TSA

Digital Twin Analytics

Digital twin: optimising **health** investment planning

A collaborative white paper by Digital Twin Analytics and TSA Health Advisory.

Digital twins are a highly effective addition to traditional model of care (MoC) and health facility planning. They allow project sponsors to run simulations that test if their proposed MoC or facility layout will function as intended.

A recent Health Infrastructure NSW project used a digital twin to test new MoCs as part of the redevelopment of a major emergency department. The digital twin revealed unforeseen issues with the proposed MoC that would create bottlenecks and rapidly overwhelm the system. This early warning has allowed the Project team to revisit the MoC during the early planning stages, before any capital expenditure or changes to operational procedures.

TSA [ ] Digital Twin Analytics

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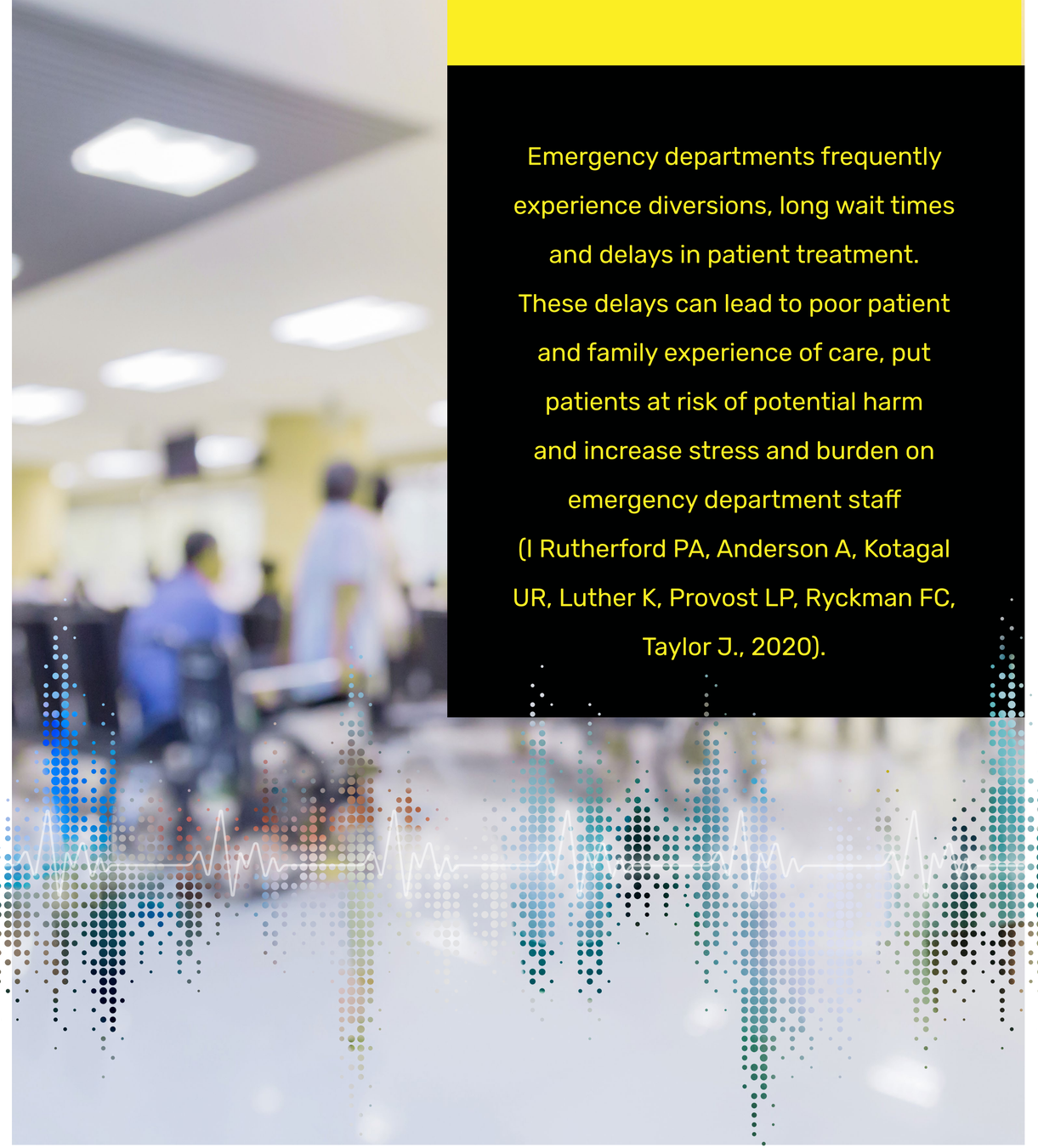


Emergency departments frequently experience diversions, long wait times and delays in patient treatment. These delays can lead to poor patient and family experience of care, put patients at risk of potential harm and increase stress and burden on emergency department staff (I Rutherford PA, Anderson A, Kotagal UR, Luther K, Provost LP, Ryckman FC, Taylor J., 2020).

Introduction

There is a growing demand on health services and emergency departments (EDs) to develop new models of care to improve the patient experience. Health services must balance this with the delivery of 'value-based care'[1] and continuous system performance improvement, there is a need for systems to flex and change over time. Regular analysis of patient flow is important to ensure safe, high quality, patient-centred care and the best use of resources such as patient treatment spaces, equipment and staff. Essentially, it is an ongoing balancing act to ensure effective patient flow and reliable care delivery, in the right care setting, and at the right time. Digital twins not only test this ongoing balancing act, but also test it against new MoCs and new facility designs.

One of the best times to develop a new MoC, or redesign patient flows and journeys, is when a new facility is being planned or existing services are being redeveloped. The traditional approach has been to do this through extensive stakeholder consultation and extrapolating evidence from similar existing services or facilities.

This white paper outlines a new approach to enhancing traditional service planning and health facility planning processes by using digital twins, fed with real-world data. This allows for sophisticated modelling of patient flows that was not previously possible. We explore a recent Health Infrastructure (HI) project and discuss our learnings from it. We also look at how this approach could be applied more broadly to enhance MoC and infrastructure planning across the entire health care system.

[1] *The concept of 'value-based care' has been widely adopted in the health sector. At its heart, it's about care that is effective and efficient, delivers positive outcomes for patients, and positive experiences of care. This drive for positive experiences and outcomes also encompasses those who deliver the care.*

Background

What is a digital twin?

A digital twin is a virtual / digital replica of physical entities - such as systems, people, processes, or devices - that help businesses make data-driven decisions. The approach is widely used in a range of industries including mining, retail, supply chain and manufacturing.

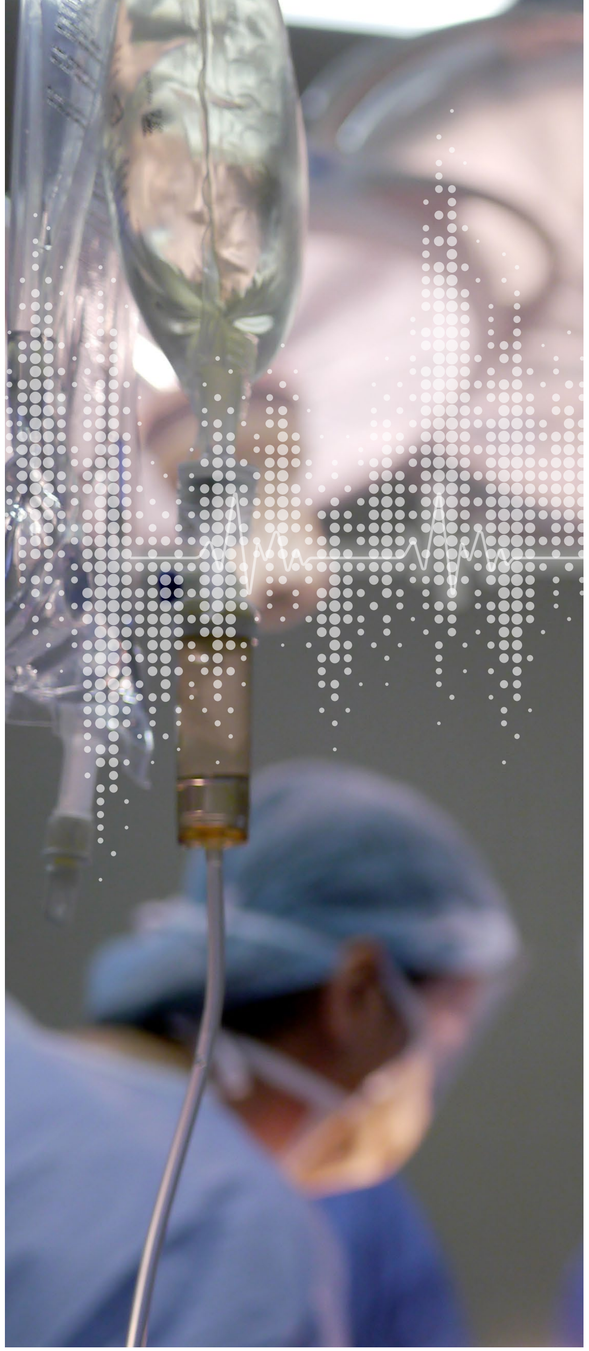
The situation and team

A large and prestigious Australian tertiary and quaternary metropolitan hospital is in the planning and design stage of a significant redevelopment (Project) that aims to deliver a whole-of-campus solution. It will bring together new MoCs, technology enablers and physical infrastructure to expand and improve service delivery.

An integral component of the Project is the redevelopment of the ED, which provides trauma and emergency care for the local population, and Sydney metropolitan and regional referral areas. Significant growth in activity and patient acuity is predicted into the future. The hospital stakeholders recognised that the Project provides a singular opportunity to achieve a truly future-focussed ED that will meet the needs of the community and predicted growth in demand, well into the future. It was a chance to support an effective design that would provide better patient experiences and improved ED patient flow.

Looking for a step change, HI engaged TSA's Health Advisory team to challenge traditional approaches to health facility planning and support innovation opportunities throughout the Project lifecycle. Together, they agreed that the best way to achieve HI's goals was to apply a digital twin to explore process flows and test potential ED MoCs. This would allow data driven insights to inform the future MoC and the design of the ED.

Digital Twin Analytics (DTA) was engaged to facilitate this process with the Project team and stakeholders. DTA specialises in the development of digital twins to help design and understand the complex interactions that thwart the ability of other methods to capture the essence of system performance.



Approach

The standard, traditional approach to health facility planning involves five interconnected project stages as illustrated in Figure 1. The approach includes broad consultation with end users. These include health consumers and their carers and families, clinicians, and other health staff.

This approach is a robust and proven methodology. However, health systems are facing rapidly increasing demand, decreasing or limited resources (including staff) and escalating operational costs. Clinicians and hospital managers need more certainty. They need assurance that designs are sound and capable of supporting the desired outcomes, and that they enable safe and effective patient care. Also, that care is affordable and sustainable from capital and recurrent expenditure, and environmental perspectives.

The Project team's approach was to add a digital twin to the Stage 1 traditional facility planning approach, to provide ED flow simulation modelling. This would help build a better, more accurate understanding of how the future system is likely to behave and flag potential issues. It would test the proposed MoCs, build confidence through data-driven insights and inform the facility design solution.

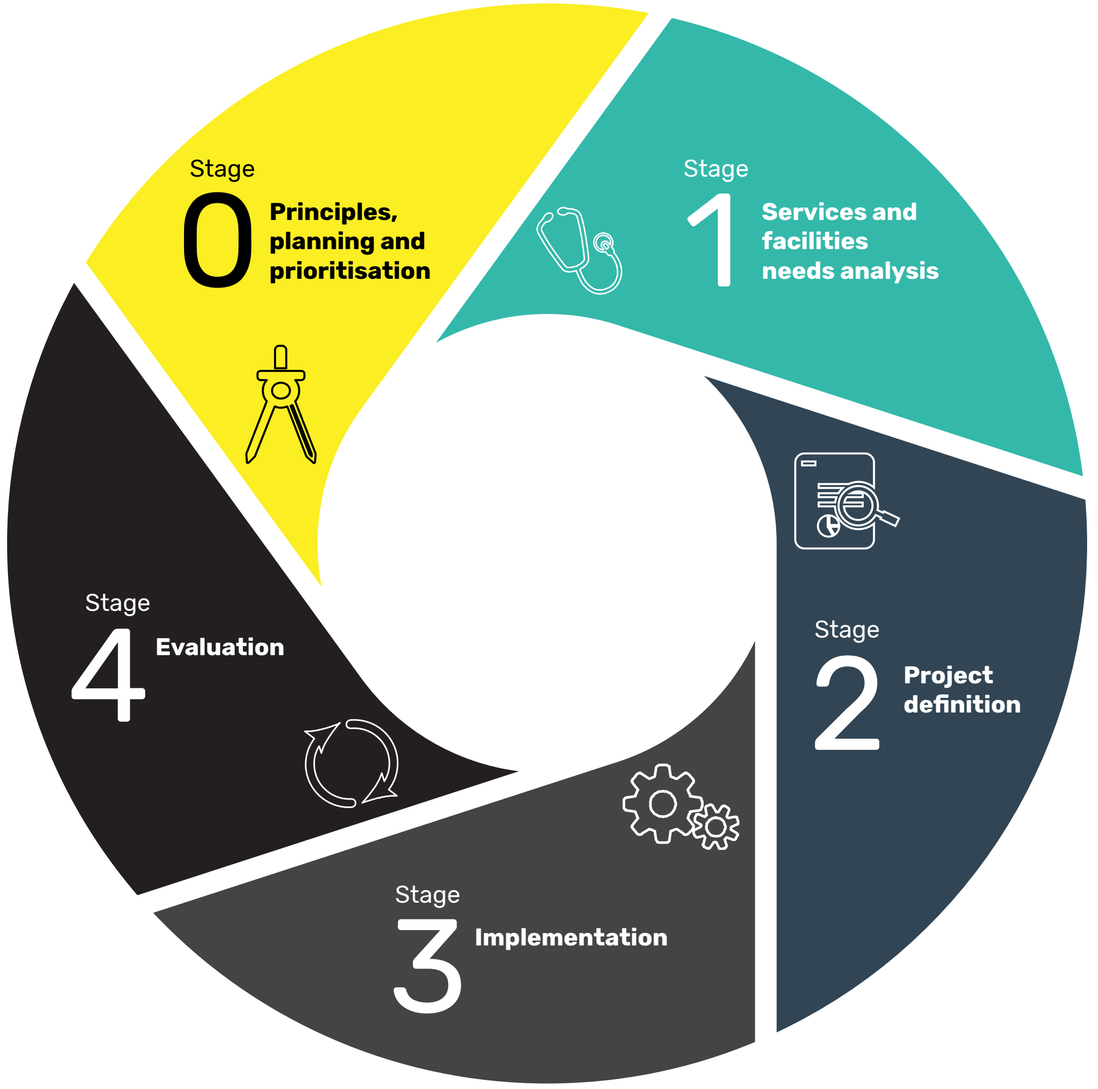


Figure 1: NSW Health Facility Planning Process

Digital twin methodology

The digital twin methodology seeks to maximise the performance of an entire system. It does so by showing how different parts of the system respond to variables, and how those responses interact across the wider system. The methodology includes:

- Bringing diverse stakeholder groups to a common level of understanding / removing silos.
- Hypothesising, testing, learning, and iterating.
- Increasing confidence / reducing risk in decision making.
- Providing insights and understanding of MoCs before going live in the redesigned environment.
- Experimenting using known, verified and reviewed datasets and logic.

The approach to developing and using a digital twin is illustrated in Figure 2.

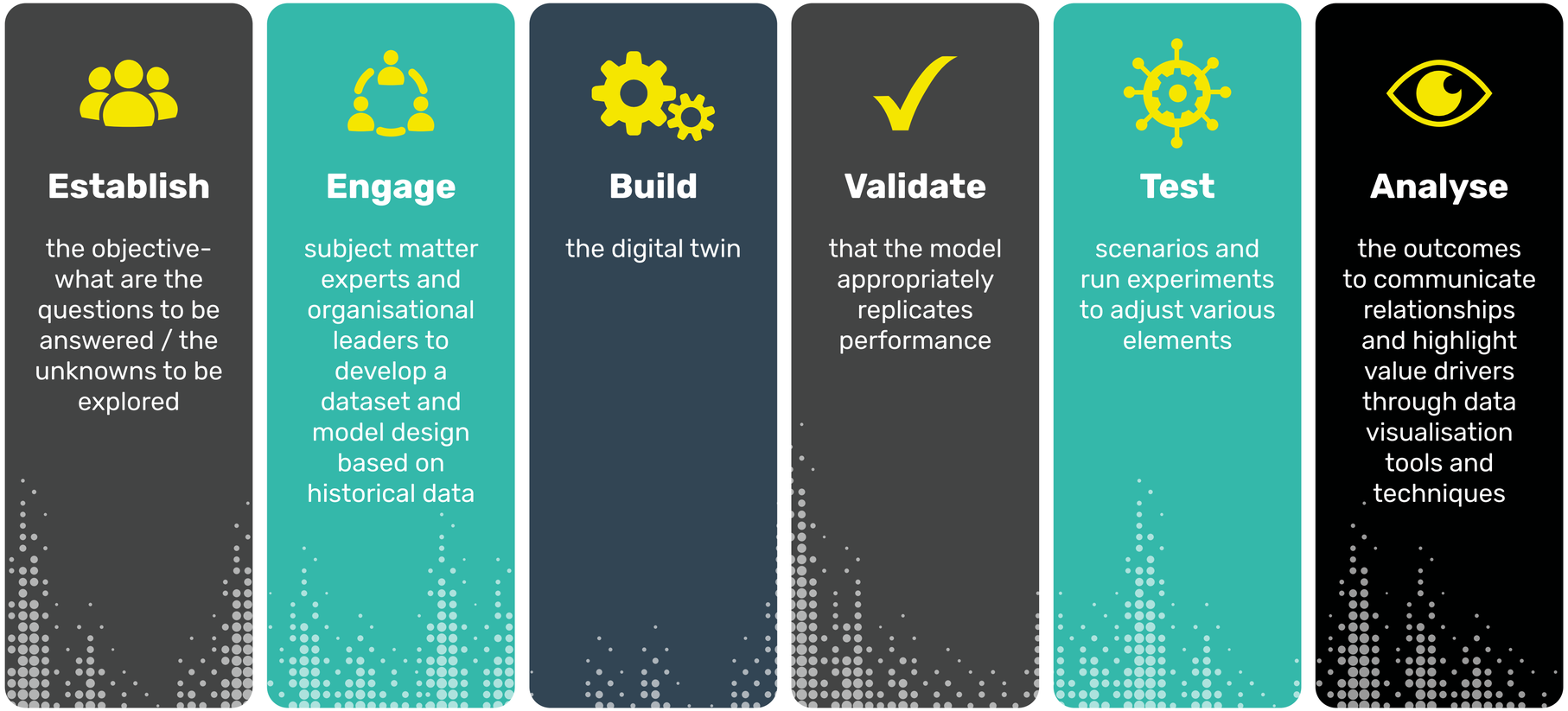


Figure 2: Developing a Digital Twin

How we built our digital twin

Working with ED clinicians, the Project team developed a dataset and simulation model based on historical ED data. It accurately represented arrival patterns, conditions of patients and treatment times. This information was applied with the existing department layout and treatment zones to form the simulation model. This dataset is a key step in building and operating a digital twin as it generates patients for presentation to the ED digital twin. These are based on analysis of historical data and then scaled to match the ED digital twin forecasts identified in the Clinical Services Plan (which informs the Project scope based off projected future service activity).

DTA then built the digital twin of the ED. The digital twin represented the proposed MoCs across the whole ED including resuscitation, acute care and fast track. Because the team wanted to test the MoCs before testing the design of the department, the initial digital twin used the current ED layout.

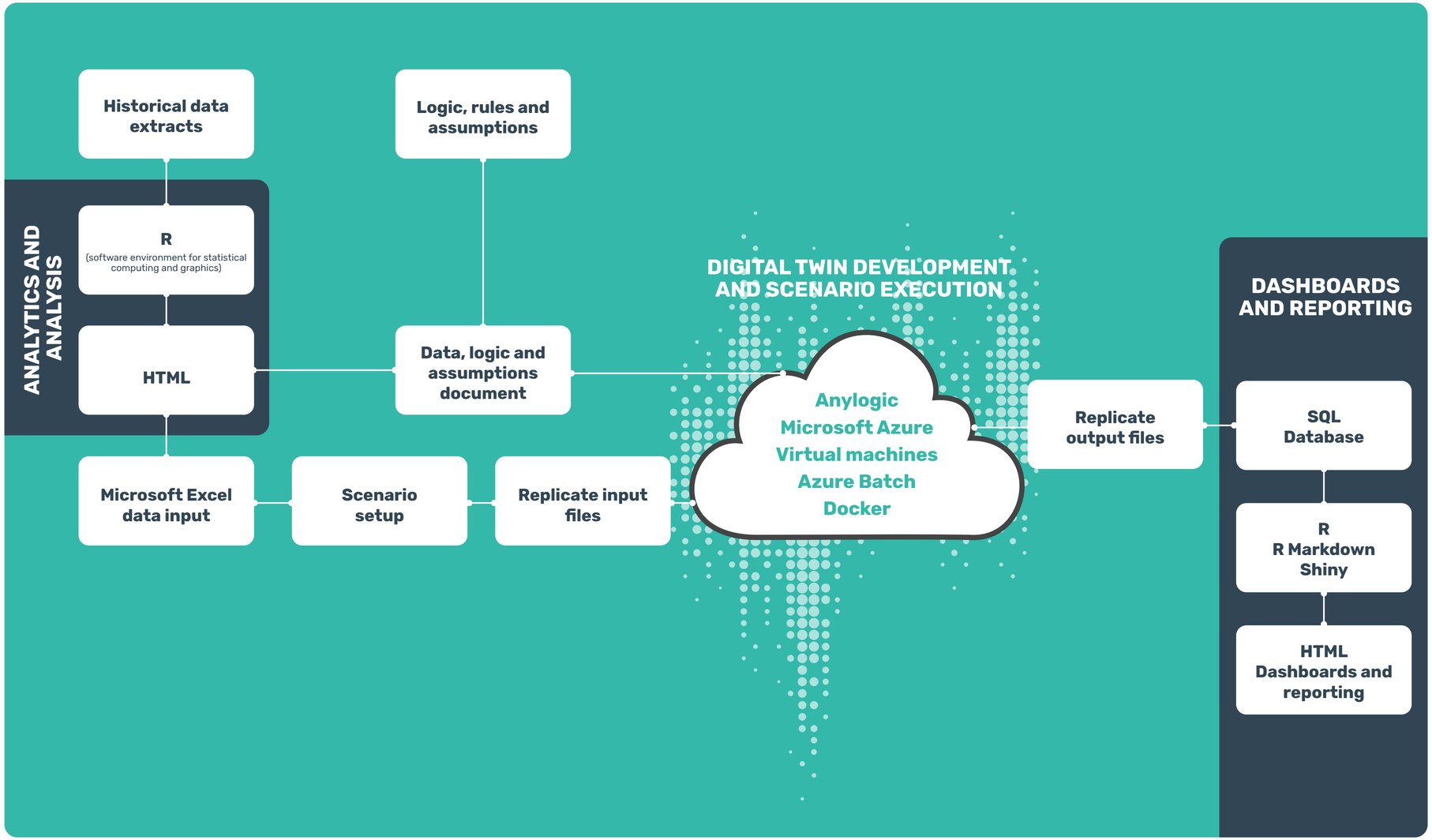


Figure 3: Digital twin development process

In the next step, applying the dataset developed above, patients ‘present’ to the digital twin at all hours of the day with age, illness or injury severity and characteristics that match historical presentations. The digital twin uses the attributes of the arriving patients to allocate a treatment pathway, which in turn dictates the preferred treatment resources that the patient will require. The duration of patient treatment is based on analysis of historical data factors such as ED congestion, resource availability and elapsed time in ED. These all contribute to influencing the patient’s journey through the ED and thus their ultimate length of stay.

The simulations were run focussing on key Emergency Treatment Performance (ETP) measures, including patient length of stay (LoS) and patient waiting times. Because this is a virtual system, the team were able to rapidly execute a large number of ‘experiments’ tweaking various elements of the MoC to see the results.

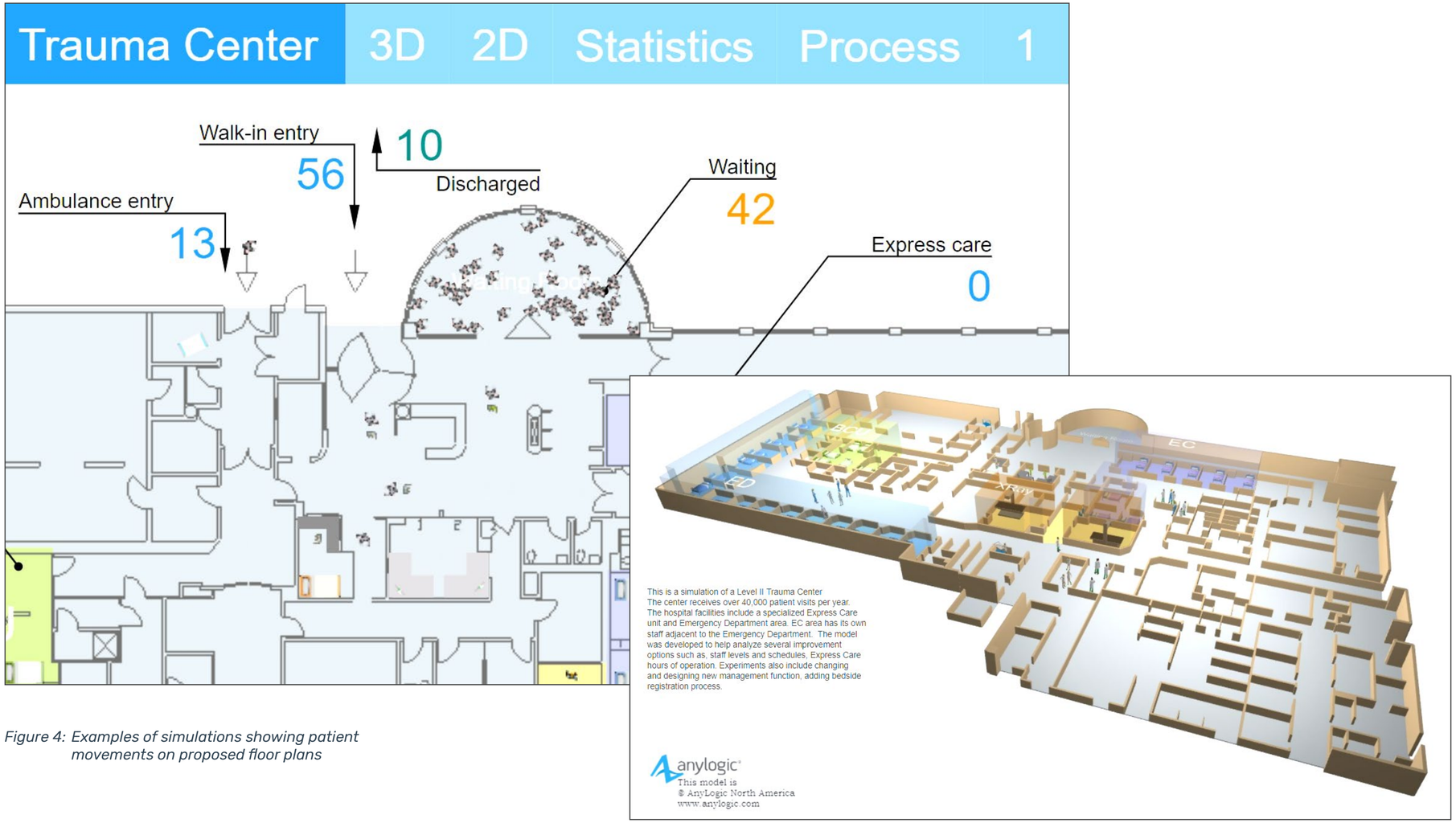


Figure 4: Examples of simulations showing patient movements on proposed floor plans

Findings and implications

Identifying bottlenecks

As described earlier, the team was simulating the MoC components across the entire ED and interconnected system. The first in the process was a new secondary triage MoC that involved early streaming, assessment and diagnostics immediately following triage. While the digital twin showed good performance for downstream MoCs, it identified bottlenecks in the workflow and patient journey for the early streaming MoC. Even after tweaking, it became clear that the way the MoC was proposed meant it would be overloaded very quickly in real-world conditions. This had flow-on impacts to downstream MoCs and department zones within the ED. Overall, it showed that if the proposed MoC was not redesigned, ED performance would decline, as patient presentation numbers increase over the 10-year planning horizon.

Using the digital twin to conduct virtual 'experiments' the team was able to identify the specific factors that were influencing performance, quickly and cost effectively. They were able to tweak configurations to refine the MoC.

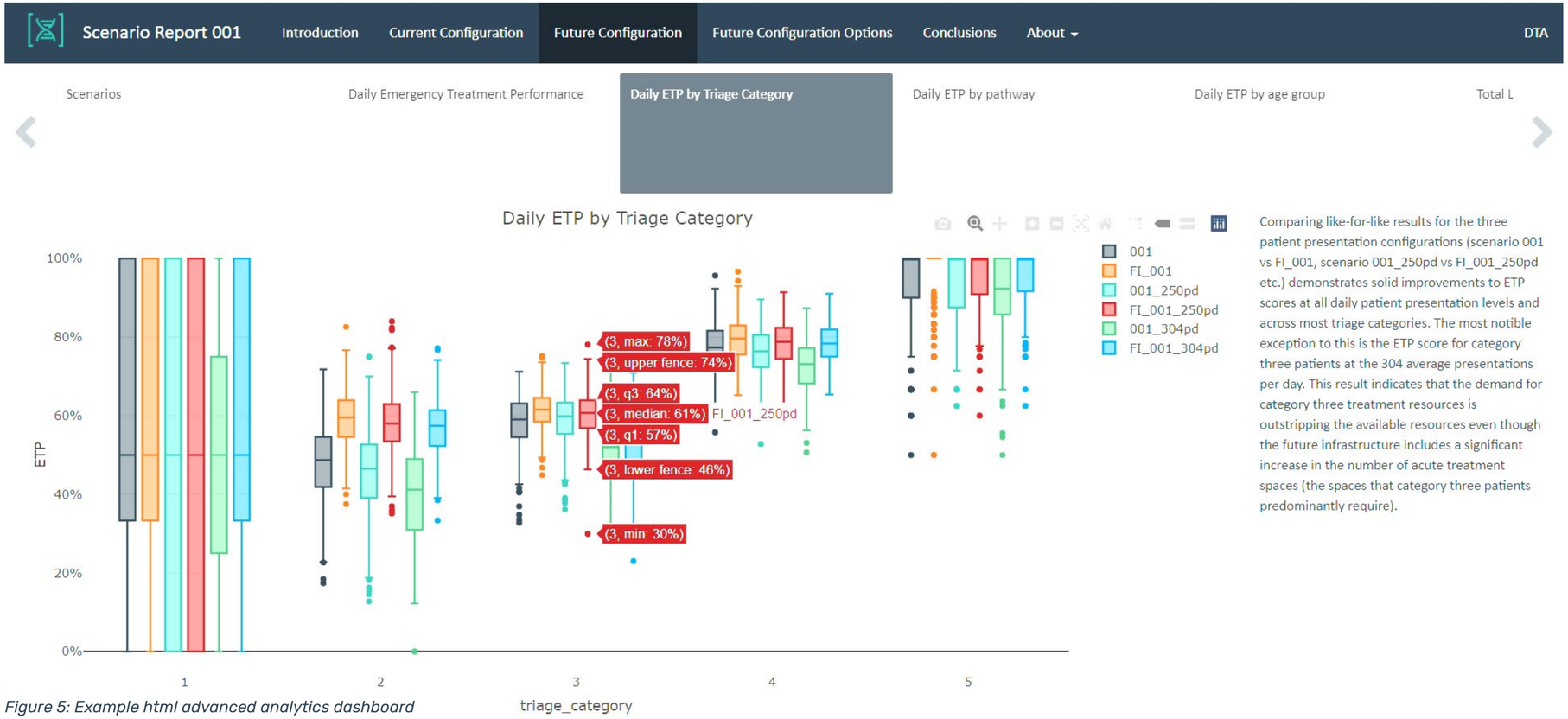


Figure 5: Example html advanced analytics dashboard

There is an opportunity to revisit and update the digital twin once the streaming MoC has been redesigned. This will provide further confidence that the proposed new MoC will provide a great patient experience and meet ED performance requirements.

Engaging stakeholders on the way forward

The next step was engaging with stakeholders, some of whom were highly invested in the proposed MoC. A high-level animation was developed to show the outcome of the simulation. This was used to quickly convey the basis of the digital twin and how it works. The myriad of outputs and results were presented in highly interactive browser-based reports and dashboards. These visual and data rich outputs were developed to aid in telling the story of what occurred and why. They also provided the reader with the ability to filter, and cut and slice the data to aid their understanding.

Armed with these insights from the digital twin, the clinicians are now able to further refine this MoC. This includes patient criteria and journey mapping, together with identifying the staff requirements to ensure optimal patient flow. Once the MoC is redesigned, the Project health planning team can review and update the design brief and assess if the layout of the ED requires changes.

The digital twin of the ED gave the ability to rapidly execute large numbers of 'experiments' to see how MoCs would perform.
Being able to do this virtually, rather than on a live system or physical simulation, saved significant amounts of time and money, without putting any patients at risk.

The future of digital twins in health planning

During the Project, the Project team collaborators identified broader system implications, and future applications of digital twin technology.

Early testing of activity projections and models

Using a digital twin would be very useful for early modelling and testing of clinical service planning activity projections and new service models. Scenario testing would provide more certainty and understanding on what, if any, infrastructure enablers may be required to deliver healthcare for the future. For example, the growth in virtual care service models could lead to a reduction in future planning for in-hospital bed numbers. However, it may have an impact in other infrastructure areas such as physical space for virtual care delivery and technology infrastructure.

The application of a virtual care digital twin could test the impact of virtual care in reducing hospital stays and better inform future clinical service and health facility planning.

'Whole of facility' patient flow planning and design

The digital twin approach could also be applied to a whole-of-facility patient flow planning and design process, rather than reviewing and planning at individual service unit levels. For example, planners could include the downstream areas of the hospital that ED patients are discharged to, or include other services such as elective admissions that impact on the daily available bed stock. This approach would provide a powerful visual understanding of the end-to-end patient journey. It would highlight bottlenecks and flow impacts across the system to inform a whole-of-facility design response. This may lead to design changes that improve patient experiences of care and clinical outcomes, reduce system waste, and minimise stress for care providers.

More engaged stakeholders for better change management

This Project tested many scenarios and displayed the results in a highly engaging and interactive format. It helped bring stakeholders 'along for the journey' by presenting very clear visual representations of the outcomes of various decisions. This collaborative and interactive approach, using data-driven analysis, shows promising signs of aiding in increased ownership and confidence in the future, refurbished department.

There is also an opportunity to utilise this approach to support and improve the change process for either new infrastructure or new ways of working. This would also support operational readiness by giving a clearer picture of interactions and flow-on effects of any changes.

> Digital twins would be very useful in optimising the integration and delivery of virtual care models.

Critical success factors for future health planning digital twins

During the Project we identified several critical success factors that would support the successful adoption of this novel approach. They include:

- Cross-sector leadership and collaboration between organisations i.e. HI, health authorities, and contracted consultant teams.
- Engaged clinical team/s with an open mind.
- Access to subject matter experts and local data repositories.

This process fostered a transparent, team-based, inclusive and collaborative approach across the entire group working on the Project. Clinicians through to administration and health planners were all part of 'designing' the digital twin. This resulted in a high degree of buy-in and ownership of the results and findings.

Future use of the approach used in this case study would be strengthened with the involvement of health consumers and carers, and the overlay of patient and staff experience data in the modelling. This would quantify how patient and staff experiences may be impacted in the refinement of MoCs and service layout.

Conclusions

Current health service, clinical and health facility planning approaches are sound, robust, and grounded in evidence.

However, these traditional approaches generally do not apply digital process modelling and analytics technology early in the facility planning stage.

This white paper illustrates how future-focussed use of data analytics, applied to the standard facility planning process, may better inform clinical service planning, MoCs and health facility design. It can help illustrate previously unforeseeable issues that would impact on the effectiveness, over time, of health facilities. It also facilitates stronger stakeholder engagement for better change management. Using a digital twin makes it more likely that the end outcome of a project will be: the right care, delivered in the right setting, by the right care provider, and at the right time.

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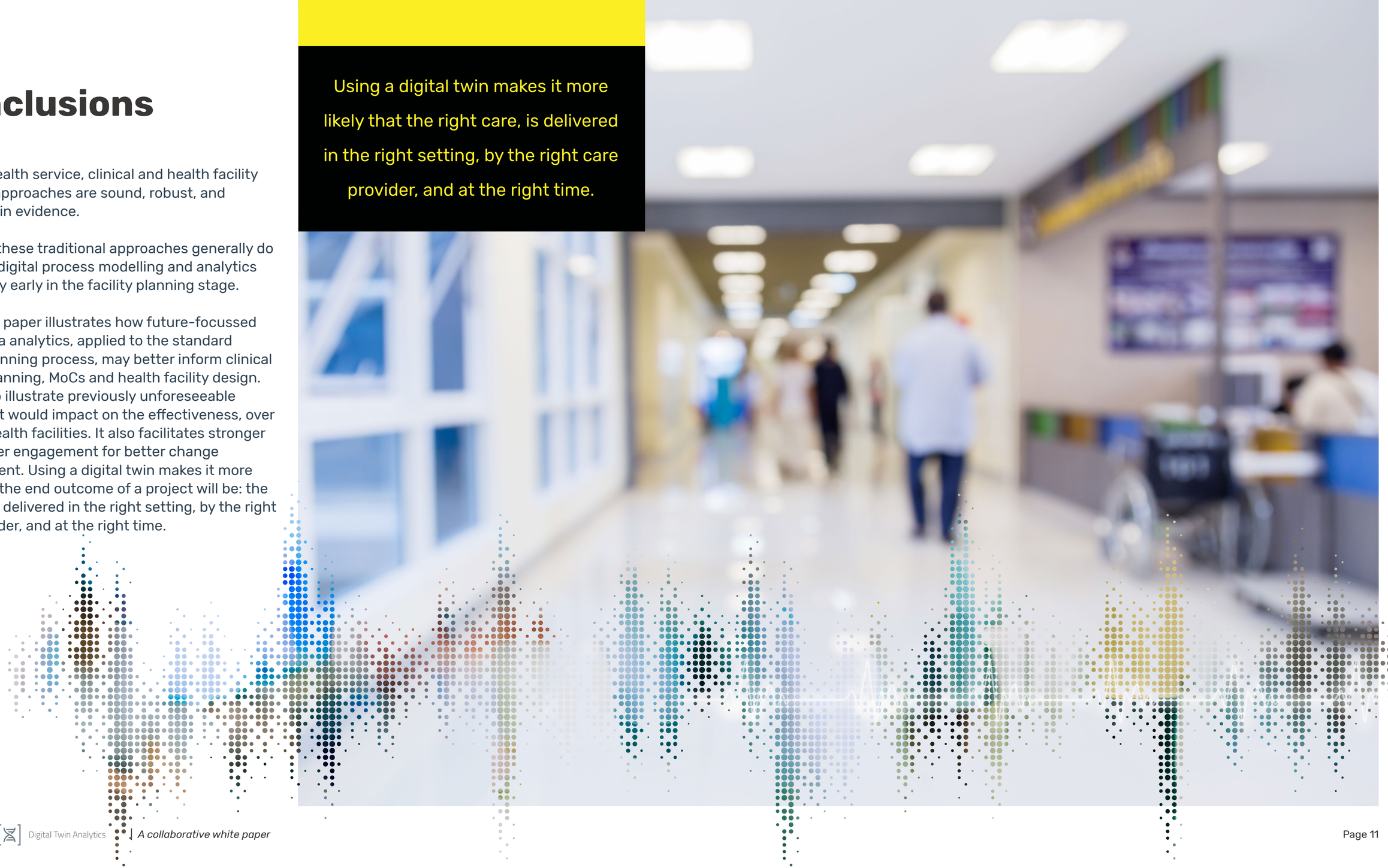

Authors

Brigden, R
TSA Health Advisory Lead, TSA Management;

Glassock, C
Principal, Digital Twin Analytics;

Bodon, P
Principal, Digital Twin Analytics;

Bott, A
Project Director, TSA Management;

Byrnes, N
Senior Health Planner, TSA Management; and

Edwards, C
Senior Health Planner, TSA Management.

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TSA

TSA's Health Advisory team combines extensive, hands-on health sector experience with strategic, commercial and capital project planning expertise. They are unique in offering a broad range of strategic, planning and delivery services informed by a deep, lived understanding of the unique needs of the health sector. They understand the balance that needs to be struck between constrained budgets and delivering quality care.

TSA's Health Advisory services fall into three broad categories: business advisory, strategic investment planning and capital project planning. Importantly, these services are delivered by people with a hands-on understanding of how the assets they advise on will operate in the real world. This helps TSA deliver impact and outcomes that matter to health consumers, carers, communities, and health staff.

Digital Twin Analytics

Digital Twin Analytics is an independent consulting firm that has extensive experience in applying operations research techniques in the resources, infrastructure, transport and healthcare sectors.

Companies around the globe have long understood the value to be gained from detailed analysis of their operations using advanced techniques such as simulation and optimisation. These techniques help our clients design and understand the complex interactions that thwart the ability of other methods to capture the essence of their system performance. They have delivered hundreds of millions of dollars of savings.

The DTA team have decades of experience in the modelling and analysis of complex systems, helping our clients to break their systems into understandable sub-systems and analyse them through rigorous experimentation techniques combined with advanced visualisation and communication tools.

Robyn Brigden
robyn.brigden@tsamgt.com

www.tsamgt.com

Digital Twin Analytics

Peter Bodon
peter.bodon@digitaltwinanalytics.com.au

www.digitaltwinanalytics.com.au