SmartCitiesWorld Trend Report

Smarter operations: Maximising returns from existing municipal infrastructure

How unifying the engineering, operations, and maintenance of public assets via digital transformation could help plug the investment gap

In association with

AVEVA

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SmartCitiesWorld **Trend Reports examine an emerging or growing trend in smart cities, highlighting progress so far and future potential, as well as spotlighting case studies from cities around the world.**

In this report, we examine how unifying the engineering, operations and maintenance of public assets, via an integrated command and control centre, could help plug the investment gap.

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Setting the scene

It would be easy to assume from the industry trade events and extensive media coverage that smart city innovation is all about futuristic city planning – with highly connected and digitally optimisable transport systems, and modern buildings replete with intelligent sensors that control heating, lighting and other utilities more economically.

Yet to focus exclusively on new-build opportunities is to ignore the significant potential for everyday operational and maintenance benefits, and budget savings, which city and even town planners and managers could exploit today. That's if they had access to dynamic, coordinated and timely information about local infrastructure, its performance and its pressure points - in such a way that enabled targeted and effective action by operational teams and engineers, to keep services running smoothly whatever the prevailing conditions.

Funding gaps

There are sound financial reasons for making existing infrastructure smarter and better connected too. A significant one is the scope to bridge budget shortfalls: the funding gap between the cost of the shiny new facilities cities and towns would ideally implement to meet local needs, and local governments' available resources.

In January 2020, Mayor Bill de Blasio's Administration announced that New York City, at great expense, would construct new water mains and increase staffing levels – among other proactive measures to ensure the continued reliability of the city's water delivery system. The initiative brings the city's capital investment in new water mains and related infrastructure to $800 million over the next two fiscal years.

This eye-watering figure is just the tip of the iceberg. The Global Infrastructure Hub, a G20 initiative, estimates that the world faces a $15 trillion gap between projected investment and the $94 trillion needed to provide adequate global infrastructure by 2040. For water infrastructure alone, the gap is $713 billion globally; for energy that rises to $2.9 trillion, while for road transport the global funding gap is $8 trillion.

Extending the useful life of current infrastructure

Making better use of existing infrastructure, and/or extending its useful life, should be a priority for any public administration, state-funded organisation, or private service provider keen to deliver value to stakeholders and to demonstrate a commitment to sustainability. Apart from anything else, optimising use of existing resources may help free up budget for more ambitious and futuristic smart city innovation. In its 2019 *Hype Cycle for Smart City Technologies and Solutions*, global market analyst firm Gartner notes that: "A smart city should be designed to achieve holistic objectives, focusing on intelligent urban ecosystem development."

All of this implies that urban planners shouldn't just invest in new infrastructure and technologies, but they should also collaborate far and wide to manage existing facilities in smarter ways. A coordinated approach also paves the way for a more holistic approach to security, to ensure that data being shared from sensors and between organisations is protected from end to end as it passes across and between different networks and systems. A 2019 Forrester Research insight notes that city security teams "are not prepared to combat data integrity attacks. They lack the ability to prove that the data and algorithms that city functions rely on for decision-making haven't been tampered with."

Unified thinking: Gwinnett County's Department of Water Resources (DWR), Georgia, USA

One public organisation currently championing smarter planning and resource use is the Department of Water Resources (DWR) in Gwinnett County, Georgia, in the United States. The Department is highly ambitious, looking to intelligent use of data – ultimately including targeted data-sharing with external partner organisations – to maintain quality services for local residents and businesses.

"Our aim, and the County's mission, is that the DWR becomes 'the utility of the future'," says Sam Paul, who looks after the organisation's 'SCADA' OT systems which collect and analyse real-time operational data. These critical control systems allow the Department to monitor and optimise water infrastructure, by targeting maintenance and pre-empting peaks in demand, so that supplies never run dry.

The trailblazing part of Gwinnett County's plan is the desire to share operational information, such as water collections/reserves data, with external partners. These include the county's emergency operations control centre – so that it in turn can monitor and respond to the impact of inclement weather, natural disasters, or other acute scenarios. Data exchange with the county fire department, meanwhile, helps ensure that residents and local businesses are not affected if there is a sudden, sharp rise in demand for water in a particular neighbourhood – for instance, as firefighters tap into hydrants to tackle a major blaze.

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Looking to greenfield smart cities for inspiration

Although greenfield smart cities, which are built from the ground up to take advantage of the latest technology innovation, have obvious advantages over more established urban environments, they offer a useful reference point for the kinds of coordinated infrastructure management scenarios that all cities might aim for.

Take Nava Raipur, India's first greenfield smart city. Here, plans for a highly coordinated, smart urban infrastructure are being optimised with a single, integrated command and control centre – which looks after everything from CCTV to energy management, traffic management systems, and city helpdesk applications.

The pioneering city, which covers an area of 237 square kilometres, is keen to get ahead of the traditional challenges faced by Indian urban infrastructure, most notably extreme conditions ranging from drought to monsoon floods. Across India, such extremes can affect everything from water supplies to transport, highways and power supplies, with implications for public safety, quality of life and business productivity.

For these reasons, Atal Nagar Vikas Pradhikaran (ANVP), the local urban planning agency serving the Nava Raipur Metropolitan Region of the state of Chhattisgarh, opted to harness smart, digital infrastructure control and monitoring capabilities from the outset. Since 2012, even before India formalised its national Smart City Mission, Nava Raipur has been exploring every opportunity to ensure quality of life for local citizens while easing the burden on municipal staff.

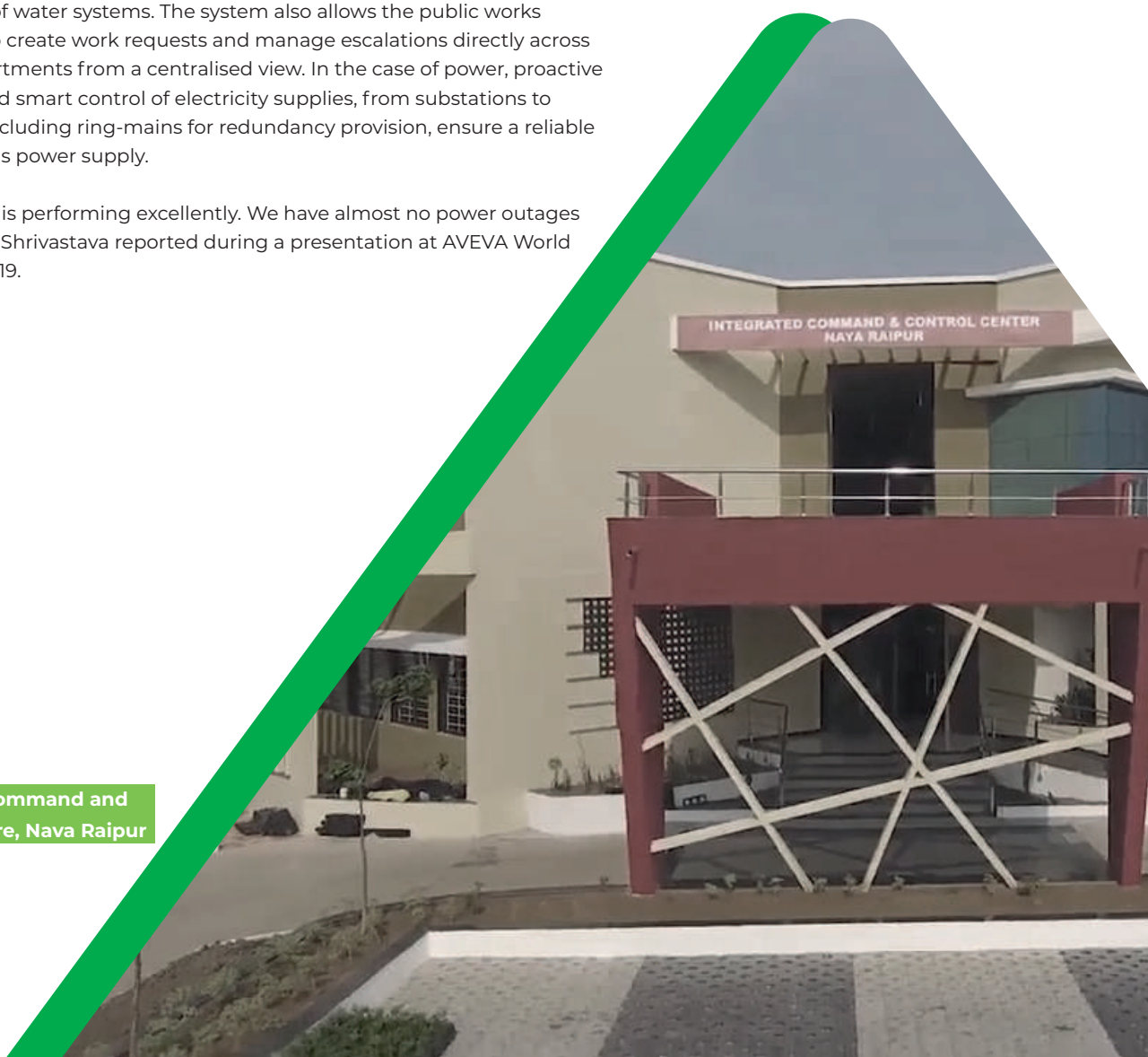
The city's ambitions for infrastructure integration and coordination are on a scale that has never been tried before, in India or anywhere else in the world. Therefore, it made sense to connect all of the different services via a single (fibre-optic) backbone, and coordinate everything by means of a single command and control capability. This would allow for numerous vertical system and service interdependencies – such as the impact of water issues on power and highways.

Central coordination

Today, a single central command and control centre – fed by smart sensors, and monitored 24/7 via geographical mapping (of all of the city's services and assets) and big-screen dashboards – coordinates everything from utility management, real-time city surveillance, traffic monitoring, smart buildings and lighting, to intelligent transport. Sub-systems (for each utility and service) are integrated – enabling rapid, coordinated crisis and emergency management, with everyone working from a 'single source of the truth', Salil Rai Shrivastava, Engineer in Chief at SNVP, says: "Even where this response is escalated and outsourced to third parties, it is all coordinated from the same central city platform."

Simply monitoring these systems is not sufficient. Feedback control via automation is a key feature, too. For instance, the central control centre can be used to remotely manage water systems and make automated changes, to boost water quality (e.g. by adding chlorine as indicated) as well as the performance of water systems. The system also allows the public works department to create work requests and manage escalations directly across multiple departments from a centralised view. In the case of power, proactive monitoring and smart control of electricity supplies, from substations to distribution, including ring-mains for redundancy provision, ensure a reliable and continuous power supply.

"The system is performing excellently. We have almost no power outages in the city," Mr Shrivastava reported during a presentation at AVEVA World Conference 2019.



Integrated Command and Control Centre, Nava Raipur

Inhibitors to innovation

Beyond the possible distraction of more extravagant and futuristic visions for digitally enabled cities, assumed to harbour the real potential for transformation, what is deterring city managers and CIOs from delivering positive change and making local assets go further in more established urban environments?

Perceived cost is one obvious issue, where those seeking to make a difference imagine that running existing services more intelligently will require new investment on a substantial scale. Similarly, smaller cities and towns might assume (wrongly) that smart city innovation is applicable only to larger and more densely populated areas – where there is more of a budget and a business case for transformation. New software subscription models are reducing capital expenses for cities looking to digitally transform their infrastructure, and some public-private partnerships are even using novel performance contracting models where the cities incur no upfront costs, but share the savings realised with the software vendors and system integrators.

Initial objections can be overcome relatively readily once there is a realisation that any city or town, of any size, can deliver improved cost-efficiencies and improved quality and consistency of public services, once they can run, monitor, maintain and refresh existing infrastructure in smarter and more unified ways. All of which depends on a collaborative mindset and a secure, common platform to support the capture, exchange and display of actionable real-time data about current infrastructure and its performance, and the ability to take automated action in response.

Talking the same language

Even before city CxOs can think about multiple organisations being able to feed intelligence to each other and operationalise any insights, it must first be possible for operational monitoring and control systems within a single organisation to ‘talk’ to each other – and to do so securely. This isn’t as straightforward as it might sound, given that the heritage, protocols and data formats of those systems are likely to be diverse and not immediately compatible. Each department is likely to have its own legacy monitoring and control systems and way of doing things.

Meanwhile, the ability to generate and act on 360-degree intelligence will rely on the cooperation and input of multiple teams internally. It demands collaboration between designers and engineers who are building infrastructure; operations personnel who run it; and maintenance people who look after those assets, fixing issues as or before they arise.

To maximise upkeep, uptime and performance, these diverse teams need to interact with each other. Operations engineers must notify maintenance engineers when a repair is required. Maintenance engineers need access to schematics and diagrams from engineering to complete a repair. And operations personnel need to enlist the cooperation of engineers to adapt or redesign infrastructure when performance is shown to be persistently poor.

Departmental & IT-based silos

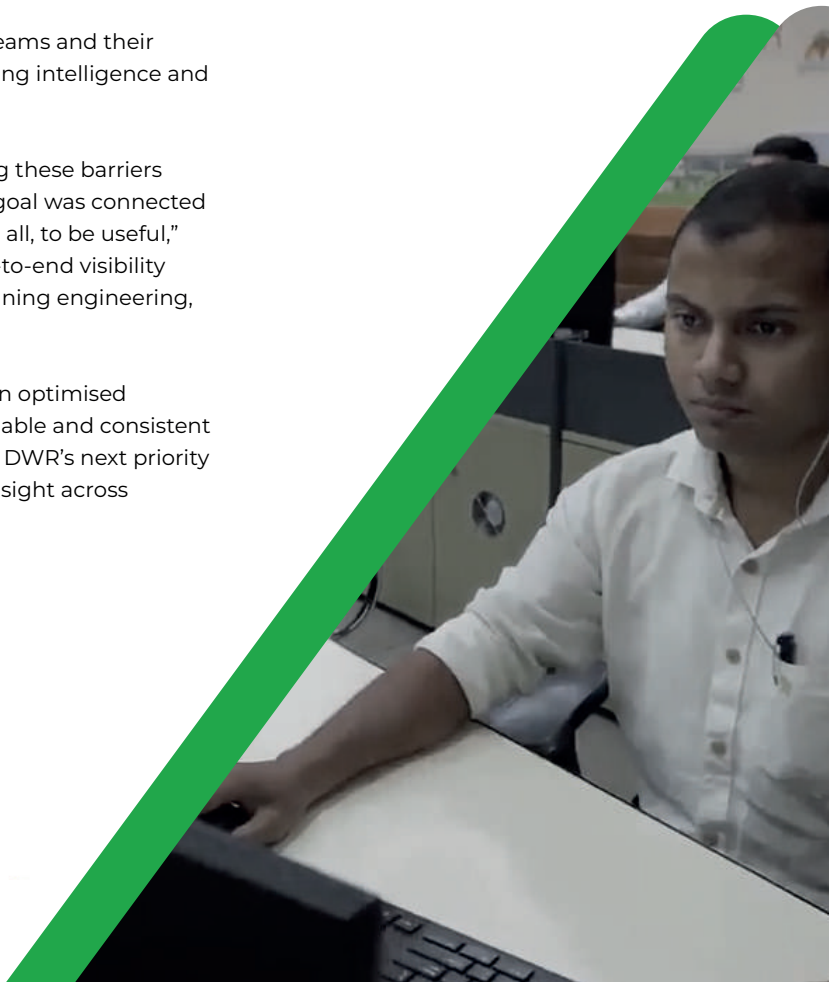
Effective, 360-degree infrastructure management requires the combination and cross-analysis of four diverse data types:

1. Engineering data: the physical schematics for public facilities
2. Process-oriented data: generated by pumps, valves, sensors, etc
3. Maintenance data: on the state of wear or repair of assets
4. Predictive or performance data, which can infer how changes to operations may impact future situations.

Up to now, traditional 'walls' between these different teams and their respective IT system silos have limited the scope for sharing intelligence and collaborating in innovative new ways.

For Gwinnett County's water department, surmounting these barriers was the critical first step to service transformation. "Our goal was connected systems, shared data and new collaboration – and, above all, to be useful," Sam Paul explains. "This meant being able to create end-to-end visibility and the ability to control infrastructure holistically – spanning engineering, maintenance and operations."

With a clear vision for service transformation – based on optimised performance, operational excellence and ultimately a reliable and consistent supply of clean water to Gwinnett County residents – the DWR's next priority was to establish the technology to support a clear line of sight across engineering, maintenance and operations.



"We needed to break down the barriers with technology and make data usable outside production, to wider populations including engineers, research teams and more; to support smarter, more prompt trouble-shooting, diagnostics, and design and development."

Over the course of five years, the DWR has moved from a scenario comprising multiple, separate OT and IT platforms (each plant had its own supervisory control and data acquisition – SCADA – platform), to one in which everything is standardised on the same, optimised platform. This allows data to flow intelligibly from two water production plants, 8,000+ miles of distribution and transmission networks, hundreds of water collection points, and three water reclamation facilities. That includes diagnostic data about the function and performance of pumps, their energy use and their output, which can be shared with both maintenance and design engineers.

Cultural barriers

Traditional mindsets and entrenched ways of working can be another barrier to smarter and more collaborative infrastructure management. Where teams have been monitoring and managing assets in a particular way for years or decades, it is not unusual for there to be some resistance to change – especially if this involves a leap of trust from the physical to the 'virtual'– in other words, greater reliance on data feeds to support decision-making and actions. This can be even more challenging in the context of municipal infrastructure, where an ageing workforce is challenging cities to hire and train next-generation support staff.

Gwinnett County DWR has encountered this. Its evolving set-up has required some cultural adaptation over recent years, as part of its 'digital transformation' towards smarter, co-ordinated and targeted data-based operations, maintenance and design/R&D.

"Traditionally, feedback has been a physical touch-and-feel process involving lifting man-hole covers," Paul explains. "Now, the emphasis is on automated data feeds – data collection, analysis and advanced modelling/calculations – which carries with it the expectation that people will trust that data, and the connectivity from production."

Making sure different teams can readily access and visualise the information and insights that are most pertinent to their roles is proving critical here. To this end, the DWR has established a 'digital twin' or digital representation of its entire infrastructure on a secure, enterprise-wide software platform. All of the different teams can access and view this, and interpret the data feeds in a way that is meaningful to the work they do. This is displayed via a consolidated

graphical dashboard, which is customisable to each team or role, and allows views from a high-level as well as via a drill-down capability to individual plants, systems or unit operations.

The operations department can use the insights to optimise pump performance and water flow. Maintenance teams can hone their response in the case of alarms being triggered, and are better able to pinpoint where urgent attention is needed. Research and development team members can use the data to monitor infrastructure performance, with a view to improving it in the future.

Failure to appreciate the bigger picture

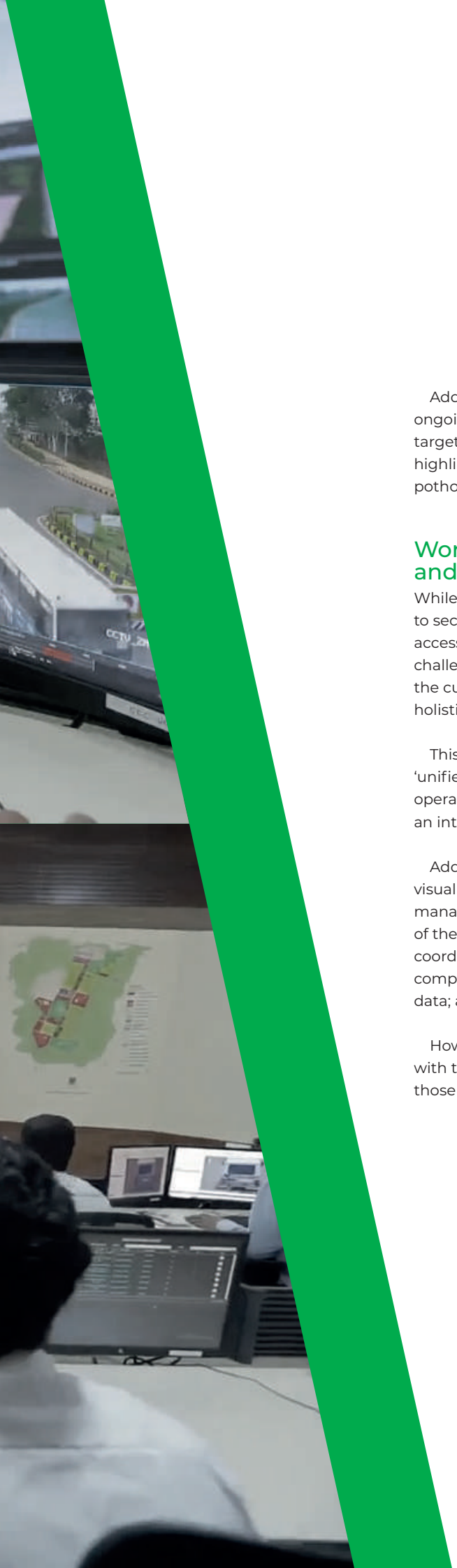
Pressure on budgets and preoccupation with everyday problem-solving can get in the way of 'blue-sky thinking', where city governors consider their Administration's remits more strategically, including their pledge to deliver uninterrupted services, improve residents' lives, support local businesses, to use budgets prudently, and to be trustworthy and transparent. Those that have discounted smart city innovation on the grounds of cost or scale may have failed to understand the link between optimising existing city infrastructure and most of these strategic objectives.

For instance, public self-service has been a big push of digital initiatives for local authorities in recent years. With more service intelligence and unified data flows, cities should be able to give local residents greater insight into service performance and real-time maintenance alerts. As well as improving the experience for citizens and local businesses, this would help stem the flow of calls to customer service helplines in the event of a service delay, interruption or outage.

By taking time out to attend smart city events as well as regional meetings with other local authorities and/or public service providers, city managers will have a chance to update their knowledge, find out what others are doing, and explore scope for new collaboration and targeted data exchange.

This, in turn, could lead to even greater improvements to the public's experience through faster issue resolution. Smarter coordination, for instance, could mean water service engineers and police officers turning up to a major water leak together, to jointly avert crisis as a major highway intersection is inundated following a burst pipe. With secure, real-time data exchange, the response would be better coordinated leading to more prompt resolution; minimised local disruption, damage and cost of repair; and reduced risk to public safety.


NETWORK CONTROL
COMMAND AND CONTROL
ZEN FIRST IOT
SMART CITY
WNO SMART UTILITIES DMS
SMART GOVERNANCE
SUSTAINABLE



Add predictive modelling into the mix, based on joint data collection/ ongoing data sharing, and infrastructure could be maintained in a more targeted and effective way – whether that's highways departments highlighting surface water on roads over time, or water companies flagging up potholes or other structural defects to roadways.

Working towards a shared vision – and control capability

While the value of data analytics has long been appreciated, today – thanks to secure services hosted in cloud-based data centres – it is much more accessible on a mass scale, to anyone who could potentially benefit. The challenge today is more about building a willingness to collaborate and tackle the current data complexity, which is essential to enable smarter and more holistic asset management.

This, in turn, will be facilitated via a shared 'system of systems' platform, or 'unified operations centre', which transcends and interconnects individual operational and IT platforms, so that these can all be viewed and managed in an integrated way.

Add in geographical/spatial information to map where assets are, and visual representation in the form of a graphical dashboard, and infrastructure management teams can start to form an extensive digital representation of their assets (or a 'digital twin') – paving the way to manage them in more coordinated, efficient and sustainable ways. That's provided that any data is complete (spanning design/engineering data; operational data; maintenance data; and performance simulation/scenario modelling data).

However ambitious city leaders may be in their aspirations, progress begins with the ability to harness, combine, interpret and display data readily, so that those who need it can take prompt and decisive action.

Building an effective digital ‘nerve centre’

The concept of a physical infrastructure’s digital twin has been around for some time, though not always in the context of the latest technologies – from the Internet of Things to AI-enhanced data analytics, and the cloud.

A state-of-the-art digital twin is essentially an integrated, centralised platform (or ‘nerve centre’), where diverse information about assets and associated services is combined, monitored, analysed and acted upon. It can be a critical facilitator of transformation – delivering benefits across all phases of the lifecycle of designing, running and maintaining/improving local infrastructure, whether within a single organisation or across an entire city.

The first priority in building an effective digital twin must be to standardise on a single, common platform. This needs to be able to support data integration from a diverse range of locations, systems and protocols, so that real-time information about different aspects of the infrastructure and its performance can be combined, analysed and shared reliably and securely with any authorised users so they can do their jobs more effectively and efficiently.

Unified Operations Center for Cities: Example of a combined dashboard

The smarter and more connected systems are, and the more data that is shared between different teams and organisations, the more critical it is that appropriate backup and security provisions are made. This is not only to directly mitigate the risk of anyone hacking into control systems to cause disruption, or holding city infrastructure managers/operators to ransom. It is also critical to making diverse teams more accepting and comfortable with working in new ways and entrusting critical processes to technology.

To bring multiple assets under coordinated control, then, it is imperative to consider the robustness and resilience of the underlying platform, and the different levels of security that are applied as it makes its connections, and stores, processes and shares data. Appropriate security certifications, use of encryption and authentication, and data segregation if data is stored or handled remotely, are essential considerations.

Agility and advanced analytics: Thinking long-term

Unified operating centres/digital twins aren't valuable only for monitoring and reacting to current and emerging situations. The ability to combine real-time data and analyse it on demand, and to combine current and historical data to build up trend or trajectory-based information, means that maintenance and design teams can start to plan intelligently based on 'what might happen'.

Scalable cloud-based analytics, enhanced with artificial intelligence/machine learning capabilities, can pave the way for powerful predictive modelling so that engineers can virtually 'stress test' their infrastructures and take pre-emptive measures to strengthen potential points of service weakness. Meanwhile, operations personnel can review infrastructure performance linked to a past crisis – using the 'replay' features of the unified operations centre to review what happened, as it happened, after the fact – and undertake scenario planning and risk-mitigation actions that will make the city more resilient to similar incidents in the future.

Again, these possibilities add to the case for choosing a flexible, futureproof unified platform where all of these critical data-based activities can take place, and be visualised. Whatever the initial drivers and business case, it is important not to limit the potential of the chosen platform. That's because, in due course, it could help point the way to new ways of working, including new methods of collaborating and engaging with these information models to create new value.

In short, integrated management platforms/digital twins should not be seen simply as a means of automating the way things happen now. Given that the longer-term vision for smart cities involves many more intelligent sensors, automated connections and interactions, it would be short-sighted to limit a coordinated command and control platform to the management's immediate goals.

Example geographical-based situational awareness

Digital transformation in action

Barcelona

In Barcelona, Spain, a coordinated control platform managed by the city operates like a central nervous system, receiving and transmitting information via a distributed network of sensors across the city, and via smartphones and tablets by teams on the ground. The unified central control platform monitors the smart city's operations – city workers can do this for multiple public operations from a single control room – and ensures efficient resource management.

Today, the city is able to optimise energy use and water supply to meet public demand. It can also intelligently adapt irrigation based on current weather conditions and the needs of flora in the city's green spaces, and control this remotely. As well as delivering more for less, Barcelona's smart city developments demonstrate the city's commitment to environmental sustainability. Over time, infrastructure managers will continue to build on these benefits and more, via access to real-time, critical data for better, faster and more efficient decision-making.

Carson City Public Works, Nevada, USA

In the case of Carson City Public Works Department in Nevada in the US, a shared municipal services infrastructure helps to maintain facilities for a city with more than 50,000 residents.

Its aims with the centralised platform were to more efficiently manage the city's water including waste-water; transportation; landfill; fleet; environmental; and renewable power systems around the clock. It also wanted to harness the latest technology, including tablets and smartphones, to make operators and management more efficient, and increase situational awareness/operational 'readiness'.

Since adopting a digital twin/unified operating centre approach, the Public Works Department has been able to do more facilities monitoring and management remotely, reducing operational hours by 15 per cent, and the work week from five standard days to four 10-hour days. Remote access to data has also significantly reduced fuel costs, as the city's maintenance workers do not have to return to a centralised location to find out about their next task. At a practical level, the data-driven nerve centre helps manage the city's solar plants, which provide up to 748,000 kWh of clean power each year, and deliver more than 22 million gallons of water while processing 6.9 millions of gallons of waste water each day.

Prioritising progress

If cities were in a position to start with a blank slate, infrastructure could be built from the ground up in an inherently connected way, supported by infinite IoT sensors and coordinated controls, as in the case of Nava Raipur in India. But few urban developments have this luxury. In established cities, progress involves overcoming some challenges, as each municipality is likely to be operating its own complex array of infrastructure and systems, many of which pre-date current technology trends and were built on standalone data architectures that do not communicate easily with other systems.

A digital twin/unified operations centre approach can help, by connecting disparate systems, and allowing diverse data to be collected and aggregated in a common repository, analysed using the latest in predictive analytics, and the findings visualised for service providers and citizens who can act on this new information in real-time.

As cities embrace this collaborative, data-enabled approach to infrastructure management, the way is paved to unprecedented levels of situational awareness for public infrastructure providers, allowing them to respond more swiftly and effectively to emergency situations, and/or to prevent potential bottlenecks or infrastructure failure ahead of time.

There is another factor prompting progress, too, and that is broader momentum and market expectation. All around the world today, smart factories and connected cities are being designed, planned and delivered by global, multi-disciplinary teams, all connected seamlessly through technology. With so many benefits to be gleaned, for so many different stakeholders, not least the public at large, it won't be long before city and town managers overseeing services for even modest populations are called to explain why they are not keeping pace with digital progress.

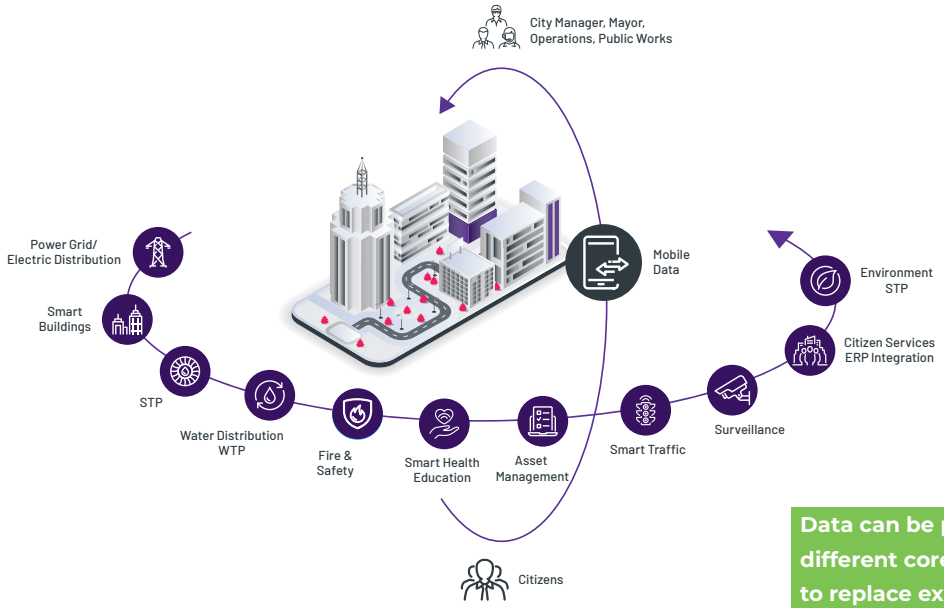
In India, Amitabh Kant, CEO of the National Institution for Transforming India, has described Nava Raipur's evolving smart city infrastructure, and centralised command and control facility, as "futuristic" and "world-class", enabling the state of Chhattisgarh to "technologically leap-frog" other regions.

It is probably no coincidence that global market analyst firm IDC has projected that by 2023, a quarter of all successful smart citiy digital twin platforms will be used to automate processes for increasingly complex, interconnected ecosystems of assets and products.

Starting the journey

Despite the cultural divides that will need to be bridged, and the system silos that are currently preventing end-to-end visibility of existing infrastructure, few public service managers would argue with the compelling drivers for transformation.

What's important to realise is that progress does not necessitate a costly and complex programme of work that requires existing systems to be ripped out and replaced. Indeed, many of the building blocks are likely to be in place already, albeit that they may currently be disjointed and out of sight. In this context, digital transformation of infrastructure management is about



Data can be pulled and combined from the different core data sources without the need to replace existing legacy system silos

unlocking latent potential, by connecting up operational intelligence that is currently underexploited.

In terms of the urgency to act, the infrastructure in many cities today is ageing rapidly or straining to meet growing demand as populations swell. This, in turn, is presenting city and service managers with a dilemma about how best to use their budgets. Do they over-extend themselves and make a huge capital investment in new infrastructure, or do they exploit and look after their existing assets in more intelligent ways?

Unlocking operational intelligence and making it more widely visible in a connected and meaningful way offers city and service managers a chance to make critical decisions more promptly and effectively, focusing spending where it is needed most urgently.

It can help save energy, reduce costs and improve sustainability. Even just being able to trace leakage/unbilled supply of water could help boost water service income without an increase in infrastructure investment, while reducing waste.

It can improve safety – by enabling preventative maintenance and keeping services running reliably.

And it can empower city workforces to work more efficiently (as in the Carson City Public Works example, where the unified control centre capability is accessible on employees' iPads, allowing managers to act swiftly, from wherever they are).

Crucially, technology is advancing so fast now, and becoming so much more accessible to anyone, that it is now very easy to equip teams with the insights they need to make better, smarter decisions at speed. What's more, cloud-based services have put capabilities within the reach – and budget – of even the smallest cities and towns, meaning those with a population of 50,000 – as well as larger and megacities – are able to manage their assets and services in ever smarter and affordable ways.

As the barriers to transformation and innovation come down, the onus is on city planners and service managers to take advantage of the tools available to them and begin to make smarter decisions about their infrastructure's future.

About AVEVA

AVEVA is a global leader in engineering and industrial software driving digital transformation across the entire asset and operations lifecycle of capital-intensive industries. Our engineering, planning and operations, asset performance, and monitoring and control solutions deliver proven results to over 16,000 customers across the globe. Our customers are supported by the largest industrial software ecosystem, including 4,200 partners and 5,700 certified developers. AVEVA is headquartered in Cambridge, UK, with over 4,400 employees at 80 locations in over 40 countries.

AVEVA's software and capabilities are ideal for cities, water and waste-water utilities, power utilities, facility and campus managers, transportation operators, and data centres that are seeking to digitally transform their operations to reduce risk, save costs, and optimise their performance and speed of crisis response. Our credentials span all four data types which are essential to create a true 360-degree view of critical infrastructure and its performance. We can combine data from engineering data systems; operational control systems; maintenance data; and predictive or performance data. The resulting digital twin, enabling a unified operation centre, can digitally transform the value of existing infrastructure while supporting future expansion.