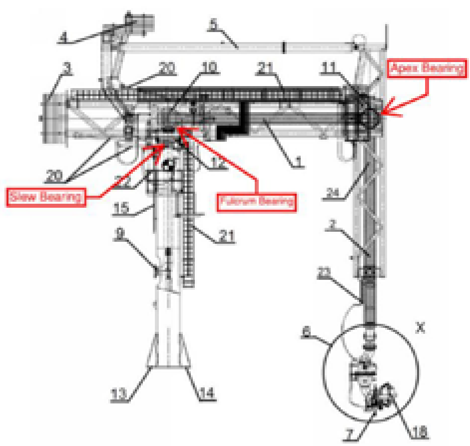

Figure 8 – LNG Marine loading arm structural bearings

Following the RCM process has found that the most economic strategy for the large bearings is to perform more PdM and CBM, with spares strategies to be adjusted to ensure spare bearings are in stock once their condition begins to degrade, in preparation for eventaul overhaul. Prior experience of the team members with this type of equipment on other facilities, these type of arms have been able to last 15-20+ years without being removed, in some cases in harsher and saltier marine environments. This key knowledge assisted in making an informed decision to revise the 5 yearly complete overhaul activity.

Due to the tight shipping windows, it is advised that a complete triple swivel assembly (TSA, circled 'X' in figure 7) be kept in stock as a repairable, 'rotable' spare, which includes the double ball valve, powered emergency release coupling, and quick-connect/dis-connect coupling. This also reduces the risk exposure of complete plant shutdown if a second arm fail, a credible consequence, as the lead-time on spares is significant, up to 8 months on some parts.

Other main components, including swivel joints, the powered emergency release coupling (PERC), the double ball valve (DBV), quick-connect-disconnect-coupling (QCDC) and various hydraulic and instrumentation components can be exchanged fairly easily with resources and equipment already on site, causing minimal disruption to shipping. Therefore, a purely PdM and CBM strategy has been recommended as the most sensible approach, and the maintenance strategy has been revised with these changes.

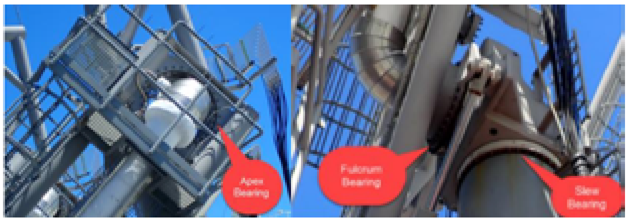

Figure 9 – Apex, slewing and fulcrum bearings

Reccomended sparing strategy ensures all major and long-lead time components are in stock, keeping rotable complete assembly of swivel joints and overhaul kits, hydraulic cylinders and overhaul kits, and a complete rotable TSA assembly. The logic for reccomending stocking a complete TSA, is due to the reduced loading of the ships attracting significant demurrage charges, causing tighter windows between ships, of as little as one day, with potential of hitting 'tank-tops' causing a total plant shutdown with significant production impacts. When failures occur, to overhaul the TSA in the workshop and test it could span over a couple of shipping windows, with significant demurrage costs each time this happens. Further to this, if any problem is experienced with one arm, then further issues might occur with second arm, this could lead to a total plant shutdown for significant duration, and is not desirable. As the difference in cost of a set of spares, vs. a complete rotable TSA assembly would pay for itself on the first failure, this makes economical sense to keep an item in stock, along with one set of overhaul spares, and this is reccomended as part of the sparing strategy for the LNG arms. Due to significantly larger dormant, non-operational windows for the LPG and condensate arms, it was not recommended to stock complete rotable major items, instead to stock ample spares for overhaul of these on site.

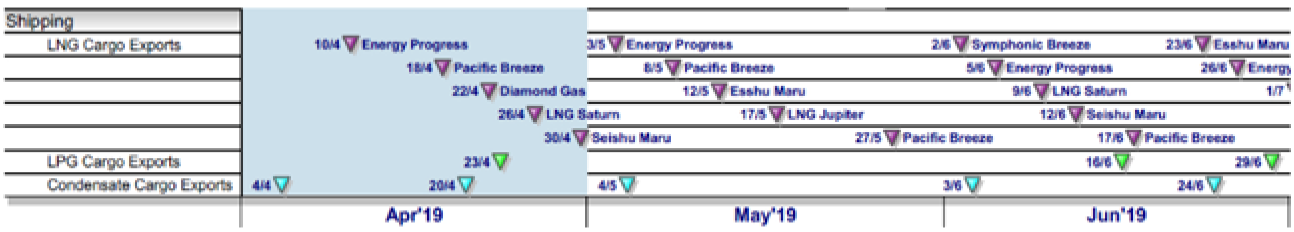

Figure 10 – Typical operational cycle for LNG, LPG and Condensate loading arms

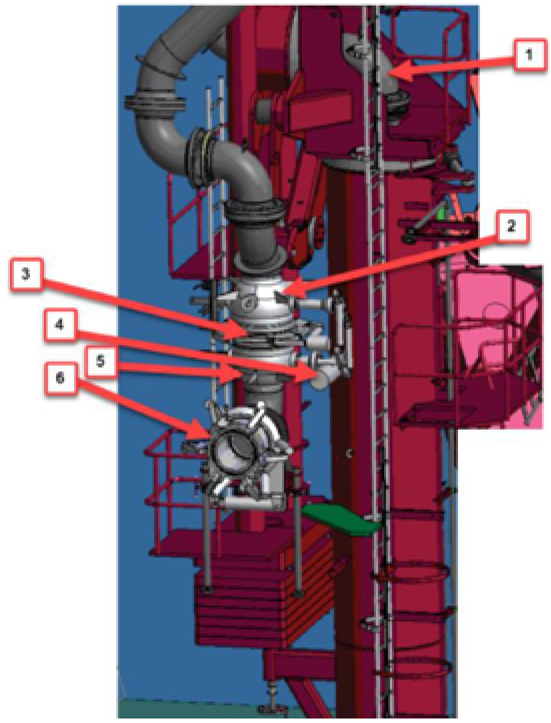

Figure 11 – Other main MLA components

NO.	COMPONENT
1	Upper swivel joint
2	Upper DBV
3	PERC
4	DBV Actuator
5	Lower DBV
6	QC/DC
6	QC/DC

Table 1 – Component list for MLA (Fig.11)

Recommended sparing strategy for the LPG arms is to keep all spares for overhauls of the various components in stock, with rotable spares of the swivel joints, as these are economical. However, unlike the LNG arms, the recommendation is to only hold a complete set of parts for overhaul of a TSA, and not a complete rotable TSA assembly. The logic for this recommendation is that the task of using the crossover spool vs. that of replacing a complete TSA, are equally disruptive to the loading of an LPG vessel, therefore there is no upside from that perspective. Unlike with the LNG arms, there is a window of several weeks between vessels. TSA could be removed and repaired in the workshop, and then reinstalled.

There is a further intangible outcome of carrying out RCM, aligned to the INPEX core value of 'collaboration' and the role of close collaboration and active engagement. The technicians now 'happily' own their new maintenance regime (they are living in the house that they built). This improvement in morale and pride by the participants is an additional benefit of great value.

4. DISCUSSION AND NEXT STEPS

Prior to the RCM analysis, there were frequent and costly preventive actions as recommended by the OEM. RCM analysis led to condition based preventive maintenance, based on preventive testing and inspection (PT&I), to maximize availability and minimise cost. The rationale of the existing recommendations from discipline engineers and technical authorities was recorded in brief in the current standards with no documentation of how this decision was reached. With FMECA and RCM analysis, it was possible to support and improve maintenance (SAI Global, 2016), integrate logistic support (SAI Global, 2011), and enhance maintainability (SAI Global, 2004). Further to this, there were additional benefits INPEX through continuous improvements of maintenance strategies, knowledge sharing, and collaboration of personnel across Engineering, Maintenance and Production.

5. CONCLUSION

Implementation of RCM on the marine loading arms at the end of jetties, led to reduction in downtimes and costs and improved spares strategy. In addition, there was a clear increase of morale and active engagement of the maintenance and operations teams. RCM is adopted as a 'living program' and proposed to be reviewed periodically for developing an excellent maintenance program.

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Optimisation of Preventative Maintenance Regime based on Failure Mode Risks Modelling

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Summary: It is crucial to have a sound maintenance plan for complex assets. Optimizing preventive maintenance schedule is not only beneficial to asset reliability, but also comes with a huge potential to save on maintenance costs. In this paper, the preventive maintenance regime for a complex asset has been developed by use of FMEA method, with the aim of improving asset maintainability and reliability, and lower the cost of maintenance through an optimized maintenance schedule. The strategy of the current research is to focus on the failure mode based preventive maintenance schedule and replacement of components. We consider a production system with distributions of exponential failure for its components. The PM tasks can then be improved using the mean time to failure (MTTF) values, with additional replacements to prevent frequent breakdown failures. The results indicate that PM replacement of components ensured an achievement of 99% overall system reliability, while minimizing asset maintenance costs and down-time costs. Further, a single PM cycle can be utilized to maintain other components of the system.

Keywords: Preventive maintenance; Reliability; Failure Mode and Effect Analysis (FMEA); Mean Time to Failure (MTTF); Partially Failure Modes; Maintenance Cost.

1. INTRODUCTION

Complex assets consist of different components. Each of the components is important in relation to the operation and performance of the whole asset. Examples of complex assets include aircraft, power generation plants, and production lines. When one of the components in a complex asset is removed from service due to maintenance, it may cause failure of operation of the whole or part of the asset. As a result, owners of complex assets seek to adopt a total lifecycle approach to system reliability from the design and building stage (Khalaf et al, 2013).

Failure of a component in a complex asset is costly in terms of both system downtime and the cost of component replacement or repair.

Such costs can have huge impact to asset owners, thus the need to change maintenance approach to preventive maintenance (PM). For complex systems, a good preventive maintenance scheme can be beneficial in cutting down the costs incurred in repair and replacement of components, and improving the availability and reliability of the systems (Kobbacy and Murthy, 2008). In addition, good PM increases the service life of complex assets.

Design of maintenance schedules are mostly created on the basis of the decisions made by maintenance managers, recommendations by manufacturers, or long-term experience (Khalaf et al, 2015). This, however may increase the cost of operation and maintenance. Furthermore, the risk of unexpected failures is high. The manufacturers' recommendation for maintenance policies fails to consider component aging, which has direct effect on a component's operation condition (Soh et al, 2012).

A suitable maintenance scheduling not only improves the reliability of the system, but also reduces the cost of maintenance. However, not all component failure lead to complete system failure. The system may still operate in reduced capacity in some failure situations (Wang, 2011). Hence, scheduled preventive maintenance should plan according to the operation and requirements of systems under failure mode risks.

This paper explores the preventive approach as a maintenance service strategy for complex assets. The research models the failure modes of the asset in terms of components, subsystems, parts, and systems, with the aim of identifying and evaluating the probable safety and functional problems in the system being designed by using failure mode and effect analysis (FMEA) method. This approach can be applied to any form of complex systems and at every step of the process starting from conceptualization to technological upgrades. Using the failure mode model and corresponding data on component reliability, the PM regime so developed can improve asset maintainability and reliability, adjust periodic inspections, minimise cost of replacement and repairs.

2. LITERATURE REVIEW

Many researches on preventive maintenance optimization aimed for improving availability and reliability of the equipment and subsequently minimizing the overall costs of the system. Different approaches have been reported in literature. Moghaddam (2013) enhanced the presentation of an optimization model composed of new multi-objective nonlinear mixed integer. This was enhanced for the determination of Pareto-optimal replacement schedules and preventive maintenance for a production that is repairable. A hybrid Monte Carlo simulation goal programming method is used to obtain a set of schedules satisfying objective functions of overall reliability, operational costs and availability of the system.

Doostparast et al (2014) enhanced the development of an integrated approach for the determination of optimal types together with PM actions frequencies for coherent systems with the components which are deteriorating. The main objective related to the determination of a maintenance plan which is optimized for the minimization of the related costs of total maintenance, with respect to system reliability level which is desired. Likewise, Ebrahimipour et al (2014) a multi-objective preventive maintenance scheduling problem comprises of parallel and serial machines in a multiple production line. The authors measured the reliability of the production lines, maintenance costs, and downtime and failure of system as multiple objectives. Different thresholds were applied for available spare part inventory, manpower, and durations under maintenance. In their study, the two types of maintenance activities considered included adjustment and parts replacement.

Zhong et al (2018) simultaneously ensured the optimization of cost objectives and reliability in PM scheduling problem. This was done with offshore wind farms as the background, and it made the problem to be more comprehensive and nearer to what is real. A new definition of reliability criterion was proposed and the nondominated sorting genetic algorithm was employed for scheduling of PM of offshore wind farms. Similarly, Duan et al (2019) enhanced the development of sequential preventive model of maintenance with multi-phase with the consideration of PM actions imperfect quality for the mechanical systems which are under deterioration with objectives relating to the maximization of the availability and maximization of the expected average cost of maintenance per unit time. A model-iteration algorithm was presented by the use of multi-attribute value model (MAVM) for the efficient programming of maintenance schedules.

A dynamic opportunistic PM policy was propped by Zhou and Lu (2018) for the systems of series multi-station with the bidirectional interaction between product quality and reliability of the station. The systems optimal PM schedule is obtained through the maximization of the cost savings in short-term which originates from the stations that conduct PM, but also originate from the PM stations downstream station. A hybrid maintenance strategy was developed by Yang et al (2018) in which the system is replaced preventively at age that is predetermined, prior to which finite number of condition monitoring are done for the revelation failures besides the measuring of degradation level. Joint optimization of monitoring interval, replacement interval and reliability criterion were the objective of the paper, such that the cost per unit time expected undergoes minimization.

The above researches aimed at minimisation of system costs but failed to consider level of impact of failures to the operations and performance of some partially working systems. Consideration of how the system fails is necessary in complex systems. In considering application of FMEA, Dong et al (2008) selected optimum maintenance strategies were applied to improve levels of availability and reliability of a fossil-fired power plant equipment and reduce unnecessary maintenance costs. They evaluated equipment criticality using an evidential reasoning method, putting into consideration the uncertainty and incompletion of evaluation knowledge of system criticality. However, preventive replacement schedule was not considered in the approach. In another study by Guo and Wolf (2016) enhanced the optimization of the preventive maintenance interval through the minimization of the expected long-term cost of operation on the basis of reliability information of aircraft indicators. The major failure modes of two applications of indicator from two suppliers were identified by the use of the information from the FMEA reports. They enhanced the application of the process of renewal reward in the optimization of the intervals of preventive maintenance of components which are non-repairable.

An approach focusing on failure mode-based preventive maintenance scheduling was proposed by Duan et al (2018) for a complicated mechanical device. The intention related to the reduction and prevention of the impending failures via the optimal preventive scheduling. FMECA was utilized for the identification of the critical modes of failure and their categorization into degraded modes of failure besides the functional failure mode. The approach proposed has its illustration by the use of ram feed subsystem of a machine which is boring. However, their methodology did not consider the reliability of failure modes.

Literature review shows that there exists limited quantity of studies that utilizes the method of FMEA in research relating to maintenance. An approach that is based on FMECA was presented by Yssaad et al (2014) for the development of a maintenance program which is cost effective for the distribution systems of electric power. The basis of the procedure is on RCM (reliability centered maintenance) method which is a process of decision making in the cost-effective maintenance program selection for the improvement of the reliability, on the basis of determined failure modes criticality.

A maintenance program generated from reliability engineering with FMEA was proposed by Nakamanuruck et al (2016). The research developed the concept of the reduction of the repair costs and production opportunity cost through the application of the RCM and the determination of the appropriate plan of preventive maintenance for individual machine. However, only one component (of 11 components of Hydrocracker Unit (HCU)) was considered in their study. AHP (Analytical Hierarchy Process) based framework was proposed by Vishnu and Regikumar (2016) for the selection of RCM strategy for process plants. The maintenance history data of a process titanium dioxide plant process used for the validation of the model. Criticality analysis of the equipment is among the steps of the approach, whose assessment is based on production, capital cost, safety and standby availability of the equipment. They utilized FMEA methodology and the strategies of optimal maintenance were identified separately for every machinery and equipment based on the criticality.

RCM is among the best known and utilized strategies for determining maintenance schedule for every piece of equipment (Afefy, 2010). It should be noted that high frequency PM interventions can increase maintenance costs, and unnecessary waste of resources Vilarinho et al (2017).

Literature review indicates that many researches worked on the preventive maintenance scheduling area, but there is a gap to design PM schedule based on the utilization of FMEA method, with detail consideration of mode of failure to decide PM activities.

3. FMEA APPROACH FOR DETERMINING A SYSTEM'S PM SCHEDULE

Failure mode and effects analysis (FMEA) is a technique found to be useful in assessing failure mode and reliability as well. FMEA is generally used during the design phase to analyses possible product failures (Mo & Chan, 2017). Generally, the common challenge of preventive maintenance scheduling is identifying the best maintenance action sequence for every part in the system within each period of a planning horizon in a way that reduces the overall costs to the minimum and maximizes the system reliability (Ebrahimipour et al, 2015). This paper's strategy is to concentrate on the failure mode based preventive maintenance schedule and the replacement are the preventive maintenance tasks. Hence, a schedule of potential preventive replacement activities could be defined based on MTTF each component. By considering a system with n components, for which a reliability goal is needed, a reliability target of R% for the system could be achieved by allocating reliability to either some or all components, putting in mind that the system may either fail partially or completely. This goal must also be met at a minimal cost.

The reliability of complex systems is evaluated using a reliability block diagram (RBD) based on their configurations. In addition, RBD provides an efficient way of comparing different configurations in order to figure out the best system design (Ostachowicz , 2016). A reliability block diagram (RBD) is a graphical technique that demonstrates how the reliability of components leads to a complex system's success or failure. The block diagram of reliability is drawn as a series of parallel or series-configured blocks. Through applying this approach, the production system has evolved to evaluate the reliability basis on the production system block diagram (Gorgin & Farsi, 2011). The RBD is necessary to determine the impact of the failure to the system, i.e. can it still operate partially.

In this paper, all system components are in a series-parallel configuration and have distributions of exponential failure. We estimated the failure rate which can then be used to compute the Mean Time to Failure (MTTF) of each part in the system for clarity in the production system's reliability calculation. The function F(t) represents the probability distribution function of a component to fail within a time interval {0, t} (Høyland & Rausand, 2009). That is,

$f(t) = Prop(T < t)$ Equation 1

Where T – a stochastic variable that represents time of component failure.

The instantaneous probability of failure after a time t is given by the failure rate function h(t) and defined as follows:

$$\frac{f(t)}{R(t)} = \frac{f(t)}{1-F(t)} = \frac{\Lambda.e^{(\Lambda.t)}}{e^{\Lambda.t)}} \quad \text{Equation 2}$$

When discussing reliability, another important aspect of failure probability distribution is the Mean Time to Failure MTTF. This is the time expected to failure. The relationship between reliability and MTTF is defined by:

$$MTTF = \int_{t=0}^{+\infty} t.\ f(t)\ dt = \int_{t=0}^{+\infty} R(t)\ dt$$

Equation 3

For constant failure rate where Reliability function $R(t) = e^{-((\Lambda.t)}$, $MTTF = \frac{1}{\Lambda}$

One way to improve system reliability is by use of optimal maintenance schedule (Lad & Kulkarni, 2012). When it is dangerous or costly for system components to fail during actual operation, it becomes important to know when preventive maintenance should be done to prevent failure. Failures during operations can be prevented by replacing a component before failure, and at the same time, maintaining other components which require replacement.

Sometimes, it becomes costly to carry out corrective maintenance after failure of a component, which may also consume unexpectedly longer time. The importance is being able to determine when and how preventive maintenance can be done before failure, rather than maintaining components with unnecessary frequency. Hence, maintenance optimization problems seek to establish the timing and frequency of preventive maintenance based on costs and effects.

All components in this system will be put to a preventive maintenance scheduling, and the time for each component determined. Executing a maintenance action on one component creates an opportunity to maintain other components as well. Let XMTTF hours being the MTTF value of a component. In prevent the component from failure before the scheduled maintenance time so as to avoid the occurrence of the CM actions, an optimal preventive maintenance interval was determined by deducting x0 hours from the component's MTTF value in order to determine the time to perform the first maintenance activity. However, if the MTTF of any component less than x0 hours, PM should be carried immediately. The following notations are introduced for easy understanding of the proposed theory:

Let say the optimum time to carry out maintenance is denoted by C_i, and X0 represents time interval which is given by:

$C_i = X_{MTTF} – X_0$ Equation 4

And the optimum time to carry out maintenance on another component that meets Y requirements ($Y \leq Y_0$) is denoted by C_n, which is given by:

$C_n = MTTF_n – C_i$ Equation 5

where n = {1, 2, ..., n} the number of components and $C_n \leq Y$.

The waiting period for spare parts is denoted by T_{sp}, while X_{sp} denotes the average time to component failure without spare part. The value of X_{sp} in this case is taken to be equal to the value of MTTF, hence, C_n to maintain other components is given by:

$CN_n = X_n – X_{sp}$ Equation 6

where n = {1, 2, ..., n} the number of components and $C_n \leq Y$, and C_n is a component's optimum time without spare part to maintain another component that meets Y.

In the following step, the preventive replacement and downtime costs are introduced. Preventive maintenance is performed at C_i, C_n and CN_n. Each cycle of preventive maintenance is determined based on sum of the cost of the maintenance action PM_c, and is calculated as follows:

$C = \sum PM_c$ Equation 7

Therefore, total cost of maintenance is given by:

$T_{PMc} = \sum C_c$ Equation 8

In a case where there is failure before C^i, then the total corrective maintenance cost T_{CMc} is calculated as the sum of the cost of corrective maintenance CM_c (labour cost L_c, spare part cost SP_c and spare part delays cost SP_{Dc}) and the downtime cost DT_c as follows:

$T_{CMc} = \sum CM_c + DT_c$ Equation 9

There are a number of assumptions that have been made:

- First replacement maintenance is carried out at C_i time for components that continue to operate without failure.
- A shutdown on one unit for preventive maintenance creates opportunities for preventive maintenance of other system units. This saves the downtime cost of operating the system.
- In case a failure occurs before C_i , then corrective maintenance will be carried out at the time of failure, and the time needed to be 6 hours. It is assumed that the cost of corrective maintenance is higher than that of preventive maintenance.
- For a component without a ready spare part, $X_{sp} = X_{MTTF}$ value.
- Replacing a component at C_i incurs the cost of planned maintenance, and the reliability of such replacement is R%.
- For a critical component that meets replacement requirement $Y \leq Y_0$ hours, its replacement should be immediate and within the maintenance time.
- The time measured is in hours, and PM of a single component requires two hours, and all preventive replacement activities are carried out simultaneously.
- One of three actions can be planned for components in the system:
    - o Preventive replacement: Here, the component is replaced immediately to assume a state of "good-as-new".
    - o Do nothing: Here, no action is taken, based on the condition that C_n and $CN_n > Y_0$ hours.
    - o Run to failure: Here, action is only taken after the component without spare part fails. This decision is taken because there are no spare parts available. PM is carried out afterwards.

4. CASE STUDY

In this research, an example of a production line system is used to demonstrate the proposed theory (Figure 1). A commercialized software known as Maintenance Aware Design environment (MADe) is used to capture the FMEA models the production system. MADe is a support tool for engineering decisions that generate a system model composed of functions, modules, components, and interactions between them. It is possible to identify failure modes and failure causes by applying failure rates to the components of the system. The modeling work begins with the model being generated and a task being assigned to the top-level.

The production system functions based on two primary missions. The first production mission will be performed for ten months, twelve hours a day, and then the next one will start, which will be just ten hours a day and for the subsequent seven months, which implies that the two missions will have 17 months of production.

The system under study consists of multiple lines of production which are divided into three blocks – B1, B2 and B3. For each block, there is a series-parallel sub-system and parts. Each of the parts is susceptible to failure. There are standard parts or all lines, and there are some parts that are specific to a particular line. In this case study, the reliability target for the system is set at R% = 99%. The preventive maintenance interval is set at X_0 = 500 hours. The optimum time to repair a comparing component is set at Y_0 = 1000 hours.

The case study system is made up of 108 elements. Ten subsystem elements (Machines from 1 to 10) and each subsystem include seven different types of components in addition to twenty additional components that serve in the production line as complementary units as shown in Figure 2.

From the systematic functional diagram, the reliability of the system depends on all sub-systems and components. To conduct the reliability modelling, the function fulfilled by each part is considered separately, and the entire system is divided into several sub-systems that consist of individual components.

The whole system operates in a series-parallel arrangement. For the system to operate as required, then all parts should be running. However, failure of any component will not cause the whole system to fail. For example, failure of the Straw Unit 1 will stop Machine 1 from operating since it works in one line. This stoppage does not affect Machine 2 or Machine 3 in B1. They will continue functioning. In such case, the system loses a fraction of its capacity only. Similarly, if the Power Converter 1 fail, the other components that are in the same block will be affected. Hence, B1 will stop working completely and as a result.

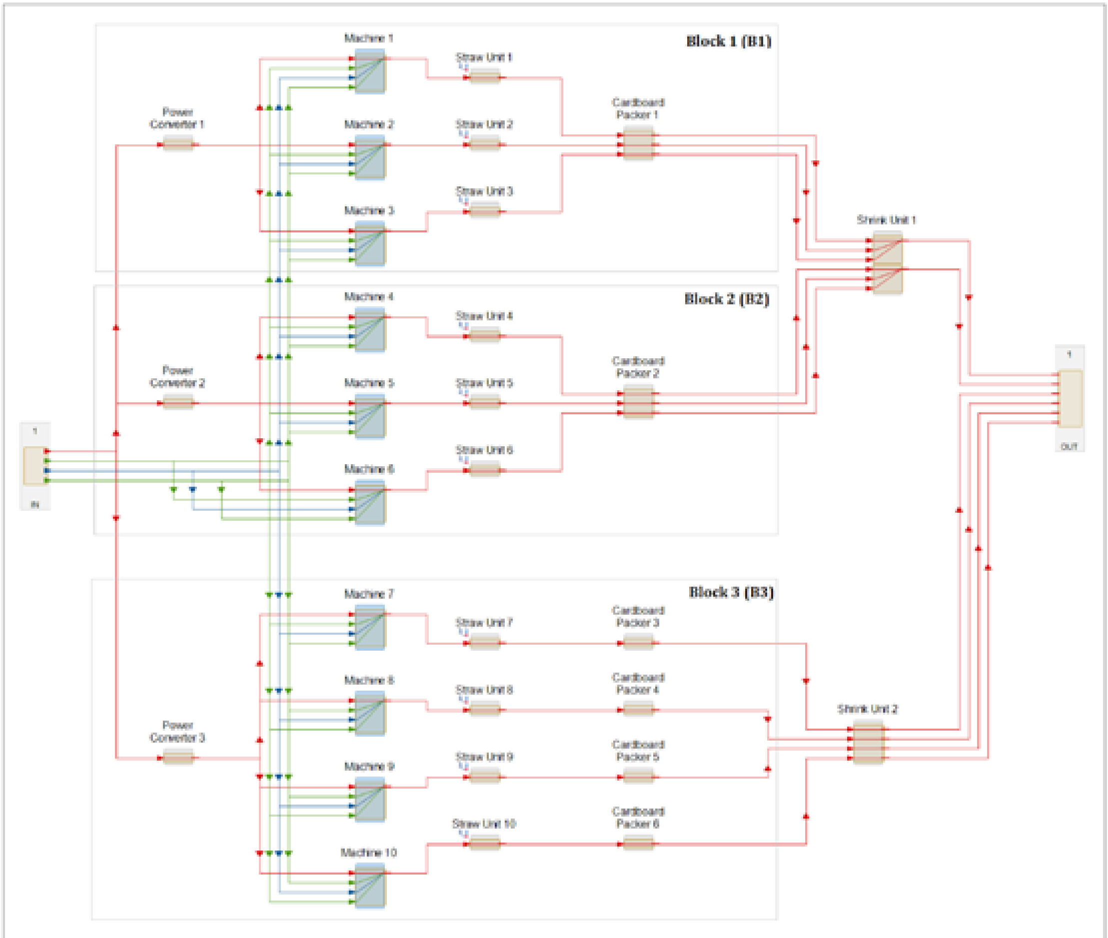


Figure 1 – Production System FMEA model captured in MADe

Again, there will be a partial effect of failure on the system, and not the entire system. The other two blocks (B2 and B3) will continue to work, but the capacity of the system will be reduced.

Another case which demonstrates the impact of component failure on the system is when failure occurs on Shrink Unit I. In this case, B1 and B2 will stop working since this component is critical to the system. Failure of this component will have a partial impact on the system. In contrast, the Power Converters and Shrink Units are considered as critical components, and if they fail, then the entire system stops working.

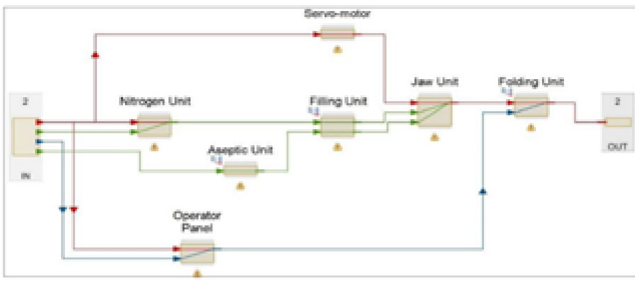


Figure 2 – Machine 1 – FMEA model captured in MADe

5.PROPAGATION OF FAILURE

The current reliability of the entire system in this study is 97% while our goal is to reach 99%. To analyse reliability, the production line system is first modelled, and the system's components taken into consideration are shown in Figure 1 and Figure 2, and a function and failure mode is specified for each element, then using a reliability block diagram (RBD) reliability is calculated. By translating the flow links between components into reliable connections, the MADe program transforms the functional diagram into an RBD. Where there are multiple flow connections between two products, a single reliability link is represented, and the reliability diagram is drawn according to this.

5.1. COMPLETE FAILURE OF THE SYSTEM

MADe software can be used to simulate failure propagation to see the impact of failure on the system. A component can be injected with a high or low response which propagates the failure to the whole or part of the system. The highest level of indenture of the system model is shown in Figure 3. Here, a production line model simulation was performed with the failure propagation path through the whole system. According to the simulation, model failure occurs at power converters 1,2 and 3. The sequence of failure is indicated by numbers as shown in the MADe model.

5.2. PARTIAL FAILURE OF THE SYSTEM

In the previous section, a simulation of failure propagation was provided in order to observe the impact of failure modes on the entire system. In this section we show a simulation of partial failure propagation to observe the impact of failure modes on part of the system. In this part the model failure occurs just at power converter 1. Here, we can see there are still some parts on the system to keep it working (Figure 4).

Hence, it is logical to design the preventive maintenance schedule according to where the failures would occur at critical components.

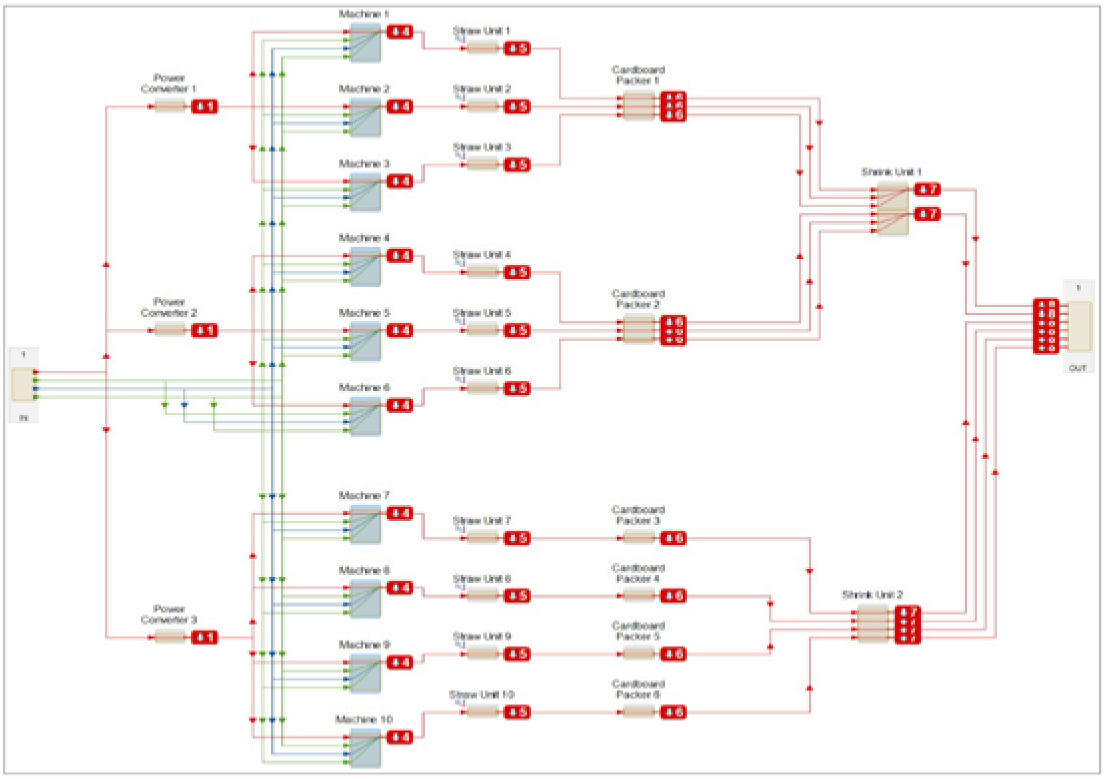


Figure 3 – Production system FMEA Model stimulated

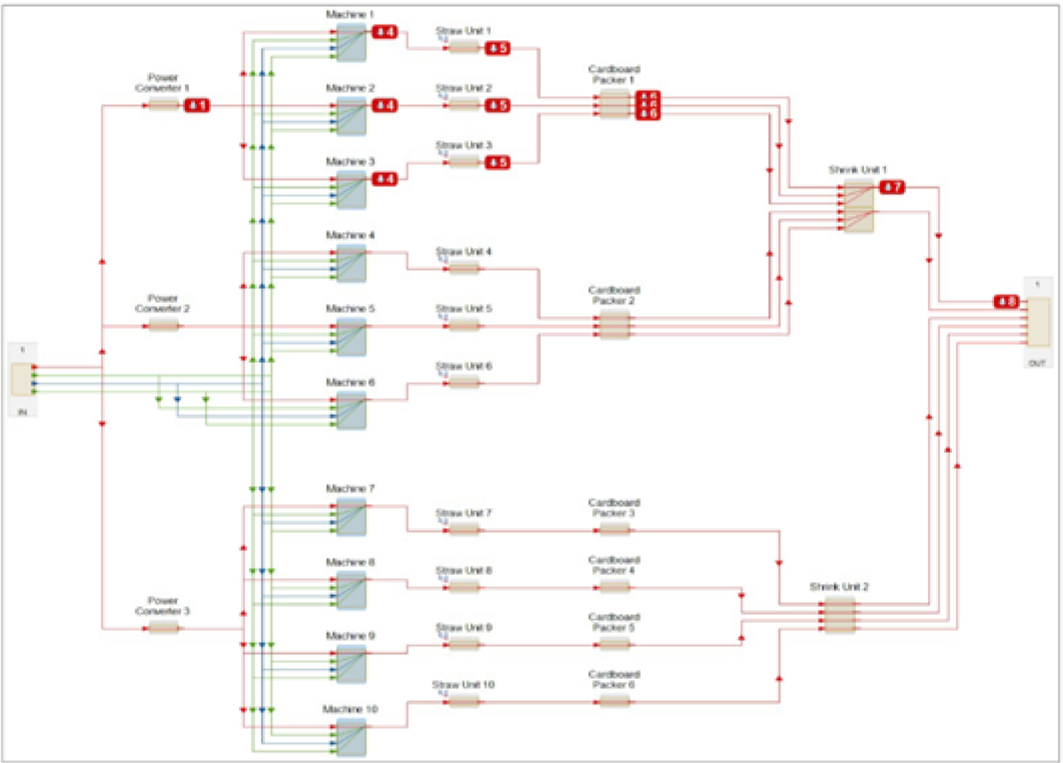


Figure 4 – Production system FMEA Model stimulated with partial faults captured in MADe

This can be determined conveniently from the FMEA models as shown in Figure 4. To simplify how to avoid the failure modes in Figure 4, an improved preventive maintenance schedule that will minimize the frequency of future maintenance operations and improve system reliability with lower cost of maintenance can be shown in Figure 5 for system block B1.

The planned maintenance is important in ensuring that the service life of the equipment is improved, and unplanned maintenance activities are minimized. Corrective maintenance can create high costs of maintenance, and increase the losses incurred during a breakdown of an equipment. Thus, PM should be carried out to minimize the costs by reducing the likelihood of equipment failure.

Preventive replacement is performed on all system components following the intervals C_i , C_n and when there is a shortage of spare parts at hand, CN_n. In the following scenarios, the implementation of preventive maintenance cycles, including cost calculation, has been shown. This strategy was implemented using Machine1 as an example.

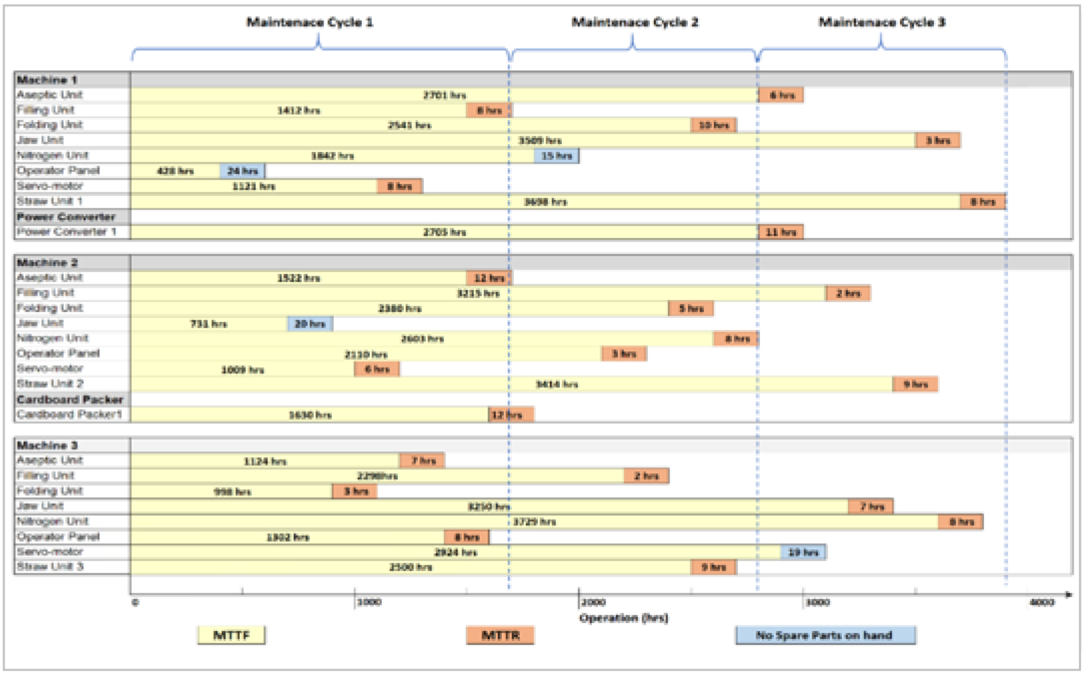
5.3. SCENARIO 1

In this scenario, it can be seen from the first cycle of maintenance Figure 6, that the MTTF of the Operator Panel component is 428 hours and the component have no available spare part. It can also be noted that it would take 24 hours for a spare part to arrive. The best action in this case is to allow the component to run to failure before carrying out a preventive maintenance task. At this point, the value of X_{sp} is equivalent to X_{MTTF} since there is no spare part available.

To minimize the cost of maintenance in this case, it would be appropriate to perform simultaneous preventive replacement for components in Servo-motor, Filling Unit and Operator Panel.

For each component, the cost of PM is $ 500/h and the time for PM is two hours. This means that PM_c for one component is $ 1000. At this stage, PM is carried out on three components at the same time in two hours. Hence, from Equation (7), the first maintenance cycle of Machin1 will cost:

Figure 5 – PM Schedule of Block (B1)



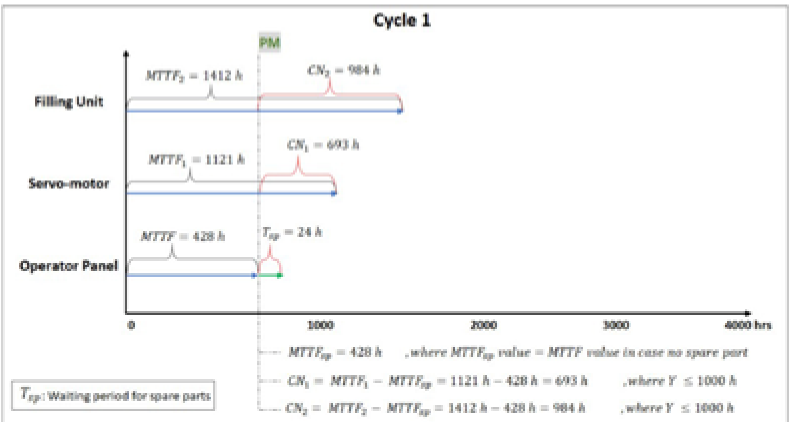


Figure 6 – Machine 1 – Maintenance Cycle 1

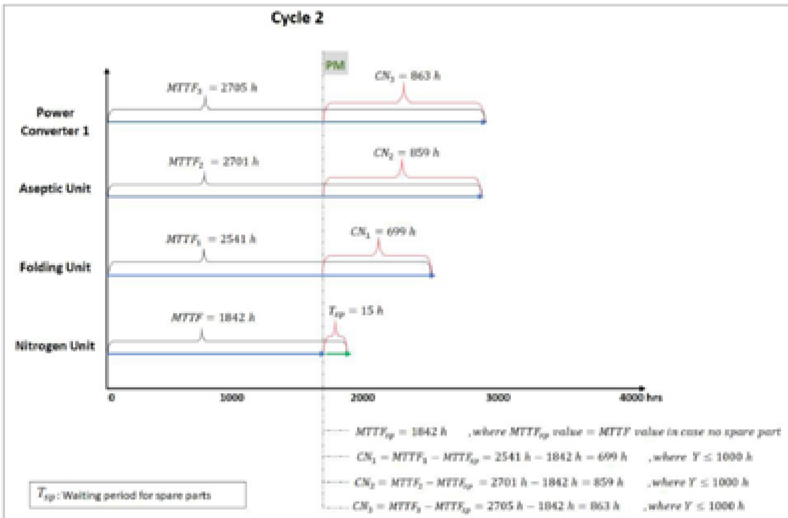


Figure 7 – Machine 1 – Maintenance Cycle 2

$C_c = \sum PM_c = \$\ 1000 + \$\ 1000 + \$\ 1000 = \$\ 3000$ Equation 10

5.4. SCENARIO 2

Scenario 2 differs from Scenario 1 being that the Power Converter 1 is a critical component that requires replacement (Figure 7). In this cycle, the first component to be maintained will be the Nitrogen Unit. However, there are no spare parts available, and therefore, $X_{sp} = X_{MTTF}$ value. The component is allowed to run to failure before carrying out preventive maintenance. During PM of the Nitrogen Unit, the other three components – the Power

Converter1, Folding Unit, and Aseptic Unit will also be under PM. The CN_n value of these components is < 1000

hours. Considering that the spare parts arrived within the same downtime, PM is carried out. It can be seen from the production system in figure 1 that B1 is in a serial and parallel arrangement, and the Power Converter 1 feeds the block B1. Thus, if the need to replace the Power Converter for maintenance, then the production on this block has to be stopped altogether. However, the entire system is not shut down, but we just need to stop B1 where the target component is found.

In such a case, the entire production block 1 (Machine 1, Machine 2 and Machine 3) will stop during the maintenance period which will be two hours. Thus, the calculated total cost of this cycle is based on a period of two hours. From Equation (7), the second maintenance cycle of Machin1 will cost:

$C_2 = \sum PM_c = \$\ 1000 \times (4$ components$) = \$\ 4000$
Equation 11

5.5. SCENARIO 3

During maintenance, any component that meets replacement requirement $Y \leq 1000$ h can also utilize the opportunity and be maintained as part of PM. For example, in maintenance cycle 3 figure 8, C_i of the (Jaw Unit 1) component is calculated by deducting MTTF from the X value. This gives the optimal time in which PM is carried out on the component. Within the same time, one component the Straw Unit 1, meets the replacement requirement Y.

That is, $C_1 = 689$ h < 1000 h. Hence, PM is performed on this component immediately, alongside the Jaw Unit1, when the total time on this cycle is two hours.

Based on Equation (7), the total cost in third maintenance cycle of Machin1 is given by:

$C_3 = \sum C_c = \$\ 1000 \times (2$ components$) = \$\ 2000$
Equation 12

After calculating the cost per cycle, the total cost of preventive maintenance carried out on Machine 1 can be determined by the Equation (8):

$T_{PMc} = \sum C_c = \$\ 3000 + \$\ 4000 + \$\ 2000 = \$\ 9000$
Equation 13

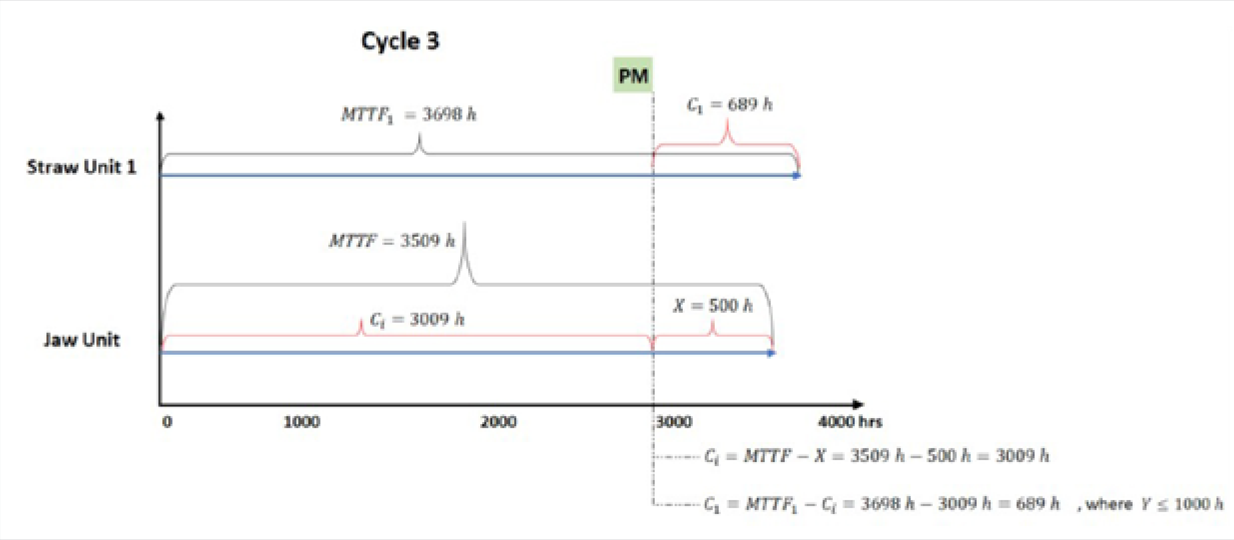
It is considered that carrying out preventive maintenance activities separately on the same Machine 1 will lead to a higher total cost of PM compared to our approach and that due to production loss costs (the costs of products that would have been produced if the equipment was working as expected) during the frequent downtimes. Using the same method, it can be the approach that maintaining multiple components during a single maintenance cycle is more advantageous in terms of time and cost than maintaining the components separately. Thus, the total cost of maintenance can be reduced by preventive replacement after scheduled maintenance cycles.

On the other hand, Corrective maintenance costs tend to be more expensive compared to PM costs because CM breakdowns are unplanned. For instance, when a component fails before PM time, then CM will be performed immediately. In case the required spare parts are not immediately available, then it will need 48 hours to get the spare parts to the job site, and this will cost \$800 and the spare part cost assumed to be \$600. It is assumed that five labours need to perform CM and will cost \$100/man/hour. The maximum hours need for corrective maintenance is seven hours, with downtime costing of \$1000/hour. In such a case, the total CM costs, i.e. total cost of corrective maintenance carried out on one component, which include spare parts, labour, delays and downtime costs as shown in Equation (9):

$T_{CMc} = \sum CM_c + DT_c = (L_c + SP_c + SP_{Dc}) + DT_c$

$= ((\$\ 100 \times 5) + \$600 + \$\ 800) + (\$\ 1000 \times (7\ h + 48\ h)) = \$\ 56900$
Equation 12

Figure 8 – Machine 1 – Maintenance Cycle 3



Therefore, the results show that the approach in this paper is more effective and efficient. This is because PM schedule improves the status of a component before failure occurs, which makes it possible to prevent unexpected failures that can come with huge losses.

After carrying out preventive replacement on this schedule, it is computed through MADe that the reliability of the components will be 99.99%. Hence, the target of R% = 99% overall system reliability while minimizing the costs associated with reaching this target. Generally, maintenance is very expensive, creating the need to have an effective, optimal PM schedule to lower the cost of system maintenance. The optimal schedule of maintenance presented in this paper will help reduce system downtime by reducing the frequency needed for maintenance.

6. CONCLUSION

The optimal preventive maintenance schedule has been determined for a complex system with multiple series-parallel components which have distribution of exponential failure. Given that it is important to consider how a complex system fails, we looked at the impact of component failure to the operation and performance of the system in partial failure. The failure modes of the production system have been captured using the FMEA software MADe. The MTTF values for components are computed by propagating the triggered faults in the model. Based on the MTTF values of the components, a schedule of potential preventive replacement activities has been defined. Maintenance schedules of components can be improved based on the reliability determined by the FMEA model, which then helps to reduce the breakdown and downtime costs of the system.

A case study of the production lines has been used to investigate the optimal maintenance of the system. The results of the investigations clearly indicate that the goal of 99% system reliability has been achieved, while ensuring that associated costs are minimized.

7. ACKNOWLEDGEMENTS

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Managing The Challenges Between Asset Procurement And Asset Performance Phases of an Asset's Life

Andrew Wheatley

Summary: The accountability transfer of an asset from procurement into operation is a significant change and can create uncertainty about the asset future for owners and other key stakeholders. The significance of the risk transferred from the procurement phase is often not appropriately understood by the asset owner. How can the objectives of an asset design be met whilst ensuring realisation of the asset utilisation goals as well as the benefits to the owner and/or social economic benefits?

The series of International Standards, ISO55000 Asset Management (AM), are starting to inform asset owners who are now challenging for a more accurate picture in the scoping of large capital asset procurements. The goals of AM suggest that appropriate asset considerations, justifications and risk management assumptions in the procurement phase of an asset should be managed over the assets complete life cycle thus ensuring the best cost benefit solution for the owner who financiers, builds and operates the asset.

These AM principles are still yet to provide substantive evidence that these principles, when applied through the whole asset life cycle spectrum, will benefit the asset owner. Ongoing evaluation of operational reliability and adoption of systems engineering practices are the means to achieve optimum value from physical assets over its lifetime.

Future research in AM needs to identify life cycle considerations for each phase of the asset and decisions that can interact, and in due course can have substantial cost benefits associated with any asset when it has been considered over its entire life cycle. This Literature review offers insight into current research available.

Keywords: Asset Management, Asset Life Cycle Management, Asset Performance, Asset Transfer, Asset Handover, ISO 55000, ISO 19650.1.

1. INTRODUCTION

Asset performance is a key element in the demand management stage of an asset's life cycle. The statement of requirement for the design of the asset looks at the needs analysis and demand analysis to justify the asset requirement (AMC, 2017). This early analysis in the asset's lifecycle is the first stage that the future assets performance is being considered before the asset owner even considers a design and knows what this asset will look like. Often the next time asset performance is measured with the asset owner, is when the asset is commissioned or the asset has commenced in its operations phase. The phase were up to 80% of total life cycle costs are expanded and the phase were 100% of the asset value is realised (Affan, 2019).

The civil construction industry within Australia can be viewed in two large sectors divided into building and large scale infrastructure sectors which are complex and different from other industries. These sectors usually requires large capital investment (often public funding) and involves many stakeholders of the assets life cycle (Chan et al., 2004). Asset procurement can take many forms from construction to purchasing and configuring an asset for a specific purpose. Project success during the Design and Construction (D&C) phase does not always mean a project/program success in the operation and maintenance (O&M) phase of an asset's life. The governance of success of public sector infrastructure projects is becoming a central focus of policymakers in implementing government sponsored programs (Khan et al., 2019).

The Value statement from ISO55002 states where an asset is generating financial benefits, the acquisition, renewal or replacement cost of assets, and their operating and maintenance costs are important considerations in decision making and the ability to derive value from the use of assets (Standards, 2019b). How can valued operations and maintenance experience be input into the design?

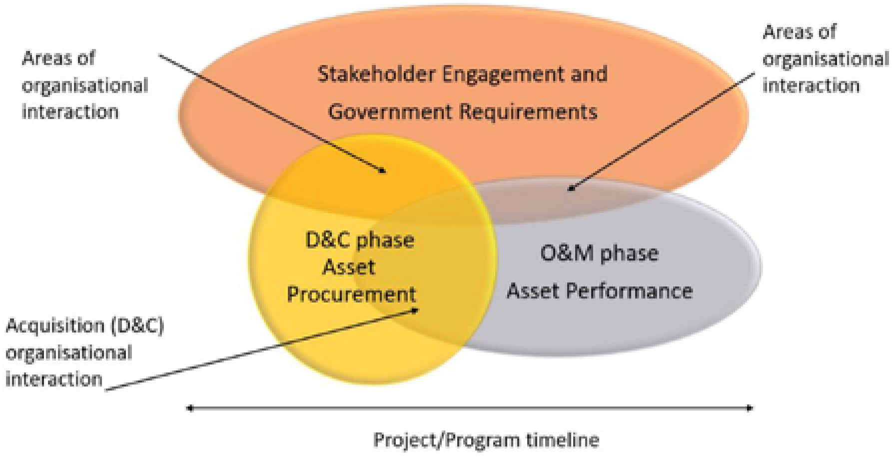

Figure 1 – An example of the project interaction required for a successful large-scale asset build.

Asset operators and maintenance organisations have considerable experience that should be considered as part of the design. Owners also need to be intimately involved to ensure their concept of the asset they are funding is exactly what they require to the asset theoretical performance and demand analysis. It is too late in the O&M phase to discover that the owner's description and specification also meant to include other parameters. Figure 1 indicates the interactions that must take place within a project timeline. These interactions are critical within the feedback loop of asset management. The challenges of these interactions and the past silos of performance has affected asset outcomes.

So why are the owners, operators and maintainers participating more in the acquisition phase of asset procurement?

A strategic approach to asset management should leverage the power embedded in various O&M applications to improve asset availability and utilisation. No other departments within the organisation have the potential to impact the bottom line as much as operations and maintenance (Hollywood, 2014).

2. OBJECTIVE

The objective of this paper is to identify shortfalls in asset procurement process of an asset's life cycle with regard to what means an asset transitions from the design and construction or acquisition phase to the asset performance phase. This phase of an asset life cycle being the largest and generally the most costly phase. Also, by what method O&M knowledge is fed back into the design process to ensure experiences and lessons learnt improve the next generation of the asset.

This paper will review any current government requirements in Australia and UK in line with the current policies or requirements stipulated by government departments for public large-scale infrastructure construction. This review will also examine the current available standards and research that could influence decision makers to examine asset procurement and asset performance issues aligned to the transition of an asset into its valued adding operational phase.

3. DISCUSSION

Risk in each phase of an asset's life cycle is managed differently due to the current contract framework and the organisational elements managing the respective phase. In the past, these organisational elements generally operate in silos from asset procurement to asset performance phases. Also, each organisation motivations are different. For example, a D&C contractor outcome could centre on purely cost, schedule and quality where an O&M service provider might have cost management, asset utilisation, on time maintenance and customer satisfaction outcomes as key performance indicators. These elements highlight the risk management requirements in their respective phase due to their contractual accountabilities.

Generally, there are technical requirements in either industry standards, regulations, government requirements and project contract documentation that manages expected risk in any infrastructure projects. This is generally known risk however what unknown situations have introduced risk into others phases? Traditional accountability between these organisations are not generally held to account or risk is not transferred between organisations. In most cases, attempts are made to bury or hide issues and shortcuts from view until the defect's liability phase has expired or the builder could not be held to account due to legal time frames. In those circumstances, the owner may attempt to hold the O&M organisation managing the asset, expecting the risk or issue arose due to lack of maintenance or negligence. In other circumstances, shortfalls may never come to light in the decisive sense but have detrimental effects of asset performance and increased operational and maintenance costs.

The series of International Standards, ISO5500X Asset Management (AM), are starting to inform asset owners who are now challenging asset designers and builders for a more accurate picture in the scoping of large capital asset procurements. In some cases, asset owners are now demanding answers to basic issues on when things go wrong or the design is not up to the contemporary standards or operational practices. The goals of AM suggest that appropriate asset considerations, decisions, justifications and risk management assumptions in the procurement phase of an asset should be managed over the assets complete life cycle, thus ensuring the best cost benefit solution for the owner who financiers, builds and operates the asset (Standards, 2019b). Another objective of AM is to enable the organisation to meet the service needs of the customers and users of its asset. How can this be achieved if the owner or operations organisation who are by past experience, the knowledge entity on what the asset needs to deliver? ISO55002 standard Annex D discusses Asset management decision making in detail. How is the phase which realises most of the O&M costs does not recommend a method of influencing the design during the procurement phase?

Up to 95% of an assets life cycle costs are specified in the design and construction phases (Wireman, 2015). The asset decisions are made with limited or no input from asset owners or experienced O&M management organisations. It is expected that designers know their asset however in most cases they have not reviewed previous designs, learnt from previous designs or interacted with asset owners to ensure the most update efficient design is being considered. The ISO 55002 standard offers no guidance or discussion of the feedback loops from asset owners or O&M organisations in the D&C environment (Standards, 2019b). The Asset Management Council Capability Delivery model (AMC, 2017) is another example of how the interactive feedback loop exists but is often not a requirement of the contract documentation during asset acquisition. What are the possible requirements for an asset owner accountability to ensure these feedback loops exist and the asset handover risk is managed appropriately? An asset design should be an interactive process and needs to involve many stakeholders including owners and O&M organisations to ensure past experiences and lessons learnt are introduced into the design (Wong et al., 2014).

3.1. CURRENT GOVERNMENT REQUIREMENTS

Government sectors in the United Kingdom (UK) are taking the lead in setting requirements and understanding the transition risks associated and being introduced in the D&C phase and materialising in the O&M phase. More needs to be achieved to manage the risks associated with the transition phase from procurement (acquisition, design and construct) to the performance (O&M) of an asset. Infrastructure management and Asset Management (AM) are going through a transformation, as Asset owners and alternative procurement methods are being investigated to ensure cost effective delivery of a project and still being fully aware of other Life cycle implications. The transfer of risk from acquisition phase is often not appropriately considered or known by the asset owner. The D&C organisation in the past has worked in isolation from the O&M organisation or the owner.

What are the objectives of the asset design associated with whole of life AM, whilst ensuring the asset utilisation and benefits to the owner or public social economic benefits are maintained?

The Australian state governments have AM policies through most of their financial departments and have subsequently expanded the AM requirements since the introduction of the ISO5500X series of standards. NSW Treasury has an Asset Management Policy for the NSW public sector that provides a whole-of-government framework to support agencies in realising value from their planned and existing assets (Treasury, 2019). The objective of the policy is to achieve a consistent and improved approach to asset planning and delivery that is underpinned by the consideration of asset lifecycle costs, performance, risk and economic modelling to support the strategic priorities of the Government (Treasury, 2019). Under this principle, agencies are required to consider asset and non-asset solutions, make asset management decisions (including acquisition and disposal), and measure performance, based on the current and expected contribution the asset makes to the agency's existing and planned service delivery needs. It discusses decisions made over the whole of the asset lifecycle including concept, planning acquisition delivery, O&M and disposal however it does not discuss the arrangement of transfer of knowledge, stakeholder engagement and the requirements for decision making. Who is the accountable organisation to ensure decision in the D&C phase are consulted with the right stakeholders? It appears 'Planning'

in many organisations is carried out in silos. The organisation drawing up the specification will be a different organisation responsible for the asset construction and a different organisation operating the asset. Then the accountable organisation/asset owner receives the asset transferred onto their register with little or no involvement until the coming weeks of the closure of the construction project

Recent policy mandates NSW Government agencies adopt a whole-of-government and whole-of-asset lifecycle approach to their assets, which will enable agencies to:

- make better use of their existing assets
- adopt clear and consistent definitions and methodologies to report to government each year on the size of any maintenance backlog and identify measures to address the backlog
- broaden assessments of asset performance to take into account economic, social and environmental benefits
- develop a 'system-of-systems' approach across interconnected infrastructure networks to drive an integrated vision of infrastructure provision and management, and create value, reduce costs, manage risks and improve the resilience of assets
- adopt innovative, contemporary technologies to improve the O&M of assets
- use quality data that will support evidence-based decision making to balance cost, risk and asset performance.(Treasury, 2019)

This is difficult when 95% of the assets life cycles costs decisions were already made in the construction of the asset. How is feedback introduced into the design phase?

Victoria government's Department of Treasury and Finance is also responsible for ensuring the Asset Management Accountability Framework (AMAF) which supports the Victorian government make decisions on asset planning, acquisition, operational and disposal issues (Finance, 2016). The AMAF does not discuss asset transfers or a handover process and operational input in a feedback loop during acquisition but discusses AM over all asset lifecycle. Performance and asset information gathering should start in the planning and acquisition phase. The framework is implying the accountable manager is required to follow reporting and document policies but it is often too late when the asset is built to change or modify data or the asset because it was not in the contract or designed into the build. The framework discusses Asset Information Management Systems and the importance of gathering data was improved in the updated version (Finance, 2019) but it does not discuss risks of each phase and how it could be managed from the concept to acquisition and O&M phases. The framework lacks depth of explanation in these accountabilities and how they should be achieved. This can be extremely difficult when different organisations/ department are responsible for different phases. The organisation that manages the finances needs to set the regulatory/contractual requirement for risk transfer and key performance outcomes and ensure experience asset owners participate in the design. It is too late when the asset is built or already in service.

West Australia (WA) and Queensland governments have both a Strategic Asset Management Framework (SAMF) (Treasury, 2020) and Strategic AM Plan Framework (Government, 2020) that provides policies and guidelines to improve asset investment planning and management across their State public sectors. In the 'value management' module, the WA department of treasury explains the benefits and business case development. The Alliance Contracting policy of the SAMF discusses alliance contract to have a governance framework that clearly identifies the roles and responsibilities of all alliance participants. It goes on to discuss a clear distinction needs to be made between the 'owner', and the 'non-owner participants' who are part of the alliance. These accountabilities need to be further explored to ensure again asset transfer and identified risks are managed through the asset life cycle and the Operations SMEs are involved in the asset design. This is not explored in any documentation.

The Queensland Treasury (Treasury, 2015) has guidance documents that provides details regarding the range of issues to consider when transitioning a project. The purpose of the Delivery service stage document is to transition a project into its ongoing service delivery mode through commissioning, implementing or rolling out the goods, services or outputs (products) produced by the project. The Benefits Realisation document post-project stage is to confirm that the benefits established and defined in the business case are being achieved and that the operational service or asset is running smoothly (Treasury, 2015).

The UK has extremely detailed requirements which started in 2011 with the requirement document called Government Soft Landings (GSL). The aim of this requirement was to reduce the cost of Government construction projects by 15-20%.(CabinetOffice, 2012). In the first year of the strategy, whole of life project cost reductions where estimated in the vicinity of £279M over a £2.6B of project spend. With a similar strategy, in 2017 the UKs

Infrastructure and Projects Authority1 (IPA) further expanded their minimum requirements where a business case of a new programme or project which included a construction element, required departments to ensure that a full reference to the Common Minimum Standards for Construction (CMS) is set out in there project documents (Authority, 2017). This document also outlined that clients should develop a clear project design brief that addresses current and future service requirements, in line with Government Soft Landings (GSL) principles as appropriate.

The GSL approach was one of the ways to improve performance of built assets such as buildings by "aligning the interests of those who design and construct an asset with those who subsequently use it" Starting with the end in mind Government Soft Landings supports better operational and societal outcomes. The ongoing maintenance and operational cost of a built asset during its lifecycle often far outweighs the original cost of its construction.

3.2. TECHNICAL STANDARDS

Formal industry standards provide a framework for both economies of design and improved product and service quality. Standards facilitate interoperability, production improvements, and scalability of asset management programs among different industries and between plants. Standards can also help improve quality of life by contributing to safety, human health and environmental protection. Unless mandated by regulatory bodies, standards compliance is voluntary; however, it demonstrates an organisation's commitment to quality, performance or safety (Hollywood, 2014).

ISO 55000 Series of standards does not recommend any requirements for D&C organisations. As mentioned previously how do asset management decisions of the future O&M phase receive any input as the asset is being designed and built. Most asset owners are growing in awareness of their life cycle responsibility as knowledge matures through from D&C to O&M the phase. It is all about owners having the accountability to ensure the asset meets its service delivery obligations. To achieve this responsibility this outcome needs to be an interactive design review process. An organisation needs to measure their level of service that its assets delivers, and evaluate

[1] The Infrastructure and Projects Authority works to ensure the successful delivery of all types of projects both across government and the private sector; from infrastructure, defence and IT, through to transformational programmes designed to improve efficiency and transform the way government interacts with citizen

these against the needs and expectations of its customers and users (Standards, 2019b). It is too late when the asset is built.

The ISO 55002 standard discusses internal and external stakeholders, there is no mention about designers and builders or an area of project transfer requirements between D&C and O&M organisations. So, the intention of the Asset Management standard needs to go further to ensure Asset owners build into contracts their requirements and the early interaction of experience stakeholders who will operate and maintain the asset. This negotiation does not dissolve the designers of their accountability being a designer of an asset. It is the experiences and feedback from other assets that should be incorporated into future designs.

Until transfer and handover requirements, are built into acquisition and construction contracts, the element of "what can the builder get away with unless discovered" will prevail for some time. As an objective of Asset management to enable an organisation to meet the service needs, the customer and users of its asset(s) will not 100% achievable usage until this interaction is mandated by asset owners.

UK appears to lead in the area of implementation of Building Information Modelling (BIM) as the previous suite of Publicly Available Standards (PAS) 1192 had a strong focus on delivery of a project and its information requirements across phases of a project (Barr, 2019). ISO 19650 standard, 'Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)' is the updated PAS 1192. The aim of ISO 19650 series of standards is to support all parties towards achieving their business objectives through the effective and efficient procurement, use and management of information during the delivery phase of assets. (Framework, 2020, Standards, 2019a). This standard enables an appointing party (owner or client) of a project to establish their requirements for information during the delivery phase of assets and to provide the right commercial and collaborative environment within which multiple appointed parties can produce information in an effective manner (Standards, 2019a). Figure 2 indicates the complex relationships that need to be considered.

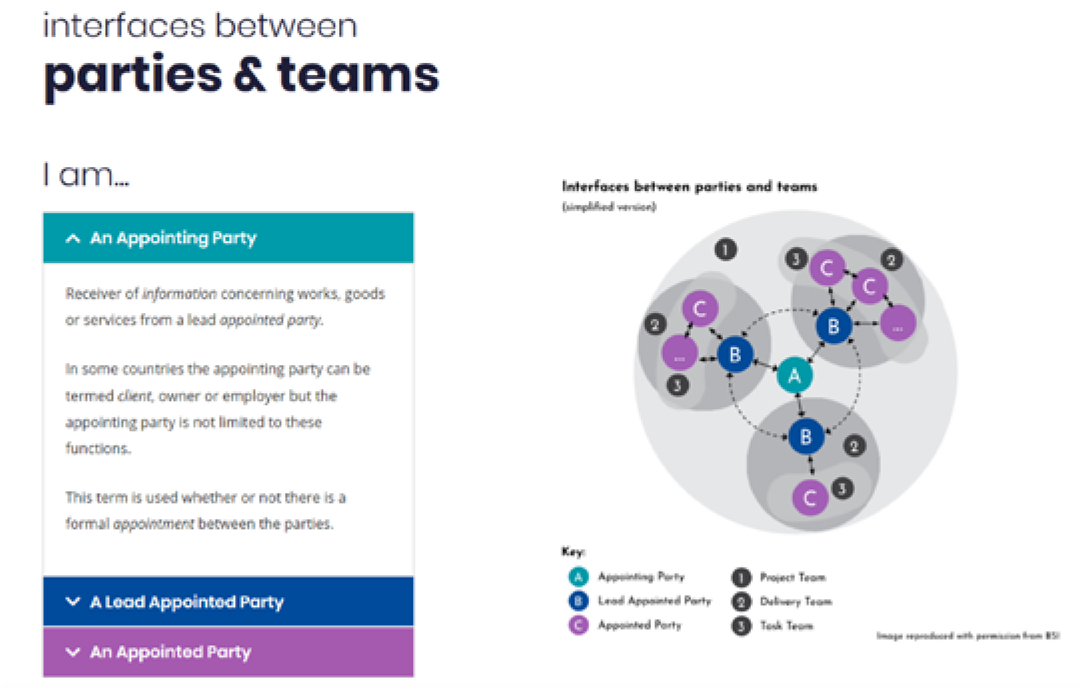

Figure 2 – Interfaces between parties (Standards, 2019a)

BIM according to the ISO 19650 series' is about getting benefit through better specification and delivery of just the right amount of information concerning the design, construction, O&M of buildings and infrastructure, using the appropriate technologies. These actions assist in the delivery, the efficiencies and savings envisaged by the UK Government and others. The ISO 19650 series applies throughout the whole life cycle of an asset and it applies to all types of assets in the built environment – buildings, infrastructure and the systems and components within them (Phillip et al., 2019). Figure 2 indicates these complex relationships without the contractual consideration. Stakeholder relationships will be more beneficial than any commercial consideration.

Private Public Partnerships. Compared with other infrastructure delivery methods that are focused on design and construction, Private Public Partnerships (PPP) are typically complex given their lengthy contract periods involving long-term obligations and a sharing of risks and rewards between the private and public sectors (Government, 2016). The aim of a PPP is to deliver improved services and better value for money, primarily through appropriate risk transfer, encouraging innovation, greater asset utilisation and integrated whole-of-life management, underpinned by private financing. (Government, 2016).

All state governments within Australia have PPP guidelines providing greater detail across all project phases, from business case, through key procurement phases and throughout contract management (construction delivery and ongoing operations). The national PPP policy explains the Whole of Life (WoL) costing benefit by delivering improved efficiency through whole-of life costing as design and construction become fully integrated up-front with operations and asset management (Government, 2016). Full integration of WoL is under the responsibility of one party and therefore accountabilities are transparent. PPPs will be further discussed in the Asset procurement section.

3.3. ASSET PROCUREMENT

Asset procurement can take many forms. Public infrastructure projects are financed either through public and/or private borrowings. In the infrastructure sector where Federal or State government fund most civil and transportation acquisitions within Australia, the traditional model usually takes a three-phase approach. For public infrastructure, the requirements for the Asset are set by government. The government agency then contracts out the design and construction element with the O&M phase of the asset managed by the government department, a commercial organisation or government business enterprise (GBE). In this example, the government project specialists monitor the build of the asset but often the asset owners (operations part of the government department) are not engaged until the asset is almost built. Subsequently this is where often the risk is realised as a result of defect, shortfalls or material changes that have a second order flow on effect in the performance of the asset. These issues of asset performance can be due to poor risk management during acquisition, poor stakeholder engagement and transfer of accountability between asset phases. Ultimately all asset risk is owned by the asset owner however in most cases, each phase of an asset's life is managed by that specialist organisation

without fully understanding the final asset performance requirement. There can be many reasons for the D&C organisation and the isolated stove pipe approach but they are not in the asset owners' favour of long-term asset performance.

Research is limited within the PPP sector and mainly focuses on the procurement phase of the asset (Wheatley, 2014). As mentioned previously models do exist within most states of Australia where Build, Own Operate and Transfer (BOOT) or Private Public Partnerships (PPP) models have been used to varying success. There are many different types of PPP funding models that change the risk framework between government and private industry which are the main two stakeholders (Fischer et al., 2010) .Modified PPP financing strategies can be incorporated into these procurements to reflect market conditions and optimise the value for money in a PPP structure (Government, 2016).

The objectives of the National PPP Policy Framework are to:

- encourage private sector investment in public infrastructure and related services where value for money for government can be clearly demonstrated;
- encourage innovation in the

provision of infrastructure and related service delivery;

- ensure rigorous governance over the selection of projects for PPPs and the competition for and awarding of contracts;
- facilitate a consistent and streamlined approach to procuring PPPs across Australia;
- be sufficiently flexible to respond to strategic priorities, project specific requirements and market conditions; and
- clearly articulate and measure accountability for risk and outcomes adopting a partnership approach to managing long-term PPP contracts. (Government, 2016)

Fischer et al (2010) states the implementation of PPP as a procurement method for public infrastructure by the public sectors has recently come to be more closely examined with attention to risk management.

Many PPP failures within Australia and overseas has embarrassed governments and many commercial organisations due to their commercial failure as a business (Cooper, 2020). However, PPPs as an asset procurement method could be viewed as extremely successful especially when the demand for the asset is modelled correctly or in excess of the design from a revenue point of view and the risk is managed within the appropriate organisation (Baker et al., 1988, Li et al., 2005).

The structure of PPP organisation starts in the tender stage of an asset's life. The private parties are represented by a bidding consortia or newly established Special Purpose Vehicles (SPV) and this organisation manages and submits the tender. When the tender is successfully awarded, the project will raise the SPV organisations [private companies with a specific purpose – Concessionaire Company, Design and Construct (D&C) organisation and the Operations and Maintenance (O&M) Organisation] (Wilson et al., 2010). The concessionaire private company will have overall responsibility for the project and design, build, own, manage and operate the project (infrastructure) for the tender and therefore whole concession period. The D&C organisation will be contractually charged with designing and building the project with the O&M specialist organisation being charged with operating and maintaining the infrastructure for the duration of the concession (Wheatley, 2014). Tender concession periods to operate these types of public infrastructure can now vary from 10 to 50 years. This duration is to allow the private/public investor who funded the project to build the infrastructure and to make their return on investment. Figure 3 indicates a typical structure of a PPP group of companies (Wheatley, 2014).

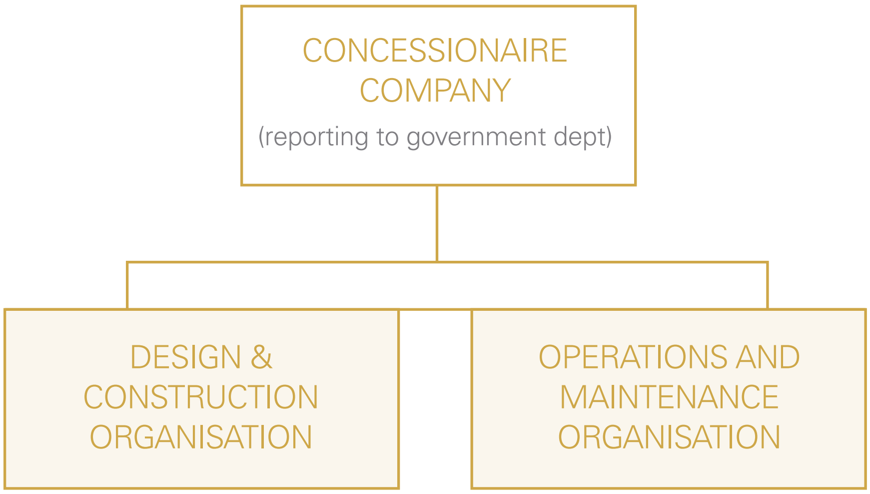

Figure 2 – Example of an organisational structure for a PPP

Project Success. Project success in different phases of a project can be different for each stakeholder. Unless there is an accountability or key performance indicator (KPI) from the asset owner to focus throughout a project/asset lifecycle to all stakeholders, a D&C contractor will not have the same success factors as an O&M contractor or the operator of the asset (Radujkovi- and Sjekavica, 2017). Phased projects objectives within the D&C phase can be completely different to the outcomes of the O&M phase for the asset. In the acquisition phase of a traditional construction project, success is usually measured by the iron triangle of cost, schedule and quality (Radujkovi- and Sjekavica, 2017). As mentioned previously, the O&M service provider might have cost management, asset utilisation, on time maintenance and customer satisfaction outcomes for project success (Wong et al., 2014, Schuman and Brent, 2005). Completely different drivers from the D&C contractor.

Past experience has shown, poor documentation and inadequate data interoperability have contributed to the overall poor performance of the built environment industry in Australia. This is evident with the significant increase in adversarial behaviour among project stakeholders (Tan et al., 2018). This can also be attributed to the silos that these organisations work within and the project completion close timeframes of project closure verse program management (longer term vision of asset management). Bishop et al (2004) discusses adversarialism is an endemic feature of the construction industry in the United Kingdom (UK).

The traditional contracting construction models promote industry behaviour to cost, schedule and quality all being balanced. A qualitative study performed in the UK indicated serious concerns over the performance of the British construction industry and an attempt to move away from adversarial modes of contracting toward a more collaborative approach (Bishop et al., 2009). These models do not provide success for the project in the operations phase.

Within the project success context, PPP have attempted to address this culture mismanagement by the establishment of teams for the project life cycle and where the asset/project owner is responsible for the asset performance through all phases of the project life cycle (Wilson et al., 2010, Parker et al., 2018). The asset owner also ensures that the goals of each phase are focused with the asset service delivery or the outcomes of the asset users. This has the benefit of what appears to be collaborative contracting but this really is only effective depending on the strengths of an interorganisational contracts and agreements engaged before the tender is awarded plus the monitoring of internal KPI's. In these environments the asset owner (concessionaire as previously discussed) has to take accountability of driving the asset outcome through the linking of KPI's and project success criteria which should be strengthen through common threads (Parker et al., 2018).

It is envisaged that contracting relationship should improve the information exchange as it promotes mutual trust and co-operation, open and honest communication and free sharing of information (Tan et al., 2018) however the culture shift in achieving this outcome is easier said than done. There can be many barriers to a project change of this magnitude. The cultural traditional acquisition project management behaviours could take time to change unless there is leadership from the asset owner and contractual frameworks in place to ensure the essences of co- operation can take place (Bishop et al., 2009). This type of change management will take time. Organisational and past managerial practise can discourage engagement (O'Dell et al., 1998) and some people just do not have the emotional intelligence or skill to manage this type of situation.

Ultimately project success is measured by how satisfied key stakeholders and how the project achieves its strategic objectives in the asset life cycle and within the asset performance (Serrador and Turner, 2015) Asset management principles need to outline project success from an asset life cycle perspective and interaction with design process. Owners need to ensure performance indicators are linked to the user requirements and linked to the procurement phase of the asset life cycle as they are all highly interrelated.

3.4. ASSET PERFORMANCE

Asset performance management is critical throughout the life cycle of the asset. Performance management of the asset is often overlooked or the asset is just accepted in its transferred condition. If a company or asset owner does not measure an assets performance or try to understand the major elements of the asset performance, this owner cannot improve the next generation of asset performance (Wireman, 2015) or improve the asset performance over the asset's life cycle. Each asset is designed and built to perform a task or function. Understanding and monitoring asset performance ensures a level of asset integrity and safety and the monitoring of any degradation of the asset performance over time. Up to 95% of an assets life cycle costs are specified in the design and construction phase (Wireman, 2015) therefore any criteria that is utilised in the D&C to ensure asset performance requires a review from a subject matter expert or validated in some form (Wong et al., 2014).

As evident by asset owners who experience outcomes of asset builds that could have been better designed, early involvement of O&M staff is key for better anticipating obstacles and learning from past experiences (Smyth et al., 2017). Smyth (2017:5) also argues the lack of integration between D&C and O&M results in a lost opportunity for mobilising synergies and levering value of total asset management solution. Project Management and Asset Management teams generally work independently with limited interaction with the priorities of the stakeholders being often different (Wong et al., 2014). This interaction has to change as the end customer expectation of the asset and the emphasis on user satisfaction is increasing to ensure sustainable buildings and designing for cost effective maintainability practises are becoming more transparent (Standards, 2019b). O&M functions and asset managers understand the asset characteristics of quality, safety, and operational durability. Yet these characteristics may not necessarily inform the design and specification during D&C. Similarly, D&C functions do not necessarily configure inputs to optimise asset management and operational solutions (Smyth et al., 2017). Operations staff are generally more aware and able to anticipate obstacles for the new asset from their past experiences so integrating them into the D&C phase can have significant benefits for the asset owner. On most infrastructure projects, 80% costs of asset life are consumed in the O&M phase but as mentioned before 95% life cycles costs are designed and specified in the D&C phase (Wireman, 2015). Again, Figure 2 from the ISO 19650 indicates the complex relationships that need to be considered.

A recent research paper on transportation projects in USA indicates that including design and operations personnel in the asset planning phase assisted them in gaining an equal understanding and vision of the final product. (Abou- Senna et al., 2018). It also led to provide a more efficient design options as well as more sensible long-term decisions that saved money and/or provide better outcomes.

3.5. FUTURE FRAMEWORKS

The structure of the construction industry within itself promotes distrust, antagonism and a pervasive spirit of adversarialism (Bishop et al., 2009). This environment within the acquisition phase does not promote a level of trust and open communication to operational personnel (Tan et al., 2018). This accountability can only be managed by the asset owner (BSRIA, 2020). Wong et al (2014:187) maintains the early involvement of O&M staff is important for better anticipating obstacles and learning from past experiences. Smyth et al (2016:7) also argues the point of view of the barriers between D&C and O&M arise due to the division of functional roles, disciplines and organisational boundaries. These barriers need to be addressed to ensure a common aligned goal for the total life cycle asset solution.

Current standards offer limited solutions. ISO 55000 series of standards details a method of feedback but there is no framework of how this ought to be achieved. There needs to be a stronger link to the Design phase of an asset's life cycle. This link could take many forms from a commercial and contract link to the one accountability described in the PPP frameworks managed by the asset owner. Whatever the understanding, the asset owner needs to take more accountability in the interactive communication between the D&C and O&M personnel to ensure experiences and learnings are integrated into the next generation of assets.

Smyth et al (2016:5) and Wong (2014:189) describes Relationally Integrated Value Networks

(RIVAN) as a framework and as an opportunity to bridge D&C and O&M lifecycles through an integrated approach in RIVANs. RIVANs as a framework draws upon systems dynamics, network theory, relationship contracting and value optimisation in project teams (Smyth et al., 2017). This framework focuses on common goals, team synergy and relationships.

Asset management through the transition phase of an asset life cycle is still in development as the asset/project converses from Acquisition to the Operations phase. There is a need to improve the effectiveness and efficiency of the ongoing O&M through the improvement of information flow between D&C phase and the O&M phase (Tan et al., 2018). The recent Government Soft Landings (GSL) (BSRIA, 2020) appears to be a successful method of open communications and engagement between stakeholders. GSL sets out the key element of the design, construction and handover process, because it maintains a 'golden thread' of the facility's purpose while still having a link to the performance standards of the asset through its life cycle (BSRIA, 2020).

The challenges with the asset management life cycle already has solutions that can achieve immediate savings. The UK government GSL framework alongside the ISO 19650 standard has frameworks for immediate implementation (BSRIA, 2020, Phillip et al., 2019). PPPs have developed engagement documents and transfer agreements which have been generally put in place for the O&M organisation. Asset owners need to take leadership and develop an understanding of their asset. Not just on the financial and performance outcomes. Long term, the performance of the asset will deteriorate if this engagement and interactions are not improved. An increased asset efficiency can be gained through numerous opportunities of lessons learnt from previous projects to improving maintenance access, asset down time, component material selection.

4. RECOMMENDATIONS

Asset management is about understanding the performance outcome of the asset and if required unlocking the value to gain the most out of the asset (AMC, 2017, Smyth et al., 2017). The project owner has a "primary interest in receiving the benefits from the project" (Zwikael et al., 2019). Therefore, this leadership and accountability gives the owner responsibility to ensure engagement and risk is managed appropriately. Early involvement of O&M staff is important for better anticipating obstacles and learning from past experience and this is difficult as both PM and AM teams generally work independently with limited interaction. (Wong et al., 2014). There needs to be a stronger link to the Design phase of an asset's life cycle. This link could take many forms from a commercial and contract link to the one accountability described in the PPP frameworks.

Performance metrics (KPI) of D&C and O&M organisations need to be further investigated as current metrics relate purely to the immediate engagement phase performance or commercial outcome. Performance metrics that relate to asset life cycle performance should be considered for all asset phases to seek a cultural change and more co-operation between stakeholders and asset life cycle phases.

Results still appear not to be validated, future research should develop policy frameworks that could lead to similar outcomes as discussed in the GSL or the development of new requirements or standards that include the management of knowledge sharing for large scale complex assets. A framework within Australia similar to GSL should be implemented but there would be a balance of adoption of this type of requirement depending on type, size and complexity of the project.

Industry bodies, like the Asset Management Council, have an opportunity to further refine the AM model and should consider providing guidance documents for asset owners. These documents would provide commercial considerations and frameworks of how the operational feedback could be achieved in critical phases of an asset's lifecycle and the potential benefits. Unlocking this value in asset management and improving the asset management systems model will allow asset management objectives to be ultimately focused as the asset is designed and built (AMC, 2017).

Projects frequently do not realise their expected benefits, and therefore do not enhance operations performance (Zwikael et al., 2019). A strategic approach to asset management should leverage the power embedded in various O&M organisations as previously mentioned the majority of costs of an asset life's is consumed in the O&M phase but up to 95% life cycles costs are decided and specified in the D&C phase (Hollywood, 2014; Wireman, 2015).

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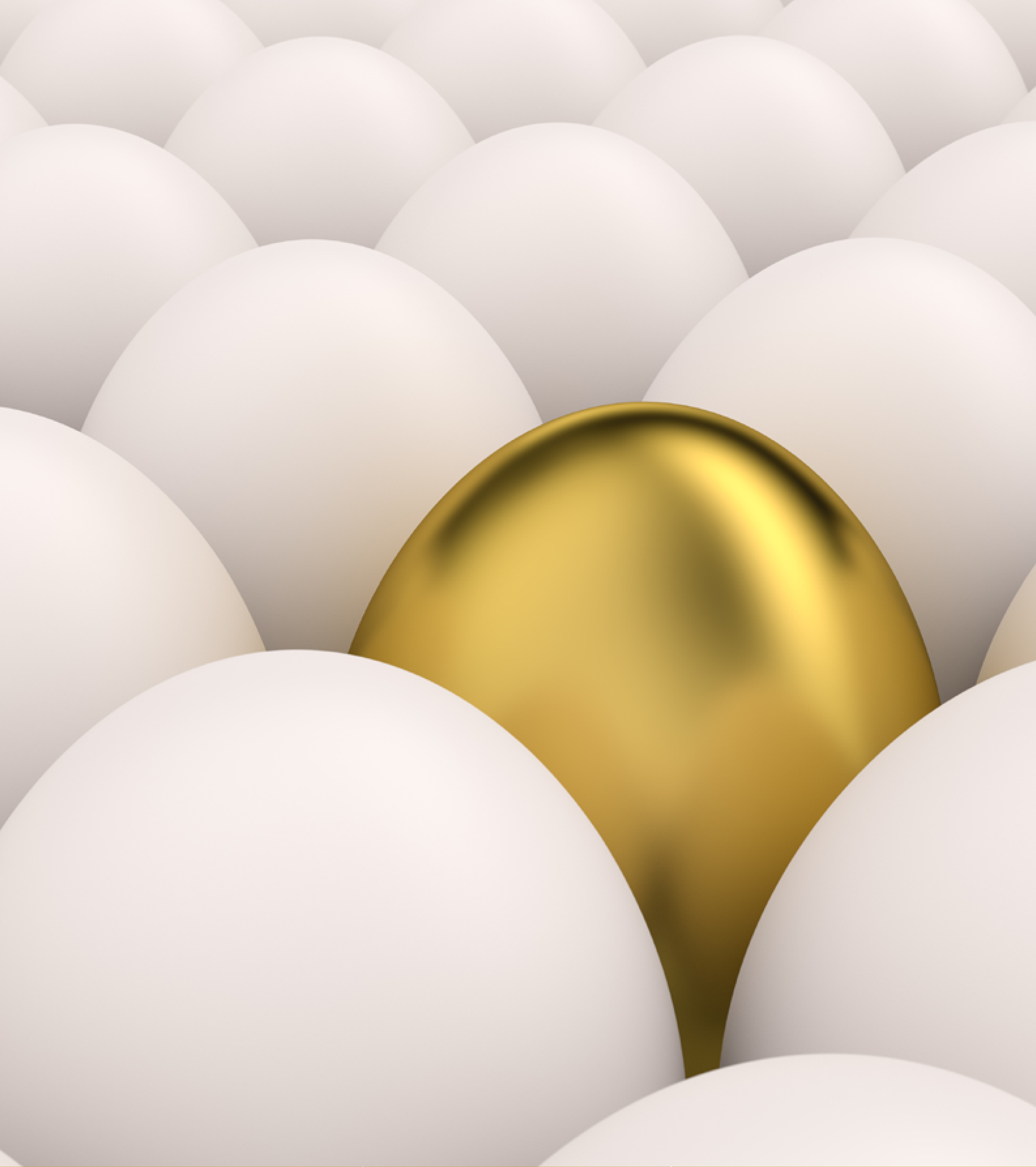
ANSTO
ARMS Reliability Engineers
Arup
Assetic Pty Ltd
Assetivity Pty Ltd
Atos (Australia) Pty Ltd
ATTAR
Aurizon Network
Australia Pacific Airports (Melbourne)
Ballance Agr-Nutrients
BHP
Brisbane Airport Corporation
Broadcast Australia
Bureau Veritas
Carbontech Composite Systems
CBC Facilities Maintenance
Copperleaf Technologies
Covaris Pty Ltd
Crystalise
Cushman and Wakefield
DAMS Safety NSW
Department of Jobs, Precincts & Regions
Department of Transport
Energy Queensland
Goulburn Valley Water
GPA Engineering Pty Ltd
Guanghua Group Pty Ltd
Hardcat Pty Ltd
Honeywell Limited
Hunter Water Corporation
IBM
Indec Consulting
Innovative Thinking IT
Institute of Quality Asset Management
Lake Maintenance Pty Ltd
LogiCamms
Logsys Power Services
Macutex
Maintenance and Project Engineering Pty Ltd
Meridian Energy
Minset
Newcastle Coal Infrastructure Group
Nexus Global Australia
Oropesa Port Management Pty Ltd
Pacific Hydro
Penrith City Council
Pindan Asset Management
Powerplan
QENOS
SA Water Corporation
School Infrastructure NSW
SEQWATER
SMEC Australia Pty Ltd
SPM Assets
Structural Integrity Engineering Pty Ltd
STRUCTURED CHANGE PTY LIMITED
Strukton Rail Australia Pty Ltd
Sutherland Shire Council
TAFE NSW
Taronga Conservation Society Australia
Taronga Conversation Society Australia
Tasports
TasWater
Terotek (NZ) Limited
The Asset Management College
Transdev Sydney
Trendspek
Unison Networks Limited
United Energy Services Pty Ltd
VicRoads
Victoria State Emergency Service
Water Corporation
WaterNSW
Work Management Solutions
Yarra Ranges Council



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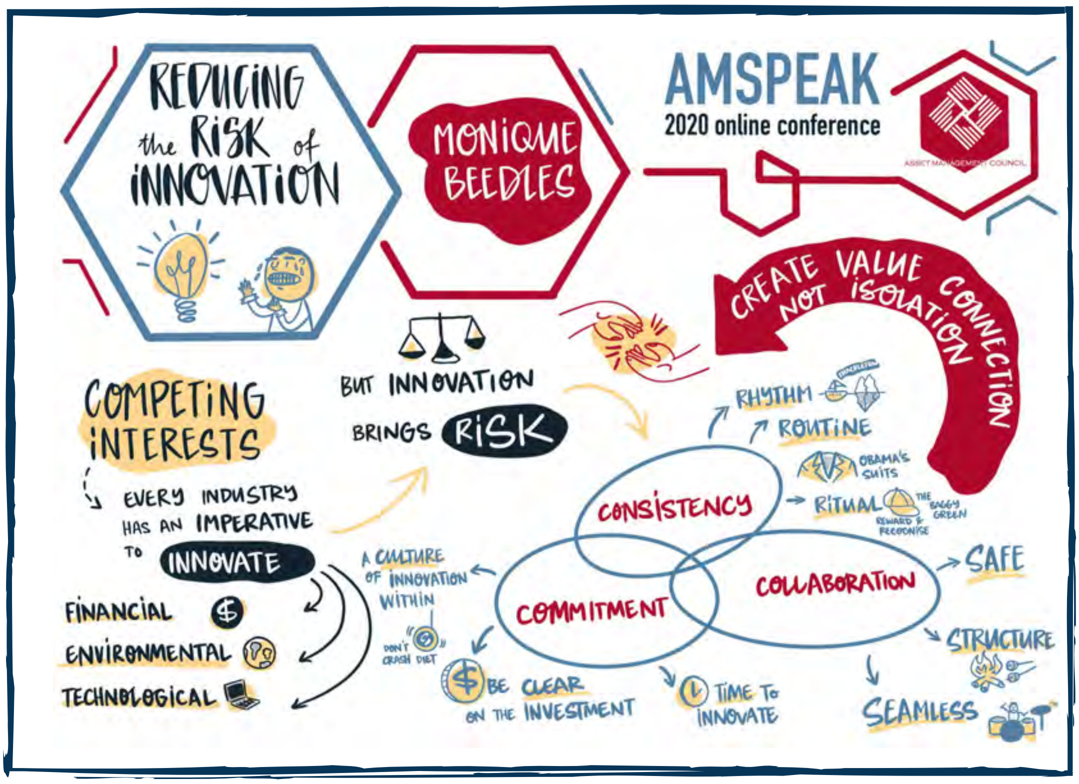
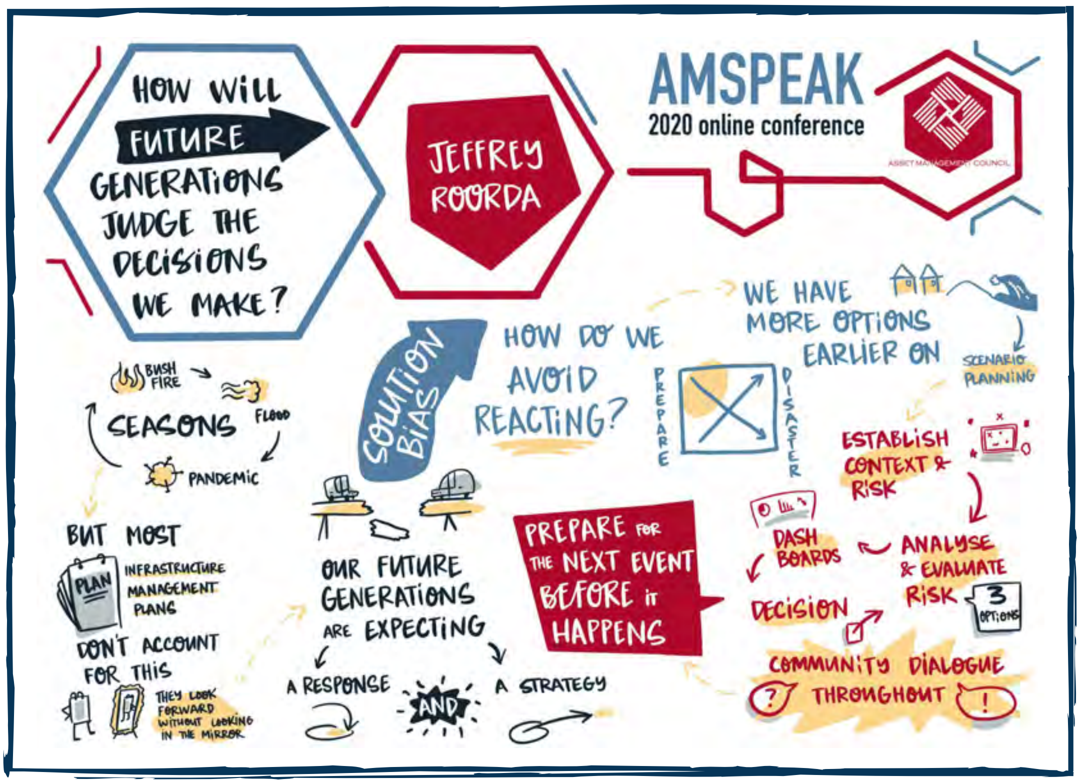
Reducing the risks of innovation in asset management

Dr Monique Beedles, *Teakyew*



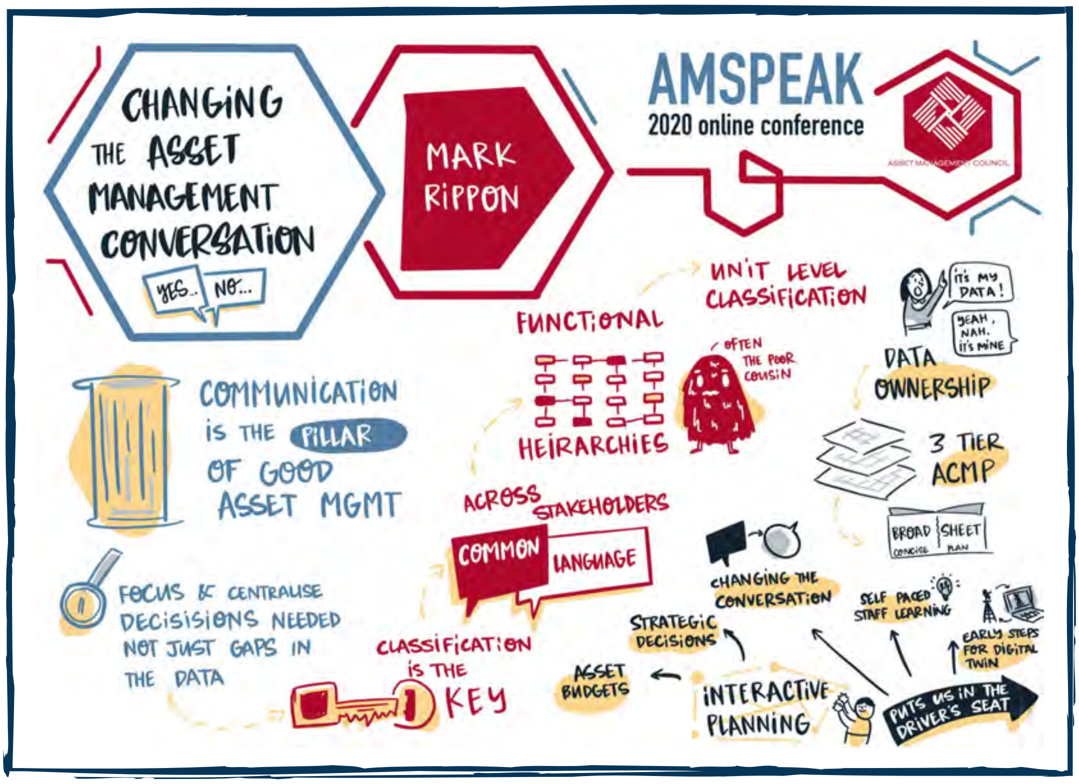
How will future generations judge the decisions we make now?

Jeffrey Roorda, *SevenGen*



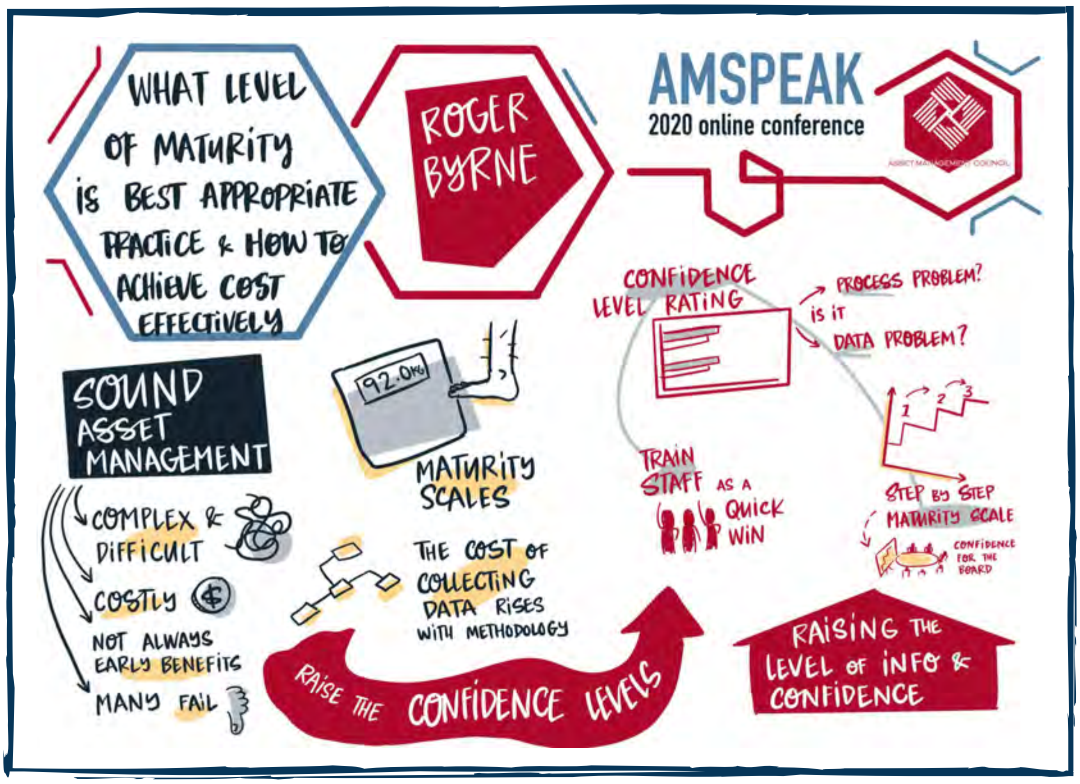
Changing the asset management conversation

Mark Rippon, *Taswater*

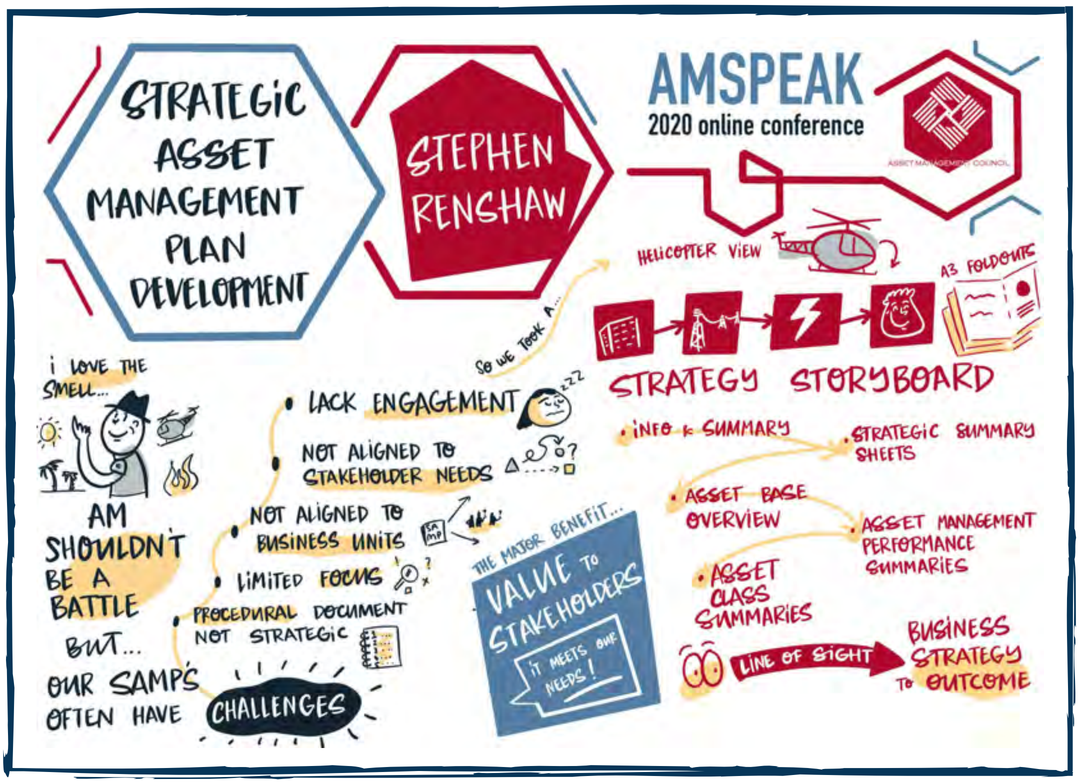


What level of maturity represents best appropriate practice and what is a way to achieve it cost effectively?

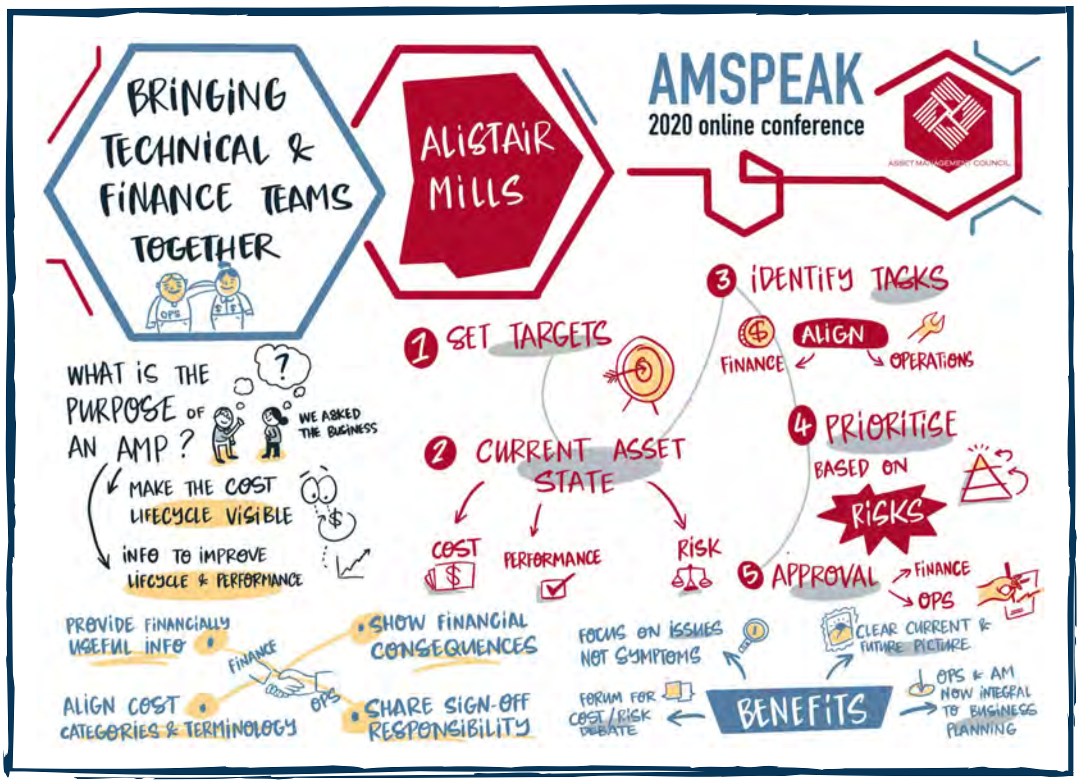
Roger Byrne, *Durban Municipality*



Strategic Asset Management Plan Development
Stephen Renshaw, *Transgrid*

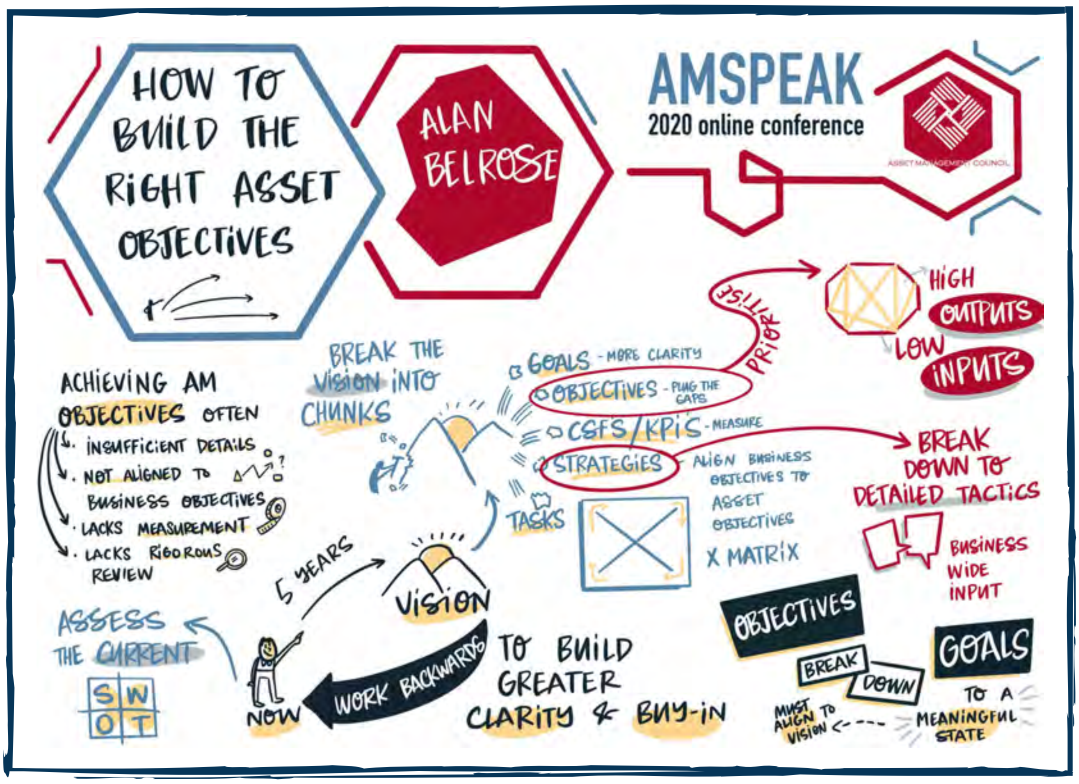


Bringing technical and finance teams together with asset management
Alistair Mills, *Pacific Hydro*



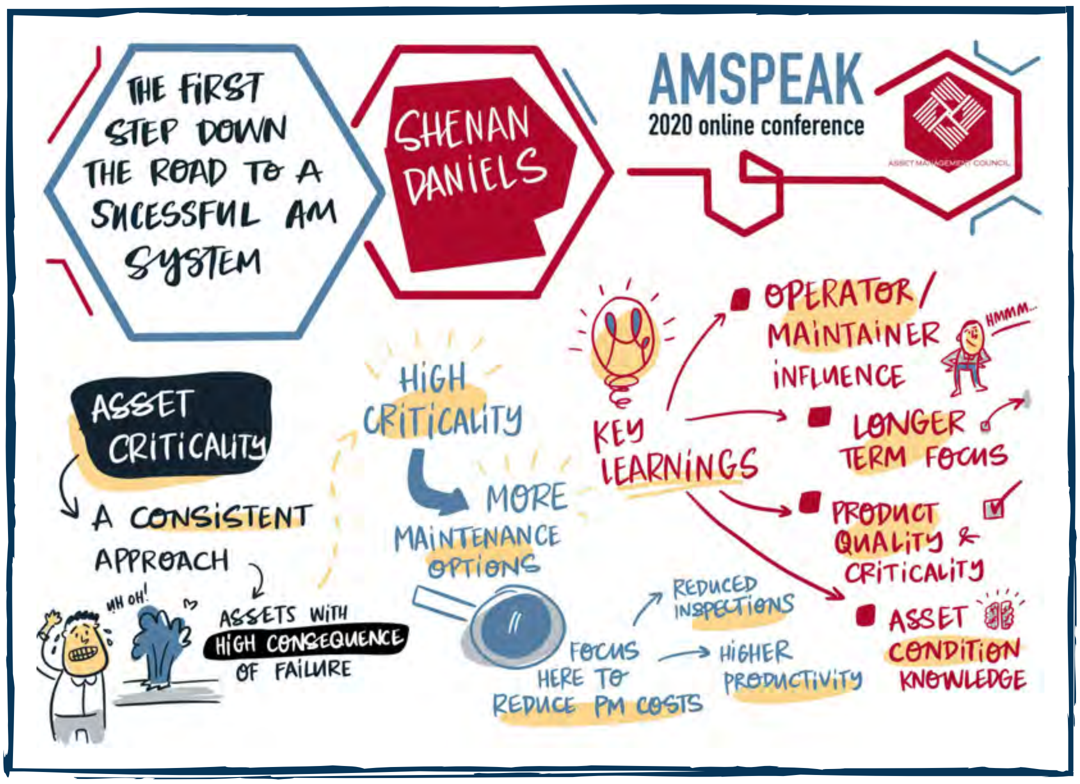
How to build the right asset objectives

Alan Bellrose, *Veritas Asia Pacific*



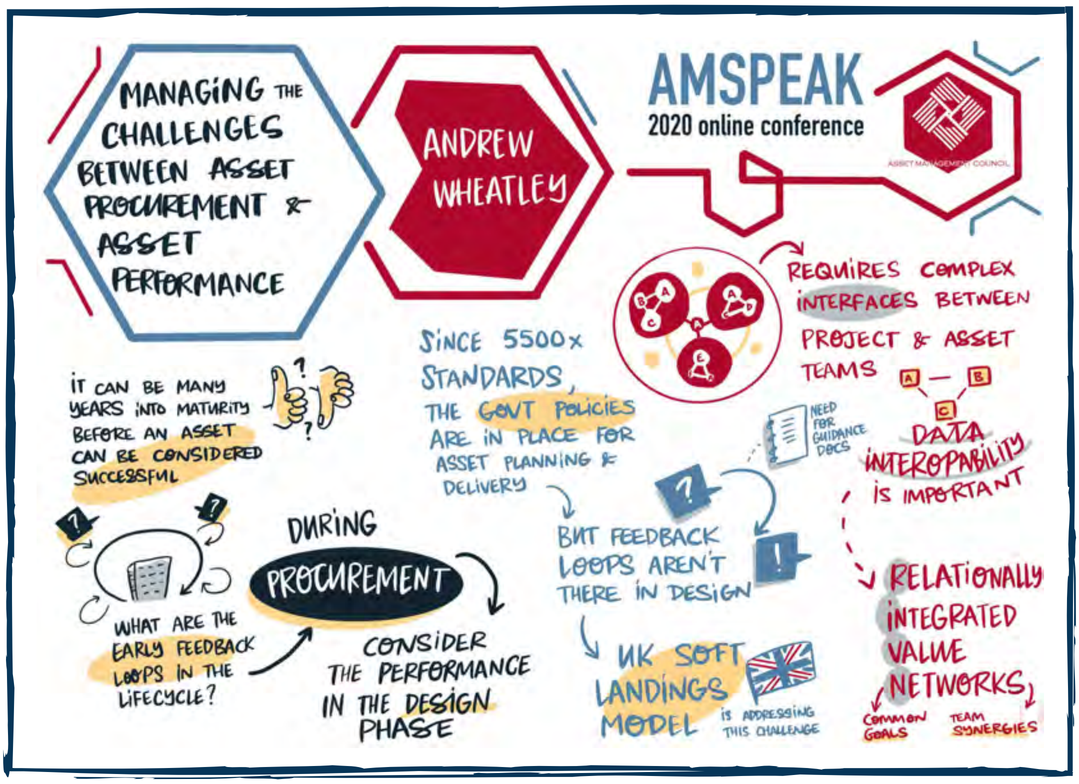
The first step along the road to a successful maintenance management system

Shenan Daniels, *Taswater*



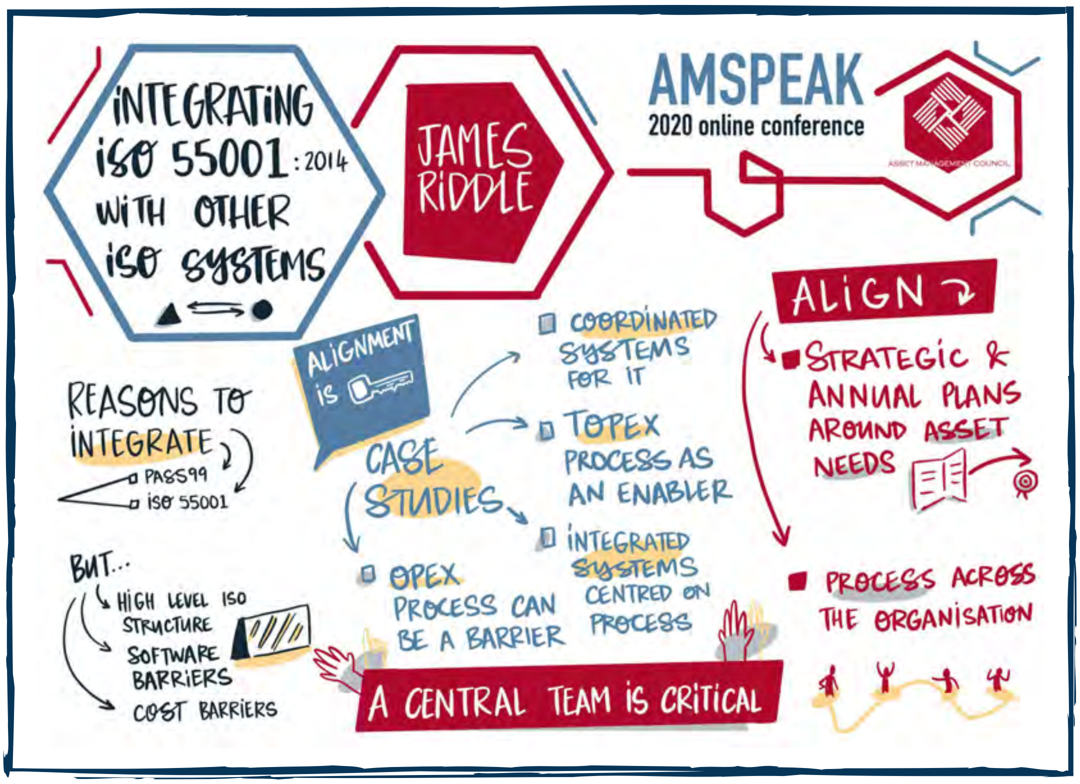
Managing challenges between asset procurement and asset performances of an asset's life

Andrew Wheatley, *Army Aviation System Program Office*



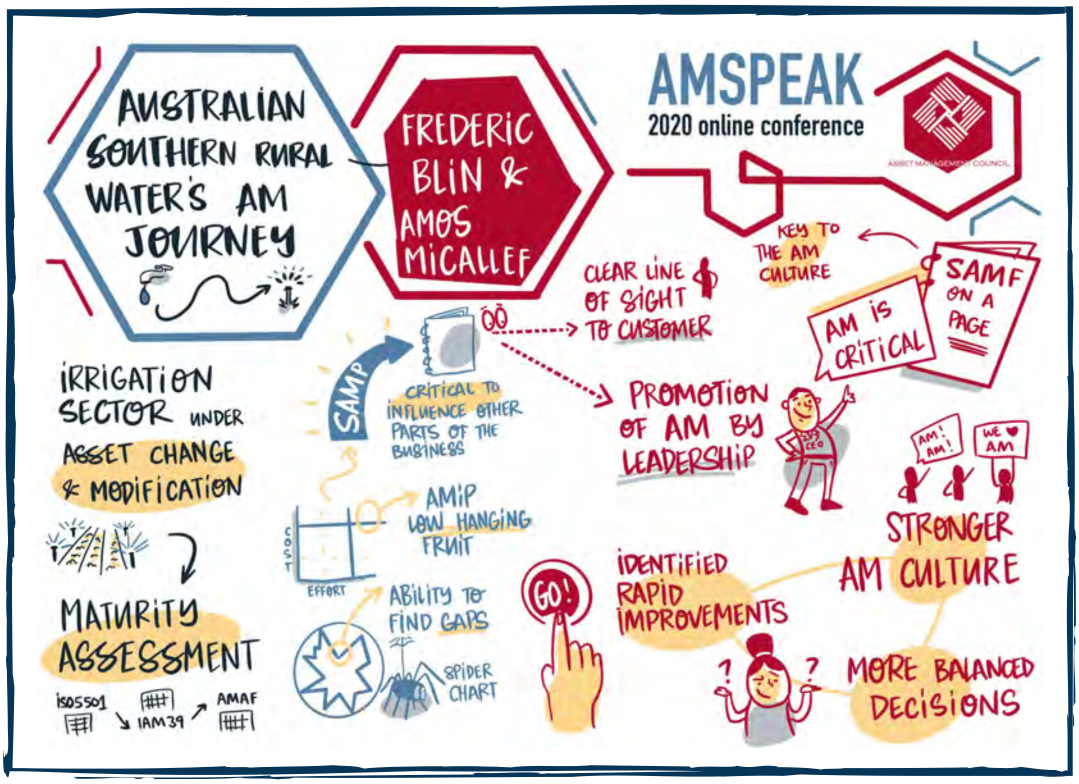
Integrating ISO 55001:2017 with other ISO systems

James Riddle, *BSI Group Australia*



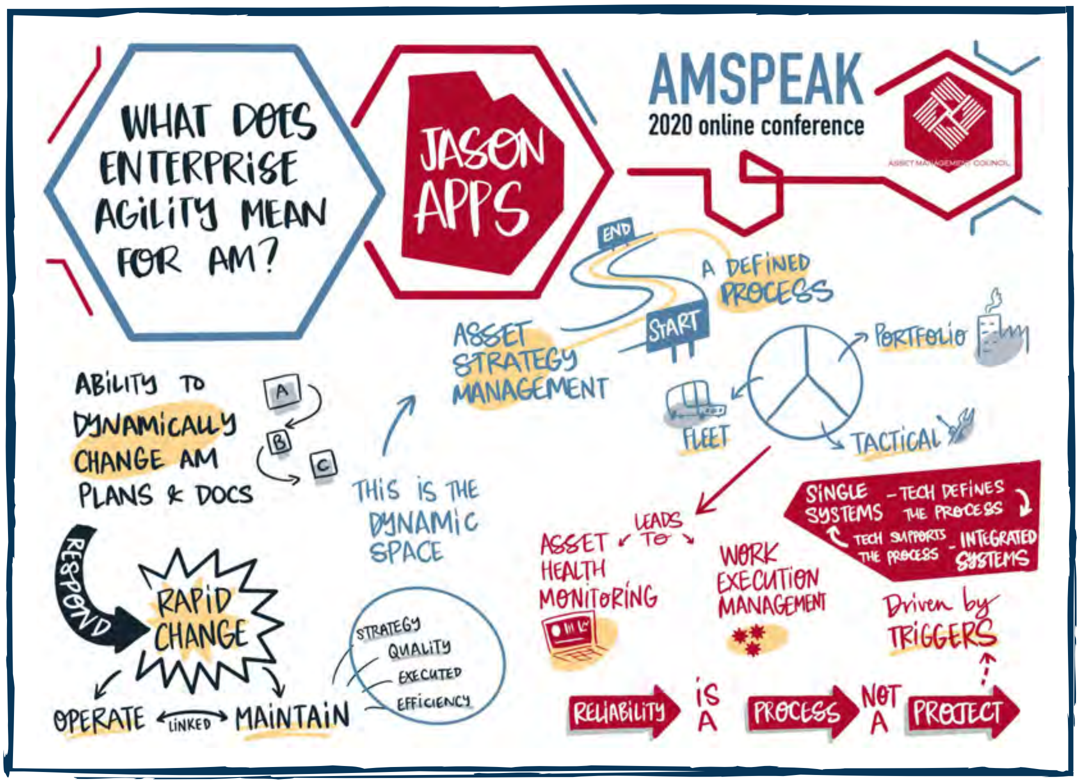
Australian Southern Rural Water's asset management maturity journey

Frederic Blin, *AECOM* & Amos Micallef, *Southern Rural Water*



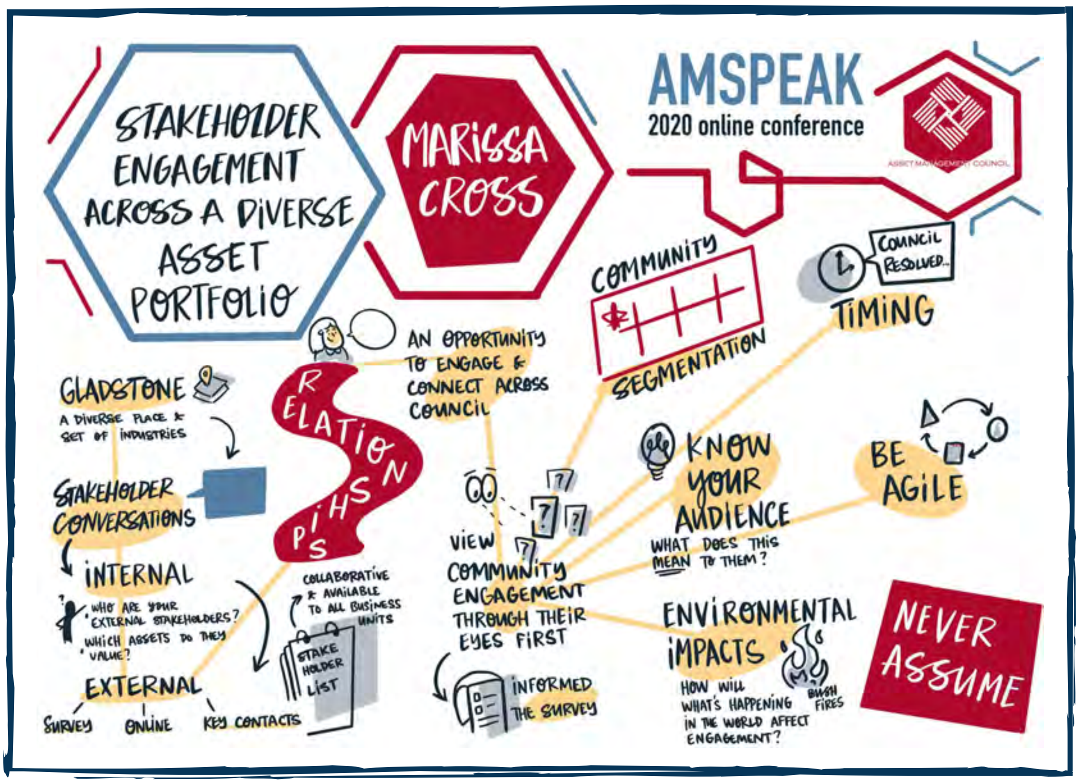
What does enterprise agility mean for asset management?

Jason Apps, *ARMS Reliability*



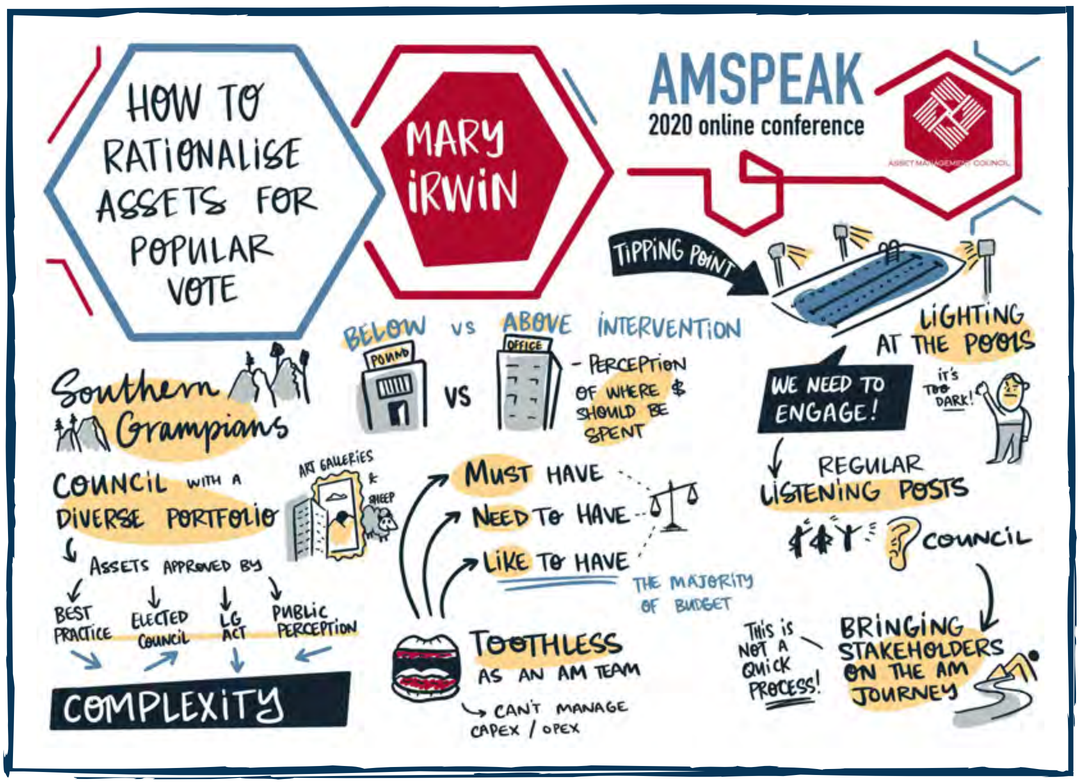
Stakeholder engagement across a diverse asset portfolio - Our journey so far

Marissa Cross, *Gladstone Regional Council*



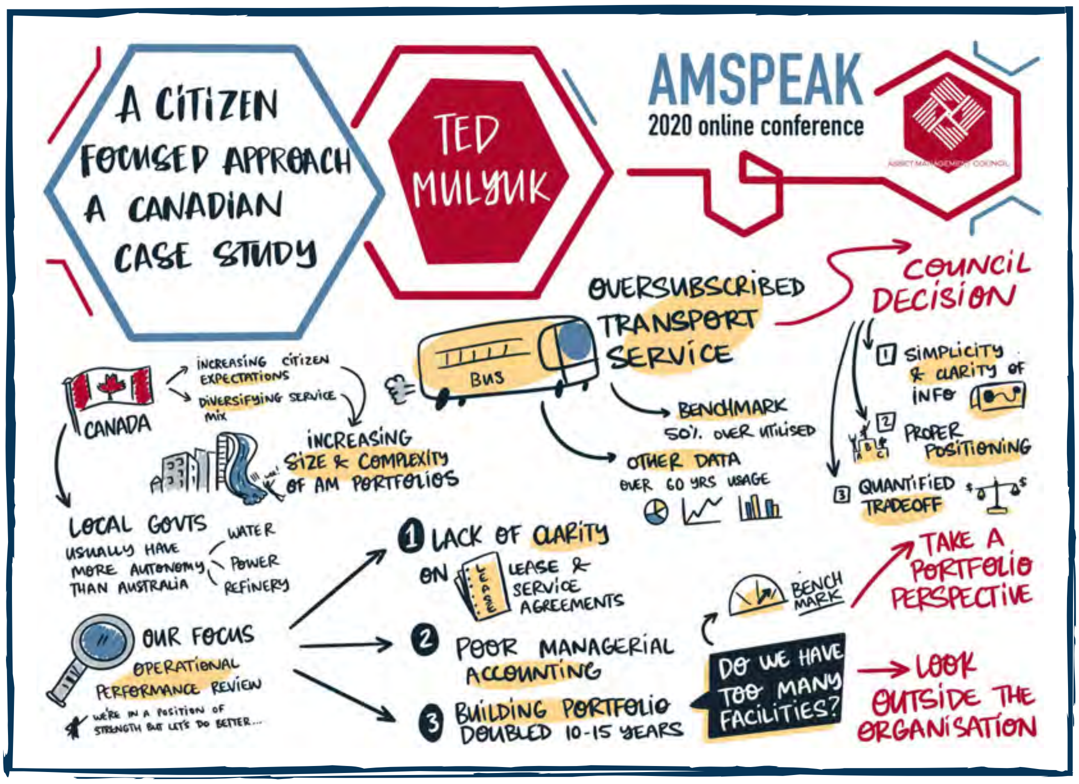
How to rationalise assets for the popular vote

Mary Irwin-Davies, *Southern Grampian Shire Council*



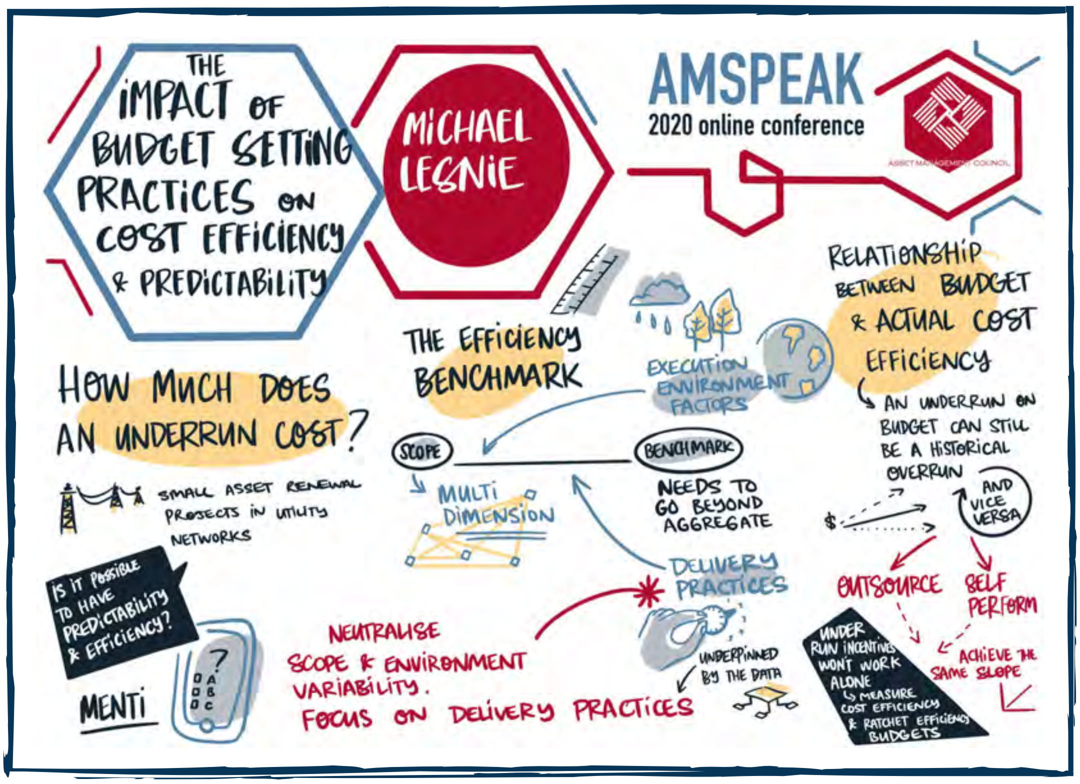
A citizen focused approach: A Canadian case study on evaluating a city's asset portfolio

Ted Mulyk, *KPMG*



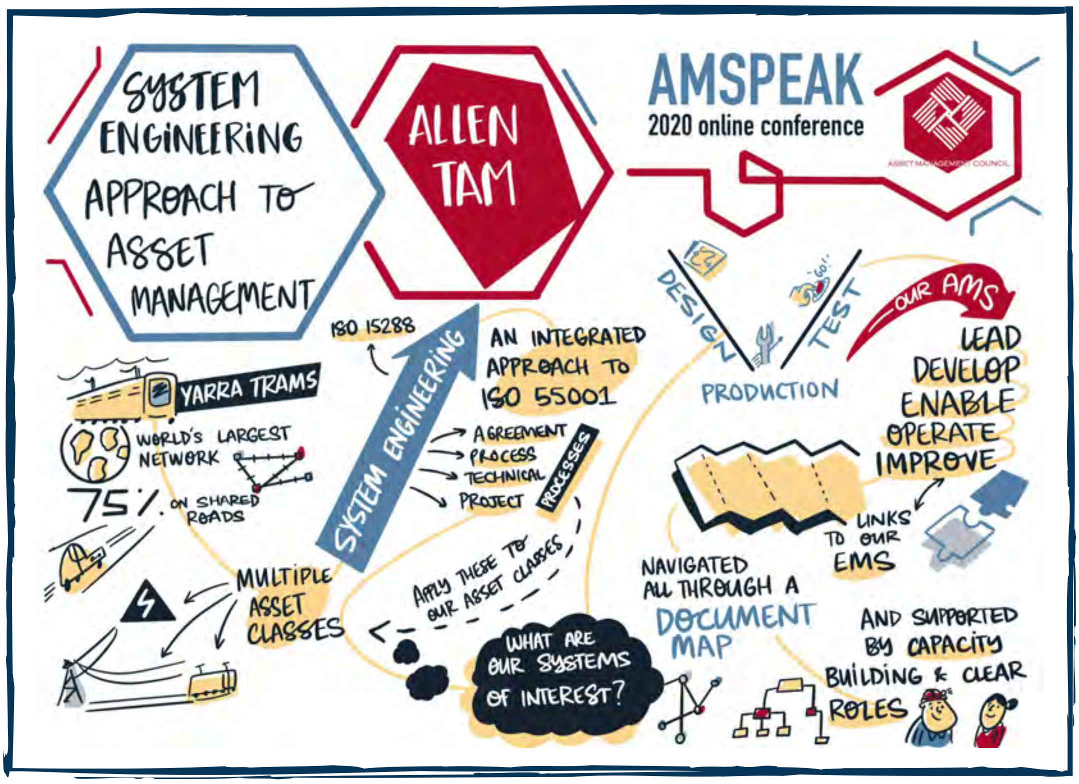
The impact of budget setting practices on cost efficiency and predictability

Michael Lesnie, *Qubist Pty Ltd*



System engineering approach to asset management system design and integration

Dr Allen Tam, *Keolis Downer - Yarra Trams*

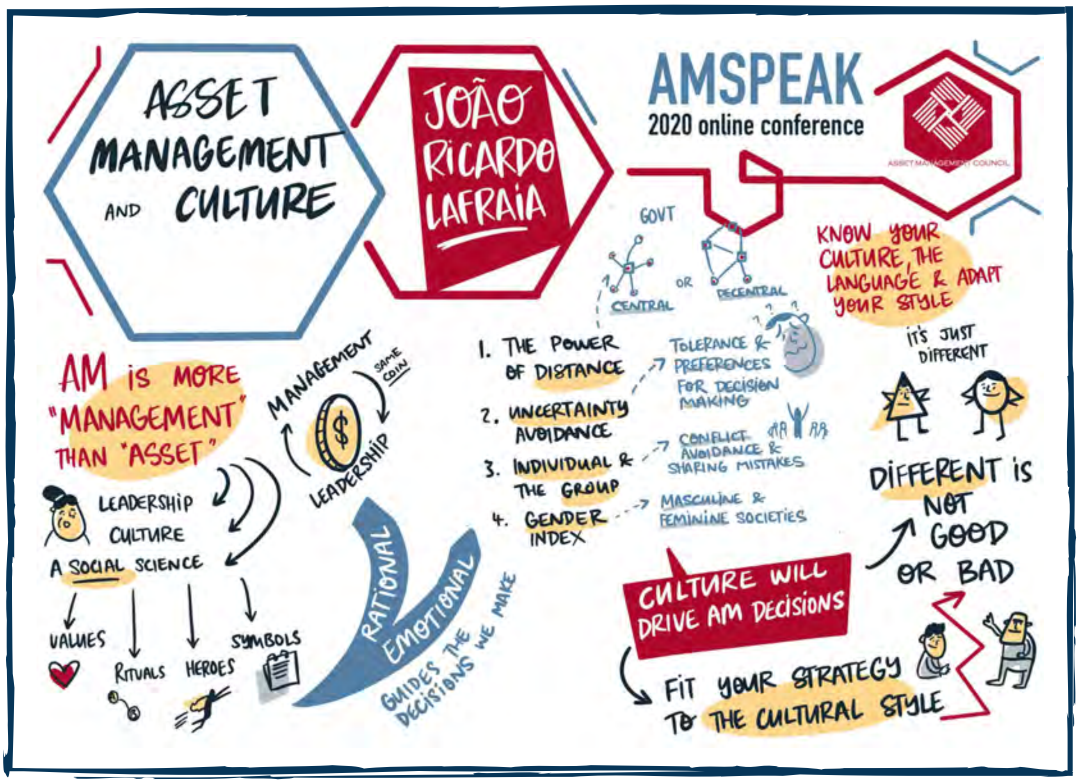


12 rules for successful asset management - Seeing the wood for the trees

Aneurin Hughes & Stephen Walker, *Cardno*

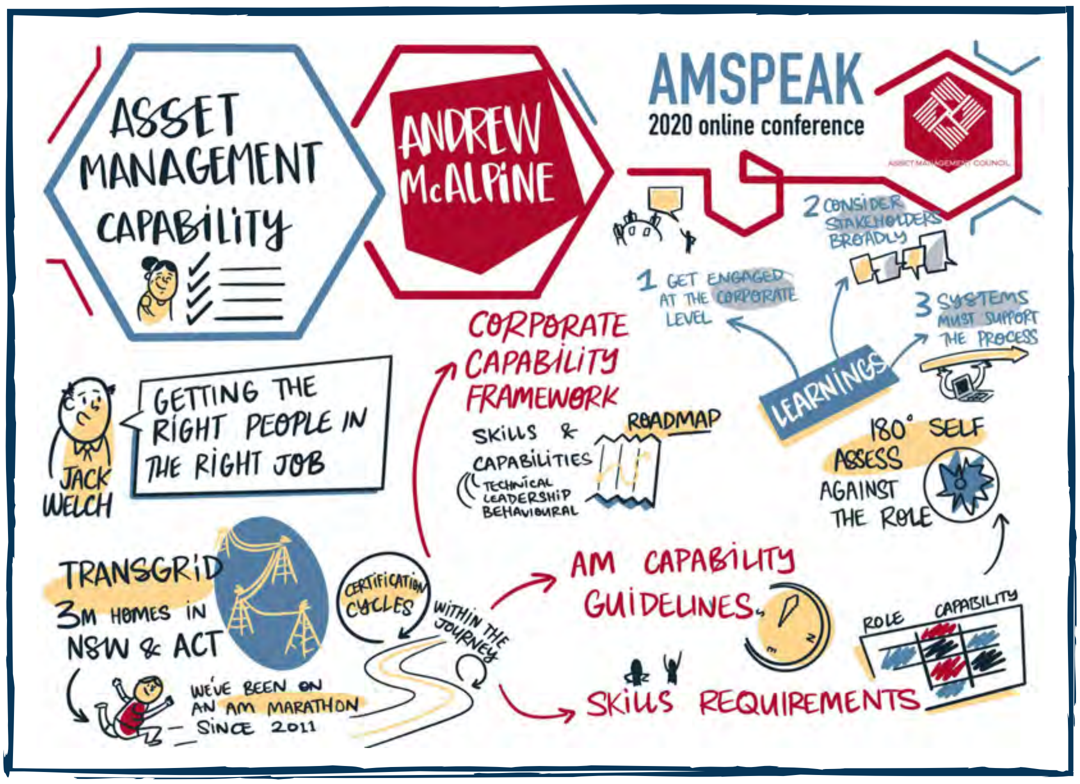
Asset management leadership & culture challenges

João Ricardo Lafraia, *Abraman*



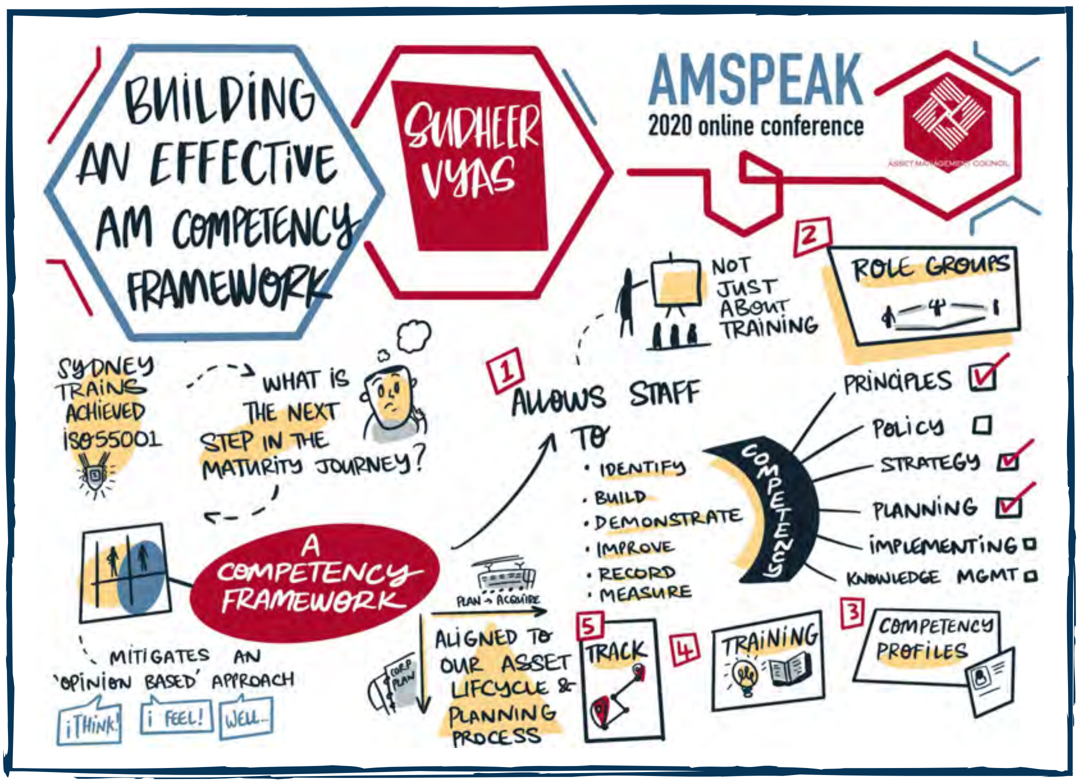
Asset management capability

Andrew McAlpine, *Transgrid*



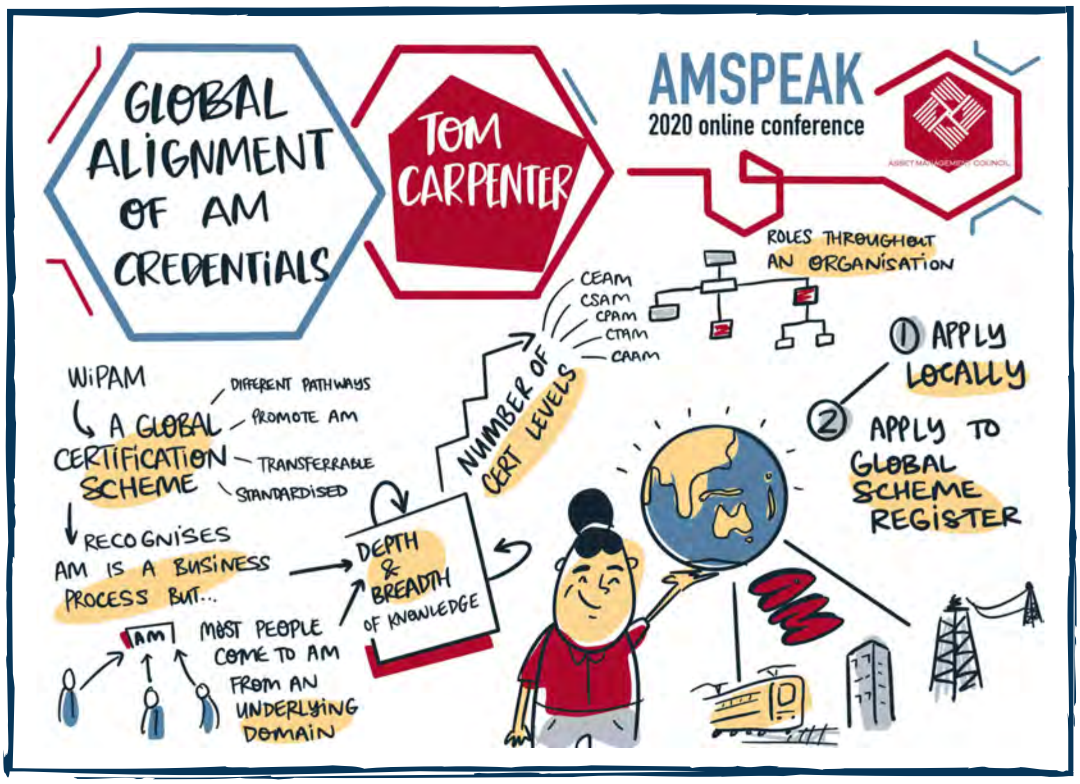
Building an effective asset management competency framework

Sudheer Vyas, *Sydney Trains*



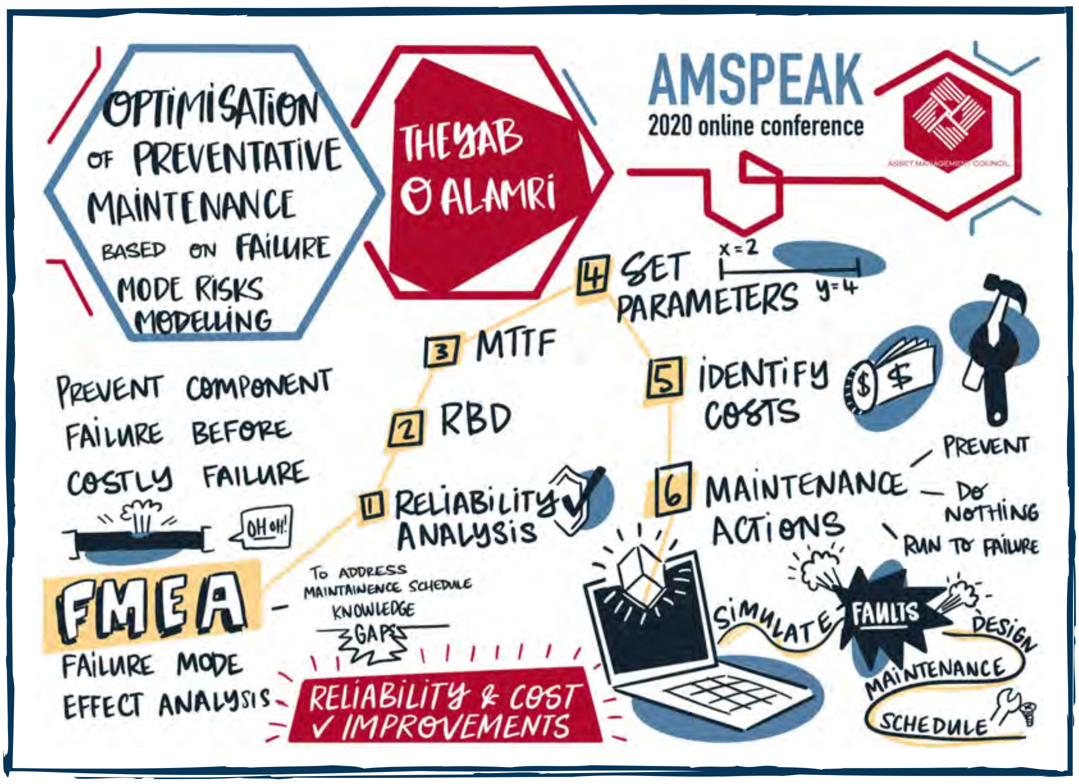
Global alignment of asset management credentials

Tom Carpenter, *IQ-AM*



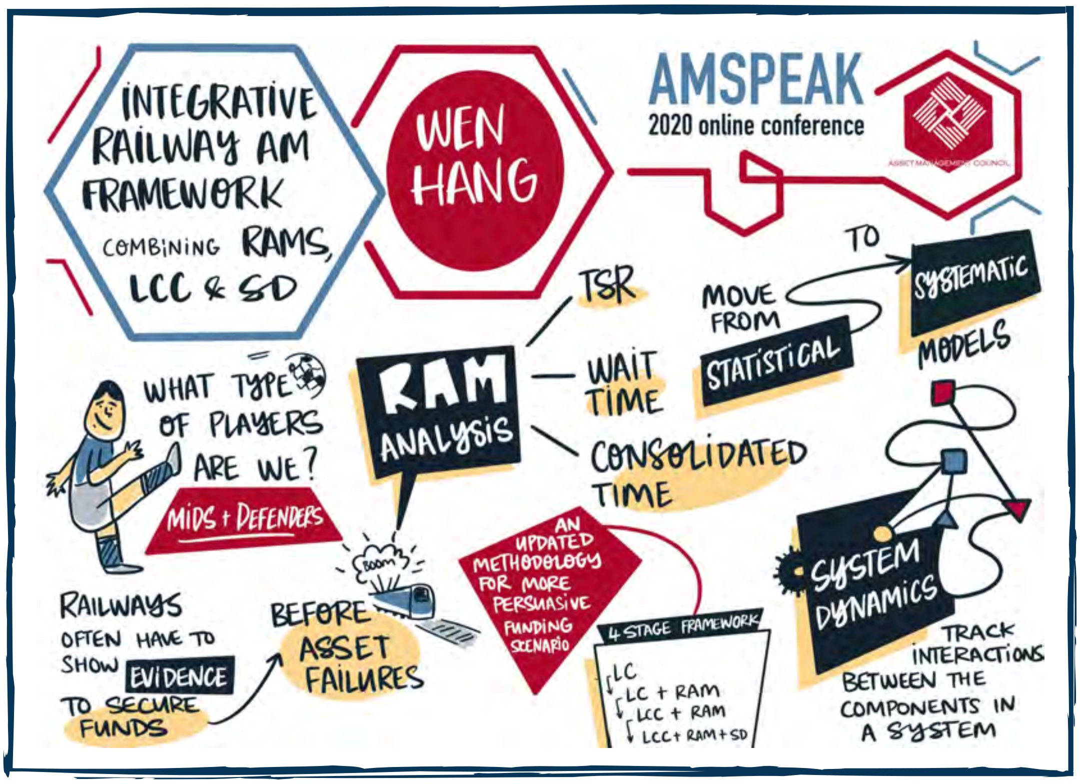
Optimisation of preventative maintenance regime based on failure mode risks modelling

Theyab O Alamri, *RMIT University*



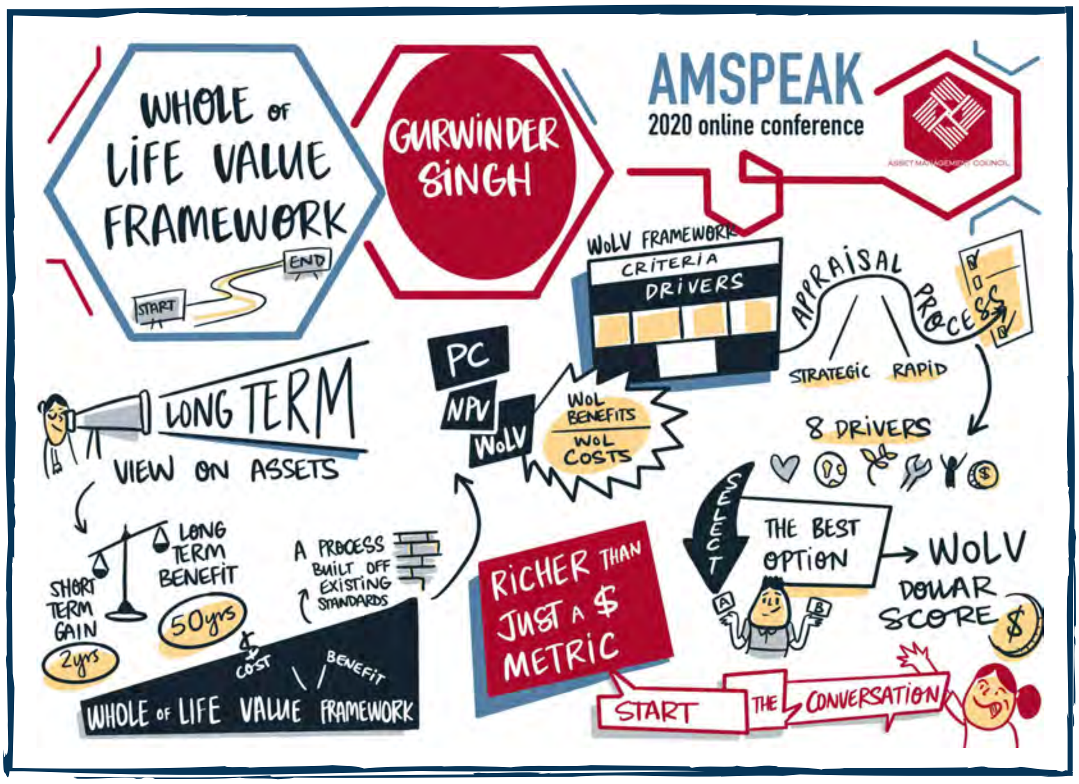
An integrative railway asset management framework combining RAMS-LCC-SD

Dr Wen Hang, *VLine*



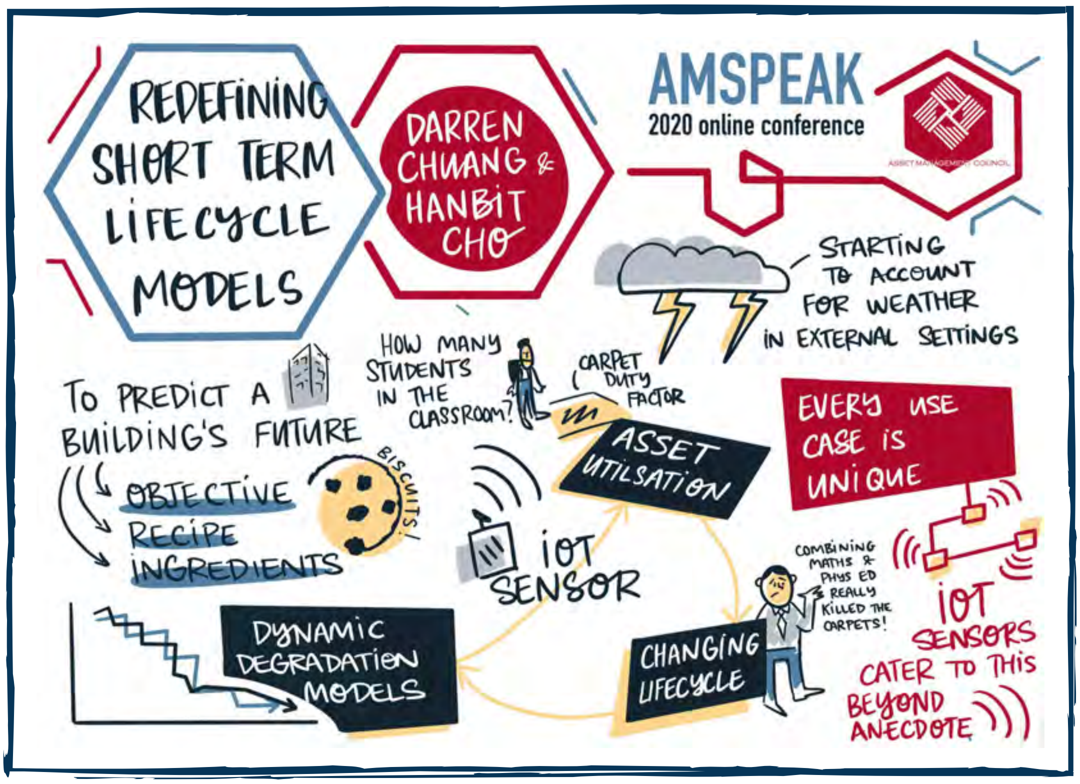
Whole of life value framework

Gurwinder Singh, *KPMG*



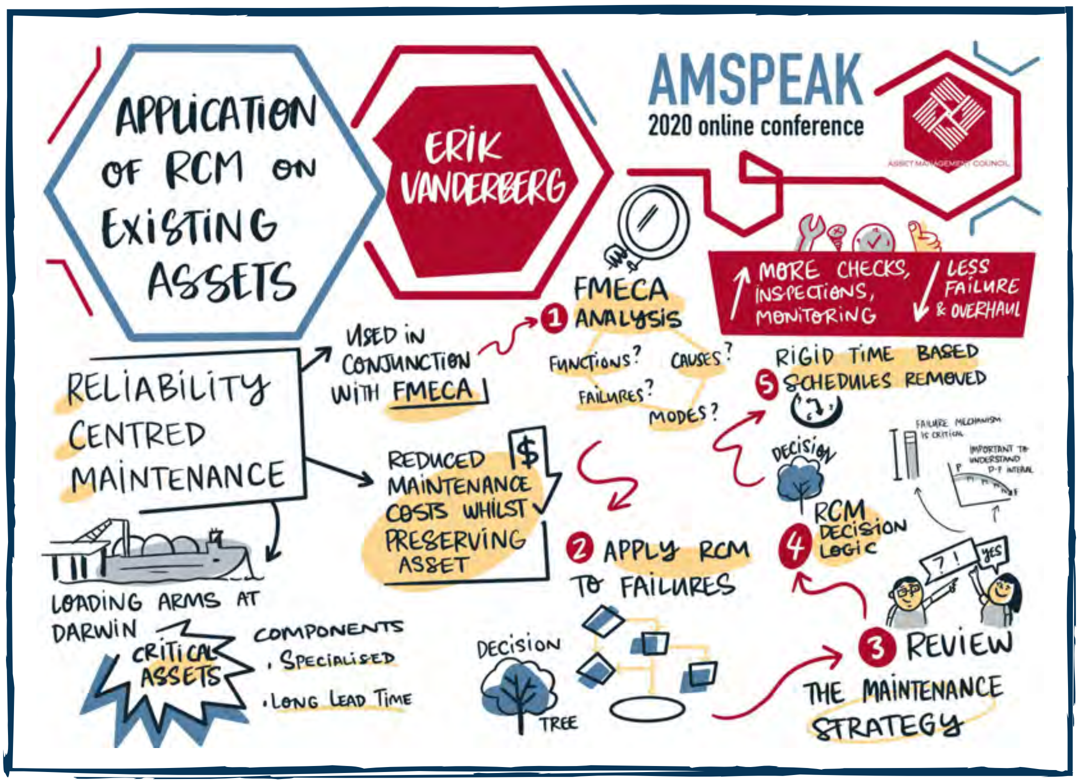
Redefining short term life-cycle models

Hanbit Cho & Darren Chuang, *AssetFuture*



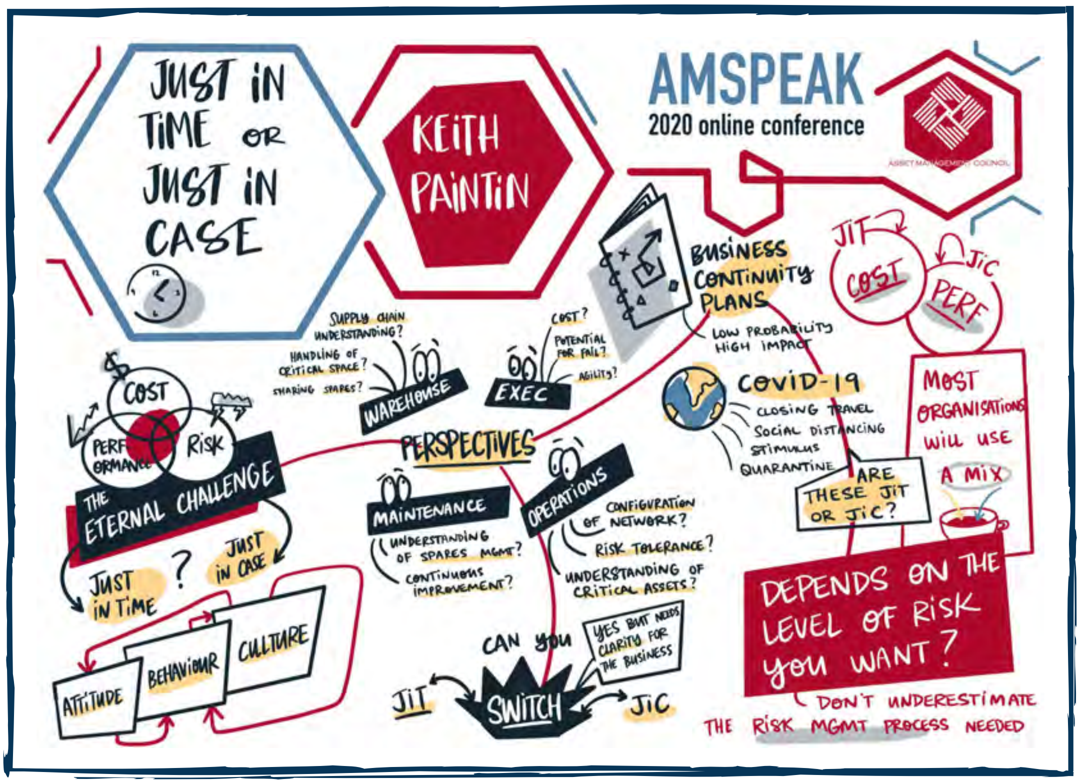
Application of RCM on existing assets for formulation of optimal maintenance strategies

Erik Vandenberg, *Inpex*



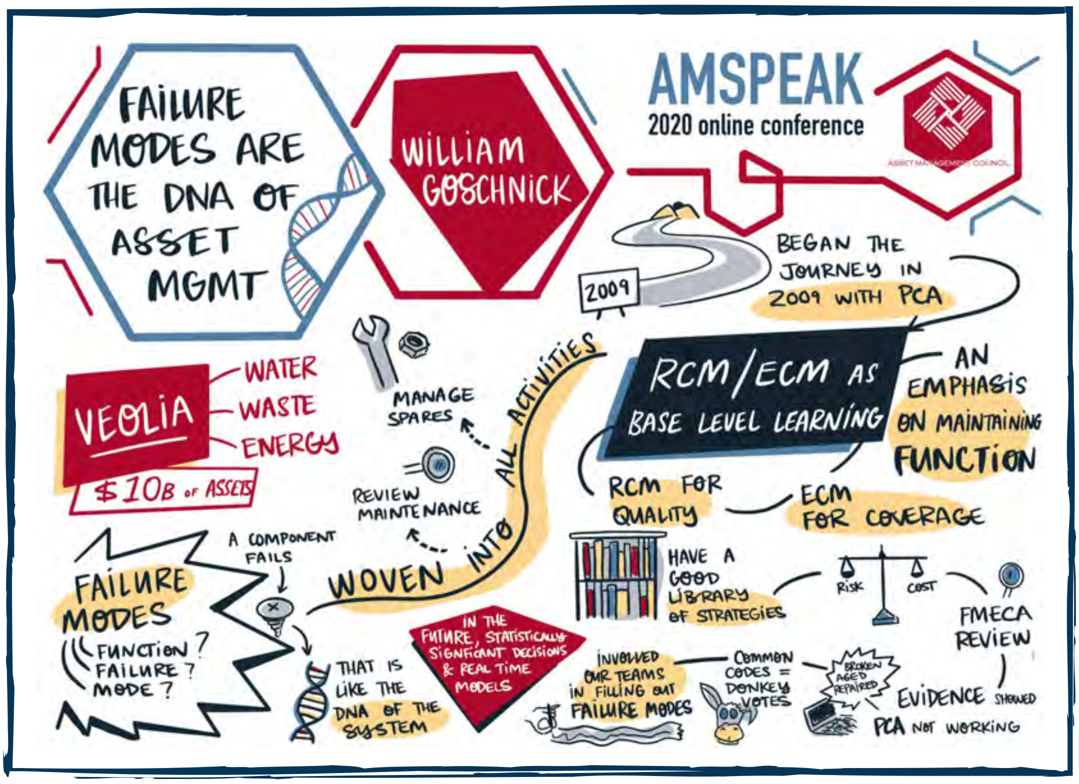
Just in time or just in case

Keith Paintin, *Jacobs*



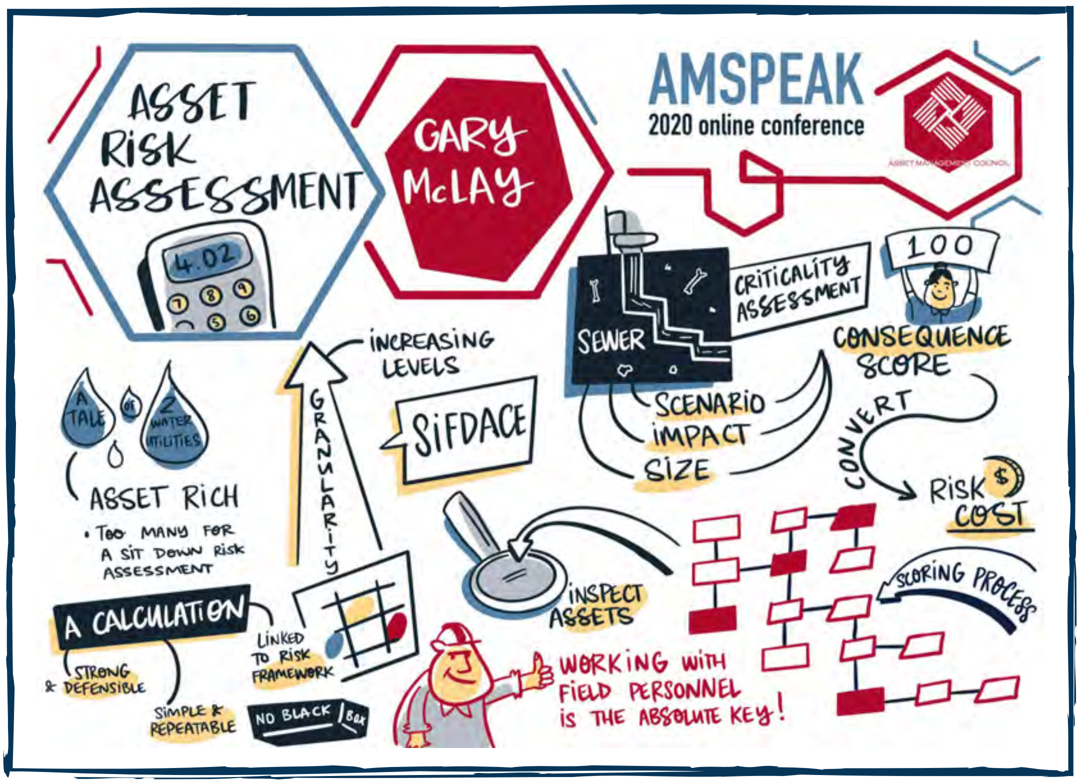
Failure modes are the DNA of asset management

William Goschnick, *Veolia*



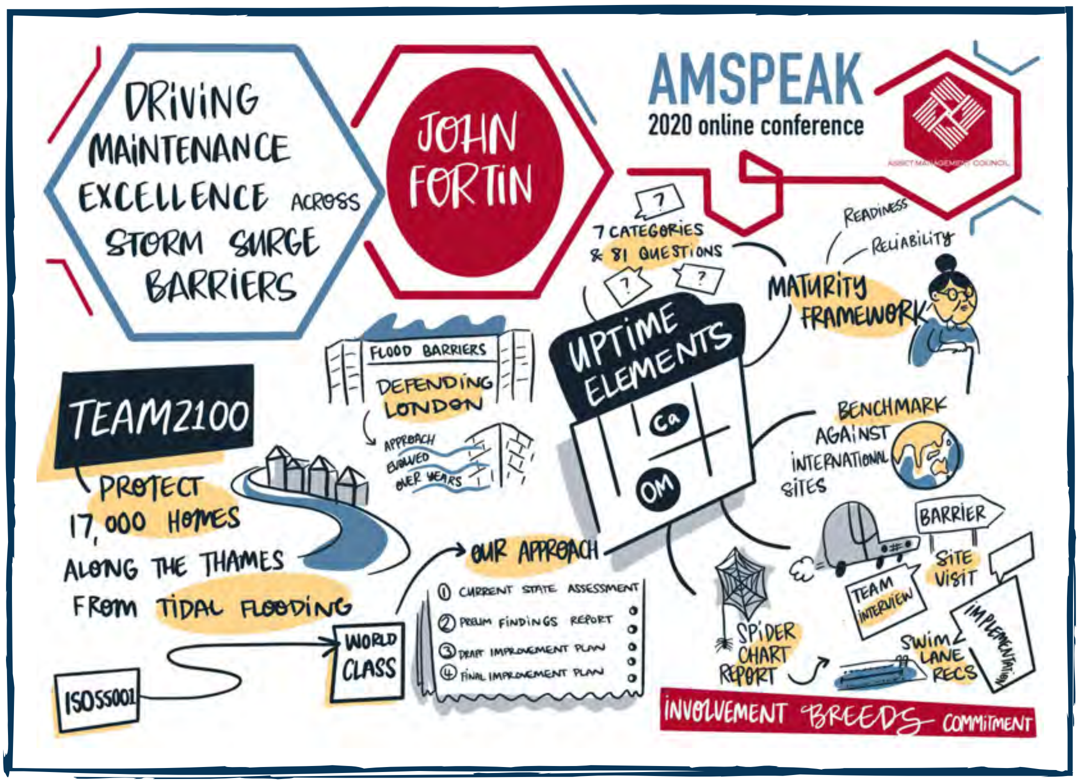
Asset risk assessment - A tale of two water utilities

Gary McLay, *Western Port Water* & Aaron Smith, *Wannon Water*



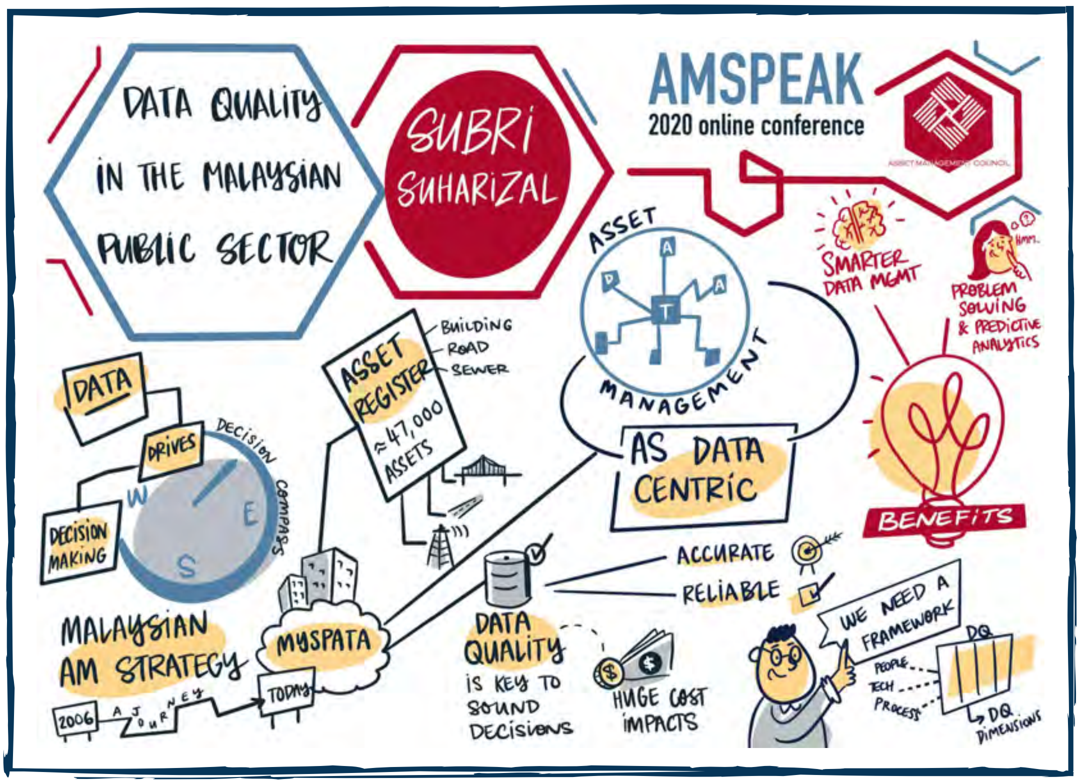
Driving maintenance excellence across storm surge barriers

John Fortin, *Jacobs*



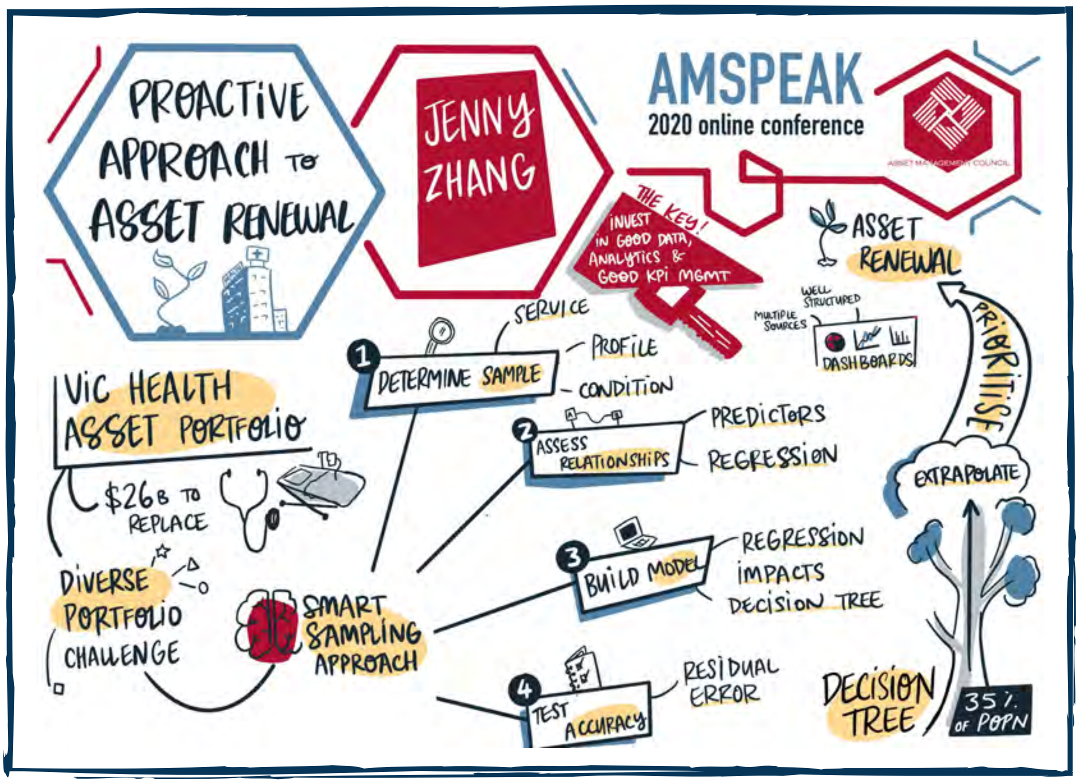
Data Quality in the Malaysian public sector immovable asset management

Subri Suharizal, *Public Works Department of Malaysia*



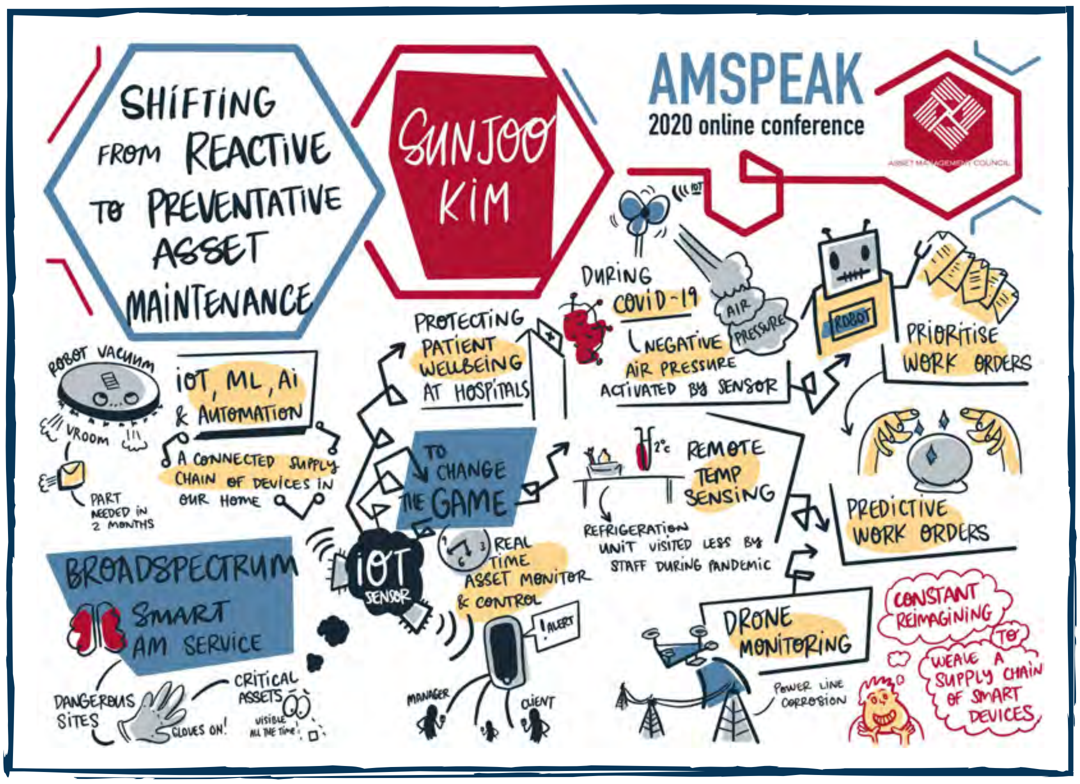
Proactive approach to asset renewal

Jenny Zhang, *KPMG*



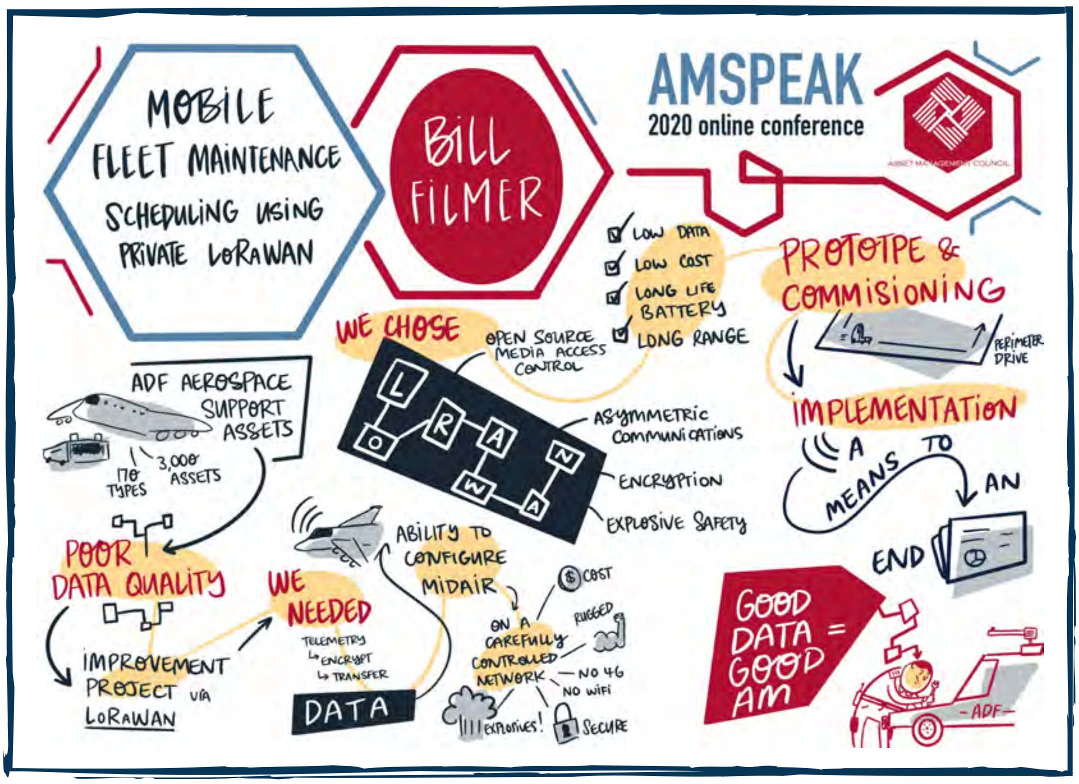
Shifting from reactive to preventative asset maintenance

Sunjoo Kim, *Broadspectrum*



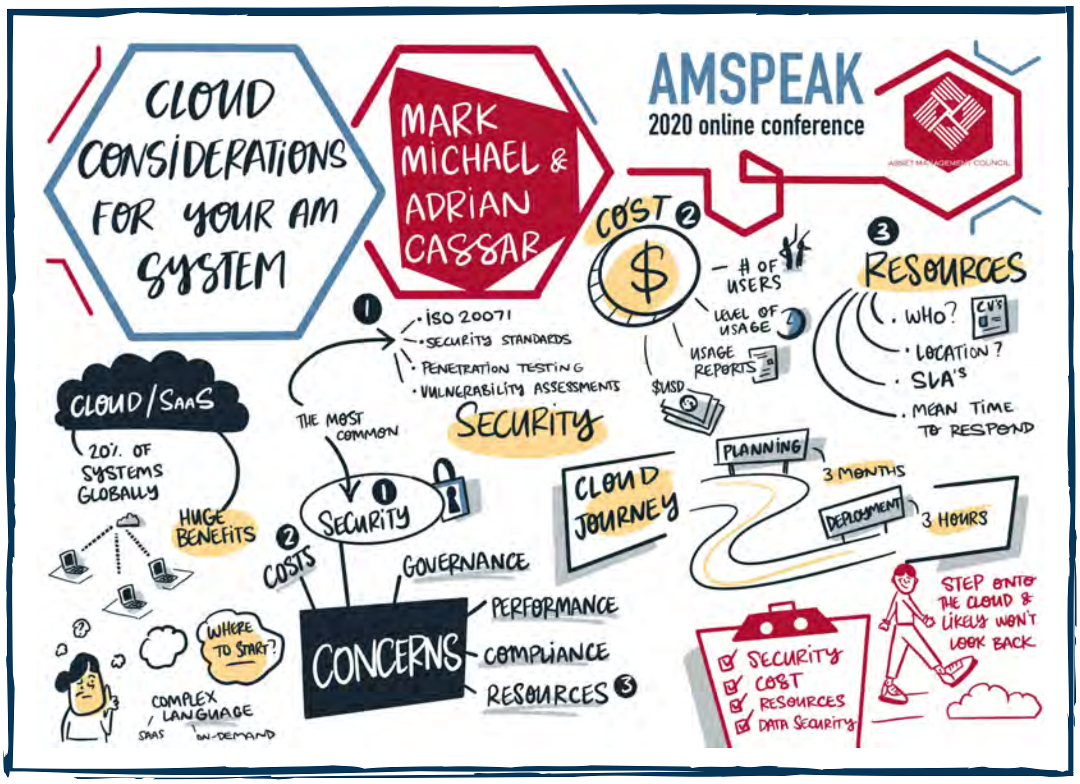
Mobile fleet maintenance scheduling using a private LoRaWAN implementation

Bill Filmer, *Babcock*



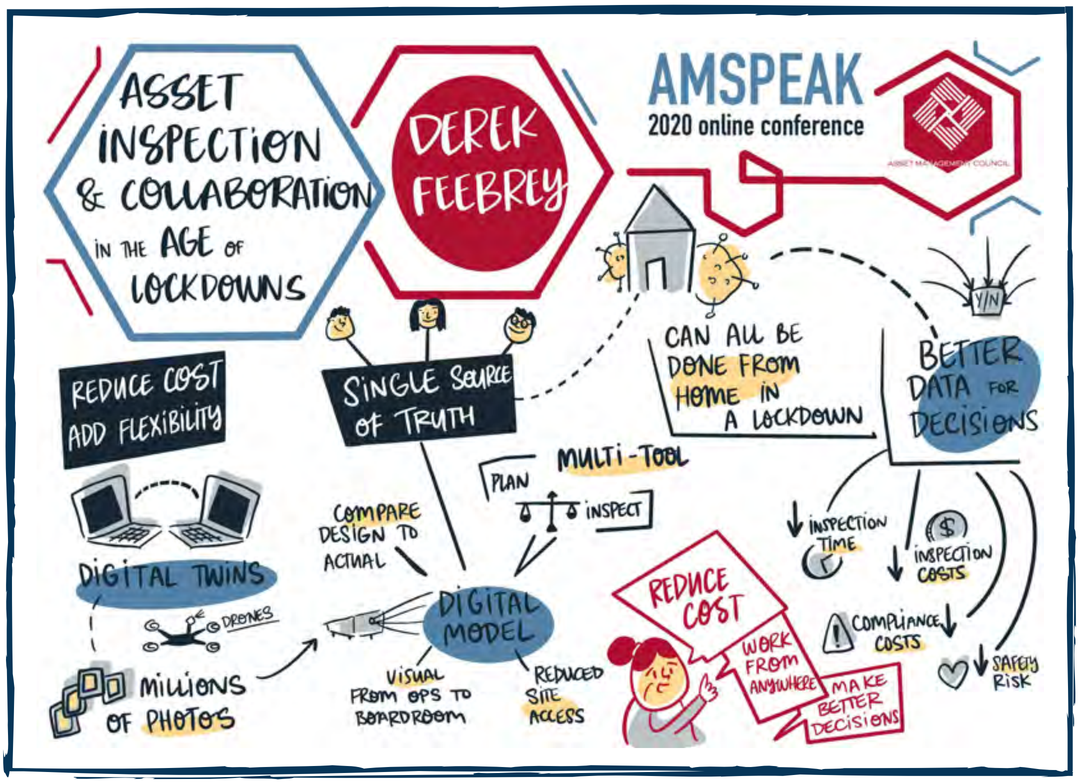
Cloud considerations for your asset management system

Mark Michael & Adrian Cassar, *BPD Zenith*



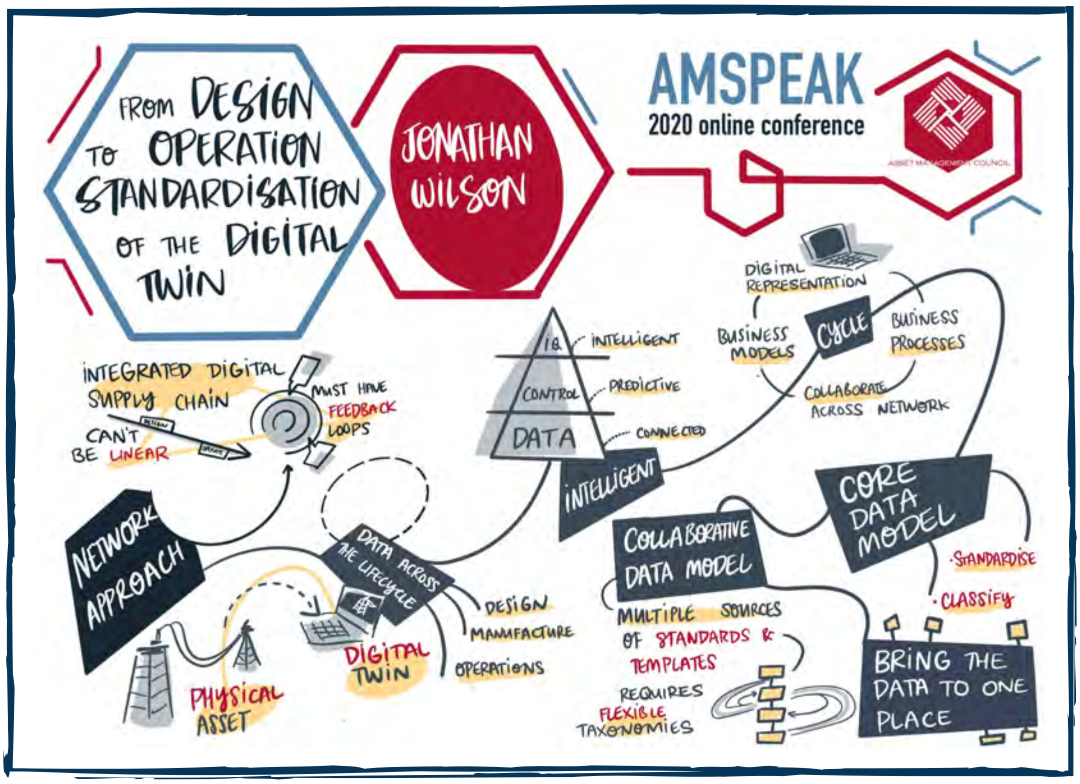
Asset inspection and collaboration in the age of lock downs

Derek Feebrey, Trendspek



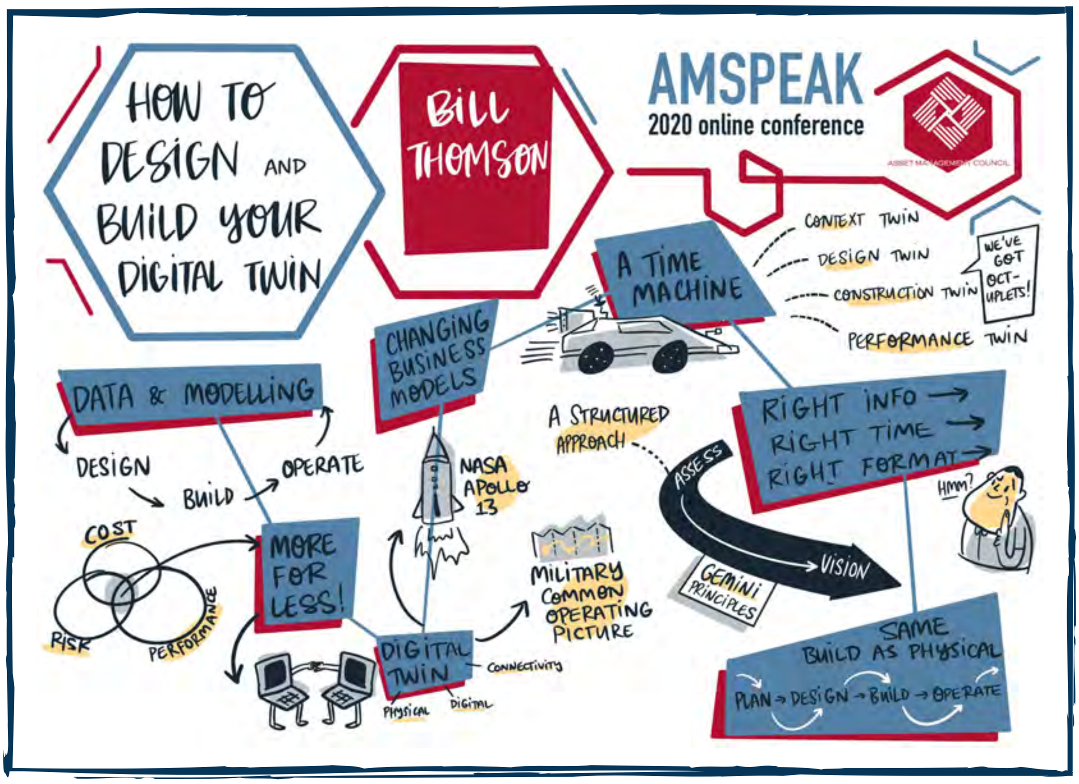
From design to operation - Standardising the digital twin throughout the digital supply chain

Jonathan Wilson, *SAP*



How to design and build your digital twin

Bill Thomson, *GHD Digital*



Digital twins everywhere, but where is my quick-start guide?

Julian Watts, *KPMG*