USING TECHNOLOGY TO ENHANCE HUMAN PERFORMANCE

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ABSTRACT (500 WORDS MAXIMUM)

The human side of operations often overlooked during the technology boom has now revealed a new level of potential threat to the Water and Wastewater industry. Skilled workers moving to other industries and generational changes which has seen large-scale retirement of experienced engineers combined with a lack of suitable replacements, is biting deep into the skills base. With an estimated 36% of highly skilled engineers in the industry expected to retire in the next ten or so years and a lack of suitable replacements, the industry is facing a potential crisis. Combined with pressure for cost control in a high cost environment means organisations must do more with less, while making better use of the experience of remaining skilled workers.

Generating actions through insights, made by implementation of an effective digitalisation strategy on a well operated plant can address many of these challenges. The key is to capture the experience of older engineers and operators and utilise that knowledge in a way which will benefit the business for generations to come. This can only be done through effective collaboration and co-innovation, using best practice examples from all industry segments.

Another issue is that many operators are faced with a torrent of current technological innovation which threatens to overwhelm them. Although many may have set out on a digital transformation journey with clear objectives and expected outcomes, others are yet to identify whether digital transformation holds anything of benefit. It is this group who are most at risk of making hasty and uninformed decisions, as pressure mounts internally and externally to take advantage of the 'digital revolution'. The risk of making hasty and ill-informed decisions, thus adopting 'transformational change' without clear objectives can not only be costly, but could be detrimental to operational effectiveness, safety and security.

This paper not only examines the threats to operational effectiveness posed by the demographic timebomb but examines how industry research and standards combined with lessons learned from other sectors can address such challenges. With real-life examples of using technology to supplement and enhance human performance, it investigates ways of helping water industry operators become better acquainted with the digital revolution.

KEYWORDS

Human, demographic change, retirement, technology, operations, resilience

PRESENTER PROFILE

Russell has over 25 years' international experience in the Process Industries. He has been directly involved in process facilities design, commissioning and operations,

fabrication and construction and since 2000 has focused on digitalization, simulation, modelling, analytics and optimization of industrial processes and operations.

1 INTRODUCTION

The human side of operations often overlooked during the implementation of technology projects and initiatives, the likes of which is currently being vigorously pushed throughout all industries, has revealed a new level of potential threat to the Water and Wastewater industry. This has manifested itself in two distinct areas. Retiring and departing experienced operator knowledge needs to be captured plus the rapidly changing operational environment which is enabled by new technologies requires new skills which the current experienced operations teams don't have.

The human side of operations often overlooked during the implementation of technology projects and initiatives, the likes of which is currently being vigorously pushed throughout all industries, has revealed a new level of potential threat to the Water and Wastewater industry. This has manifested itself in two distinct areas. Retiring and departing experienced operator knowledge needs to be captured plus the rapidly changing operational environment which is enabled by new technologies requires new skills which the current experienced operations teams don't have.

In order to gain an understanding of the solutions to these issues it's important to understand the interplay between a broader range of issues. The range of issues that shall be discussed in this paper which are particularly relevant to the water industry and how the personnel can deal with these efficiently and safely are

- Ageing infrastructure
- Processes and Procedures
    - Loss of experienced personnel
    - Training of new personnel
    - Paper based processes and procedures
    - Management of multiple third party service providers
- Poor Quality Data
- Geographically dispersed infrastructure
- Unreliable connectivity
- Cyber Security
- Lack of familiarity and trust of the cloud
- How best to Digitalize Operations

Although many of these are common to most industrial companies and organisations there are a number of water industry specific circumstances that must be recognized in order to provide the most effective solution for the different parts of the water industry

and the actual geographical environments experienced. What's good for Outback Australia in summer does not necessarily work in South Island New Zealand in winter.

2 AGEING INFRASTRUCTURE

2.1 AGEING INFRASTRUCTURE

Ageing infrastructure requires closer monitoring than new. It also requires the closer attention of the more experienced personnel as old equipment cannot necessarily be handled in the same way as new equipment. Transferring this knowledge can take years of on the job training especially for processes and procedures that are only used infrequently. For the main treatment plants this is easier to achieve than for the remote pumping stations and other remote infrastructure. Just because some equipment is remote doesn't make it less critical than the main treatment plant. Quite the opposite, some remote sites and pumping stations can be difficult to repair in a timely manner and can affect whole communities to the point of causing negative impact to peoples safety. A clear understanding of the relative importance of a piece of equipment should be the basis of determining how much effort should be applied to maintain it's efficient and reliable operation.

A critical advancement in technology addressing this is predictive analytics. Asset monitoring with predictive analytics which turns unplanned down time into planned maintenance is getting quicker, easier and cheaper to implement especially when using cloud-based applications. The existing instrumentation which is used for regulatory and automatic control may provide some of the data required to perform predictive analytics, such as pump failure prediction, however additional data is usually required. As this additional data will not necessarily be required for closed loop control the change management regime to have it generated and collected will not be so onerous and will not require any changes to the regulatory control system or code.

This may include

- smart wireless or cloud connected vibration monitoring devices,
- pump winding temperature measurement,
- gear box lube oil test results,
- corrosion monitoring devices coupled with simulations that predict corrosion potential,
- ultra high speed pressure measurement devices that can detect cavitation etc.

This additional information along with the already available data is fed into the analytics engines which provide the predictions back to the operations team, or whoever needs to know, for suitable plans and actions to be made.

Having these extra insights could be viewed as loading up the existing teams with more information for them to deal with however the responses to this additional and valuable insightful information can be automated or semi-automated thus enabling the operations teams to better operate the assets.

This automation can be easily applied to procedures and processes which directly addresses the issue of *capturing the knowledge from experienced personnel* and *enabling*

new personal to benefit from that experience without the need for direct supervision but the experienced personnel along with transitioning from paper to digital.

2.2 PROCEDURES

The aim is to enable an operator to know exactly what procedure is required for any eventuality and to assist them to execute that procedure in the best way every time regardless of the time of day or how many hours a person has been on shift.

Procedures have historically been kept in paper manuals which find their way into the experience base of an operator having been carried out by that operator a number of times.

This approach has it's limitations.

- Finding and choosing the correct procedure may not be obvious or easy.
- Plants and equipment can change over the years so an infrequently used procedure may be out of date or just wrong, with a potentially disastrous consequence.
- If a written version of the procedure cannot be found then the plant or equipment may have to shut down, either automatically or manually, in order to wait for a suitably experienced person to come to restart and carry out the procedure which they have in their head based upon their experience.
- The procedure can be easily executed under ideal weather conditions but may not be possible in seasonally adverse weather conditions.

This list is not exhaustive, and the reader can probably add a number more from their own experience. The point is that paper based procedures have many and potentially serious or dangerous limitations.

Procedural Automation offers a solution which has critical valuable functionality. One of these deals with the demographic time bomb of losing experience on retirement and generally enables operations to leverage the digital revolution.

- It allows the knowledge of the most experienced operators, maintenance and safety personnel to be codified, linked with all relevant information and presented to the operator exactly when it is needed, without having to look for it.
- It will lead the operator through the procedure step by step, with all the checks required before moving from one step to the next.
- It is available either tightly linked with the control system, on the same HMIs, or via a separate HMI depending upon the control systems and the control room layout.
- It is a tool not only to guide the operators but also for the operators to actively use and set up enabling multiple procedural approaches to be compared, agreed upon, tested and then implemented, with all the required management of change processes followed before a new procedure is implemented.
- The procedural automation tool can used in advisory mode, offering the operator manual intervention and check points as they are guided through the procedure. Alternatively those steps which can be automated the tool can take over the execution of the procedure. This is useful as it may take time for operations personnel to check that a newly added procedure is correctly implemented before they enable it to run automatically.

- In this way each progressively implemented procedures enable continuous operation improvements, such as improvements in product quality, operational stability and reliability, reduced power consumption, closer to optimum operation.

Another really valuable outcome is the decreased time for new operations personnel to become effective without supervision. This directly addresses the problem of losing experienced personnel due to retirement or otherwise and the need to enable new personnel to run the operations without supervision as quickly as possible.

2.3 PROCESSES

To achieve a step change in efficiency the aim is to move from paper-based processes which take up a lot of the operations, maintenance and accounting teams time to a much easier, audit trail enabled and less time-consuming digital system.

These processes include:

- Logbooks
- Shift Handovers
- Work Instructions (incl linkage to spare parts management, ordering and invoicing)
- Permits to Work (incl work pack generation)
- Incident management (provides visibility for OHS and ESG)
- Management of change (incl Maintenance, Modifications, Upgrades etc)

Figure 1: Digitalization of Operations Management processes

With a personal mobility device, such as a tablet, the in-field operations, inspection and maintenance teams can be an integral part of these digital processes even if working in areas with no internet or Wi-Fi coverage. Field personnel can synch their device with the system before they leave home, their office or the control room, go into the field, onto the plant or to a remote site, follow their work packs, work instructions activities, have all the information they require for the tasks, complete all the necessary digital forms then return to their home base, resync to update the system and receive their next work

packs, tasks etc. Mobile network connection is not required in the field. This is far more efficient and safer than a paper-based system as it is up to date, essentially live and current.

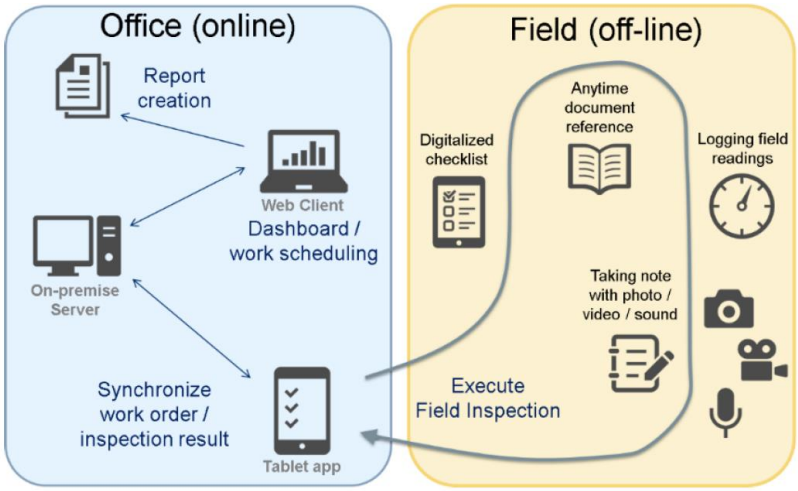

Figure 2: Mobility Device interaction with RPO OM digital processes management.

This system can be set up based on the existing paper-based processes in conjunction with a few of the most experienced operators and maintenance personnel to clarify or fill in any gaps there may be in the paper based processes. This goes a long way towards mitigating the problems of capturing the knowledge of more experienced personnel who may be nearing retirement and passing on / making their knowledge available to any person who is required to follow the digitized processes.

Having a digitalized system for the operations and business processes provides a platform to link, enable and manage all your own departments. It is also the platform to link, enable and manage any third parties who are involved in or have an affect on any aspects of all of these processes; Logbooks, Shift Handovers, Work Instructions, Permits to Work, Incident Management and Management of Change.

One well integrated operations process management platform can provide so many valuable improvements in efficiency and safety.

2.4 POOR DATA QUALITY - LOOK AFTER YOUR INSTRUMENTS TO LOOK AFTER YOUR DATA

Data quality is a critical issue when moving to digitalized and automated operations. The old adage of 'rubbish in rubbish out' applies. One way of assuring good quality data is to spend a lot of time cleaning data that comes from the plant operations. A commonly quoted statistic is that 80% of data scientist's time is spent cleaning data sets. This is clearly not an efficient and viable long term approach.

Automated data quality assurance is what is needed. For such a data quality assurance system to work well it needs to include monitoring and assessment of the health of the instruments, analysers and devices which create the data. If you know an instrument is functioning correctly you can believe the data it generates and rely on the control systems and analytics that use that clean data.

An incorrectly functioning instrument can be detected and indicated as such. The NAMUR NE-107 specification offers the following categorization.

Maintenance	Although the output signal is valid, the wear reserve is nearly exhausted or a function will soon be restricted due to operational conditions e.g. build-up of deposits.	
Off Specification	Off-spec means that the device is operating outside its specified range or a internal diagnostic indicates deviations from measured or set values due to internal problems in the device or process characteristics (e.g. bubble formation in flow metering or valve sticking).	
Check Function	Output signal temporarily invalid (e.g. frozen) due to on-going work on the device.	
Failed	Output signal invalid due to malfunction in the field device or its peripherals.	

Figure 3: NAMUR NE-107 categorization and visualization for standardized instrumentation status

When applied to an operator control station analytic summary graphic, such as provided by Plant Resource Manager, enables the operations team to quickly assess where action, attention and/or resources need to be applied. This can be done manually or automated by linking to the procedural automation (ExaPilot) and digitalized operations management (RPO-OM) systems.

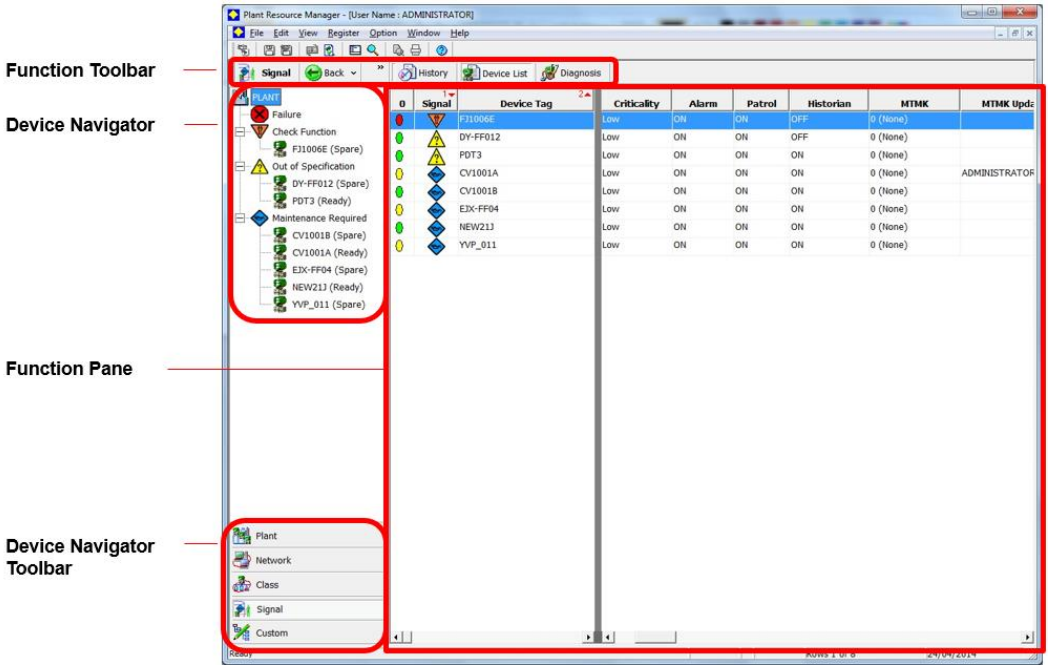

Figure 4: Simple visual indicators draw attention to where it is required

This enables experienced and new operations personnel alike to head off problems before they occur, turning unplanned downtime into planned maintenance or to quickly determine the specific nature of a problem and dispatch a maintenance crew with the correct tools and spare parts to remedy the situation, which is especially important for travel to a remote site. Having to visit a remote site in bad weather twice because of being incorrectly equipped on the first visit is costly and dangerous.

If you know that an instrument, analyser or device has started to drift or not work correctly, based upon a leading indicator that determines the onset of a problem and can project at what point it's poor performance will become critical, then you can

- compensate (automatically) for the drifting / poor data quality,
  - Put that control loop or part of the process into manual, if required or
  - Adjust operational set points
- plan to fix or replace the instrument or device

- by (automatically) generating a work order with your digital operations process management system (RPO OM), inform all relevant parties of the situation, which enables a planned maintenance approach based upon the criticality of the data to continued smooth and safe operations.

Every way of predicting the onset of declining performance should be explored to turn unplanned downtime into planned maintenance and also to reduce the frequency of unnecessary, time cycle based planned maintenance.

Using the full capability and information available with Smart Instruments such as using the extra information available via HART enabled instruments is therefore very valuable.

Automated predictive analytics systems such as PRM can use this data to detect the onset of many process and instrument performance problems. Here is one example from a differential pressure transmitter with high speed pressure detection response.

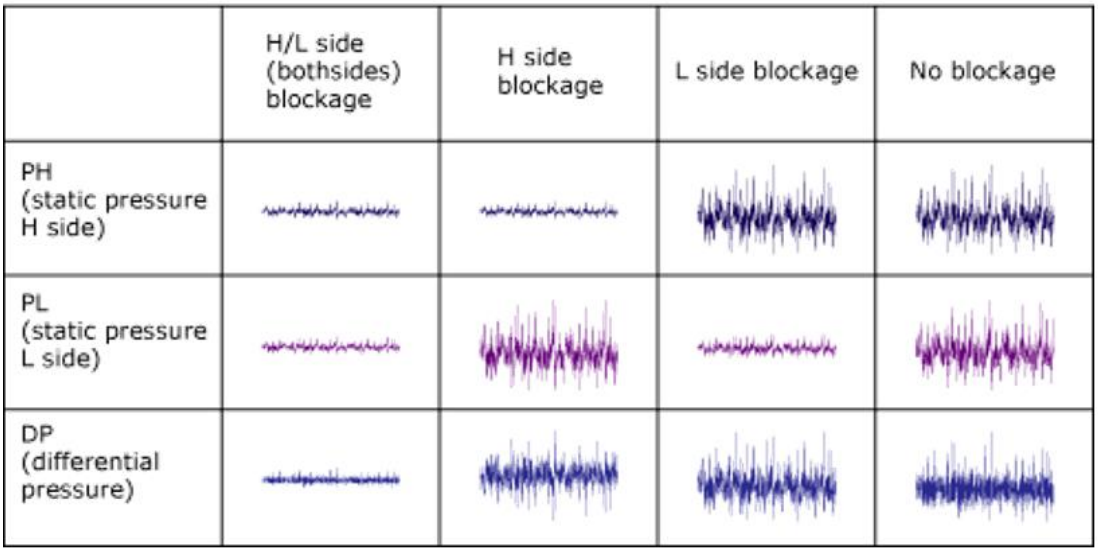

Figure 5: Analytics using HART detecting a blocked impulse line

Such pressure fluctuations can also be used to detect the occurrence of cavitation which could indicate the presence of volatiles such as methane in the water or possibly air ingress via the suction. Knowledge of the process coupled with such rich data and the appropriate analytics can enable a step change in performance prediction.

Using this approach the performance of a control loop can be closely monitored such that the onset of performance deterioration can be detected. A control loop may include a combination of instruments, valves, start/stop signals etc

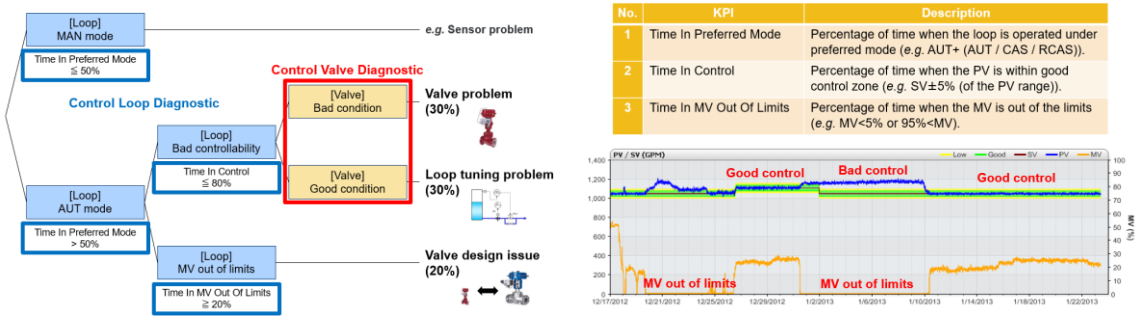

Figure 6: Automated Control Loop monitoring to predict onset of deteriorating performance

2.5 GEOGRAPHICALLY DISPERSED INFRASTRUCTURE

The Water industry on any scale has to deal with a significant number of geographically dispersed assets.

Using the West Australian Water Corporation as an example of the large scale they have:

- 82 water treatment plants
- 488 pumping stations
- 34,799 km of water mains
- 16,903 km of sewer mains
- 128 dams and weirs
- 75 recycled water schemes
- Approx. 30,000 instruments, many Smart with multiple variables

They are on a progressive digitalization pathway.

Generally, a combination of SCADA, PLCs and RTUs are used for data management and control of geographically remote and dispersed sites with a DCS or PLCs used at the major treatment facilities. Keeping such systems current, physically and cyber secure and well maintained is a costly endeavor.

SCADA in the cloud and SCADA as a Service offers a cost effective approach which does not require significant inhouse capable teams to maintain the IT & OT infrastructure. This offers benefits to both large and small water resource management teams alike.

- Easy to implement
- easy to maintain
- supported and maintained remotely
- IT infrastructure owned and maintained by others
- Cyber security managed by others
- no need for local expertise

SCADA as a Service is a new but naturally evolved method of providing process control to traditional wide area network applications. From an operations point of view, the method of system interaction (view & control) remains exactly the same. This provides a straight forward approach to adopting a service orientated SCADA system.

The method in which an operator controls and monitors the process remains the same. What changes is the mode in which field information is gathered and processed, as shown below.

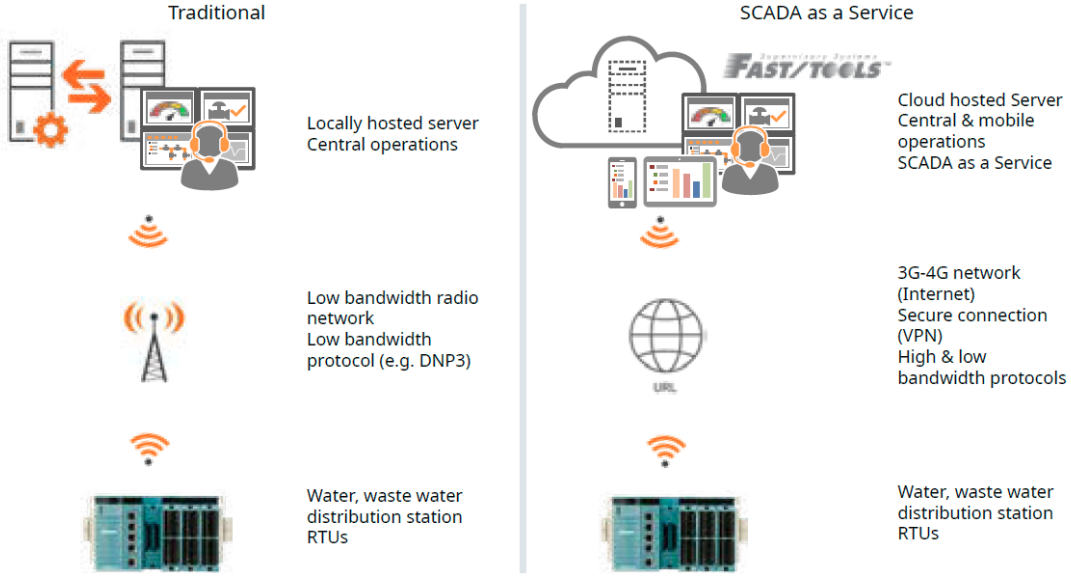

Figure 7: Control and monitoring of the process with mode of information gathering.

Having a SACADA system which can be mostly supported and maintained remotely will greatly reduce unnecessary trips to remote sites which will reduce carbon footprint, reduce risk to personnel especially in bad weather with all the associated cost savings, OHS and ESG benefits.

2.6 UNRELIABLE CONNECTIVITY

SCADA and SCADA as a Service can operate effectively even with unreliable connectivity.

With efficient data collection frequency and sufficient data buffering capacity at a site the data can play catch up when intermittent connectivity allows.

The remote site PLC will be programmed to operate the facility safely when communications are interrupted.

In the case where there is essentially no communications available at a site the data can be collected by a regular drive by or drone flight, the data collected and delivered to the main database, analyzed and then acted upon in the same way. Although not close to real time it's still far more valuable than no analytics at all. It still enables predictive analytics to be carried out and scheduled maintenance planned rather than a costly check regularly regime.

2.7 CYBER SECURITY

Cyber security is managed by others. Data Centre teams and dedicated cyber security teams with remote access to the facilities and sites have many times more resources dedicated to Cyber Security than most operating companies. Offering 24/7 protection, support and disaster recovery.

In a company's ESG portfolio there is a growing demand from regulators and insurance companies to prove a reliable 24/7 cyber security regime. For an operating company

whose primary goal is to provide water and sewage services this cyber security requirement is going to become increasingly onerous.

Outsourcing this service or using a hybrid of internal capability augmented by a third-party cyber security service which can be tightly coupled with the OT equipment requirements of the SCADA and controls systems is well worth investigating.

2.8 LACK OF FAMILIARITY OR TRUST OF THE CLOUD

There is a level of reluctance to move into the cloud by many industries. Concerns about cyber security and privacy are valid concerns.

The benefits of SCADA in the cloud and outsourced Cyber security has been discussed earlier in this paper. Data security falls under the same banner. Cloud service providers have many times more dedicated personnel to ensure data and cyber security than most operating companies. Levels of protection can be specifically defined under contract.

IBM's definition of the cloud:

"Cloud computing, often referred to as simply "the cloud," is the delivery of on demand computing resources — everything from applications to data centers — over the internet on a pay for-use basis.

• Elastic resources — Scale up or down quickly and easily to meet demand

• Metered service so you only pay for what you use

• Self-service — All the IT resources you need with "self-service access"

With cloud computing a software system shifts from being a framed platform of certain capabilities, to being an elastic platform that expands and contracts on demand, through the use of "unlimited" amount of processing power and storage capacity provided by a data centre. A hosted virtual environment coupled with the near ubiquitous nature of the internet, unlocks and gives rise to SCADA as a Service which can be quickly and easily adopted into the industry.

Whilst hosted or cloud systems may sound like a new concept to some, it actually isn't at all.

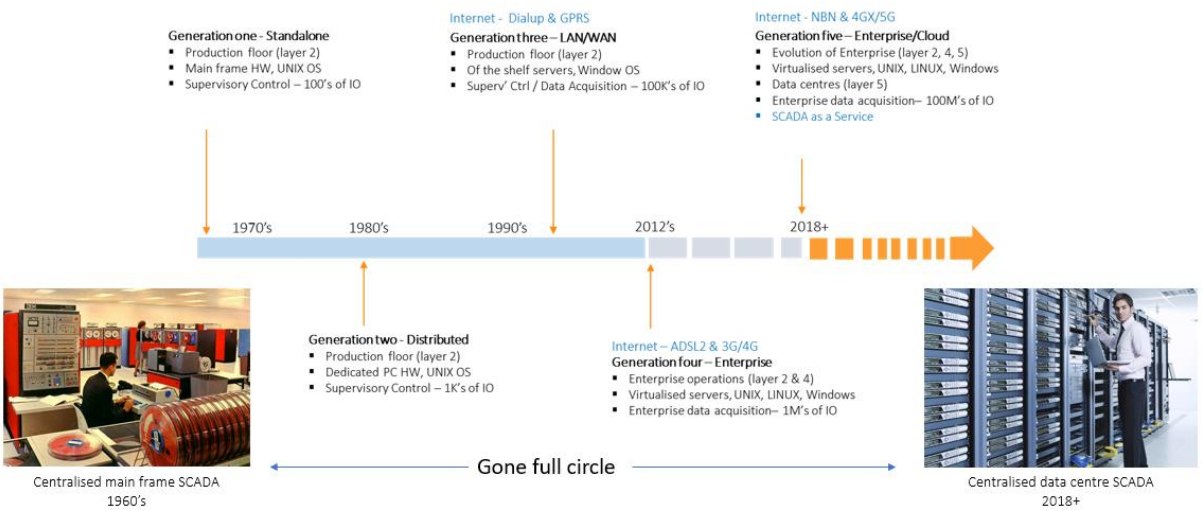

Figure 8: Evolution of the cloud and Internet

Due to the increased availability & reliability of the internet in remote areas and the continued focus for councils to operate in the most cost efficient manner for rate payers, the water, waste water industry is the most logical and immediate beneficiary of cloud based industrial solutions across New Zealand and Australia.

2.9 HOW BEST TO DIGITALIZE OPERATIONS

This paper has discussed a number of different issues that the water industry faces and how some of those can be addressed with a number of different applications of Digitalization solutions.

All digitalization initiatives require new technology and more than likely a change in behavior for a number of people to a new way of doing things.

An old proverb states: "Change is easy, people are not".

In order to determine where to start on a journey of Digitalization it's first important to define the "desired outcomes" keeping in mind that enabling your people to achieve the desired outcomes is the key.

desired outcomes → nature of required insights → data requirements → system architecture → technology

Figure 9: Recommended Digitalization decision pathway

Assemble a team across all the disciplines who will ultimately be affected by the changes. Bear in mind that some of these teams are not historically used to working with each other and may have a different view of digitalization. Such as the IT and OT teams. OT is the Operations Technology or Operations team.

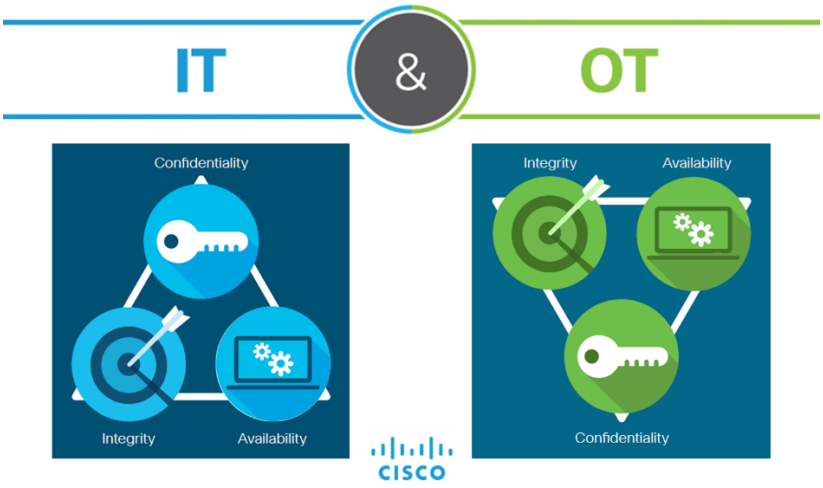

Figure 10: The CIA triangle priorities of the IT & OT teams

In determining the most effective way of getting from desired outcomes to technology the data cycles need to be carefully considered and understood. The specific pathway from the source of a piece of date through historization, analytics and onto the implementation of the insight and the resulting action that will be undertaken and who or

what should take that action. These 3 data cycles, occurring at different levels and latencies are represented diagrammatically:

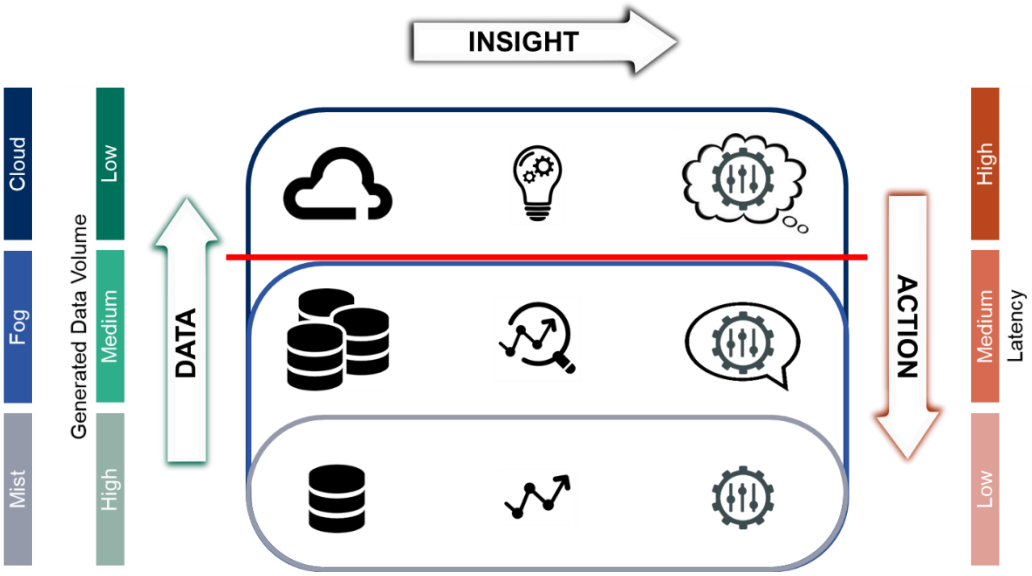

Figure 11: The 3 Data Cycles. Data to Insights to Actions.

Only spend time on actionable insights and data collection.

Based on our experience from carrying out digitalization projects there are a number of recommended steps required to develop a Digitalization Plan. The steps should include:

- Identify and gather all stakeholders & collaboration partner(s)
- Obtain consensus on the specific desired outcomes
- Evaluate and document the as-is state across people, processes & technology (base line to measure outcomes)
- Define the future (to-be) state across people, processes & technology
- Document expected benefits and value
- Define the nature of the required insights
- Define likely data requirements
- Choose flexible & scalable system architecture
- Choose appropriate security aligning with operational requirements
- Evaluate and define priorities. Roll out phases.
- Understand the transition stages of the transformation/ implementation
- Create clearly defined roadmap with visible and measurable first step

Some operations teams and businesses want the desired outcomes and benefits that a successful staged digitalization implementation can provide without the need to develop the inhouse capability to plan and implement such projects and initiatives. Under such circumstances it is necessary to select a Digitalization Partner to assist in scoping, planning, implementing and supporting the digitalization solutions.

Carefully selecting a digitalization partner with the following attributes is important.

- OT Domain Experience
- IT Domain Experience
- IT OT Convergence Projects Experience
- Trust enables a Collaborative Approach

3 CONCLUSIONS

The human side of operations are affected by many aspects of a digitalization implementation all of them with the potential to provide significant improvements to almost every aspect of the operations.

This paper has discussed a few of the issues facing the water industry and there are many others such as planning and scheduling, power usage optimization, corrosion monitoring and predicting, operator training systems using simulation tools and other analytical tools. There is insufficient space to address them all.

Digitalization offers many transformational benefits some of which are clear some we have not yet anticipated. Suffice it to say that embracing digitalization will offer many benefits and improvements in profitability, cost saving, safety and other efficiencies. It is critical to enable your people and business to enjoy the benefits of leveraging the digital revolution to enhance human performance.

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REFERENCES

Digital Transformation Vendor Briefing – Deanne McDonald GM Digital Transformation WA Water Corporation

Digital Oil & Gas – Geoffrey Cann, Director