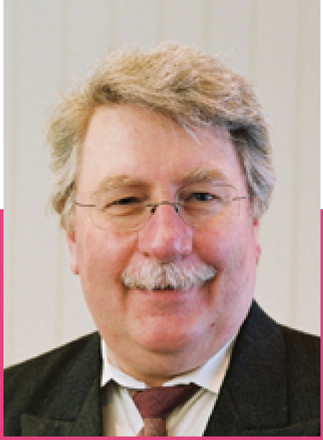
MARCH 2019
ISSUE 01
Volume 13

THE ASSET JOURNAL

ASSET MANAGEMENT COUNCIL

INTELLIGENT ASSET MANAGEMENT



ERNST KRAUSS

EDITOR IN CHIEF

Intelligent Asset Management

The topic of this issue of "The Asset" is sure to cause some discussion. The part of 'intelligent' Asset Management needs some definition in my view, as there are many ways of applying intelligence into any system. We trust that some of the articles provide further ideas about the topic than this editorial. The simplest format of Intelligent Asset Management of course is to fully understand the intent, application and limitation of a system in one's own environment and structure the underlying processes accordingly. But that does no longer satisfy today's demands as we have now the promises of multiple layers of 'intelligence' providing the Asset Management organisation with even more options to gain instant access to the status of the Assets and possibly also the Organisation.

To me the question is one of 'why', 'how much', 'what' and 'when'. There is no doubt that we require more and deeper knowledge of what goes on with and in our Assets and what the various activities and management actions and associated decision making. One thought leader on the topic of measurements, analysing and interpreting, states that there is nothing that can't be measured – it only depends on the quality of thinking to establish the criteria of why to measure something. He further says that the concept and purpose of measuring is 'a method to reduce uncertainty'. Asset Management as a subject is holistic and multidisciplinary, which by necessity introduces a high degree of uncertainty in an Asset Management System.

To reduce this uncertainty could be the aim of Intelligent Asset Management, certainly should be the intent. Through rapid advancing Technology we find ourselves at times a little overwhelmed with the emerging possibilities. The availability of ever smarter and more capable technology systems will profoundly change the way we think about Asset Management and how we manage our Assets. The challenge for Businesses is to find the right type of technology, whether it is in data gathering, analyses or interpretation and most of all the appropriate integration of the multitude of signals and data into a coherent model that truly represents our Assets, the need to reduce uncertainty and support positively the often complex decisions required.

Further ideas and thinking on this so important area of Asset Management future can be expanded on during this year's AMPEAK Conference in Perth. We look forward meeting with you there and trust that this edition of "The Asset" provides some informative views on this future defining topic. As always, your feedback is encouraged and welcome!

CONTENTS

Publisher: The Asset Management Council
Chief Editor: Ernst Krauss
Publication Design: nonilou
ISSN: 1834-3864

For all enquires please contact:
publications@amcouncil.com.au
Asset Management Council
PO Box 2004 Oakleigh Vic 3166 Tel 03 9819 2515

FROM MY DESK: CHAIRMAN'S LETTER

CHAIRMAN,
DAVE DAINES

Language is a complex beast and no more complex is understanding words and the context within which they are used.

Consider the word "Intelligent" when paired with Asset Management. Most people would conclude that this would refer to a definition of Intelligent that refers to " (of a device or building) able to vary its state or action in response to varying situations and past experience: In this context a majority view would be that the subject is about SMART Cities, Predictive Analytics, Machine Learning an so on.

The article in this edition of the AM Journal certainly focus on those key elements of asset management today. The advances in this area are occurring at a significant rate, probably faster than people can comprehend and business can adopt. A key challenge for all of us in Asset Management is to keep abreast with what is happening and then consider the value of its application.

This brings me to the second context of the term Intelligent Asset Management, when used with the alternate definition of " having or showing intelligence, especially at high level" in relation to people, where intelligence is viewed as the ability of acquiring and applying knowledge and skills.

Careers in Asset Management do not demand a University degree, but more so a passion to follow and continue to grow and learn. This is an area that the AM Council continues to play a big part through various Special Interest groups, the Certification scheme, various education programs and bringing people together to share and learn from each other.

The theme of the upcoming AMPEAK Conference to be held 7th to 10th April in Western Australia is "The Meeting Place for Asset Management" and I can see from the agenda that it promises to be more than just that, with a numerous streams covering various aspects of Asset Management.

It is an exciting time to be engaged in the field of Asset Management and the AM Council is here to help you stay involved.

David Daines
National Chairman, Asset Management Council.

ARTICLE 1 – DATA QUALITY IN ASSET MANAGEMENT – THE NEGLECTED ASPECT OF DATA ANALYTICS

Allen Tam, Relken Engineering (previously with AusNet Servcies)
Iris Kwan, AusNet Services

SUMMARY

Data analytics (in particular "Big Data" analytics) is a hot topic in recent technology wave. There is an increasing trend and focus on the value data analytics can bring to the business. Internet of Things (IoT) and advancement in technology have made even more data being created and assessed. There are many new tools and software developed that provides "silver bullet" solution, with advanced dashboard, reporting, graphic visualisation and predictive capabilities. However, there is little attention to the data quality aspect of the puzzle. Incorrect data can lead to loss opportunity and incorrect decisions being made.

This paper provides an overview of the challenges contributing to master and transaction data quality issues in asset management and highlights the potential loss opportunities due to inaccurate data. The value of text analytics and reviewing of fault data is highlighted. This paper also offers a four step solution to data quality improvement.

Keywords: Data Quality, Faults Data, Text Analytics

1.INTRODUCTION

Data analytics (in particular "Big Data" analytics) is a hot topic in recent technology wave. There is an increasing trend and focus on the value data analytics can bring to the business. Internet of Things (IoT) and advancement in technology have made even more data being created and assessed. There are many new tools and software developed that provides "silver bullet" solution, with advanced dashboard, reporting, graphic visualisation and predictive capabilities. However, there is little attention to the data quality aspect of the puzzle. Incorrect data can lead to loss opportunity and incorrect decisions being made.

Data quality is fundamental for building decision models that support evidence-based asset management [1]. It is also noted by [1] that mathematical models themselves with incorrect data do not guarantee accurate insights and therefore may not support right decisions being made.

Different models require different datasets. Previous work by [2] identified the key data requirement for maintenance optimisation models, where the data is captured and also the priority ranking of significance for enterprise level optimisation. The data can be both master data and transactional data. The type of models and the optimisation objectives will drive the data quality requirement for specific parameters based on the sensitivity analysis pointed out by [2]. A study by [3] highlighted that data requirement for ensuring good condition-based maintenance (CBM) models outcome.

This paper provides an overview of the challenges contributing to master and transaction data quality issues in asset management and highlights the potential loss opportunities due to inaccurate data. The value of text analytics and reviewing of fault data is highlighted. This paper also offers a four step solution to data quality improvement.

2. MASTER AND TRANSACTIONAL DATA QUALITY

2.1 Master Data

Master Data are business objects that are shared across the enterprise, relatively static. In Asset Management, some examples of key master data objects are: the Functional Locations, Equipment & Material Master.

A system configuration is the specific information that describes what the system is made up of. The data describe a system behaviour is configuration data. For example in electricity network, protection devices have setting information that describes how the device should operate during a fault, the data in these settings are configuration data. This data can sometime be found within Master data tables but they should not be confused as master data.

2.2 Transactional Data

Transactional data is data that describes an event. Work orders, notification, projects and faults response dispatch orders, material orders are transactional data.

For Transactional Data especially in the maintenance world, work orders and loss of availability records are the most important data objects for reliability analytics purposes. Work Orders contains data that describe what work has been done to the asset and when, and also the nature of the work (planned or unplanned).

Loss of Availability data is also a key transactional data. Loss of Availability or downtime system record event data where there is an outage or a stoppage in the production line or power generation. In some operations, operators will record the cause of a stoppage (or loss of availability) and record if any works have been done to ratify the issue.

2.3 Data Quality

A measure of data quality is by assessing the 5 key attributes – the 5Cs [4]. The 5Cs are:

- Clean – no error
- Consistent – no arguments about which version of data is correct
- Conformed – common, shareable for business use. Same datasets are used for decision making
- Current – up-to-date

- Comprehensive – all data needed is available regardless of where data comes from and its level of granularity

Achieving all the 5 Cs (Clean, Consistent, Conformed, Current & Comprehensive) of data quality are challenging due to:

- Semi-integrated (or non-integrated) systems and suboptimal interfaces: Geospatial Information System (GIS) – e.g. GE Smallworld & ArcGIS; Enterprise Asset Management (EAM) & Enterprise Resource Planning (ERP) – e.g. Maximo, SAP; Outage management system (e.g. PowerOn Fusion); Customer information Systems (CIS); SCADA
- Major systems implementation and changes: EAM & ERP systems changes and/or upgrade – changes of enterprise systems (e.g. from Maximo to SAP or vice versa) – common issues of data mapping and translation between systems
- Business Process Compliance – no or not-adequate business process in place. If process is in-place, business do not follow process.
- Increased Volume – the amount of data collection requirement increased

3. DATA QUALITY IMPACT TO ANALYTICS – AN EXAMPLE

This section provides an example of how data quality can impact on the analytics outcome and also how improving data quality changes the analytics outcome. Figure 1 below is plot of raw data from a utility work order system showing the Pareto chart of all faults responses in a given year. The top category is "Unknown" and "Deterioration," which is too generic and unusable.

Figure 2 plotted the results after text analytics. Text analytics are carried out, reviewing the description field entered by the operator during the outages and all other information available with the order (including checking other systems). The analyst then reclassified the causes code after reviewing all information available. The cause – unidentified denotes that there is not data available in the system and N/A refers to event that should not be rasied as a fault. If we remove these two categories and replotted the graph, as shown in Figure 3,the top causes are: Tree, Age, Bird or Animal and Corrosion.

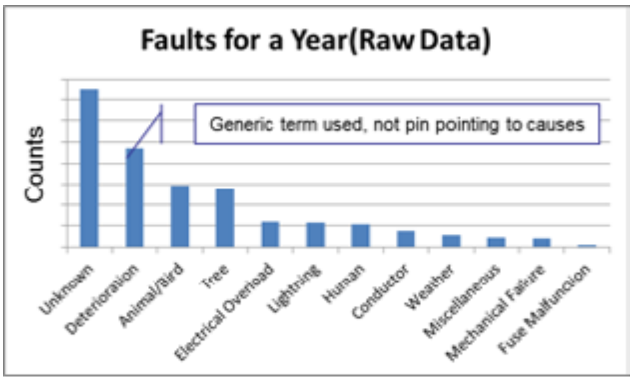


Figure 1 – Raw Data from work order system – looking at causes of outage

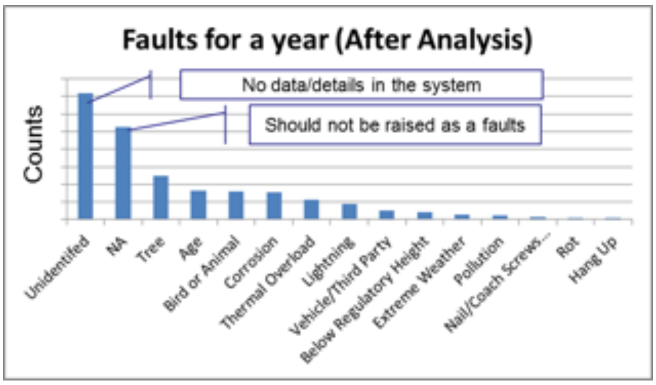


Figure 2 – Plotting the same data after text analytics – recoding the causes

4. FOUR STEP SOLUTION

The paper has highlighted the challenges and importance of data quality. This section, the paper offers a solution to remediate and improve asset data quality. Data Remediation is the process to clean-up data of poor quality – data that do not meet the quality 5 Cs (data that is incomplete, inconsistent, out-of-date, i.e. "wrong"). The four steps process is: Identify, Fix, Stop & Automate (IFSA).

- Identify what data is wrong/ incomplete, how it gets into the system
  - o Develop Data Standard
  - o Develop and monitor data quality dashboard as per data standard
  - o Identify & prioritise key data fields first – monitor data where its quality has major impact to the business
- Fix the data, ensure correct values are in the system
  - o Perform analytics to obtains correct values
  - o Analytics can involve desktop analysis and looking through old drawings
  - o Carried out field visit to capture missing information
- Stop bad quality data from getting into the system
  - o Apply data standard at point of data entry
  - o Introduce mandatory fields
  - o Reduce the number of data entry requirement, has a single source of data entry – like establishing the data management office for master data
  - o Develop cascading drop down list in EAM/ERP system to allow the right codes being available for field workforce & operator
- Automate: Reduce Handling and Simplify Process. Automate if possible.
  - o Eliminate double data entry requirement – if data is needed in different systems, use an interface
  - o Clearly define data master system – where if data is to co-exist in 2 systems, define which one is the master and synchronise data from the master to the rest using interface
  - o Use as much automation for data entry as possible

    Bar code, QR code or RFID

    Use upload tool for mass data update (for example: SAP LSMW, WinShuttle)
  - o Using analytics, develop tools/scripts to identify incorrect or conflicting data values within systems; then use advance analytics such as Bayesian theorem and Text Analytics to automatically correct data.

5. CONCLUSION

This paper has highlighted the challenges and importance of data quality to creating and maintaining a foundation for data analytics and intelligence. In some data quality challenges, the paper has pointed out that in some instances – such as work order faults codes text analytics, the only way is to relay on experienced analyst. The analyst read through tens of thousands of the comment free text field and digging different database and discussion with operators to identify the true fault codes. With advancement in technology, it is possible to invest in "machine learning" approach where we can train the computer to pick up patterns on data. Data quality is pivotal to success in any data analytics & intelligence implement and is the most important aspect to deliver good value to the business. A continuous improvement approach coupling with the 4 steps IFSA model as proposed in this paper is needed to ensure data quality is always one of the top priority in the enterprise performance dashboard.

REFERENCE

[1] A. K. Jardine and A. H. Tsang, Maintenance, Replacement and Reliability Theory and Applications, 2 ed., FL: CRC Press, 2013.

[2] A. S. Tam and J. W. Price, "A generic asset management framework for optimisating maintenance investment decision," Production Planning & Control, vol. 19, no. 4, pp. 287-300, 2008.

[3] A. H. Tsang, W. Yeung, A. K. Jardine and B. P. Leung, "Data management for CBM optimisation," Journal of Quality in Maintenance Engineering, vol. 12, no. 1, pp. 33-57, 2006.

[4] R. Sherman, Business Intelligence Guidebook From Data Integration to Analytics, 1 ed., USA: Morgan Kaufmann, 2015.

[5] A. S. Tam and I. Gordon, "Clarification of Failure Terminology by Examining a Generic Failure Development Process," International Journal of Engineering Business Management, vol. 1, no. 1, pp. 33-36, 2009.

ARTICLE 2 – "The Eternal Apprentice?"

SUMMARY:

The paper will summarise the results from a piece of research to test the hypothesis that "Artificial Intelligence Techniques" could support the process of autonomous "Corrosion and anomaly Inspection" of above ground, uninsulated steel pipelines. To expand further this would include, identifying corrosion or anomaly and providing exact position of the corrosion or anomaly on the pipeline. The technique used to explore this hypothesis is one of "Cognitive Perception" This is a technique where an API (Application Programming Interface) is trained in the function of identifying images or video for a specifically trained set of outcomes that would normally be carried out by humans using a visual inspection. The research team used drone technology to capture images and visual analysis software (Visual Recognition API) to investigate the practicalities and effectiveness of the technique in autonomously determining pipeline corrosion and anomaly detection.

Keywords: Artificial Intelligence (AI), Application Programming Interface (API) Autonomous Inspection, Cognitive Perception, Drones, Visual Recognition API, Pipeline Inspection.

INTRODUCTION

There has been a significant amount of interest in "Artificial Intelligence" (AI) from a broad spectrum of Industries: analyst Gartner places it at the top of its top 10 strategic technology trends for 2017. The analyst says the technology has reached a tipping point and AI is beginning to extend its tentacles into every service, thing, or application. [1]

This research project explored the practicalities and accuracy of using "Cognitive Perception" a sub category of "Artificial Intelligence" as a methodology to support the engineering practice of pipeline inspection and the classification of corrosion and anomalies. The classification and identification of corrosion and anomalies over vast distances of pipeline is both time consuming and difficult to expedite. It is a common practice to have resources travel the length of a pipe structure to inspect it for corrosion or anomalies and record them via photographic and written evidence.

The use of drone technology has steadily gained pace in its use for capturing the images of structures, however the analysis of the data has still on the whole been carried out via human analysis of the images, for incidence of corrosion or other anomalies. The current manual process is perceived to be mundane and laborious with human fatigue seen as a factor in the continuous assessment of images in the inspection process.

The objective of this piece of research is to explore automating the identification, classification and confirming the position of incidence of corrosion and anomalies in above ground steel pipe structures. This piece of work investigated the feasibility to use drone technology to capture data image, data orchestration to process the imagery in preparation for loading into the Visual API and determine if the techniques could support the pipeline inspections.

The research project investigated three objectives:

1. The use of AI to Identify corrosion from a series of Images of an above ground Pipeline
2. Autonomously classifying an anomaly observed on pipeline images
3. Identify the specific position and co-ordinates of the corrosion or anomaly.

METHODOLOGY

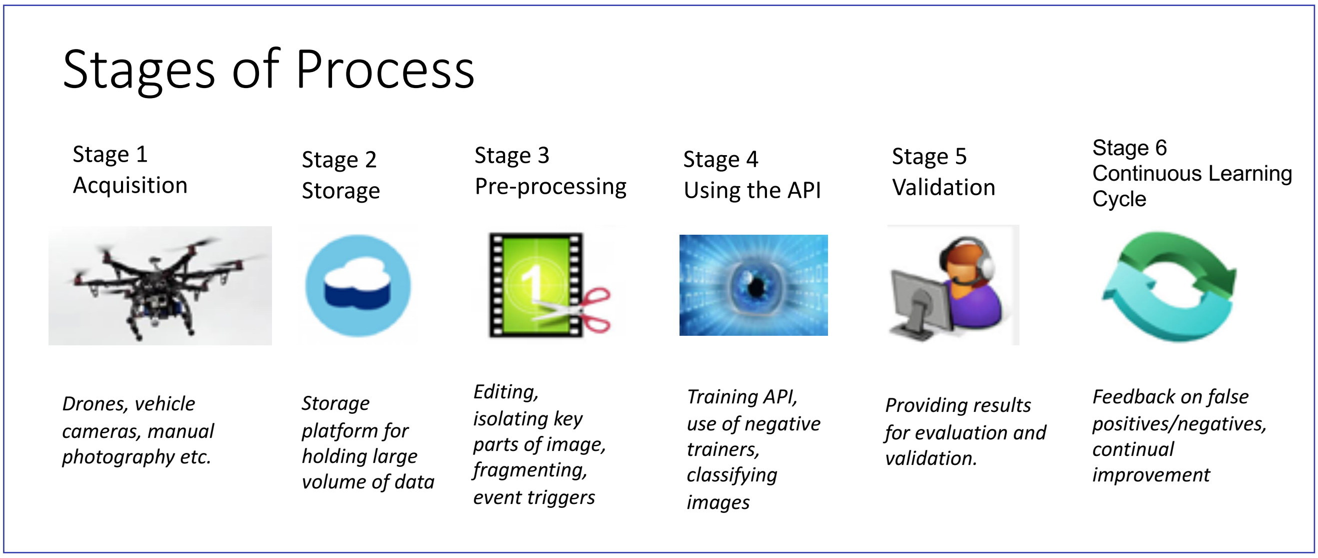
The steps taken to investigate the use of a Visual Analytics API for autonomous Pipeline Inspection were are follows:

The research followed a 6 stage process of Data Capture (Figure I)

Data Acquisition

The data was captured using drone technology, taking high definition images every 2 second along a series of pipe runs to collect a representative sample of date for the research. The output was RAW image files of approx. 80Mb per image. This data set became the Meta Data for the research. [2]

Figure I – Stages of Process



Processing the data.

For the purpose of this research the data was stored in the cloud on a standard data orchestration platform with a storage capacity of 1 Terabyte. An automatic pipe object extractor program was created and used to automatically extract pipe images from drone collected RAW images.

Training the Visual Recognition API

The Visual Recognition API service uses deep learning algorithms to identify items of interest. The API is trained to identify and classify the images to the required objective.

API can be trained to read images and classify images in terms of different classifications for example to detect corrosion, joints, previous repairs, leaks, valves and any other feature that could be of interest to discover.

To train the classifiers in the API we must initially present images that are positive in depicting the object of interest, then we present images that are not the object of interest.

For each image, the response includes a score for each class within each selected classifier. Scores range from 0 - 1 with a higher score indicating greater likelihood of the class being depicted in the image.

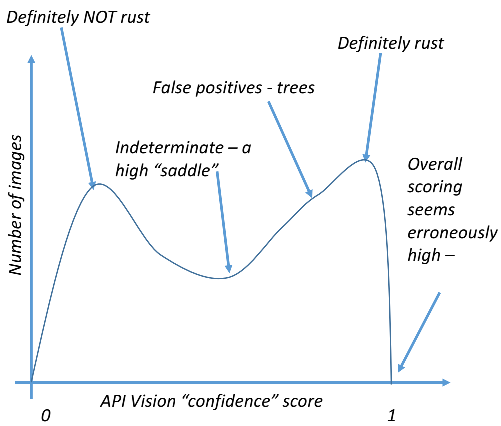
Figure II – A selection of Positive and Negative sample images on pipe

RESULTS

1. The use of AI to Identify corrosion from a series of Images of an above ground Pipeline:

First Training Run

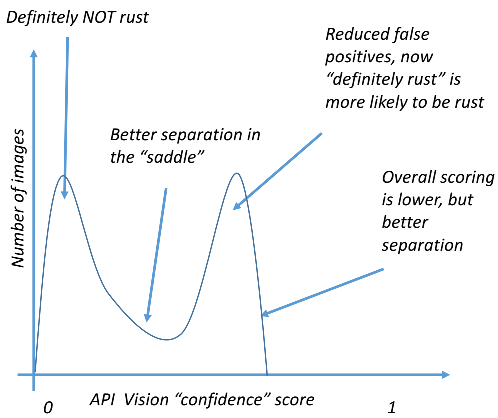
- Trained classifier on 123 positive rust images
- No negative training images
- Tested against a patch of rust – returns 0.999 confidence.
- Returned many false positives (roughly 0.70) for trees overhanging the pipeline
- Quite a weak "saddle" i.e. not clear delineation between positives and negatives
- Concluded more training the classifier on what to reject



** Note – histogram is a sketch / indicative, not precise graphing of results*

Second Training Run

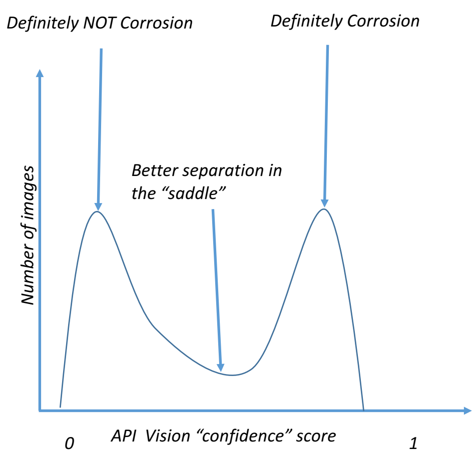
- Trained classifier on 150+ positive rust images, and ~1300 non-rust
- Overall scoring is lower
- Better separation of negatives and positives
- The previous false positives now are reduced – it is rejecting trees, red dirt, etc.



** Note – histogram is a sketch / indicative, not precise graphing of results*

Third Training Run

- Trained classifier on 18000+ positive rust images, and ~11300 non-rust
- Overall scoring getting higher the more data that is used for training
- Better separation of negatives and positives
- The previous false positives now are reduced – it is rejecting trees, red dirt, etc.



** Note – histogram is a sketch / indicative, not precise graphing of results*

2. Autonomously classifying an anomaly observed on pipeline images.

From the data set used for this project, the classifier identified that remediation repairs to the pipework was the most common anomaly present in the image data. To investigate the accuracy of the classifier to isolate an object of interest we used pipework repairs as the anomaly for the classifier to detect.

The classifier detects bands on pipes at a high confidence levels of 0.85 – 1.

Figure III – Remediation repairs on pipes

The classifier consistently detects concrete blocks as false positive matches with confidence levels between 0.8 – 1. It was concluded that the classifier will need to be trained further, with more training images to discreetly detect concrete blocks as a feature on pipe images.

Figure IV – Concrete blocks detected as false positive matches

A minor number of other false positive matches were detected which were caused by vertical shadows on pipes. Adding more training images to the classifier resolved this false positive match.

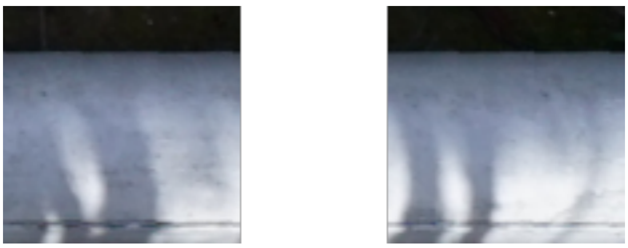


Figure V – Other false positive images

3.Identify the specific position and co-ordinates of the Corrosion or anomaly

The data was processed with meta data of the exact GPS position of the images and this could be correlated to the pixel on the data image, this enabled the exact position of the anomaly and corrosion to be specified.

Figure VI – Linear Anomaly Location Marking

This approach would enable the pipeline to be quickly benchmarked for incidence of corrosion and anomalies over its entirety, using the technique of "delta over time".

CONCLUSION

The research project highlighted a number of challenges and benefits of using the techniques described in this paper.

The use of drone technology to acquire the data was effective in creating a sample of data for this research project. It highlighted the pre requisite for high specification cameras and CASA certified operators. [3] However, to have effective autonomous inspection, the rules and regulations on the flying of drones only in line of sight of the operator, would need to be amended. There would be a real benefit in "delta over time" benchmarking of pipelines over a given time period. This would enable engineers to monitor corrosion propagation and anomalies and ensure the future remediation programs were effective and timely.

With regards to data processing and training of the "AI" API, there was a significant amount of effort in preparing the data for ingestion and subsequent continuous training of the API classifier. However, once the classifier had been trained to an acceptable level of accuracy the human intervention became low. We are investigating how to automate the real time ingestion of data directly from the data acquisition vehicle to feed the Visual API's more effectively and support autonomous inspection.

Whilst, the data images used in the research only reflect 1800 degrees of visual inspection from above, it was felt that the results depicted a useful representation of the corrosion and anomalies associated with the health of the pipeline. There is a risk that significant corrosion on the hidden 1800 degrees could be missed using this technique alone. The general conclusion of the research was that Artificial Intelligence could support the inspection of steel pipework for corrosion and anomalies. One of its benefits would be the ability to classify large amounts of data relating to vast geographical dispersed assets to support remediation programs. The technique would also add a health and safety value by reducing the amount of time required by personnel to be out in the field and any requirements to inspect at height or in difficult terrains.

The use of "Artificial Intelligence" via a "cognitive perceptive" API demonstrated the technology has the capacity to continuously learn and provide decision support to operations and productions. Therefore, in this piece of research, AI provided evidence that it has the potential to be Industries "Eternal Apprentice" supporting many engineering disciplines moving forward.

REFERENCES

[1] Kasey Panetta, Gartner's Top 10 Strategic Technology Trends for 2017, October 18, 2016

[2] Steve Brown, Altitude Imagery Sample Data Set, July 2016

[3] CASA, Remote Pilot Licence (RePL) and RPA operator's certificate (ReOC), September 29, 2016,

Research team contributors for this project:

Mathew Tan : IBM
Rory Costello: IBM
Joel Van Haastert: IBM
Steve Brown: Altitude
Ross Lewin: Outline Global
Anthony Roe: IBM

ARTICLE 3 – Is Virtual Reality a Waste of Time?

Owen Plagens, Ben Mckelvey,
Louisa De Vries and Saad Khan.Downer Rail

ABSTRACT:

Virtual Reality has yet to provide significant value for industrial applications, despite the benefits and savings having been confidently touted for decades. Inevitably following each proclamation, the critical discussion of realised value brought by adopting Virtual Reality technologies consists of an even split of optimistic futurists and pessimistic moderates. Other than applications in technical training (which are excluded from this paper), it is not clear how Virtual Reality can be integrated into current industry practices to provide a benefit. In other words, a two-dimensional interactive screen is better than or at least as good as a three-dimensional interactive screen in these cases. The only way benefits can be widely achieved through the use of Virtual Reality is to change current industry practices by revolutionising how work is done through automation, centralisation and smart systems. The more physically removed a person is from a manual task, the applicability of Virtual Reality technologies tends to increase. Conversely, the applicability of Augmented Reality technologies tends to increase for tasks requiring more manual human intervention. The exploration of uses, scenarios and design considerations of these technologies, collectively named Mixed Reality, for use in Asset Management are described.

Keywords: Virtual Reality, Augmented Reality, Mixed Reality, Asset Management, Maintenance, Automation, Smart Systems.

INTRODUCTION

Virtual reality (VR) has remained a 'future technology' for many industries since its earliest conceptions, where it was fundamentally a set of older technologies working together, namely computer graphics, human computer interfaces and simulation software [1]. Modern capability in these areas of computing allow today's virtual reality systems to provide real benefits to asset management and to Architecture, Construction and Engineering (AEC) in general [2-6], but in many cases to achieve the benefits, the VR systems become excessively complex in terms of processing power, physical set-up of the system, data analytics, data handling and data capture. Additionally, implementing VR into current work processes is a step-change, fundamentally changing the processes. The complexity of VR systems translates to heavy investment, with speculative returns on that investment. Ultimately, the development of VR systems capable of delivering on the promised benefits of the technology is stifled.

An augmented reality (AR) system is a more modular system compared to VR, since whatever data or information is available can be added to the real environment. Implementing AR into current work processes does not have to fundamentally change the processes. Gradual increases in data capture and data analytics capabilities should lead to increases in efficiency of processes as more interactivity with systems and on-demand information are made possible with AR technology.

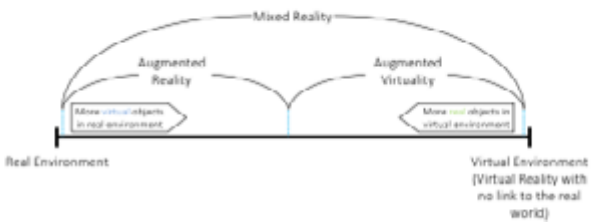
BACKGROUND

Virtual reality broadly describes an immersive environment that is interactive, computer-generated and three-dimensional [7]. This definition does not account for how representative the computer-generated environment is of reality, where data from sensors can be used to map real objects to the virtual environment. As such, the term 'virtual reality' has seen reduced use, where more descriptive terms have been favoured such as mixed reality, augmented reality and augmented virtuality, which take into account that some of the real environment is mapped to the virtual environment. For this paper, virtual reality is a virtual environment with some number of real objects accurately mapped to that environment, which can be updated through the use of new data measured of the real versions of the objects.

Augmented reality broadly describes a view of a real environment with superimposed computer generated graphics [8]. Rudimentarily, this includes head-mounted displays and heads-up displays, the latter of which has seen notable military use for decades [9].

Mixed reality is defined as a spectrum shown in Figure 1 with one extreme being a simple version of AR where the real environment is overlayed with minimal graphical content, and the other extreme a simple version of VR where the user perceives a computer generated environment with minimal mapping to objects in the real world.

Figure I – A definition of the mixed reality spectrum. AR is the overlay of computer generated objects on the real environment, and AV is the mapping of real objects onto a virtual environment [8].



Current tech and capabilities

There are a range of commercially available MR solutions. They are developed by various sized technology companies, from start-ups to Microsoft, Sony and Google. The cost of developing asset management capabilities on current platforms is typically not value for money, unless there is clear alignment to asset management objectives relating to the development of such expertise.

The limitations of current AR technology are:

1 Cumbersome headset

- No best practices framework for designing interfaces
- Controls/navigation
- Small field of view
- Processing power
- Battery life

In terms of hardware, the development of less cumbersome designs is a major factor in adoption of the technology. For software, research into how to design interfaces and responsive controls/navigation are critical for effective AR systems [10]. The opportunities made available by investing and developing on current AR solutions are mostly to develop in-house expertise in preparation of future generations of the technology.

The limitations of current VR technology are [11-13]:

- Ergonomics and human factors
    - o Vergence-accommodation conflict
    - o Short-term and long-term physiological effects
    - o Latency/ processing lag
    - o Depth perception
    - o Adaptation
    - o Fatigue and eye strain
    - o One size fits all
    - o Astigmatism and chromatic aberrations
- No best practices framework for designing interfaces
- Controls/navigation
- Download/upload speeds

The ergonomic and human factors limitations are compounded by findings that a non-trivial fraction of the population show adverse effects from using current VR systems [14, 15]. Additionally, a lack of guidelines for effective interface design in VR is a very large risk for developing on current VR technology. Fundamental improvements in VR technology are required to get value out of VR.

Training

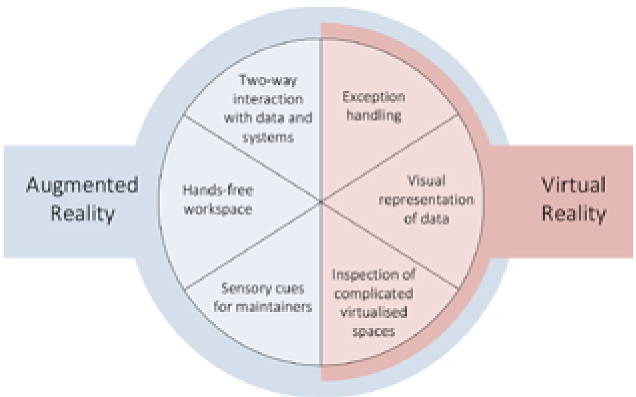
The industrial applications of Virtual Reality in a training context have been in practice for decades and have produced measurable benefits and value-add. VR training programs tend to be purely simulations, where virtual objects behave in a realistic manner, but do not map to an object in the real world. This means that the simulation behaves completely independent of the real world. The relatively low cost of off the shelf equipment, training software and scalability has meant immediate value for training and competency purposes and posed few barriers to introduction. The low barrier to entry, coupled with the ability to develop an exhaustive range of scenarios in a risk-free environment, has produced value through a reduction in operational risk with an increase in operational quality.

VR and AR have seen immediate impact in competency and training in rail and other heavy industry. The next step in maturity of Mixed Reality for these asset intensive companies and industries is to explore broader applications in the business for potential value-add.

GENERAL USES FOR MIXED REALITY

The uses of mixed reality technology for maintenance are shown in Figure 2. When employed for these functions, the respective technologies can bring value to asset management.

Figure II – The general uses of augmented reality and virtual reality systems for asset management.



Augmented reality allows those in close proximity to an asset to have increased awareness, control and access to information, but has diminished capability at a distance where it can mimic virtual reality, such as producing a model of a component on a real tabletop rather than in virtualised space. Virtual reality has limited capability for users in close proximity of an asset, where seeing the asset in person provides greater value, but through immersion of the user in an environment, can remove that person from the proximity of the asset and place them in a centralised location.

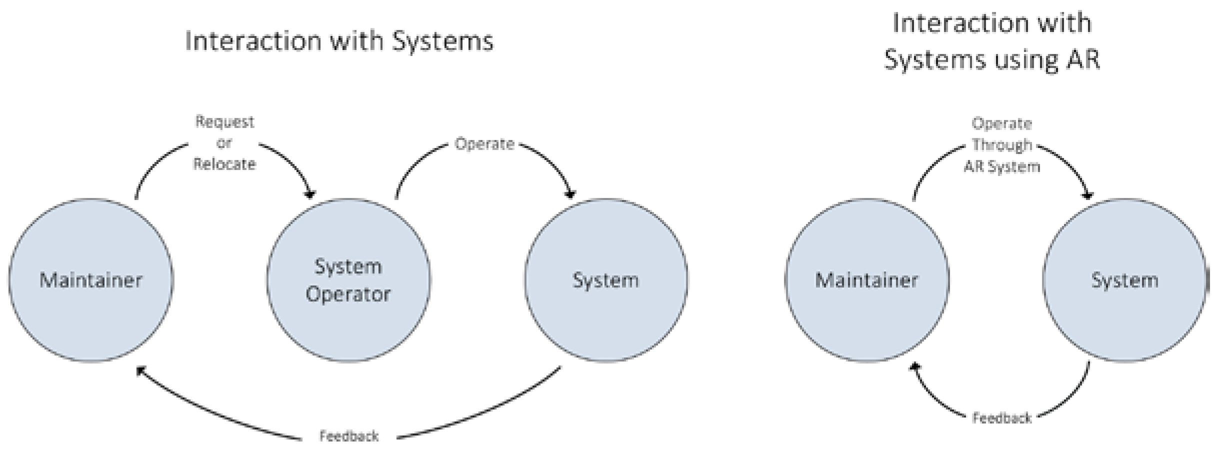
TECH 3

Two-way interaction with data and systems:

The potential value of large amounts of asset data comes from turning the data into information, making it accessible and interacting with appropriate systems. AR provides a platform for all interaction with data and systems for personnel working on assets as shown below in Figure 3.

An example is viewing a component's fault history and logging new faults.

Figure III – Interacting with systems using an AR system increases the efficiency of this type of task and adds value.



Hands-free workspace:

The platform provided by an AR system functions as a hands-free workspace, reducing or eliminating manual handling and delivery of data through integration with work management systems.

An example of this is having work orders and work instructions available to navigate and interact with while physically working on an asset.

There are multiple factors that limit the adoption of mobile devices in industrial spaces due to the inability to easily interact and hold a touch screen device. Much of this limitation stems from the manual nature of a lot of asset maintenance interventions, requiring gloves and/or resulting in dirty hands and surfaces. The hands-free workspace integrated into AR systems could leapfrog mobile tablet technology.

Additionally, mobile devices are often characterised as safety risks in high risk areas, requiring a user to not use them in a workplace or stop the task to utilise the device.

Sensory cues for technicians:

AR has huge potential to increase the efficiency, quality and safety of maintenance tasks by providing visual and audio cues. These cues provide additional information to users at the right time and the right place to aid in the asset management intervention and/or provide a safer environment to undertake the intervention.

Some examples are personnel being alerted through sounds and visuals that:

- particular circuits or components are electrically live
- particular hatches were flagged as open by automated inspections
- specific components need change out or attention, with the specific components visually highlighted.

Exception handling:

The ability to handle exceptions is largely fault finding and the subsequent remedy of the fault. The value of AR to fault finding is to provide various asset data to inform the fault finding and intervention process to those within proximity of the asset. VR can provide the same value with remote exception handling, through bringing all condition and contextual data to experts at a centralised location and providing fault finding knowledge back to the asset location.

Exception handling also applies to the management of quality, where an AR system is able to identify and provide notification in real-time if a technician has performed work to an inadequate quality.

Visual Representation of Data:

Displaying many sets of data simultaneously is typically limited by computer screen size. With AR and VR technology, this limitation is greatly reduced, where the screen size is essentially one's field of view. Additionally, the ability to organise the information can be greatly enhanced by visualising information in any part of a 3D virtual space.

An example is to have a customisable virtual workspaces with multiple dashboards positionable anywhere in space.

Inspection of complicated virtualised space

The inspection of real spaces mapped to virtualised space has value over physically walking through a site. The main benefits are:

- able to do inspections or work without the person being in close proximity to assets, removing safety risks
- Control over perspective and filtering of the environment, such as 'flying' or eliminating walking time between assets distributed across a site.

An example is remote site inspections for safety issues and anomalies in a virtualised copy of a site using a combination of spatial measurements such as satellite data and LIDAR models.

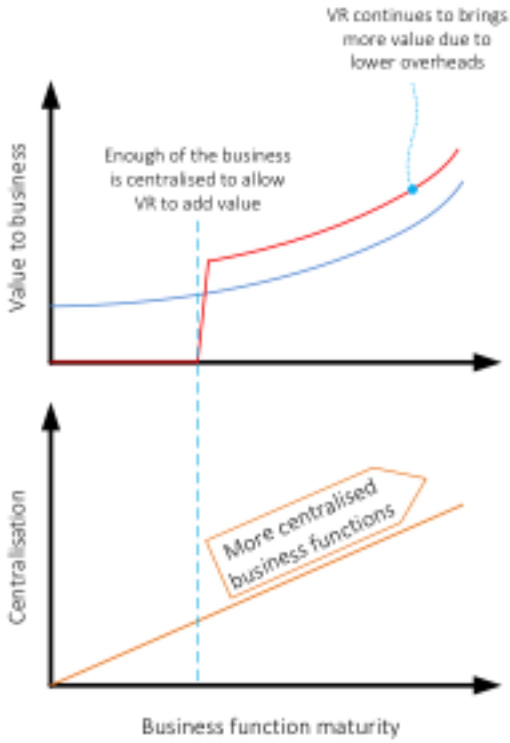
FACTORS AFFECTING VALUE OF AR AND VR TECHNOLOGIES

The context of the diagrams in this section is the application of AR and VR technologies to a large industrial asset management organisation with long asset lifecycles requiring significant maintenance regimes. Additionally for VR, there is an assumption that the people interfacing with the VR system are located far from the asset, and for AR, the people interfacing with the AR system are in close proximity to the asset.

Centralised business model

The more centralised a business is, generally more value can be provided by AR and VR technologies. The value from AR comes from the enhanced efficiency and accuracy of technicians through the aid of sensory cues, a responsive hands-free workspace and interaction with asset data and systems. For VR, there is a threshold to be passed for centralised business functions around assets to enable VR to become relevant, where the need to have a team of engineers in the proximity of the asset can be completely replaced by a smaller team of engineers located a non-trivial distance away from the assets.

The value brought by VR technologies is seen to be greater than that of AR for highly centralised businesses due to the inherent lower overheads associated with centralising, where one user can coordinate activities at multiple locations with virtualised environments.



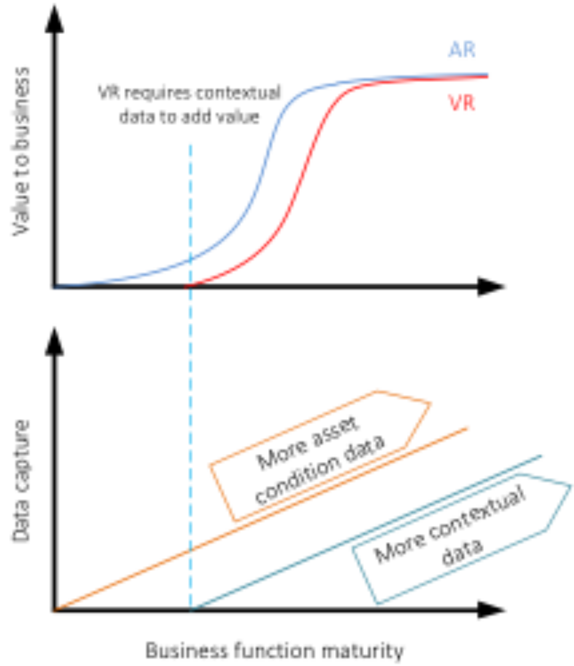


Figure IV – Effect of centralised business functions on value of AR and VR systems.

Figure V – Effect of data capture on value of AR and VR systems.

Data capture

The more high quality data captured, the more value can be provided by AR and VR technologies. The lag of VR behind AR is due to the need for contextual data around an asset to enable virtualisation of the environment around the asset. An example of contextual data would be updated 3-D scans of a site for VR-based inspections, rather than walking around the actual site to do an inspection in person. This contextual data is relatively much harder to capture than asset condition data, which enables AR applications.

The rapid increase in the value of AR and VR technologies comes from reaching a critical amount of quality data being captured, allowing interaction with the data to greatly improve work done. Prior to this critical amount, not much can be done with the small amount of data leading to little value being gained. Increased data captured past the critical amount has diminishing returns on value as there are fewer value add activities left.

Corrective and preventative maintenance

As a business matures, the amount of corrective maintenance should tend to decrease and the preventative maintenance should tend to increase. The value of AR and VR decreases, since both derive some value from corrective maintenance activities though enhancing fault finding processes. Where the amount of corrective maintenance carried out falls very low, AR retains value due to providing sensory cues and a hands-free workspace for those in the proximity of assets.

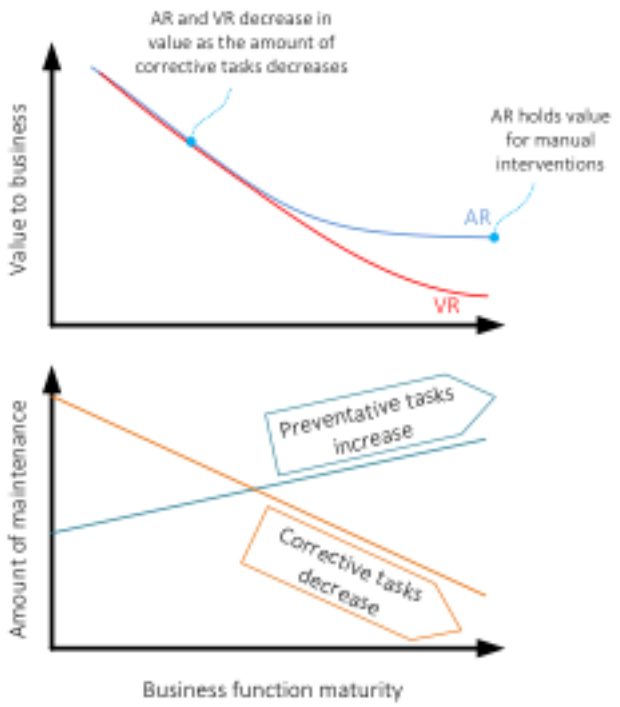


Figure VI – Effect of amount of maintenance tasks on value of AR and VR systems.

Automation

As a business increasingly adopts automated inspections, AR and VR become increasingly useful as they allow more efficient monitoring and management of activities and assets based on data from the inspections. The automation of activities reduces the value of AR as the need for manual tasks decreases. The value of VR is maintained as the automated tasks can be monitored and managed at a centralised location.

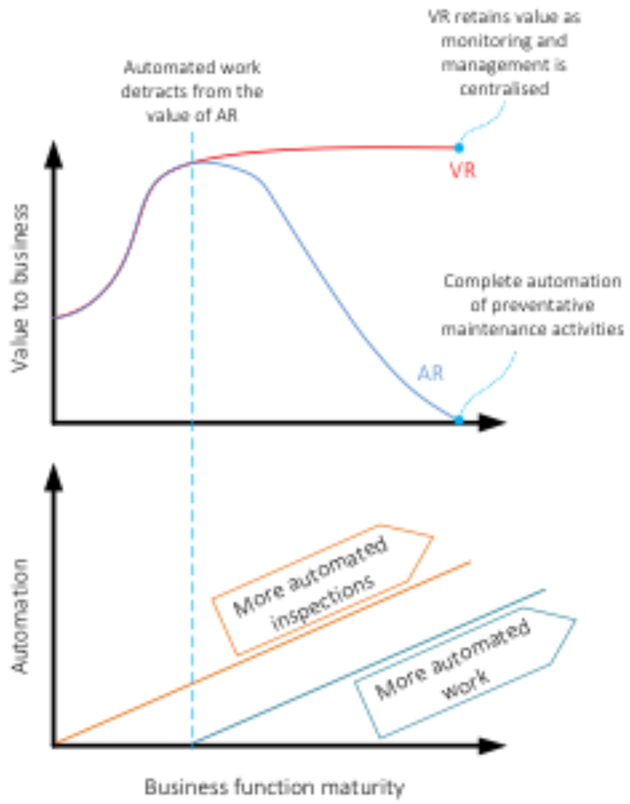
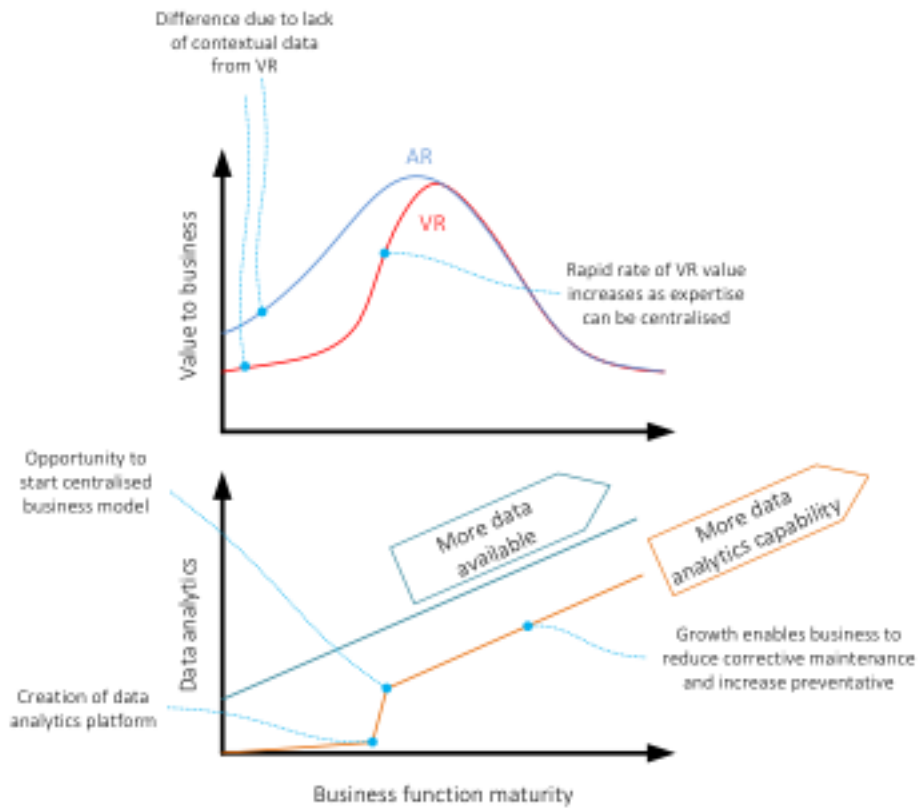


Figure VII – Effect of automation of inspections and work on value of AR and VR systems.

Data analytics

As more data becomes available, it becomes necessary to use a dedicated data analytics platform. The transformation of data into information using data analytics increases the value of AR and VR; however, as the capability of data analytics further increases, the reduction in corrective maintenance reduces the value AR and VR technologies.

Figure VIII - Effect of data analytics capability on value of AR and VR systems.



Knowledge of asset

With little knowledge of an asset, failures are unlikely to be predicted and those working in proximity of the asset don't know in advance what needs to be done. With great knowledge of an asset, the opposite is true. The value of AR and VR increases with increased knowledge of an asset because these technologies enable more effective fault finding and decision making based on data. The drop in value for both AR and VR when there are mature processes and knowledge of assets, stems from the decrease in effort required for successful fault finding.

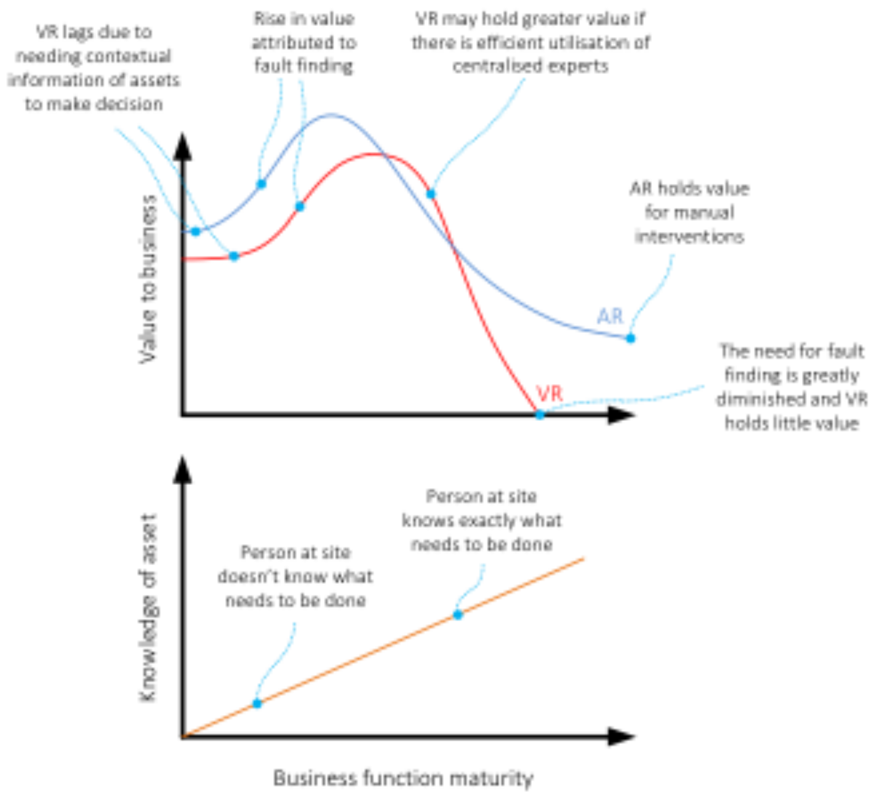
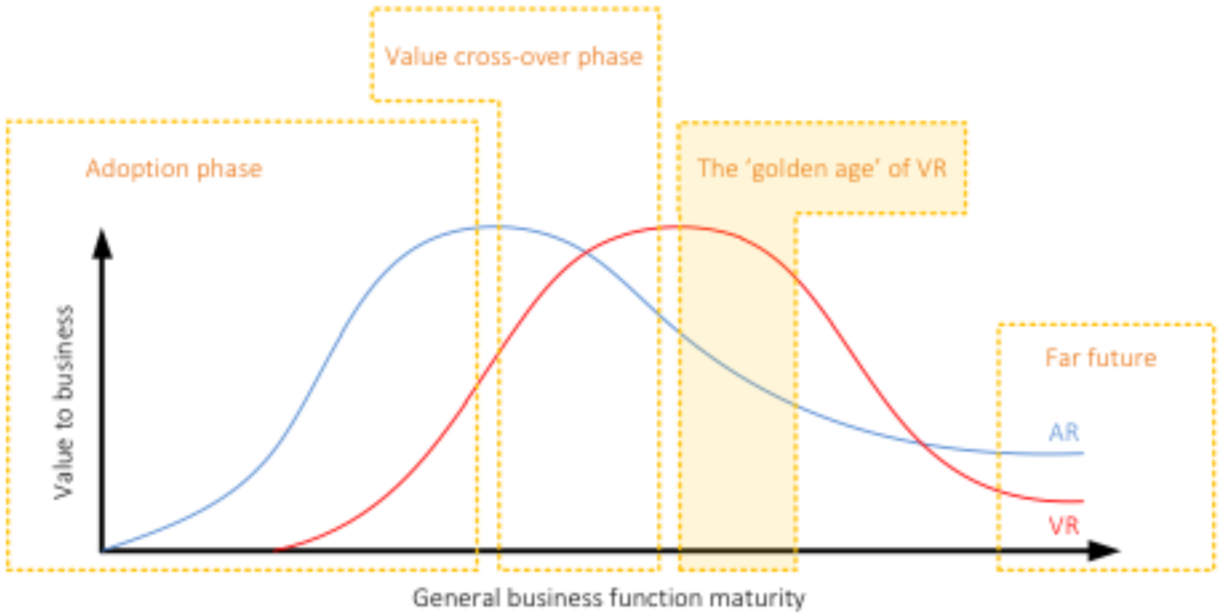


Figure IX – Effect of knowledge of assets on value of AR and VR systems.

OVERALL VALUE OF AR AND VR TECHNOLOGIES

The value of AR and VR technologies depend on the combination of effects described above, collectively, the overall maturity of business functions.

Figure X - Potential value of AR and VR technologies as business function maturity increases.



Adoption phase

At low business function maturity, the value curves shows AR having immediate value, while VR only begins to provide value once more maturity is achieved. This is due to multiple factors all limiting the value of VR, while not limiting AR and allowing AR to provide immediate business value. Business centralisation, data capture, data analytics, asset knowledge all contribute to limit the business value of VR systems for lower maturity businesses.

For example, small amounts of configuration management data can be immediately useful to technicians with an AR system by validating the documented configuration of an asset portfolio.

Far future

For highly mature businesses more value is gained from AR from a combination of Corrective and Preventative maintenance and Asset Knowledge drivers. In high preventative/low corrective maintenance regime, manual asset interventions are still required for preventative tasks, retaining value for AR systems due to provide sensory cues and a hands-free workspace.

Both VR and AR theoretically will ultimately reduce their business value to zero. Asset knowledge will ultimately reduce the value of VR systems to zero, while automation will reduce AR to zero. These two factors are ambitious end goals in Asset Management, requiring highly mature organisations with multiple mature business functions to attain 'complete' automation and 'complete' asset knowledge. Therefore, reducing the value of AR and VR systems to zero will occur in a very long outlook of business maturity growth.

Value cross-over phase

The range of business maturity where the value of VR grows as the value of AR diminishes stems from a combination of factors from Automation, Asset Knowledge and Corrective and Preventative maintenance maturity. Increasing automation maturity is the major driver in producing the disparate growth rates of AR and VR. In particular, the asset interventions where AR offers value tend to be removed through automation, such as removing and replacing modular components. Conversely, VR retains its value as task automation has little to no effect on VR value activities and uses.

The 'golden age' of VR

The 'golden age' of VR occurs at the specific combination of business maturity, where the business:

- Is centralised enough to remove technical expertise from the location of the asset
- Has a data analytics platform, with enough asset and contextual data
- Still performs significant corrective maintenance
- Has a level of automation and process to remove the need to have technicians do significant planned work on the assets (decreasing the value of AR)
- Has not too much asset knowledge to still require exception handling capabilities from VR technology.

CONCLUSION

In comparing VR and AR technology for various levels of business function maturity, the authors found that the business value provided by each respective technology changes as business functions mature. The value of VR and AR to maintenance applications is very dependent on the capabilities of systems and how data is handled. Only a specific combination of maturity across business functions renders VR or AR as a large value-add. Maturity in centralised functions, distance from asset of those functions, capability to capture contextual data, ability to perform data analytics and the maintenance regime (weighted towards corrective vs preventative) of a business are key factors in determining which technology will provide better value for investment.

Ultimately, AR provides greater value for businesses with lower levels of maturity in data analytics and centralised functions as well as retaining value as asset knowledge of a business matures. As a result, over the lifetime of a business, AR is able to provide greater total value.

REFERENCES

[1] Bouchlaghem N., Thrope A., and Liyanage I. G., Virtual Reality Applications in the UK's Construction Industry, CIB Report, 1996.

[2] Wang X., and Dunston P., A User-Centred Taxonomy for Specifying Mixed Reality Systems for AEC Industry, Journal of Information Technology in Construction, 2011.

[3] Nee A., and Ong S., Virtual and Augmented Reality Applications in Manufacturing, Saint Petersburg, Russia, International Federation of Automatic Control, 2013.

[4] Nolle S., and Klinker G., Augmented Reality as a Comparison Tool in Automotive Industry, IEEE Computer Society, 2006.

[5] Lee J., Han S., and Yang J., Construction of a Computer-Simulated Mixed Reality Environment for Virtual Factory Layout Planning, Computers in Industry, 2010.

[6] Tatic D., and Tesic B., The Application of Augmented Reality Technologies for the Improvement of Occupational Safety in an Industrial Environment, Computers in Industry, 2016.

[7] Amin D., and Govilkar S., Comparative Study of Augmented Reality SDK's, International Journal on Computational Sciences & Applications, 2015.

[8] Milgram P., and Colquhoun H., A Taxonomy of Real and Virtual World Display Integration, Mixed reality: Merging real and virtual worlds, 1999.

[9] Rosenberg L., The Use of Virtual Fixtures as Perceptual Overlays to Enhance Operator Performance in Remote Environments, Stanford University Ca Center for Design Research, 1992.

[10] Dunston P., and Wang X., Mixed Reality-Based Visualization Interfaces for Architecture, Engineering, and Construction Industry, Journal of Construction Engineering and Management, 2005.

[11] Kruijff E., Swan II J., and Feiner S., Perceptual Issues in Augmented Reality Revisited, IEEE, 2010.

[12] Lambooij M., IJsselsteijn W., and Heynderickx I., Visual Discomfort in Stereoscopic Displays: A Review, International Society for Optics and Photonics, 2007.

[13] Wann J., Ruston S., and Mon-Williams M, Natural Problems for Stereoscopic Depth Perception in Virtual Environments, Vision Research, 1995.

[14] Stanney K., Kennedy R., and Drexler J., Cybersickness is not Simulator Sickness, CA: SAGE Publications, 1997.

[15] Kennedy R., Lane N., Berbaum K., and Lilienthal M., Simulator Sickness Questionnaire: An Enhanced Method for Quantifying Simulator Sickness, The International Journal of Aviation Psychology, 1993.

King Bolt through split Cross-arm

Determining Asset Inspection Reliability using Bayesian Statistics

Mike Schulzer CFAM

INTRODUCTION

The background to this paper is the work undertaken by Asset Management Engineers in the attempts to improve the efficiency of timber pole inspections, in particular the strike rate for correctly selecting timber poles for condemnation. The engineers considered various statistical approaches, such as the age of the pole, its location, the type of timber, the preservation treatment, and research into various types of condition monitoring technologies.

The current method of assessment is to drill into the pole at ground level and measure the depth of "good wood," to determine if there is sufficient to ensure the pole meets strength standards. An obvious criticism of this approach is that it is not entirely "non-destructive," however of more concern was that when a number of condemned poles were removed and sectioned for post-mortem analysis, a very high proportion was found to meet strength requirements.

This raises the question, how good it pole inspection by drilling, and are there technologies that provide superior results? The reader will recognise that this is a common problem with asset management, wherever a large number of similar assets, subject to deterioration, need to be inspected at regular intervals, and replaced prior to catastrophic failure.

Bayesian statistics can help resolve this problem.

THOMAS BAYES

Thomas Bayes was born in London, England in 1701 or 1702, the son of a Presbyterian minister. From 1719 to 1722 he studied logic and theology at the University of Edinburgh, after which he assisted his father in a chapel in London. In 1734 he moved to Tunbridge Wells, Kent, where he worked as a minister till 1752.

In his lifetime, Bayes is known to have published "Divine Benevolence", or, "An Attempt to Prove That the Principal End of the Divine Providence and Government Is the Happiness of His Creatures (1731) and An Introduction to the Doctrine of Fluxions", and a "Defence of the Mathematicians Against the Objections of the Author of The Analyst" (1736). He published the latter anonymously and countered the attacks by Bishop George Berkeley on the logical foundations of Sir Isaac Newton's calculus.

Bayes was elected a fellow of the Royal Society in 1742.

It was in his later years that Bayes became deeply interested in probability however he never published what would become his most famous accomplishment. His notes were edited and published after his death by Richard Price.

He became quite ill by 1755 and died in Tunbridge Wells in 1761. (Wikipedia, Thomas Bayes, 2019, and Encyc. Brit. 2019)

BAYES THEOREM

Bayesian analysis had been established long before the now more familiar frequentist statistics that was developed in the early 20th century. Bayes' theorem (alternatively Bayes' law or Bayes' rule) describes the probability of an event, based on prior knowledge of conditions that might be related to the event. For example, the main bolt holding a cross-arm to a pole (king bolt) is often dangerously rusted, but the rust is not visible without removing the bolt for examination, an expensive, time-consuming job. Most of these rusted king bolts cause the cross-arm to split, which is a useful indicator, visible from the ground. Bayes' theorem provides an analysis of how much more accurately an indication of a split in the cross-arm can be used to assess the probability that the king bolt through it is rusted, compared with not knowing the condition of the cross-arm.

Bayes theorem states the following:

$$P(A|B) = \frac{P(B|A) \times P(A)}{P(B)}$$

P(A|B) is the likelihood of event A occurring given B is true e.g. a king bolt is is actually rusted, given that the cross-arm is split.

P(B|A) is the likelihood of event A occurring given B is true e.g. the cross-arm is split when the king bolt is actually rusted. (80% of rusted bolts split the cross-arm)

P(A) is the likelihood of event A e.g. a rusted king bolt. (Say 1% of all kingbolts)

P(B) is the likelihood of event B e.g. a split cross-arm. (We know from previous work that 9.6% of good bolts are in split cross-arms, so the total number of split cross arms is 1% x 80% + 99% x 9.6% = 10.304%)

So substituting numbers for variables,

P(A|B) = 80% x 1% / 10.308% = 7.76%

By checking for split cross-arms, we have improved our chance of finding a rusted king bolt by a factor of 7.76.

How accurate is the test?

If the reader now considers the scenario presented in the introduction regarding pole inspections, how is it possible to estimate the accuracy of the pole drilling test?

Forensic examination of condemned poles by sectioning after delivery to the depot provides a successful strike rate P(A|B) of 3 out of 10 poles. For every 10 poles replaced, only 3 are truly deteriorated to the point where replacement was necessary. Engineers estimate that the quantity of faulty poles in the population P(A) is about 2%

The number of good poles wrongly selected from a faulty test = P(Good) x (1-P(test))

The number of bad poles correctly found from a true test = (1-P(Good)) x P(test)

The ratio of good poles to bad poles found from inspection is

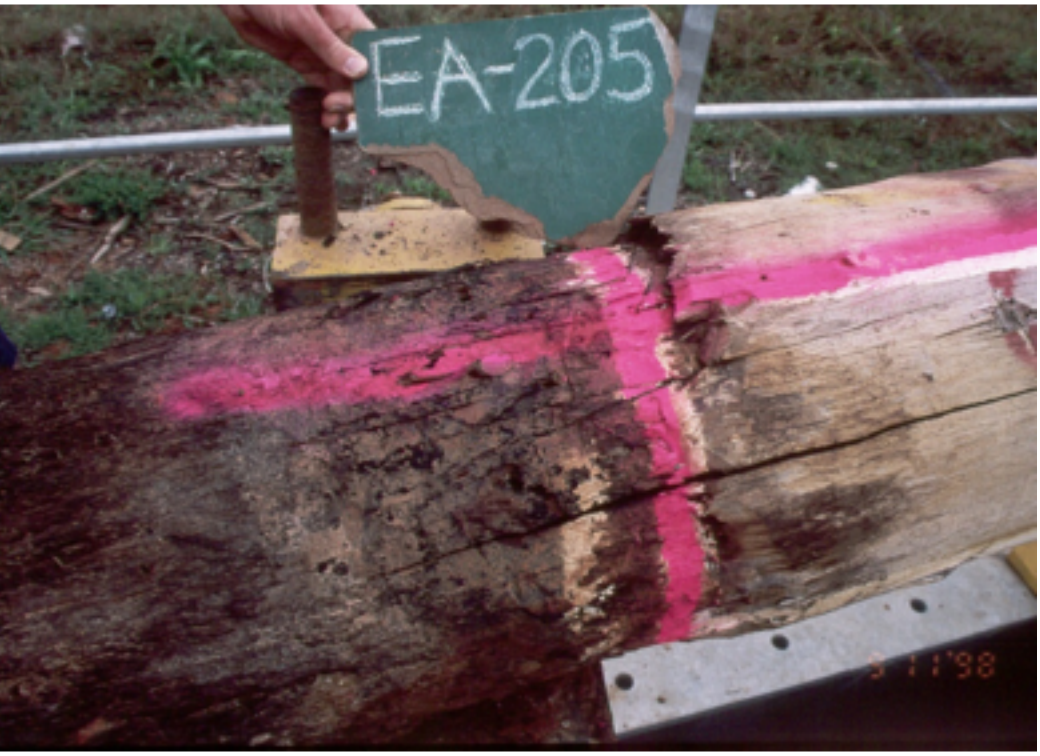
$$R(Good/Bad) = \frac{P(Good) \times (1-P(test))}{(1-P(Good)) \times P(test)}$$

Solving for P(Test)

P(Test) = P(Good)/[R(Good/Bad) x (1 – P(Good) – P(Good)]

Substituting Numbers

P(Test) = 98% / [(7/3) x (1 - 98%)+ 98%] = 0.9545



Condemned pole ready for further inspection

Pole sectioned to reveal extent of good wood

Using this result in a tree diagram:

100% poles

- 98% Good
  - 95.45% True Test -> 93.54% Good poles with true test
  - 4.55% False Test –> 4.455% Good poles falsely tested as bad
- 2% Bad
  - 95.45% True Test -> 93.54% Good poles with true test
  - 4.55% False Test –> 4.455% Good poles falsely tested as bad

Out of 100% of poles inspected 6.364% are condemned, and out of those, 30% are bad poles, and 70% falsely condemned good poles, and 0.089% of bad poles are falsely tested as good. This is with a test accuracy of 95.45%!

CONCLUSION

This research confirms the already well established observation that where the ratio of defective items in a population is very low, unless the test is extremely accurate, there will be a high ratio of good items that are falsely tested as defective. It is important that this principle is understood, to consider what if anything can or should be done about that. Suggested alternatives are:

1. Conduct research to find a more accurate inspection/testing process. This may involve more advanced technology, or better processes supported by adequate training.
2. Subject condemned poles to a more rigorous, and possibly expensive test prior to replacement. This is an approach used in the medical field, for example a prostate specific antigen (PSA) blood test to screen for prostate cancer, where a low cost test is use to narrow the probability, and detailed, more invasive biopsy tests are uses to weed out false positives (The Royal Australian College of General Practitioners, 2015).
3. Consider if it is possible to reuse, or cannibalise assets that have been falsely condemned.
4. Replace the assets that are subject to failure with those having a more advanced technology. For example, replacing timber poles subject to rot with concrete poles.
5. Adjust business expectations and budgets to account for the expected level of condemnation of sound assets.

Further research could be carried out to determine the practicality of the second point, since less than 5% of poles tested return a false positive.

REFERENCES

Encyclopaedia Britannica, 2019 Thomas Bayes English Theologian and Mathematician, viewed 14 January 2019, **<https://www.britannica.com/biography/Thomas-Bayes>.**

Wikipedia 2019 Thomas Bayes, viewed 14 January 2019, **<https://en.wikipedia.org/wiki/Thomas_Bayes>.**

Wikipedia 2019, Bayes' theorem, viewed 14 January 2019, **https://en.wikipedia.org/wiki/Bayes%27_theorem**

The Royal Australian College of General Practitioners (2015), "Should I have prostate cancer screening?" 100 Wellington Parade, East Melbourne Victoria 3002.

Remotely Piloted Aircraft (RPA) for Cost Efficient and Safe Building Façade and Roof Inspection to Support Asset Management Decision Making

Dr Julie-Anne Latham1, Dr Frédéric Blin1
[1]AECOM, Docklands, Australia

SUMMARY:

Obtaining useful information on the condition of assets is critical to decision making. However, this can be challenging when the information on asset components such as building roofs and façades cannot be easily collected.

Traditional methods of close visual inspection of building roofs and façades of multistory buildings typically involve rope access, elevated work platforms (EWPs) and/or swing stages. Each of these methods involves high risk working at heights. In addition, there can be logistical limitations including greater mobilisation times, larger work crews, and landscape limitations (for EWPs). Ropes access and swing stages typically require roof access and anchors, which are not present on many older buildings. Trees, stairs and uneven ground can prevent the use of EWPs. Without these methods inspections are often undertaken on foot from street level, in which case the roof cannot be viewed (unless it is pitched) and the view of the façade is skewed or must be viewed from a distance either unaided, with binoculars or a high zoom camera lens. If building congestion is high, then much of the façade is not viewable at all.

Remotely Piloted Aircraft (RPA) can minimise many of the issues raised above. RPA can have quick mobilisation, are typically unaffected by terrain and do not require any special access requirements. Most importantly, they remove the safety risk of deploying personnel at height.

However, there are still some pitfalls in the use of RPA. The quality of footage captured, and how, is paramount to a successful outcome. We have found that a combination of resolution, flight height, angle of photography, weather conditions, still photos versus video, have a big impact on outcomes.

This paper outlines practical lessons learnt from the use of RPA for the collection of roof and façade data to assist with asset management decision making.

Keywords: RPA, UAV, drone, inspection, building, façade, roof

INTRODUCTION

Inspection of building façades and roofs is traditionally undertaken using personnel working at heights. This is either by use of elevated work platforms (EWPs), swing stages or ropes access. This is high risk work and is often costly, resulting in close inspections being undertaken irregularly. Often façade inspections (and sometimes roof where the pitch makes it partially visible) are undertaken from ground level as this significantly reduces the safety risks and cost. However the quality of the inspection is often compromised by the ability for the inspector to identify defects and other issues from a distance, even with the aid of binoculars or a high-zoom camera.

Inspection using remotely piloted aircraft (RPA) has become more popular as it addresses the issues posed above for the different techniques:

1) It eliminates the need for personnel working at heights and is relatively cheap; and

2) It provides high quality footage and allows close photography unaffected by skewed viewing angles experienced from ground level.

However, the commercial use of RPA is highly regulated and also introduces new safety and quality challenges that must be considered before undertaking building inspections with this technique. How these challenges are managed will have a direct impact on how useful the information obtained is for assisting asset management decisions. This paper provides practical lessons learnt during visual inspections that have been undertaken of buildings using this technology and recommendations to manage these challenges to obtain quality outcomes.

WHAT ARE REMOTELY PILOTED AIRCRAFTS (RPA)?

RPA, also known as unmanned aerial vehicles (UAV) or drones, are small aircraft that are remotely operated by a pilot. They come in two main types: fixed wing (like a standard airplane) and multirotor rotary wing (Figure 1). RPA can be further separated by grade, including military, recreational, public and commercial [1]. Like many new technologies, RPA were originally developed for the military, which has a long history of use of these vehicles. In the last decade RPA have become more widely available as a result of considerable drops in prices. Between 2016-2021 the U.S. Federal Aviation Administration (FAA) expects number of consumer drones to increase from 1.1 million to 3.55 million, with commercial drones to increase from 42,000 to 442,000 [2]. Globally the drone business market is expected to exceed US$84 billion by 2025 [3].

Figure 1 – Rotary wing RPA – DJI Mavic Air used to capture images in this paper

RPA INSPECTION METHODOLOGY

Flights of RPA in Australia must conform to current CASA (Civil Aviation Safety Authority) guidelines of safe flight, in line with the Civil Aviation Regulations, 1998 [4]. These include the following main restrictions (unless special exemption is obtained):

- RPA must not operate within 30 m of people (this does not include the operators or those working with the operators)

1. RPA must not operate above 120 m (40 ft)
2. The RPA must be within the line of sight of the pilot at all times
3. RPA must only be flown during the day
4. Not within restricted airspace or 5.5 km from a controlled aerodrome.

Of these requirements, we have found that for building inspections the first point typically requires the most attention to ensure safe operation during inspections. Exclusion zones must be set up at the RPA take-off/landing site and along the flight path where the RPA is flying directly over the ground where people may be exposed. This introduces difficulties associated with:

- Entry and exit points of the building that must remain operational during the inspection (e.g. main entrances). Where the flight path requires that the RPA fly over a point of entry/exit to the building (typically due to line of sight requirements by CASA or to ensure adequate photography for inspection) the timing of the flight and location of take-off and landing must be organised for each entry point to ensure that they are only obstructed for a short period of time. This can increase the complexity and amount of time the inspection takes.
- Non adherence of public and personnel to erected physical barricades or instruction by spotters. Our experience undertaking inspections of buildings in public locations has found that spotters are always required in addition to any physical barrier around the flight exclusion zone. Often despite the erection of bollards and tape, people will enter flight areas unless directly approached by another person instructing them not to.

Line of sight requirements with the RPA mean that large roofs cannot be inspected in a single flight and multiple take-off and landing sites (and therefore additional exclusion zones) must be set-up to capture the entire surface. In addition to the regulatory challenges, RPA are also affected by weather conditions and are unable to fly in rain or high winds (maximum winds for flight will vary based on the specific RPA).

Flight times of RPA can vary, but for the rotary wing RPA typically used for these inspections flight times are usually between 15 and 30 minutes in duration. High wind speeds on the day of inspection will also reduce the maximum flight time (e.g. the DJI Mavic Air, featured above, has a 21 minute flight time when free of wind). Therefore it is important that spare batteries and charging facilities are available.

The time to complete the inspection will depend on the style of inspection; however inspection of the façade and roof of a large building can be completed in half a day – depending on the complexity of the building. Large and complex roof areas can typically be completed within a couple hours. Simple roof areas may be completed within half an hour.

BENEFITS OF USING RPA OVER TRADITIONAL METHODS

There are a number of key benefits of using RPA for asset inspections, including:

1. **Removes the hazard associated with personnel working at height:** Alternate inspection methods for façade and roofs include elevated work platforms (EWPs), swing stages and ropes access. All require high risk working at heights.
2. **Not affected by layout of roof:** Many buildings have complex roof layouts, such as multiple wings and roof levels, as well as uneven roof pitch and limited access locations. This will make use of swing stages and ropes access more complicated and time consuming. In addition, many older buildings have no roof access or anchor points to allow for ropes access or swing stages to be used.
3. **Not affected by landscaping:** EWPs are restricted by terrain and landscaping as they have limited capacity to work safely on slopes, cannot move over stairs and are obstructed by trees surrounding the building. While access via ropes and swing stages are less affected they also have limitations particularly where vegetation is in close proximity to the building. While trees close to the building will also impact the flight pattern of the RPA and the extent of façade that it can accurately capture, this can normally be worked around to limit the impact on the condition assessment outcomes.
4. **Full record of asset captured:** During a traditional inspection photographs will only be captured of points of interest, such as defects, which are at the discretion of the inspector on site. The RPA flight path and video and/or photographing sequencing can be scheduled to give complete façade and roof coverage.

5. **Fast Inspection:** Inspections can be completed in a number of hours as opposed to a number of days. While desktop inspection of the photos this still only adds a few hours (however, this may be removed entirely with the ongoing sophistication of visual recognition and machine learning tools).
6. **Relatively Inexpensive:** Partially due to the efficiency of the method, RPA inspections are significantly less expensive compared to use of ropes, EWP and swing stages (sometimes by 40 to 70%, depending on the specific building and location).

LIMITATIONS OF USING RPA OVER TRADITIONAL METHODS

Despite the significant benefits, there are some limitations of using RPA for inspections:

1. **No physical contact:** When undertaking an inspection via ropes, swing stages and EWP the inspector often has the ability to touch the structure. This can be useful for assessing safety of architectural features (e.g. loose fixings).
2. **Inconclusive features:** Is that a crack, spider web or dirt? Sometimes identifying features using only photography can be difficult. While this issue is sometimes also encountered using the other methods, movement in viewing angle of the inspector and use of tools or their hands can often immediately remove any confusion.

In addition to the two points above, adherence to the Civil Aviation Regulations may mean that RPA cannot be used in some locations (e.g. restricted airspace).

IMPORTANT THINGS TO CONSIDER WITH RPA INSPECTION

Still Photography vs. Video Capture

The use of still photography or video capture may come down to preference. Video has the advantage of allowing context by moving through various time points; however, it has some very significant disadvantages:

- Pausing the video in a media player may result in blurred stills
- Revisiting the footage and finding the exact point can be difficult
- Review of the footage is often slow and very time consuming.

Still photography allows for quick review of images for any points of interest and individual photos can be easily referenced for later. Context of the photo (i.e. where is it) can still be gained by moving through previous photos, assuming the entire surface is captured. In addition, capture of still photography allows for stitching (creating one large image out of multiple single photos) and photogrammetry (creation of 3D models of an asset).

Video footage will also be gathered at a lower total resolution than still photos from the same camera. For example, a 12 MP camera that captures HD and 4K video will capture 4256 x 2832 pixel stills vs. 1920 x 1200 pixel and 4096 x 2160 pixel video, respectively. High resolution video will also take more storage space and 4K video requires internal storage or external SD cards that can write at ≥ 100 MB/s.

Flight Height and Camera Resolution

The camera resolution and height that the RPA flies at will determine the time it takes to complete an inspection as well as the level of detail in each photo. Therefore, prior to an inspection it is important to know the level of detail required in order for the photography or video footage obtained to be useful. This may mean that the RPA has to be flown closer to the building or that a better camera is required to undertake the inspections.

Figure 2 shows examples of photos taken of the same bolt on a portion of steel roof at progressively increased heights taken with a 12 MP camera. This visually demonstrates the change in visible detail as the RPA is moved further away.

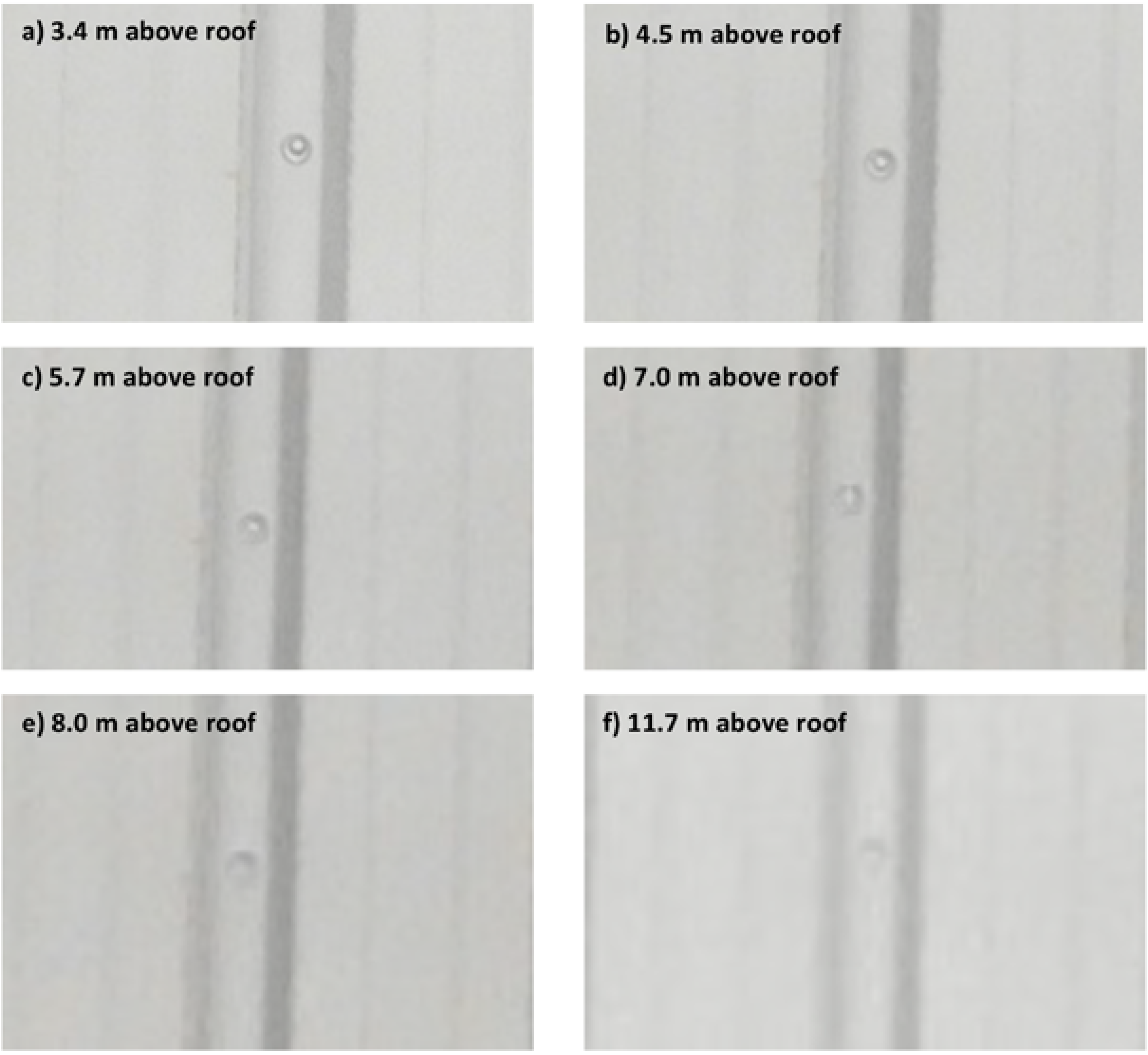


Figure 2 – Image cropped image of the same portion of roof at progressively increased heights taken using 12 MP camera on DJI Mavic Air: a) approximately 3.4 m above roof surface; b) approximately 4.5 m above roof surface; c) approximately 5.7 m above roof surface; d) approximately 7.0 m above roof surface; e) approximately 8.0 m above roof surface; f) approximately 11.7 m above roof surface.

Flying closer to capture required detail will also significantly increase the number of photos required to cover an asset. This increases the burden on the person reviewing photos, but also on data storage.

Larger cameras need a larger RPA to carry them and these will typically cost more to hire. Therefore a compromise between cost, performance and time must be made. Typically, defining the size of artefacts required to be captured by RPA contractors is sufficient for them to be able to determine the most suitable equipment to undertake the work.

Roof Pitch

For roof inspections many RPA contractors undertake automated flights using third party software that allow flight paths to be created and followed by the RPA. The RPA will then automatically take photos that cover the entire roof. The automatic flight will produce bird's eye photos and if the roof has any pitch the lower part of the roof will appear smaller than the highest point. If the roof is small or has a minor pitch this may not make a significant difference, however for large or highly pitched roofs this distorts the appearance of the roof surface (as lower areas appear further away) as well as resulting in loss of detail at lower areas.

This can be avoided by matching the angle of the camera to the roof pitch when taking photos and as a result the RPA will need to be flown manually. Figure 3 shows the appearance of a small roof with an approximate 22 degree pitch. A view of the same area of roof with the camera matching the roof pitch is shown in Figure 4.

Photo Exposure

The exposure of a photo can affect the level of detail that can be viewed, and is influenced by a number of factors, including: contrasting surfaces, (such as asphalt car parks or roads may affect automatic settings on the cameras leading to over exposure of the roof surface), weather conditions, (whether it is sunny or overcast, or frequently changing between the two). Photos should be reviewed at the start of inspections to ensure exposure settings are suitable for the conditions on site.

IMPROVED ASSET MANAGEMENT DECISION MAKING

Decision making in asset management should be informed and evidence based. Inspections using RPA can assist this in two main ways:

1. By increasing inspection efficiency and lowering costs to undertake inspection, inspections can be undertaken more frequently – providing more information over time to assess changes in asset condition and early identification of defects that may impact the operation of the building
2. Wholesale capture of the building using still photography can allow for stitched images of surfaces or the creation of 2D or 3D models of the entire building.

Figure 3 – Bird's eye view of a pitched roof. The area further from the camera becomes more difficult to view with an increased pitch and roof size.

Figure 4 – View of the same portion of roof with the camera angle matching the roof pitch.

These images and models can be compared between inspections to identify change over time. By capturing all surfaces of the building, the condition can also be reviewed multiple times and by different individuals. This can facilitate cross-discipline collaboration and ensure that items of interest are not missed due to the specific experience of the inspectors on the day of the inspections.

SUMMARY

The use of RPA to undertake building inspections is a powerful method to reduce the safety risk to personnel, increase efficiency, lower cost and still provide a high quality outcome.

However, in order for these inspections to be successful particular attention must be paid to the regulatory requirements, the specific environment (and its challenges) that the flight will be taking place, site management and people movement, and the level of detail required from the inspection (i.e. what are you trying to achieve?).

REFERENCES

[1] J. Howard, V. Murashov and C. M. Branche, "Unmanned aerial vehicles in construction and worker safety," America Journal of Industrial Medicine, vol. 61, pp. 3-10, 2017.

[2] M. Chavers, "News Ledge," 29 May 2017. [Online]. Available: https://www.newsledge.com/consumer-drones-2017-numbers/. [Accessed 19 February 2018].

[3] Drone Magazine, "Drone Magazine," 21 February 2017. [Online]. Available: http://www.dronemagazine.com.au/news/drone-business-market-to-exceed-us-84-billion-by-2025. [Accessed 19 February 2018].

[4] Commonwealth Government of Australia, "Civil Aviation Regulations," 1998.

ASSET MANAGEMENT

AMPEAK

PROMOTE EDUCATE ASSIST KNOWLEDGE

2019

THE MEETING PLACE FOR ASSET MANAGEMENT

Sun 7 – Wed 10 April 2019

The Esplanade Hotel Fremantle
by Rydges, Fremantle WA

AMPEAK19 is a world leading asset management conference and features a range of exhibits, case studies and technical content from all industries

AMPEAK19 is the meeting place for asset managers and a place to find lively discussion on emerging topics of interest in asset management, sharing of new ideas and knowledge, and finding of practical solutions to take and use in your workplace.

Come and hear from asset manager experts, take part in interactive sessions, chat to exhibitors and network with professionals from across all industries.

Seven distinct topics that will be of interest to academia, directors, CEO's, executive managers across asset rich organisations, asset management and maintenance practitioners, including:

- Leadership and Culture, Governance and Influence: growing the asset management mindset
- Strategic Asset Management Planning
- Shared Value: value of asset management to community and organisations
- ISO55001 Case Studies, Asset Management Frameworks, Standards & Certification
- Technology and Innovation: how to use to advance asset management
- Measuring Continuous Improvement - navigating through the data
- Equipping yourself and your workforce for the future

PERTH LOCATION

The conference is being held at the Esplanade Hotel in the ambient port city of Fremantle, WA.

You won't want to miss our Gala Awards night located in the maintenance shed at the historic Fremantle Prison.

NOMINATE YOUR ORGANISATION FOR AN AWARD

Nominations are available in a range of categories and close 8 March 2019. Awards will be presented at the gala dinner.

MORE INFORMATION

Visit **www.ampeak.com.au**, follow us on Facebook and Twitter or connect with us on Linked In

PRINCIPAL CONFERENCE PARTNER: BROADSPECTRUM ferrovial services

SUPPORTED BY: ENGINEERS AUSTRALIA

STAR PROFILE – DANIEL SONG

1. **Why asset management?**

   Asset Management is the philosophy that can create value and have positive influence on the enterprise bottom line, it can make difference to the day to day activity in how designing, operating and maintaining assets. We do maintenance, we do overhaul and inspection, we also do forecasting and life cycle costing, the concept of Asset Management is to bring up all the elements and harmonise the assets and people, balance risk cost and performance to achieve the best output from physical asset and create value for stakeholders

2. **How long have you been working in the asset management sector?**

   I started in Knorr Bremse in 2013 as RAMS engineer, where I first embraced this concept of Asset Management and I was fascinated by what difference this philosophy can make to all stakeholders from senior executives and shop floor staff. Now I am Systems Assurance Manager in Downer Sydney Growth Train project, working in the very early phase of asset management- Design, construction, testing and commissioning, the project had successfully delivered more than 14 new Waratah B sets train.

3. **What is your speciality?**

   I guess my background in engineering and accounting is my speciality, I have Bachelor in Electrical Engineering, Master in Accounting and I am a CPA, an interesting combination. The underpinning concept of Asset Management is to humanise and balance cost, risk and performance, an engineer with accounting background and qualification make it unique.

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

   The opportunity with working in Downer gives me more in-depth understanding of Asset Management during every phase of asset V life cycle. One of key asset performance indicator is reliability, reliability is a design feature. Asset cannot be made more reliable by doing maintenance, maintenance can only sustain the inherent design reliability, as a result, I would like to explore more on how to incorporate design for reliability, design for maintainability and design for safety into the design phase of asset management life cycle to build more reliable trains.

5. **What's the best career advice you've ever received and who gave it to you? / What makes a great asset manager?**

   I am lucky enough to work with some experienced engineers in the railway industry. Aaron Robinson was my manager when I worked in Knorr Bremse, he said I have got all the good 'ingredients', I need to utilise what I have got; another career advice was when I came to Downer for interview, Train Design Manager Neil Smith said to me, the opportunity to work on mega project helps to build confidence, which is essential for a young engineer, that is why I accepted the offer from Downer.

In the railway industry, Shane Day is a well-regarded and recognised asset manager, he is head of Downer Asset and Data Management Office. I got the opportunity to work with him, I believe his solid background as reliability specialist and down to earth attitude make him a good asset manager

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

The change of mindset from reactive asset management to proactive asset management is the trend I have noticed in railway industry. Asset delivery and asset management professional focus more and more on the inherent capability of asset such as reliability and maintainability, and incorporate those capabilities into design phase.

7. 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?

I guess the biggest challenge is how do we collect and analyse data in making informed decisions. The quality of data is paramount, data is building block in asset management, the challenge to collect meaningful, prices and accurate data, and tell an insightful story of asset performance, it will determine how well the asset will be managed.

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

The asset management philosophy is gaining momentum is all asset heavy industry. In railway, the biggest challenge is the demand for qualified and experienced asset managers are far greater the supply. Railway assets portfolio is expanding at a phenomenal rate in NSW, to manage the rolling stock, signalling systems, tracks and other infrastructures assets requires more qualified asset managers.

9. What is your proudest career achievement?

As Systems Assurance Manager, I am honoured to be part of the Downer Sydney Growth Train project. Downer made history by delivering the first Waratah series 2 train set into revenue service within 18 months of signing the contract. This is an important career milestone. Also, to be awarded as Certified Practitioner in Asset Management is also something I am proud of.

10. What's next for you?

I would like to focus on the delivery phase of asset management in the next 5-10 years, to put more trains or physical assets into service before asset managing them in the long run

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

'Train Sales' is not an easy job, on the weekend, I normally go swimming with my wife to relax, and of course, online shopping.

CHAPTER **NEWS**

WHAT'S HAPPENING IN THE MELBOURNE CHAPTER?

The Melbourne Chapter has had a great start to the year with over 30 keen AMCouncil members and associates who got together late February to discuss challenges in transforming culture and behaviour in asset centric organisations. A discussion was had led by Greg Williams, Executive, Executive Director Asset Performance, Yarra Trams, and Julian Watts, Director Engineering & Asset Management, KPMG.

Together they explored the culture and behaviour challenges we all face as asset managers, tackling ones such as what is culture and how does it manifest, why is it important to consider culture and behaviour for asset management, what strategies and tactics work to change culture and behaviour, and what doesn't work?

Following that an Annual General Meeting was conducted including committee election. We thank outgoing chair Greg Williams for his tremendous efforts with the chapter and welcome incoming chair Julian Watts. The 2019 Melbourne Chapter Committee now stands as:

- Chair: Julian Watts
- Co-Deputy Chair: Mo Barghash
- Co-Deputy Chair: Timothy Gowland
- Secretary: Andrew Sarah
- General Committee:
- David Washbrook
- Tom Carpenter
- Gopinath Chattopadhyay
- Ian Thomas
- Nicole Opie
- Nathan Peime
- James Carroll
- Varan Karunakaran
- Ian Burns
- Raphael Ozsvath
- Alex Afshar
- SIG Liaisons:
- Dianne Scheepers (WiAM)

WHAT'S HAPPENING IN THE SYDNEY CHAPTER?

The Asset Management Council was proud to play a major part in the earlier part of 2019 in a meeting of the NSW government village along with Infrastructure NSW. The purpose was to formally launch the new NSW Government endorsed Asset Management Policy. It was also an opportunity to receive an update from the CEO of Infrastructure NSW on the key asset management policy reforms underway in line with the State Infrastructure Strategy 2018-2038.

The new NSW Asset Management Policy is critical to ensure a consistent and improved approach to asset planning and delivery across NSW Government based on current leading industry asset management standards and approaches.

On the agenda were discussions around topics such as:

- Why asset management is more than just maintaining assets and requires a whole of organisation and whole of government response
- The Government's new asset management policy requirements and what they mean for agencies
- NSW Health Infrastructure's latest update on the development of their asset management framework
- The benefits, support and opportunities that membership of the Asset Management Council can provide
- Opportunities for networking and future asset management community of practice events
- Key speakers included:
- Tim Reardon, Secretary Department of Premier and Cabinet
- Jim Betts, CEO Infrastructure NSW
- Michael Pratt, Secretary NSW Treasury
- Rami Affan, Executive Director Asset Management, Infrastructure NSW
- Helen Carroll, Manager Strategic Asset Management, NSW Public Works
- Dave Daines, National Chair, Asset Management Council

Nearly 40 of our Sydney AMCouncil members and associates came together late

CHAPTER **NEWS**

February to hear from Hazem Khamis, Digital Infrastructure Specialist, Transgrid who shared experiences and lessons learnt from Transgrid's asset data transformation project. He discussed the driving philosophy, where they started, the steps taken to correct structures and data points, where they are now and the benefits realised so far from Planning, Maintenance, Analysis and Regulatory Reporting.

This was preceded by an Annual General Meeting where the successes during 2018 were reflected on, and it was mentioned noteworthy that the formal partnership established between the AMCouncil and iNSW during 2018 and continuing is beginning to yield tremendous value in the asset management space as understanding about asset management grows and key people are equipped with items such as the AMCouncil's Maturity Assessment tool and/or service. This value yield is directly associated with the requirements from iNSW and NSW Treasury to incorporate systematised asset management into the operations of all NSW government departments responsible for infrastructure assets, through the iNSW SIS and AM Policy.

As incoming chair, David Wilkinson, stepped up to be welcomed to his new position, outgoing chair Steve Doran mentioned on a personal note that:

"I will be stepping out of both the chair role (of almost three years) and committee member role (of many years) as at the conclusion of this AGM and tonight's presentation to promote healthy change and opportunity within the committee. It is great to have been involved at such a time of strength as now, not only in this Chapter, but in the AMCouncil more broadly. In my view it is clear that both the AMCouncil the asset management space will become even more valuable with every foreseeable year ahead. This chair role has been a privilege and pleasure to hold, due mainly to the attitude of those it connects with. I look forward to ongoing involvement with the AMCouncil for many years.

Estimating the trajectory from here, I would say that the ongoing committee will be driven by a firm goal to increase and sharpen the value of the AMCouncil in Sydney to your needs and will continue to openly welcome your input to achieve this.

Thank you to all AMCouncil Sydney Chapter members for your involvement, feedback and patronage of events throughout 2018."

. The 2019 Sydney Chapter Committee now stands as:

- Chair: David Wilkinson
- Deputy Chair: Richard Arthur
- Secretary: Glenn Hopkins
- Treasurer: Imtiaz Chowdhury
- General Committee:
- Samiha Najem
- Lucio Favotto
- Stephen Poropat
- Mark Ragusa
- SIG Liaisons:
- Lucie Mitchell (WiAM)
- Nik Proufas (YAMP)

WHAT'S HAPPENING IN THE PERTH CHAPTER?

Thank you to Water Corporation who hosted our Perth Chapter event in February. Karen Riddette, Principal Asset Risk, Water Corporation WA presented on how data-driven asset risk assessments are transforming asset management decisions at Water Corporation. Karen shared their experience with developing and applying a new Objective Risk Assessment (ORA) approach across the organisation's $36 billion asset portfolio.

Karen detailed that by connecting big data with expert opinion and developing standardised risk assessments, ORA is delivering improved transparency in asset management decision-making, greater understanding of organisational risk exposures and is supporting a shift in asset management culture to embrace risk information throughout the asset life cycle.

Next up, Carlos Gamez, Lead Engineer Asset Performance, Western Power discussed how they incorporate digital technology into the management of assets and the benefits it brings. Carlos also discussed the challenges to implementation and how Western Power is approaching those obstacles.

The Perth Chapter were also delighted to hand over Carmel Moynihan's prize as Carmel was the lucky winner of the AOG 2018 Asset Management Competition.

CHAPTER **NEWS**

WHAT'S HAPPENING IN THE BRISBANE CHAPTER?

February was also the month our Brisbane chapter kicked off the new year with a room full of dedicated AMCouncil members and associates to learn about Bayesian Analysis from Rebecca Beasley. Rebecca has been managing assets on behalf of Evoenergy for a number of years. She has been investigating the effectiveness of Evoenergy's timber pole inspection program using Bayesian analysis, and she presented on her method of analysis, and rather surprising findings.

Bayesian analysis is generally less well understood than the more commonly used frequentist statistics, so Rebecca's presentation shed some light in an easy to understand language and with visual examples they mysteries of Bayesian statistics and how asset managers can practically apply this technique to situations which involve testing a sample population for pass/fail states.

Following that an Annual General Meeting was conducted including committee election. The 2019 Canberra Chapter Committee now stands as:

- Chair:Mike Schulzer
- Deputy Chair: Ryan Chenery
- Secretary: Brett Morrison
- General Committee: Alex Wilson

WHAT'S HAPPENING IN THE HOBART CHAPTER?

Chapter Chair, Clint McDonald is looking forward to the first meeting on 2019 to be held in the Engineers Australia Hobart Office in late March.

They will have a presentation from Adrian Tanner on data analysis using regression and the underlying assumptions when using this technique as well as a special guest to talk about data in asset management followed by a round table discussion on Data in Asset Management.

Moving to another part of Tasmania, May's technical event will be held in Launceston and will focus on Asset Management Frameworks. We look forward to hearing all about these in the next issue.

WHAT'S HAPPENING IN THE ADELAIDE CHAPTER?

During recent Adelaide chapter meet, Sammar Abbas, a professional engineer with 23 years of experience encompassing Maritime, Oil & Gas and Power Generation industries went through his thesis for his Masters in Maritime Engineering through the University of Tasmania. Sammar's thesis aims to evaluate the proposition of transforming human expert knowledge in to Machine Learning models, and how this approach can influence Maritime Asset Management, particularly in the context of the Defence Maritime Industry.

We are pleased to note that the Adelaide Chapter is up and running with a new committee for 2019. Following Sammar's address, the following fresh faces were elected and the 2019 Adelaide Chapter Committee now stands as:

- Chair:Ian Pibworth
- Deputy Chair: Indra Gunawan
- Secretary: Andrew Wilson
- General Committee:
- Shane Bissmire
- SIG Liaisons:
- Bill Filmer (DiAM)

UP COMING **EVENTS**

EVENT	DATE	LOCATION
March 2019		
Asset Management across Multi-mode Transport: a Perspective	20-03-2019	Sydney
Continuing AM Development – Maintenance Seminar	21-03-2019	Brisbane
Webinar – Drone Data Shaping Asset Management	26-03-2019	Online
Data Analysis Using Regression	28-03-2019	Hobart
April 2019		
Networking and Technical Event	05-04-2019	Wellington
AMPEAK International Conference	7,8, 9, 10-04-2019	Fremantle
Webinar – Smart Cities	30-04-2019	Online
May 2019		
Digital Engineering applied for Asset Management	16-05-2019	Sydney
Joint Technical Presentation with ESSA	16-05-2019	Canberra
Continuing AM Development – Data Use	22-05-2019	Brisbane
Technical and Networking Session	23-05-2019	Perth
June 2019		
Bring a Problem Night	19-06-2019	Sydney

UP COMING TRAINING

EVENT	DATE	LOCATION
March 2019		
Asset Management Fundamentals	21-03-2019	Melbourne
Asset Management Fundamentals	28-03-2019	Canberra
April 2019		
Asset Management Fundamentals	03-04-2019	Brisbane
Asset Management Fundamentals	11-04-2019	Fremantle
How to Develop a Strategic Asset Management Plan and Asset Management Plan	12-04-2019	Fremantle
May 2019		
Asset Management Fundamentals	10-05-2019	Melbourne
Asset Management Fundamentals	23-05-2019	Sydney
Asset Management Fundamentals	30-05-2019	Canberra
June 2019		
Asset Management Fundamentals	17-06-2019	Melbourne

BROADSPECTRUM

ferrovial services

CENTRE OF EXCELLENCE FOR ASSET MANAGEMENT

OPTIMISING SUSTAINABLE ASSET VALUE

New Members

Arthur	Karagiannis
Ashma Ul	Husna
Ashraf	Awadalla
AssetFuture Pty Ltd	
Aurora	Fonte
Avinash	Deshpande
Barry	Watson
Bede	Austin
Ben	Gullquist
Ben	Leske
Benjamin	Forrest
Benjamin	Tsang
Bernard (Bill)	Cant
BHP	
Boutros	Abd
Bradley	Hamilton
Brendan	Wilkins
Brett	Stevens
Brett	Hovingh
Brian	Cooper
Brisbane Airport Corporation	
Carbontech Composite Systems	
Caroline	Bracken
Charles	Kurniawan
Chris	Zito
Chris	Connelly
Chris	Goodwin
Christopher	Wright
Christopher	Rule
Claire	Harding
Colin	Langford
Craig	McKervill
Craig	Muller
Damon	Tan
Daniel	King
Daniel	Lie
Daniel	Lee
Darren	Chunag
Darren	Lane
David	Scott
David	Wilkinson
David	Counsell
David	Bolden

David	Goodale
Davin	Paul
Dean	Scheutrim
Dennis	Noble
Diane	Hicks
Dirk	Vermooten
Dishani	Dissanayake
Domenic	Fonte
Donald	Firth
Donna	Bright
Doreen	Lum
Duncan	Mitchell
Duncan	Mitchell
Dylan	Norton
Elizabeth	Sim
Elliot	Egan
Erin	Bohrmann
FILIZ	TIGLI
Fran	Pesich
Frank	Win
Frans	Posset
Gary	Hadfield
Gary	Hanson
Gary	Martin
Gavin	Mooney
Gayatri	Dhawan
Gideon	Leighton
Glyn	Jackson
Goodness	Aula
Greg	Pattison
Gregory	McKay
Gunasingham	Ramanan
Gurpreet Singh	Taak
Hazem	Khamis
Hira	Munir
Horizon Power	
Hui Shien	Smart
Iain	Beach
Iain	Lund
Isabella	Wong
James	Stevenson
James	Carroll
James	Westacott

James	Gawne
Debashis	Dutta
Matthew	Barber
Derek	Dymond
Katie	Jones
Josee	LeBlanc
Ljiljana	Radman
Andrew	Pyke
Ken	Goh
Nathan	Minett
Chris	Hyde
David	Bailey
Bevan	Hall
Chris	Young
Katherine	Cochrane
Jason	Kane
David Belmont-Kleingeld	
Paul	Berend
Joshua	Tench
Roy	Karimi
Ben	McKelvey
Matthew	Ferris
Christopher	Davey
John	De Angelis
Jamie	Jeremiah
Jane	Agnew
Jason	Akroyd
Jayson	Valerio
Jeff	Seeney
Jennifer	Roe
John	Fardon
Jon	Clemesha
Jonathan	Ringrose
Jonathon	Dragos
Keith	Johnson
Kelly	Allert
Kenneth	Henderson
Kira	Hemsley
Kristina	Sestokas
Lara	Kirchner
Laura	Young
Laurie	Curro
Laurissa	Madden

Leena	Wood
Leon	Reeves
Liliana	Ferro
Ling	Qian
Lou	Reid
Lynne	Jarman
Maria Isabel	Jimenez
Mark	Brennan
Mark	Herbert
Martin	Oaten
Martin	Canova
Mary	Whalan
Mary	Irwin-Davies
Matthew	Dellaway
Matthew	Walker
Matthew	Lynch
Matthew	Brown
Matthew	Burdett
Matthew	Perry
Matthew	Reedman
Matthew	Sleaford
May	Cheong
MD GYAS	UDDIN
Melonie	Lister
Michael	McMaster
Michael	Gunton
Michael	Yandell
Michael	Lesnie
Michel	Pieterse
Michelina	Pratt
Michelle	Thomas
Myles	Siegersma
Natalia	Kotevska
Natalie	Kobica
Natasha	Bartlett
Nathan	Simiana
Nicki	Carroll
Nicole	Ransom
Nigel	Jones
Nishit	Shah
Nyrie	Anderson
Patricia	McGarry
Patrick	Fernandez

Paul	Myhill
Paul	Costanzo
Paul	Smith
Paul	North
Peta	Smith
Peter	van Heerden
Pinank	Patel
Prashant	Bajad
Quocdat	Ho
Rajendra	Singh
Ramkumar	Govindaraj
Raymond	Patterson
Rebecca	Sellars
Riaz	Ul-Islam
Richard	Delacruz
Richard	Combe
Roads and Maritime Services	
Rob	Woodall
Robert	Sharwood
Roopa	Jogunoori
Roshan	Aryal
Ross	Taranec
Rowan	Youell
Russell	Caird
Ruth	Baker
Ryan	Pearce
Sally	Busch
Samantha	Gartland
Sandra	Dunn
Saravanan	Asaithambi
Seti	Hoo
Shane	Tymmons
Sian	Miller
Simon	Jeffery
Simon	Bogle
Sonja	Gaspar
Srdja	Stepanovic
Stacey	Vorwerk
Stavi	Tsioustas
Stephen	Brooks
Stephen	Lloyd-Jones
Stephen	Baxter

Subhadip	Sengupta
Sudarshani	Manoharan
Sukham	Kaur
Sylvia	Der
T.K	Wang
Tayyab	Zubair
Tim	Bradnick
Tim	Massey
Tony	Spencer
Tony	Bond
Trevor	Jennings
Vallipuram	Sivakumaran
Vijay	Pradhan
Vijay	Eden
Vipul	Lunkad
Virat	Behla
Vivian	Wei
Wade	Pritchard
Wencyslouv Timu	Makondo
Wendy	Su
Will	Hilary
Yasmin	Cox
Zamikhaya	Mbalu

How Much KNOWLEDGE & EXPERIENCE Protects Your Assets?

CFAM
Certified Fellow in Asset Management

CSAM
Certified Senior Practitioner in Asset Management

CPAM
Certified Practitioner in Asset Management

CAAM
Certified Associate in Asset Management

ARE YOUR EMPLOYEES ASSET MANAGEMENT COUNCIL CERTIFIED?

Improve Retention ▪ Enhance Recruitment ▪ Increase Portability

Get the facts: www.amcouncil.com.au/certification

Membership Application

ASSET MANAGEMENT COUNCIL

ASSET MANAGEMENT COUNCIL LTD

A Technical Society of Engineers Australia

ABN: 15 141 532 747 www.amcouncil.com.au
Phone: +613 9819 2515 Email: accounts@amcouncil.com.au

Thank you for joining the Asset Management Council. Please complete all sections. Phone or email with any queries.

PERSONAL DETAILS (Please print in BLOCK CAPITALS)

Title (Please circle) Dr Mr Mrs Ms Miss Other (Please specify) ____ Sex (Please circle) F M

Family Name ____ Given Names (in full) ____

Date of Birth ____ Engineers Australia Membership No ____

CONTACT DETAILS (Please print in BLOCK CAPITALS)

Preferred Address: ☐ Private Address or ☐ Business Address

Position ____

Organisation ____

Postal Address ____

City ____ State ____

Country ____ Postcode ____

Phone ____ Fax ____

Mobile ____

E-mail ____

AREAS OF INTEREST (Please tick)

Technical Topics

- ☐ Reliability
- ☐ Availability
- ☐ Maintainability
- ☐ Performance
- ☐ Spares Planning
- ☐ Maintenance Planning and Scheduling
- ☐ Maintenance Plan development and implementation
- ☐ Maintenance Policy/Strategy development
- ☐ Logistics
- ☐ Shutdown planning and the maintenance interface
- ☐ Asset Management
- ☐ Other:

Issues

- ☐ Skills development
- ☐ Training
- ☐ Other:

Industries

- ☐ Facility Management
- ☐ Consulting
- ☐ Power
- ☐ Transport
- ☐ Defence
- ☐ Oil and Gas
- ☐ Mining and Industry
- ☐ Water and Utilities
- ☐ Infrastructure
- ☐ Other:

Return completed Membership Application with payment to:
Asset Management Council
PO Box 2004, Oakleigh Vic 3166

GROUP AFFILIATION

☐ Young Asset Management Practitioners (18-35 year olds)

CHAPTER AFFILIATION (Please tick one)

☐ Newcastle	☐ Canberra	☐ Sydney	☐ Illawarra	☐ Mackay
☐ Melbourne	☐ Adelaide	☐ Brisbane	☐ Hobart	
☐ Darwin	☐ Overseas	☐ Gippsland	☐ Perth	

MEMBERSHIP FEES Effective Jan 2015 (Please tick one membership type only)

Individual Annual Fee (including GST)

☐ Member $154.00

☐ Student $33.00

Corporate Annual Fee (including GST)

☐ Platinum $9,570.00 ☐ Gold $3,608.00

☐ Silver $1,804.00 ☐ Bronze $957.00

GST (10%) does not apply to overseas memberships.

CORPORATE MEMBER NOMINEES

Platinum – 30 nominees, Gold – 10 nominees, Silver – 10 nominees, Bronze – 5 nominees

	Name	Email	Date of Birth (Mandatory)	AM Council Chapter
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Contact Asset Management Council to provide more corporate nominee details.

PAYMENT

Method of Payment (please tick one and enclose payment)

☐ Cash

☐ Money Order or Cheque drawn in AUD from an Australian bank) payable to **Asset Management Council Ltd**

☐ International Money Order

☐ Credit Card
(Australian or New Zealand Bankcard only acceptable)

Credit Card Details Please charge my card (tick one card type)

☐ Visa ☐ Bankcard ☐ Mastercard

☐ Diners ☐ American Express

Card no

Expiry Amount $

Name on card

Signature Date


HOW CAN YOU MAKE MONEY ON SOMETHING IF YOU ALREADY SOLD IT?
IT'S SIMPLE.
THE ANSWER IS SAP HANA.
What if you could gain completely new insights from your assets, and correct problems before they even occur? Efficiently manage the entire asset lifecycle with world-class enterprise asset management software from SAP. With real-time visibility into asset performance and powerful analytics, it's easier to optimise asset usage, shrink costs, better manage capital expenditures, and ultimately maximise your return on assets (ROA) – including fixed property, plant, and equipment.
What if you could turn current products into future revenue? SAP HANA® monitors millions of parts in machines around the world. Helping manufacturers provide intuitive maintenance services for their customers, and new streams of revenue for themselves. Just think what you could do.
For more, go to go.sap.com/australia/solution/lob/asset-management.html
SAP
Run Simple

Partners, Corporate Members & Contacts

Partnering Organisations

Broadspectrum
www.broadspectrum.com

IFM Investors
www.ifminvestors.com

SAP Australia
www.sap.com

STRATEGIC PARTNER

ASC Pty Ltd
iNSW
TFV

PLATINUM

ASC Pty Ltd
Asset Standards Authority, Transport for New South Wales
Ausgrid
BAE Systems
Broadspectrum
Downer Group
Industry Funds Management (IFM)
Infrastructure NSW
Roads and Maritime Services
SAP
Ventia Pty Limited

GOLD

Airservices Australia
AssetFuture Pty Ltd
Austal Ships Pty Ltd
Bombardier
Capability Partners
Department of Defence CASG
Department of Health and Human Services
Energy Queensland Limited
Essential Energy
Evoenergy
GHD Pty Ltd
HATCH Ltd.
Health Infrastructure
ISW Solutions Pty Ltd
Jacobs
K2 Technology Pty Ltd
KPMG
Lendlease Services Pty Ltd
Naval Ship Management (Australia)
Power and Water Corporation
Public Transport Victoria
SMART ASSET SOFTWARE
Sodexo Australia Pty
Stanwell Corporation Limited
Sydney Water Corporation
Thales Australia Limited
TransGrid
Transurban Ltd
Utopia Global Inc.
Ventia Pty Limited
Vesta Partners
Victorian Health and Human
Services Building Authority
Warship Asset Management Agreement
Western Power
Xenco Pty Ltd

SILVER

AECOM
AGL
AMCL
Australian Rail Track Corporation Ltd (ARTC)
Babcock International Group
Broadcast Australia
Cardno (QLD) Pty Ltd
Crystalise
Gladstone Ports Corporation
I @ CONSULTING (PTY) LTD
Jemena
Kellogg Brown and Root Pty Ltd (KBR)
Laing O'Rourke Australia
Lycopodium Infrastructure Pty Ltd
Metro Trains Melbourne (MTM)
Norship
Nova Systems
NSW Office of Environment and Heritage, National Parks and Wildlife Service
Origin Energy
Programmed Facility Management
Public Transport Authority
Refining NZ
SNC-Lavalin Rail and Transit
Sodexo Australia Pty
Sydney Trains
VicRoads
VicTrack
Wood Plc (Australia)
WSP Parsons Brinckerhoff

BRONZE

ABB Enterprise Software
Activa Pty Limited
Alinta Energy Loy Yang B Power Station
Anglo American Metallurgical Coal
ANSTO
ARMS Reliability Engineers
Asset Management Council
Assetic Pty Ltd
Assetivity Pty Ltd
Atlas Engineering
ATTAR
Aurecon Australia Pty Ltd
Aurizon Network
Australia Pacific Airports (Melbourne)
Babcock Pty Ltd
BHP
Boeing Australia
Boeing Defence Australia - Wedgetail In Service Support
Brisbane Airport Corporation
Broadcast Australia
Bureau Veritas
Campeyn Group
Carbontech Composite Systems
Certus Solutions
Covaris Pty Ltd
Cushman and Wakefield
DAMS Safety NSW
Delta Facilities Management Pty Ltd
Department of Environment, land, Water and Planning
Energy Queensland
Frazer-Nash Consultancy Limited
Fremantle Ports
Gladstone Area Water Board
Goulburn Valley Water
GPA Engineering Pty Ltd
Guanghua Group Pty Ltd
Hardcat Pty Ltd
Hexagon PPM
Honeywell Limited
Horizon Power
Hoverscape | Professional Drone Services
Hunter Water Corporation
Icon Water Limited
Indec Consulting
Innovative Thinking IT
Institute of Quality Asset Management
LogiCamms
LOGiT Australia Pty Ltd
Logsys Power Services
Macutex
Maintenance and Project Engineering Pty Ltd
Melbourne Water
Meridian Energy
Nexus Global Australia
Nihar Associates
North East Water
NRG Gladstone Operating Services
NSW Ports
Opus International Consultants
Oropesa Port Management Pty Ltd
Pacific Hydro
Paradoxian Pty Ltd
Penrith City Council
Pindan Asset Management
Port of Newcastle
Public Transport Victoria
QENOS
Redeye Apps
Road and Transport Authority
Government of Dubai - United Arab Emirates
School Infrastructure NSW
SEQWATER
Shoalhaven Water
St George Community Housing
State Automation
Structural Integrity Engineering Pty Ltd
Sutherland Shire Council
Taronga Conversation Society Australia
Tasrail
TasWater
Terotek (NZ) Limited
The Asset Management College
Transport For Victoria
United Energy
VicRoads
Water Corporation
WaterNSW
Wood Plc (Australia)
Work Management Solutions

Testimonials

Mark Mackenzie: *" It's the peak body, not only in Australia, but for asset management around the world. We've got representation on a number of international forums and organisations. Australia, surprisingly, is leading the world in asset management. A lot of countries are adopting what we're doing and so being part of that is, I guess, being part of best practice with asset management in Australia."*

Greg Williams: *" I think it's not associated with any particular industry. We're not water, we're not electricity, we're not gas. We're about sharing knowledge, we're about providing forums for people to express points of view, we're about connecting together. Those are the three key reasons that I'm involved and I think those reasons are probably the same that most people get involved in the AMC."*

Melinda Hodkiewicz: *"They have done a tremendous amount to promote the professionalism of asset management and I really applaud the work that they have done to assist asset managers - not only to professionally develop, but to also provide events like the AMPEAK that bring a whole bunch of people together who wouldn't otherwise have any way to connect."*

Dave Daines: *"I think now asset management is really starting to draw people in the ability to use the standard to save money and improve performance, so that's really the key now to what the standard was developed for. I think now, when people are talking about it, they come together and there's that vibrant feel to get some activity generated from that."*

Tom Birdseye: *" It's really given me a leg-up in terms of my ability to be able to network and my ability to be able to communicate with the other professionals in the asset management industry. As a young asset manager, I guess you would call me, I would never really have exposure to any of the types of people or the contacts that I have been able to be exposed to as the Adelaide Chapter Chair."*

Martin Kerr: *"We're always looking for a new set of eyes, new ideas and of course experiences, and I think it's the richness of those things that actually contribute and make the AmBOK team as powerful as they are. All the models that we actually create, we actually use to create other models, so it actually demonstrates that we're actually testing ourselves for everything we do."*

Peter Kohler: *"Not just learn from the approach the AMCouncil might take to doing things in terms of its advice as to how you might manage your assets better, but also to be able to talk to people. There's a lot of huge amount of experience - good and bad - in the room and you should get a hold of that, listen to that, and take what you think would be useful and relevant out of that."*

ASSET MANAGEMENT COUNCIL

THE ASSET JOURNAL

Asset Management Council
PO Box 2004
Oakleigh Vic 3166
Tel 03 9819 2515
www.amcouncil.com.au