DIGITAL SYSTEMS INTEGRATION TO IMPROVE MAINTENANCE RESPONSE TIME AND KPI METRICS

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ABSTRACT (500 WORDS MAXIMUM)

The Sydney Water Partnering 4 Success Program comprises Ventia, Jacobs and Downer as 'Confluence Water', providing Design, Construction and Maintenance services across northern Sydney. Co-developed program-wide Key Performance Indicators (KPIs) are in place to accelerate Innovation and Digital Engineering across the program. Traditional KPIs for Health & Safety, Environment and Community are in place, alongside measuring delivery performance and speed of response to reactive maintenance work-orders, and managing backlog.

The contract went live in July 2020, scaling from a bid team of around ten to over three hundred staff today, including around 80 staff employed as Mobile Technicians in the Maintenance Team.

The speed of contractor response to unplanned maintenance work orders is an important KPI for the program. The team targeted 85% compliance with required speed of response each month, but struggled to achieve this.

The team recognised intervention was required to accelerate KPI compliance. In April 2021 an automation routine was created using PowerAutomate where emails were sent to supervisors along with priority work orders of level three to six (six being highest priority). This resulted in an increase in compliance from 70% up to the 85% target within a month.

After consulting with field Technicians it became clear that an automated SMS alert defining the work order would be more useful than an email alert. This drove a further system integration to provide automated SMS alerts, achieveing a further compliance improvement.

The team felt more support to the maintenance dispatch team who controlled the apportion and dispatch work orders to Technicans across the region could be provided. A range of unconnected systems were been used to manage live vehicle location (IOT), driver trend data (ERoads), Driver of the vehicle, Work Order data (Click) and our Jacobs in-house GIS (Geospatial Information System), MapApp containing asset data, and asset locations in Esri.

The in-house innovation team created a systems integration plan **to overlay these disparate data sets on to a single GIS map**. Mobility of the solution was essential so it could be used by dispatch staff when off-site and on call.

On 1st April 2022 the system went live, harmonising the work order location and priority, from the client's work order system, location of vehicle, and position of

assets in a single visual display (figure 14) Immediately, Maintenance Planners could better assign technicians to work orders across the region due to improved visability of work order, vehicle type, and vehicle position. This was an improvement on the previous strategy, where crews would work in fixed geographical zones during the day with no visual oversight from Maintenance Planners. Numerous examples emerged after the integration showing how Technicians could be quickly dispatched from the control room to attend to high priority work-orders due to this improved visibility.

This paper outlines the approach taken, the lessons learned, and the positive outcomes that integrating the data sets had on improving and achieving target KPIs and efficiency.

KEYWORDS

Digital Systems Integration, Efficiency, Maintenance, Digital Twin, GIS

PRESENTER PROFILE

Ian is a water innovation leader at Jacobs for the Australia and New Zealand region. He is working on the Confluence Water joint venture to trial and deploy technology to increase efficiency in how the team designs, constructs and maintains water assets.

He is a chartered Civil Engineer with over 20 years of experience from projects and programs across the globe. He is passionate about cross-industry partnering for success and increasing diversity and inclusion in our industry.

INTRODUCTION

Confluence Water is a joint venture bringing together experienced and talented water professionals from Jacobs, Downer and Ventia – to deliver design, construction, maintenance and facilities management services in Sydney's north and north west (Figure 1) for a ten year period. Together, we are delivering differently to leave a positive legacy and ensure the voice of the customer drives our business, to create a better life with world-class water services.

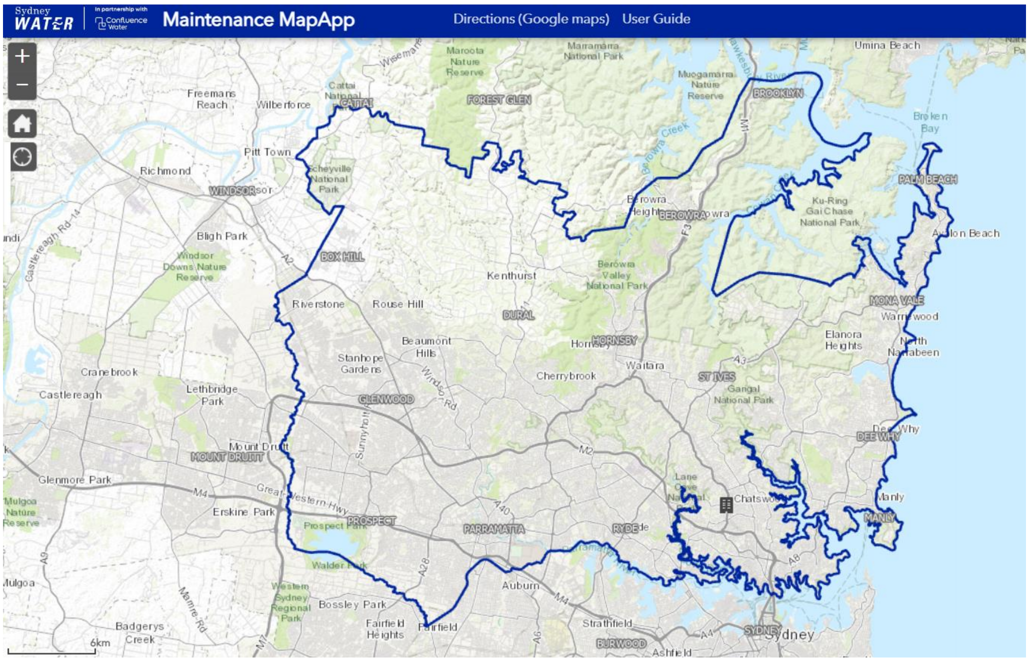


Figure 1: An overview of the geographical area of the North Delivery Team, outlined in blue.

This paper outlines:

- a range of use cases of technology to assist our team to deliver maintenance services,
- the importance of systems integration to create new products and services
- the process undertaken to integrate multiple data streams to create a unifying GIS maintenance environment for Confluence Water
- lessons learned in this process, outcomes and future planned improvements.

DISCUSSION

THE CHALLENGE

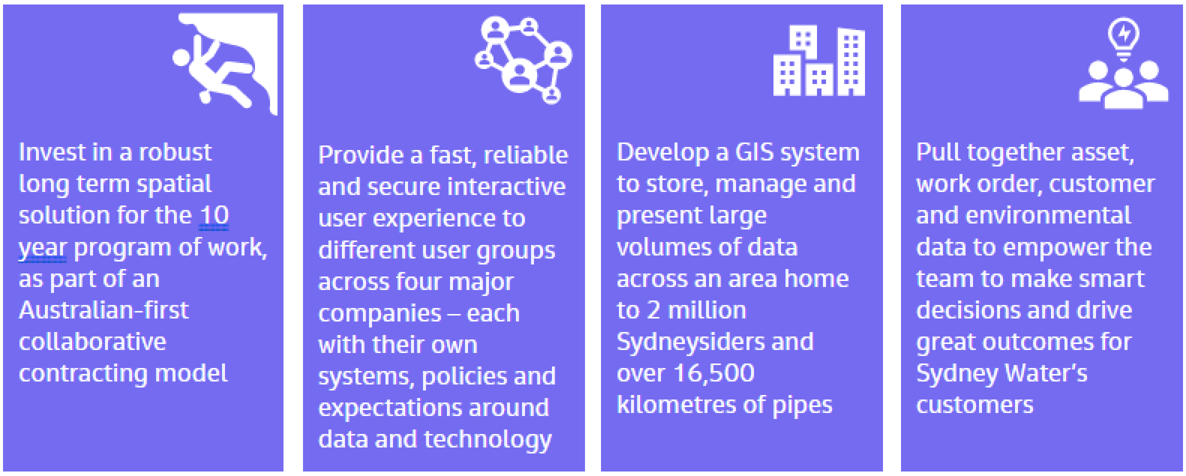


Figure 2: An overview of the primary drivers that shaped our GIS solution design

To address these challenges, we developed a spatial solution that was more than just a standard web mapping application:

Confluence Water Hub is our landing page accessed on an internet browser, that provides an on-brand, easy to navigate gateway to our range of spatial tools, ensuring they are at the team's fingertips.

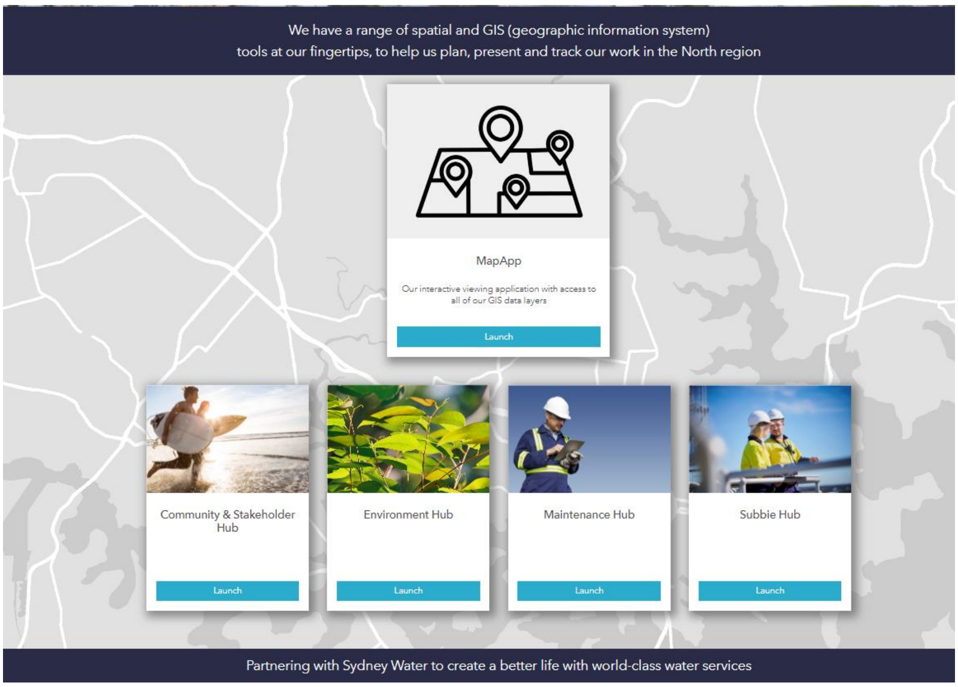


Figure 3: The MapApp Landing Page

MapApp is our interactive mapping application that presents all our GIS data layers. It allows the team to visualise, collaborate and interact with numerous datasets brought together in one web-based environment.

CommunityMapApp, Environment MapApp and **Maintenance MapApp** are additional mapping applications, all with bespoke functionality tailored to the specific needs of those teams, and are accessed from dedicated sub-hubs

ESTABLISHMENT OF DIGITAL ENGINEERING AND GIS SYSTEMS ON THE CONTRACT

Prior to being awarded the contract, the team recognised a customised Geospatial Information System (GIS) system would serve as a unifying mechanism to provide controlled, managed, secure and tailored access to project and programme information quickly for a range of roles within the team. The system would need to be suitable for treatment assets, major network facilities, linear networks, maintenance and facilities management.

A GIS Manager role was created in the organisation from the very start to develop the scope of the GIS system collaboratively with our client and technical specialists. It was recognised that four specific GIS environments; **Community MapApp, Environment MapApp, Maintenance MapApp** and **Subbie Hub** would provide enhanced experiences tailored to the needs of our individual teams and the roles they undertake. Furthermore, they were built with a philosophy to incorporate functionality to place control in the hands of the user, reducing the need of reach back to a GIS resource. In this methodology, the GIS resource was focused on building and extending the functionality of the GIS platform and associated apps to address user needs, instead of addressing individual project requests. This approach has facilitated greater consistency and scaling up of our platform.

COMMUNITY MAPAPP

Figure 4: Community MapApp screen shot

Community MapApp is used by our Community and Stakeholder Team to identify business and residential addresses likely to be impacted by our work in the north region of Sydney. This is then used to arrange stakeholder consultations and leaflet drops.

This environment includes live dashboards to track customer engagement, with updates entered directly by the community & stakeholder team, providing a live snapshot of private property access approval status to the project team, to ensure customers are aware of a visit on their property.

ENVIRONMENT MAPAPP

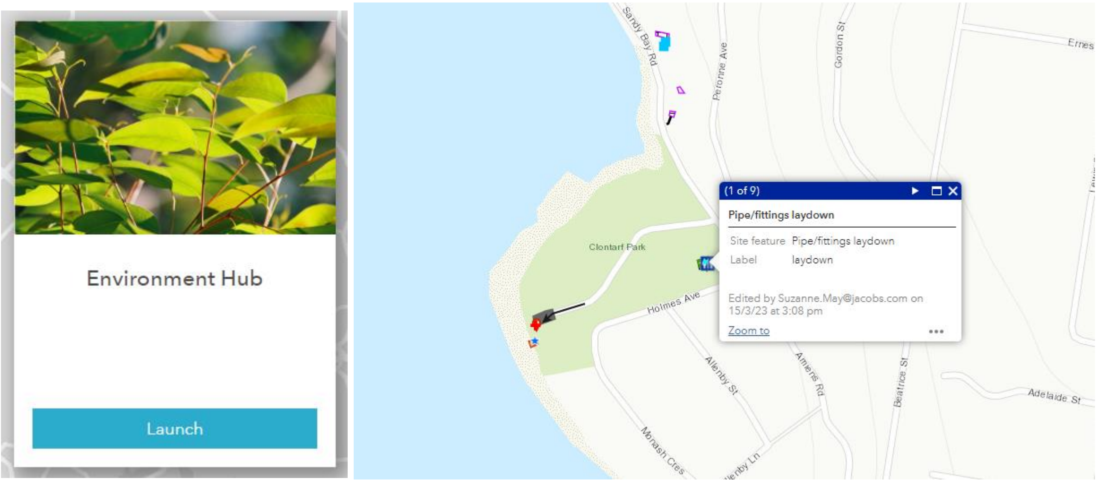


Figure 5: Environment MapApp screen shot

Environment MapApp is used by our Environment Team. It contains a wealth of information of species and environmental information from across the region including habitat management plans for sites. Approved spoil locations are visible to help construction teams plan the most efficient route to remove spoil from site. First aid points, site cabins, laydown areas and sediment control are located in this environment.

MAINTENANCE MAPAPP

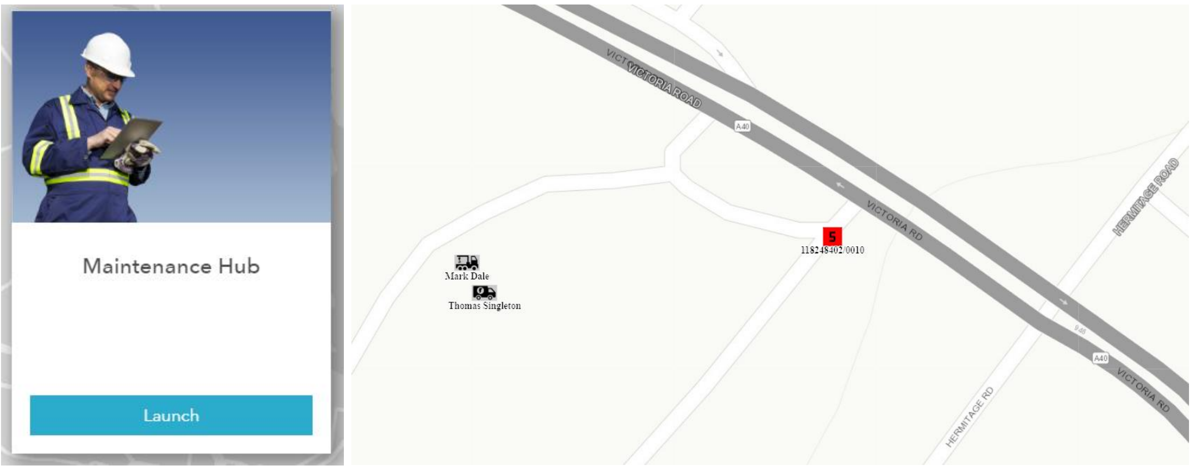


Figure 6: Environment MapApp screen shot

Maintenance MapApp brings together asset data, Near real-time vehicle IOT tracking information and live breakdown maintenance work orders. Further information about Maintenance MapApp is included within this paper. Separately, grounds maintenance data is provided through this interface through hyperlinks within our secure SharePoint environment.

SUBBIE HUB

Subbie Hub is a portal for our construction partners to access project information. This environment has restricted information available and is administrated by our GIS Manager.

MAPAPP

A base build of MapApp was created for all staff on the contract. This GIS solution provides controlled and secure access to streamed client data (restricted where necessary) and publicly available information such as historic mapping services.

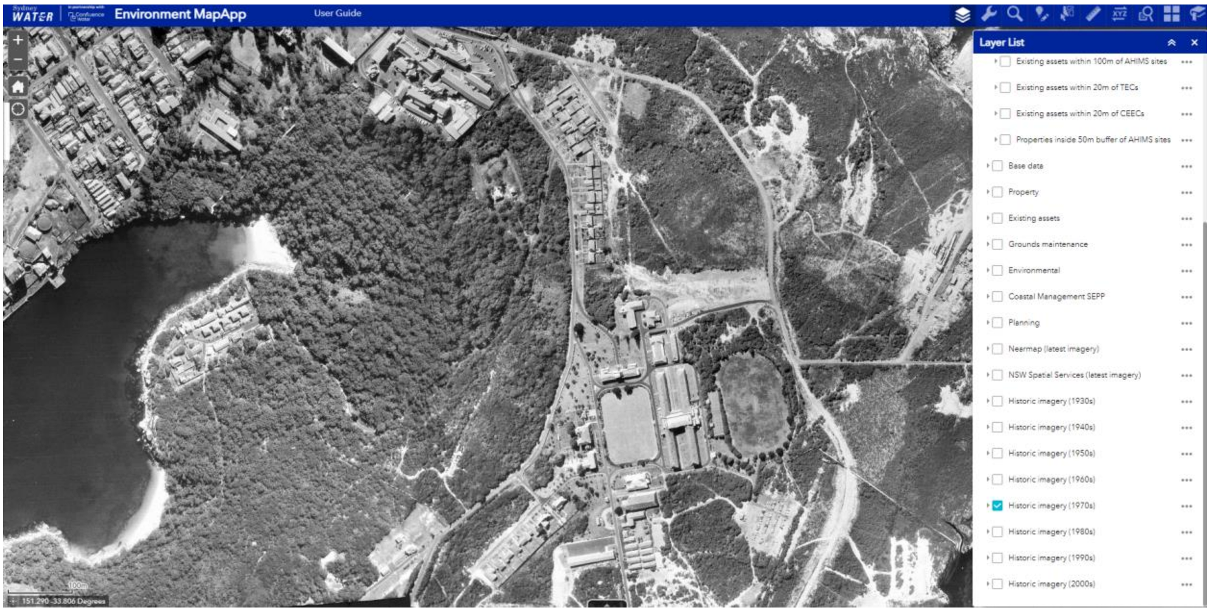


Figure 7: Historic Imagery loaded into MapApp, image shows North Head, Manly in 1970.

Historic imagery is geo-located in the app for the Sydney region to support review of historic site use. A compare function was designed and added to the MapApp interface to allow staff to toggle between base maps of different eras.

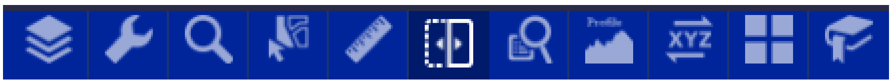


Figure 8: The MapApp tool bar with Compare Function Highlighted.

Figure 9: North Sydney today (LHS) and in the 1940s (RHS) using the Compare Tool

The base-build MapApp incorporates asset information, location of underground services, office, depot and current delivery project sites. Background imagery can be toggled on and off to which is provided by NSW Government and geo-located within the environment.

PRIMARY CONSIDERATIONS FOR THE GIS SYSTEM

During the mobilisation phase it was determined that the Sydney Water's impressive and integrated GIS system would not be suitable for the Regional Delivery Consortia (RDC) as a primary delivery platform due to the lack of ability to develop work-in-progress projects on the platform. Customisation, API connectivity and in-house development were essential requirements at this stage for the RDC, however, they did recognise that information (data) from Sydney Water and publicly available information sources should be streamed, or bulk uploaded in to the RDC's GIS environment.

Over-arching requirements for data sovereignty, control of access to data and major platform reliability and support have guided the systems we have selected to form part of our evolving solution.

CCTV IMAGERY FROM PROJECT SITES

CCTV Timelapse data (still imagery delivered periodically) from numerous sites across the region has provided the opportunity to share site construction progress with colleagues. Cameras are located at the perimeters of sites with the Project Manager advising of the optimum position to capture footage during the project, not impact safety or constrain activities on a changing site.

Traditionally images or video footage created by the camera are stored in memory within the camera or on a hard-drive close-by. However, the team recognised an opportunity to access streamed data stored on the cloud, which is then presented through a PowerBI interface. This systems integration exercise has the benefit of:

1. Managing user access to CCTV BI dashboards
2. Providing access to images of project progress to a number of engineers, designers and managers
3. Providing a BI interface which makes 1,000s of stored images easily viewable based on the camera and date/time selected.

CCTV footage of site progress allows the Regional Delivery Consortia (RDC) to better understand site conditions at any given time or date, understand activities being carried out and review footage to better understand processes adopted (time and motion studies) and opportunities for improvement to be applied to future projects.

CCTV cameras also offer an opportunity to provide oversight of equipment and premises. Artificial Intelligence (AI) linked to automated alerts will help raise the alarm of unexpected visitors outside of normal working hours.

Figure 10: Image showing a construction site in the region from the CCTV timelapse camera.

BOM WEATHER STATION DATA CONSUMPTION AND ANALYSIS

Like many Water Utilities and construction & maintenance providers, activities are highly susceptible to weather events. Estimated durations of activities need to be cognisant of seasonal and prevailing weather conditions. Our data scientist developed a PowerBI dashboard to ingest over 1,300,000 points of rainfall data provided by The Bureau of Meteorology (BOM) for weather stations across the region. This interface to the detailed and extensive BOM data set provides at a glance review of rainfall by month for 13 sites across the north and north-west of Sydney, within the RDC region.

The interface was co-developed with the estimating function who wanted to review the impact of La Nina locally and better anticipate seasonal variability of rainfall. Functionality was included to filter the number of wet days based on a user-inputted threshold amount. This then allows the estimator to better anticipate which days will have impacted productivity on site. The consistent formatting of the BOM source data has enabled the creation of a BI interface that can be scaled across many BOM sites.

Figure 11: Image showing customized BI Dashboard showing BOM rainfall data for a weather station.

DRONE INSPECTIONS TO REDUCE WORKING AT HEIGHT RISK EXPOSURE

Falls from heights is one of our industries' biggest causes of fatalities and we look for ways to eliminate this risk from our work. One method that has been deployed is the use of aerial imagery taken by drone to negate the need for at height inspections of roofs. Our trials have successfully shown the resolution has been sufficient to accurately assess the condition of the roof and reduce the number of physical inspections than the original methodology.

The flying of drones required close collaboration with Sydney Water to define a new process to safely fly drones on operational sites, whilst fulfilling all CASA requirements such as pilot licencing, drone registration and addressing site safety pre-requisites such as ensuring people are not positioned under the drone during a flight. Ventia is our drone partner who who's Remotely piloted aircraft operator's certificate ReOC we fly under.

DIGITAL FORMS FOR SITE ACTIVITIES

Digital Forms are a necessity for the consistent capture of data, availability of data and data analytics. When working across a geographically large area with disparate sites it is an imperative that information can be easily collected and analysed. The innovation team worked closely with the maintenance and construction crews to understand priority forms in the safety management system (IMS) then went through the process of creating these forms on the Jacobs Echo system. It was essential that forms could be heavily customised in-house to mirror the master file in the IMS, available off-line to suit some remote and underground operating environments and all data resided in Australia; criteria which the Jacobs Echo solution excels in.

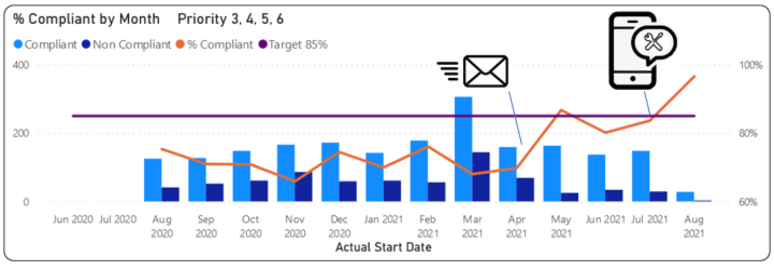
Since Go-Live Our Maintenance crews use Digital Forms for Permits to work, Safe Work Method Statements (SWMS), Critical Risk assessments, Sub-contractor evaluation and site inspections in the Echo platform. To date over 10,000 digital forms have been submitted on the program. An Australia-based SQL server with PowerBI dashboard was established to make this data easily available and searchable. Further investment by the contract has extended the capability of the Digital Form solution for commissioning works. The team expect staff to complete an agreed number of site inspections based on their role. The team established a KPI BI dashboard which registered actual and expected number of digital forms submitted against each person, this helped raise awareness of the KPI and raised completion statistics.

TRACKING KPIS

Traditional KPIs for Health & Safety, Environment and Community are in place, alongside measuring delivery performance and speed of response to reactive maintenance work-orders and managing backlog.

The speed of contractor response to unplanned maintenance work orders is an important KPI for the program. The team targeted 85% compliance with required speed of response each month but struggled to achieve this (Figure 12).

The team recognised intervention was required to accelerate KPI compliance. In April 2021 an automation routine was created using PowerAutomate where emails were sent to supervisors along with priority work orders of level three to six (six being highest priority). This resulted in an increase in compliance from 70% up to the 85% target within a month.



% Compliant by Month Priority 3, 4, 5, 6

Actual Start Date	Compliant	Non Compliant	% Compliant
Aug 2021	28	1	96.55%
Jul 2021	148	29	83.62%
Jun 2021	137	34	80.12%
May 2021	163	25	86.70%
Apr 2021	159	69	69.74%
Mar 2021	306	144	68.00%
Feb 2021	178	56	76.07%
Jan 2021	142	61	69.95%
Dec 2020	172	59	74.46%
Nov 2020	166	86	65.87%
Total	**1999**	**718**	**73.57%**

Figure 12: Maintenance KPI compliance over time and intervention points

After consulting with field Technicians, it became clear that an automated SMS alert defining the work order would be more useful than an email alert. Emails weren't as often noticed on tablet devices in the field. This instigated a further system integration sprint to provide automated SMS alerts linking the maintenance system to an automated text messaging service through an API, achieving a fully automated messaging system which published key data from the work-order to technician in the field. Response KPIs rapidly improved again (Figure 12).

Due to the large geographical area of the north teams were arranged into geographical hubs across the region. All Technicians were equipped with a Tool of Trade Vehicle (ToTV) containing tools, which was tracked using Verizon or EROAD systems. However, there was no aggregated screen showing a visual oversight of the position of the vehicle, the location and priority of the work order and the name of the driver.

THE DEVELOPMENT OF MAINTENANCE MAPAPP

The team felt more support to the maintenance planning team who controlled the apportion and dispatch work orders to Technicians across the region could be provided. A range of unconnected systems were used to manage various components of maintenance reactive response; these are captured in the table below:

System	Purpose
Verizon/EROAD	Corporate vehicle location
Click FSE	Work order data including location and priority of incident
MapApp (ESRI GIS System)	Geospatial location of client assets
Text Alert System	Automate the dispatch of text messages to staff

Table 1: Stand-alone systems used on the contract.

A small team was established containing systems integration specialists, Maintenance Planners. They worked together to define a goal which was to: **Integrate existing business systems to provide greater oversight of staff location, work-order location and priority and client asset location to enhance maintenance planning reactive tasks.**

The in-house innovation team created a systems integration plan to overlay these disparate data sets on to a single GIS environment. Due to the extensive capability of the Jacobs GIS system, it was natural to introduce the additional data into this secure environment.

The user of the system was to be the Maintenance Planners, who dispatched mobile Technicians to work-orders across the region. All Maintenance Planners are based at the Chatswood Head Office in a purpose designed Maintenance Hub area with large screens to display this data. However, one design requirement was that this information needs to be available on a laptop from outside the office in case the team need to relocate or need to engage a member of staff who isn't in the office. The Esri platform enabled this requirement.

DESIGN OF THE INTERFACE.

Specific solution architecture decisions were required to be understood and addressed which would impact the functionality and cost of operating the system.

The two main drivers for this were to balance the cost of the IT service and the frequency of information update. We found that one vehicle tracking system provided a superior API which streamed information when the vehicle's information updated, such as location change, or status change (i.e. ignition on/off). The lesser tracking system didn't do this. The change of the vehicle data could not be directly identified by consuming the API from the provider. To overcome this we had to facilitate an additional-service and process to help identify the updates for all vehicles within Microsoft Azure. Each computational process in the cloud has a cost so this routine incurred additional cost into the solution.

The number of system connections also impacts the cost of operating the routine and the speed of connection, so the team needed to be judicious with which the allowance of services capacity and the user experience through this process.

Because of the criticality of time to respond to unplanned work-orders the flow of data from Click FSE containing priority and information was required to be almost real time.

One major consideration was if the development should be compatible with other web apps created by using no-code tools such as ArcGIS Web AppBuilder provided by the Enterprise ArcGIS portal (using ArcGIS API for JavaScript, Version 3.x), or utilizing the latest API to create custom web app with rich and modern user interface support (ArcGIS API for JavaScript, Version 4.x).

Although greater API functionality was believed to exist by building a custom web app, it was decided that the compatibility to all exiting or future web apps created by Esri Enterprise portal was more important. This is because it would place fewer requirement on having specialist coding resource available in the future, provide greater on-the-ground update, and allow security access configuration to be managed by the GIS manager in the Esri platform, without needing to hard-code this into the Application.

The solution would need to integrate the location of a fleet of over 60 maintenance vehicles, with updated positional information being pushed to the interface every two minutes.

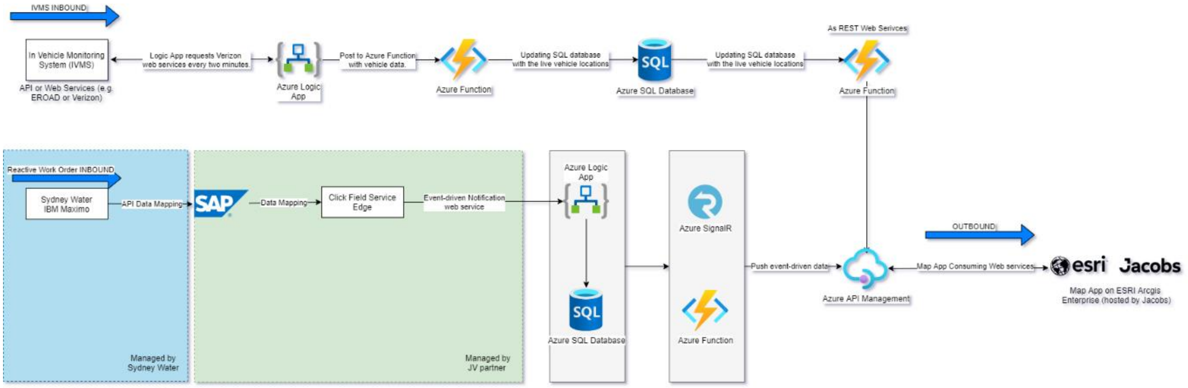


Figure 13: An outline of the implemented systems architecture created to develop the SMS alert and GIS Maintenance MapApp environment.

INTERFACE WITHIN THE APP:

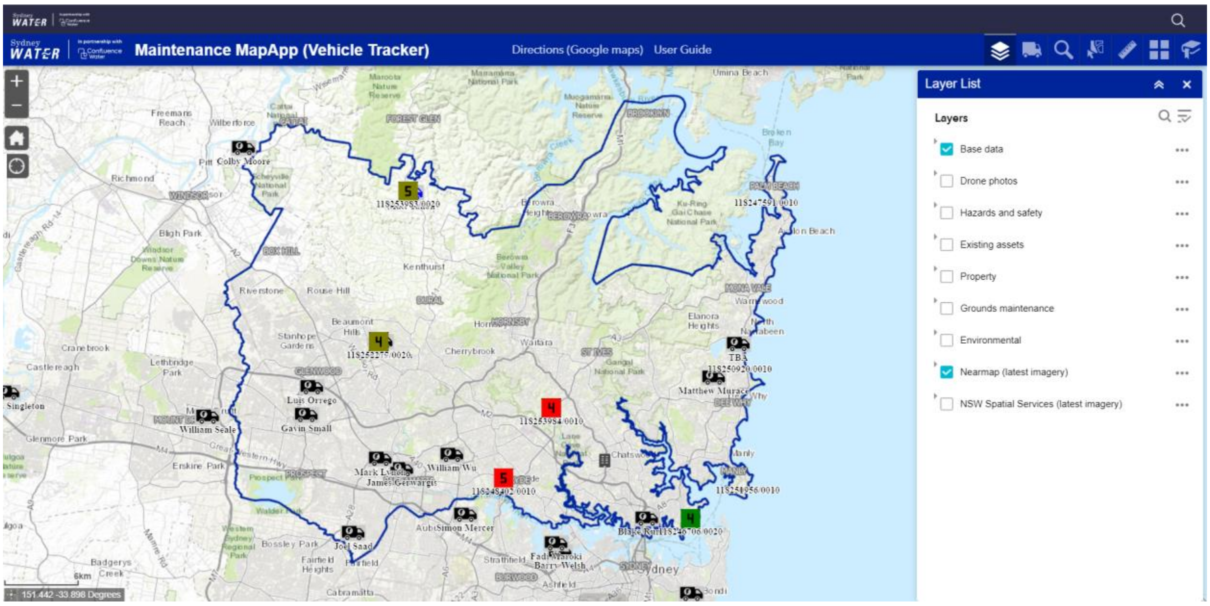


Figure 14: A view of the Maintenance MapApp interface.

Simplicity of the interface was essential to make the Maintenance MapApp intuitive to use for Maintenance Planners.

Work orders with priority are highlighted as numbes in square boxes. Vehicles are shown as icons in real-time in the map. Layers can be turned on and off to add and remove information. Work orders were give numbers (text) and colour coding to be functional for those with colour blindness.

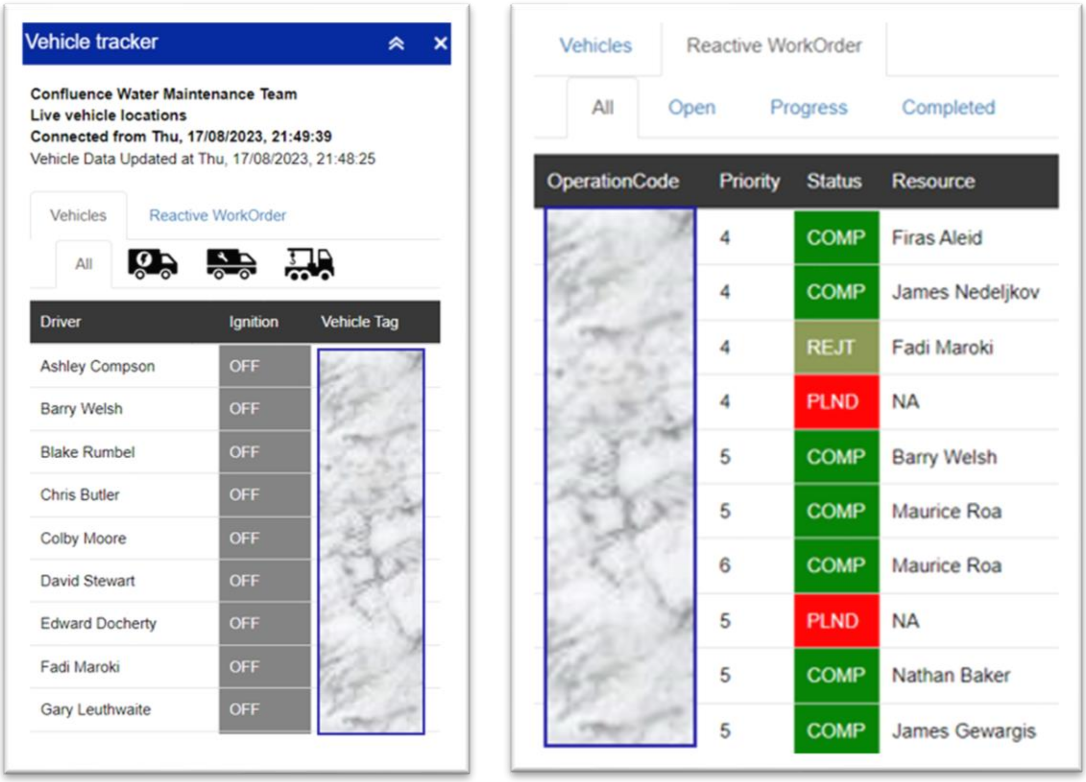


Figure 15: Vehicle Tracker and Work Order Information Panels.

Initial testing showed that some maintenance work-orders were assigned by the client without location information. To flag this these errors, work orders without location were assigned a location 20km off-shore to help identify poor data. (Figure 15)

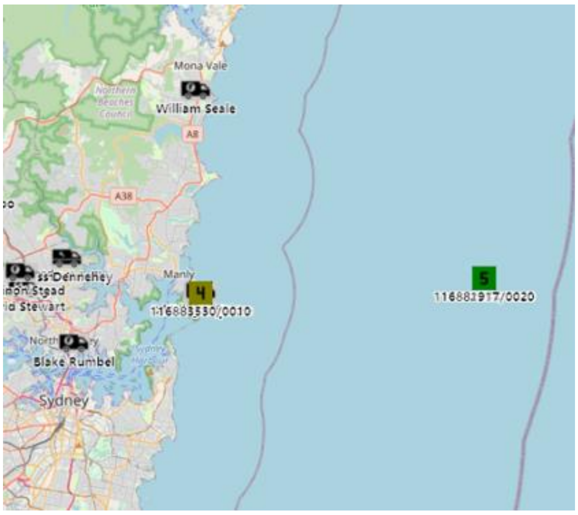


Figure 16: Work Orders without a location positioned within the ocean to avoid confusion.

SECURITY

Because vehicles potentially provide information on where people live, the access location data is restricted. Additional functionality like removing the vehicle from the display when the ignition is off and is stationary out of hours has been implemented.

GO LIVE

On 1st April 2022 the system went live, harmonising the work order location and priority, from the client's work order system, location of vehicle, and position of assets in a single visual display

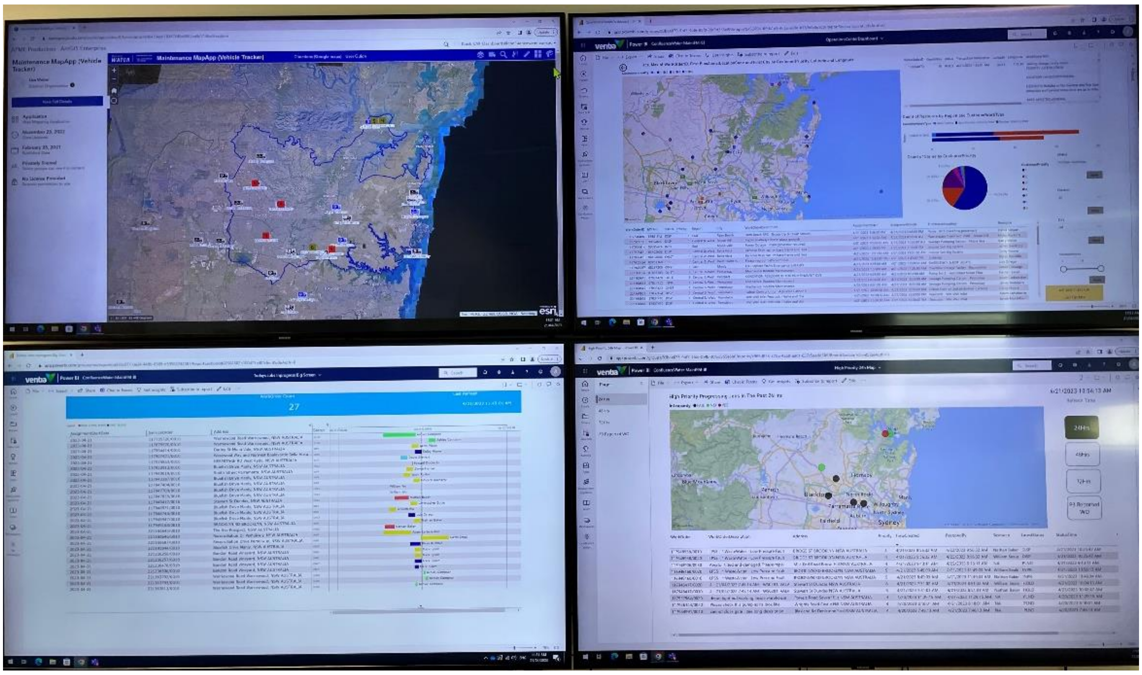


Figure 17: Images showing the TV screens in the Maintenance Hub showing Maintenance MapApp

Immediately, Maintenance Planners could better assign Technicians to work orders across the region due to improved visibility of work order, vehicle type, and vehicle position. This was an improvement on the previous strategy, where crews would work in fixed geographical zones during the day with no visual oversight from Maintenance Planners. Numerous examples emerged after the integration showing how Technicians could be quickly dispatched from the control room to attend to high priority work-orders due to this improved visibility.

IMPROVEMENTS

One improvement that has been evaluated but not implemented is to integrate the Technicians' capabilities, credentials, and timesheet data into this system. Prior to dispatch, the system can help the Maintenance Planner better understand the specific credentials held by the Technician and better manage fatigue of the workforce. This would allow certification such as Confined Space

Entry, or Electrical Licences to be easily viewed to assess the suitability of the Technician to the type of reactive work.

CONCLUSION

The team successfully developed a number of digital products and services to support the RDC using systems integrations techniques. The robust and usable Maintenance MapApp interface for staff has proven to be a significant step forward in the joint venture to improve KPI response time for unplanned work orders and manage the dispatch of skilled mobile maintenance Technicians.

Feedback has been extremely positive from the Maintenance Planners, and they utilise the GIS Maintenance MapApp interface to plan work and assign mobile Technicians to work-orders every day. The team have not been affected by any significant outages and the integrations have remained functional after routine software upgrades.

A focus on simplicity of the user interface and early consultation with users has been critical to the adoption of the tool by the team. IT architecture decisions were defined and discussed early to ensure items such as frequency of update of data streams and associated cost implication were considered in the design of the system. The ability to share data through API connections was essential and none of this would have been possible without dedicated staff who were self-motivated to expand their knowledge of digital cloud tools and their implementation.

ACKNOWLEDGEMENTS

We would like to acknowledge the support from our client, Sydney Water and JV Partner organisations; Downer; Ventia and Jacobs.

I would also like to recognise the work of Lei He and Lisa Weber from Jacobs who designed and implemented this system for Confluence Water.

Sydney Water and Confluence Water respectfully acknowledges the Traditional Custodians of the Wallamedagal and Cammeraygal clans where we work today. We also pay our deepest respect to Elders past and present, and all other Traditional Owners across Australia where we work, live, and learn.