

See Further

AECOM's thought leadership magazine

THE SMART REVOLUTION

Productivity enhanced

Discover how process optimisation together with digital advances can bring efficiencies to industrial systems

Making lean leaner

What is lean thinking and how is Industry 4.0 shaping its evolution?

The power of smarter

Realise the power of off-site and renewable energy generation in the future of manufacturing

Standardise to optimise

Learn how standardised building design can reduce the time it takes to upgrade or build a new facility

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Foreword

Our increasingly digitised world is heralding more intelligent, automated and data-driven product design and manufacturing, bringing transformational change and innovation to process and factory design.

In our first Industrial See Further issue, *Embracing the revolution*, we shared our thoughts on how Industry 4.0 — big data, the Internet of Things and increasing automation — is revolutionising the way things are designed, made and sold.

Under pressure to make faster business decisions and respond more quickly to changing customer demands, manufacturers are getting better connected and planning ahead.

We're investing in the future too and working with our industrial clients to help them understand and capitalise on the power of data to bring real value to their businesses.

In this, our second issue on Industry 4.0, we delve further into what 4.0 means in practice, drawing on real project experience where we've harnessed digital processes such as intelligent data capture and digital simulation to optimise our clients' processes and facilities.

We look to our partnership with a German car manufacturer to show how, through digitally mapping and simulating an existing process, it's possible to pinpoint areas of improvement and avoid production bottlenecks.

With leading industrial research suggesting that 60 per cent of production activities do not add value to the end product or customer, we also investigate how adopting lean thinking can optimise process and product design. But, what is lean all about? And what role are digital processes playing in the evolution of lean thinking?

We also explore how investing in on-site, renewable energy generation could deliver more resilient, sustainable and affordable power, as we've done with one of our clients at their research facility.

Finally, with speed to market everything for today's industrial clients, we look at how standardised building design can be used to facilitate existing facility upgrades or build a new one more quickly.

As the industrial world continues to undergo great change, it's important that businesses learn and understand all they can about the promise and potential of Industry 4.0 to stay competitive.

By unravelling the digital revolution, it's possible to see how the convergence of data and industrial processes can be harnessed to optimise entire processes and facilities and add real business value into tomorrow.

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Standardise to optimise

Speed to market is everything for today's manufacturers. We take a look at how standardised building design helps businesses adapt and design new facilities with speed so they can respond more quickly to customer demands.

Productivity enhanced



The opportunities to make manufacturing processes more productive and efficient are endless. Process engineers **Stephen Mounsey** and **Paul Whitehead** look at how process optimisation and digital technologies can make systems work harder using fewer resources, and inform smarter factory design.

The use of digital technologies in manufacturing is transforming business processes. From analysing sensor data to predict when production line equipment failures will happen to virtual simulations that pinpoint process bottlenecks before process designs are finalised: Boston Consulting Group research suggests that those who invest in digital, smart technologies and processes could increase productivity by around five to eight per cent.

Process optimisation involves taking an existing process, analysing it for waste, such as space being used inefficiently or duplicated effort, looking to see where the process falls behind on the manufacturer's requirements, and redesigning it to drive value and efficiencies.

Process optimisation can reduce production downtime, allowing production equipment to make more products, so you get a quicker and greater return on investment. Costs are also reduced through higher uptime and there's less disruption to delivery of customer orders.



Digital transformation

Digital processes and technologies can enhance and make this entire process faster and more accurate. Smart sensors built into production equipment collect a range of data that allows manufacturers to understand exactly how their process works.

This data can be fed into software to create and refine a virtual simulation of the process that reflects the real world, and generate simulated stress tests such as equipment failures, to see how they could affect production.

Rebooting risk

From here, it's possible to investigate and highlight weak points in a process as identified by the simulation or analysis. This information can then be used to make adjustments to the production flow, prove how the changes will improve production and drive efficiencies, and identify problems before making the changes to the shop floor, reducing overall risk.

A major advantage of Industry 4.0 is the ability to digitally connect, store and centralise all process and facility information in real time, usually through a cloud-based system. Compared to a non-Industry 4.0 factory, data is usually siloed, can be difficult to access and typically requires going through many people and multiple systems to retrieve the information.

Modelling the future

In 2016 we designed and optimised a new vehicle body and skid-handling process for a German car manufacturer at one of their South African plants. To do this, we reviewed their existing, similar process designs at other plants and designed a new system to meet the South African plant's requirements, such as desired production rate and spatial constraints.

We modelled and refined our system designs using Lanner's WITNESS software before generating a 3D model of the designs. We fed this data through to the structural engineers using a collaborative Building Information Modelling platform, allowing them to wrap the building design around the equipment.

No bottlenecks, no blockages

The simulation demonstrated to the client that there were no bottlenecks in the system and that if a blockage was to occur in a key production area, the process would continue running for an hour before stopping; a key criterion set by the client.

The simulation also showed how many pieces of conveyor equipment would be needed: our optimised designs used significantly fewer pieces of conveyor equipment compared to their existing systems, reducing overall investment.

From the inside out

Typically, factory shells are designed with little reference to the process design. But to truly drive efficiencies across processes and entire facilities, it makes sense to use process-led design, as our designs for a British car manufacturer show.

By grouping their low and high level processes and re-sequencing the entire assembly line, we reduced the number of overhead carriers needed, leading to a cost saving for the client. Reducing the overhead carriers meant we could reduce the strength of the building in parts, lowering building costs. Through grouping the processes and changing the manual process layout we also reduced the building's total footprint.



Disrupting the status quo

Smart digital and virtual processes are enabling us to generate, collate, analyse and use data to make better-informed business decisions, leading to greater connectivity between process, product and people, helping manufacturers respond to customer demands more quickly.

Manufacturers are already starting to adapt to these smarter ways of doing things, with those willing to embrace the digital revolution, and do things differently from how they've always done them, the most likely to stay competitive in the long term.

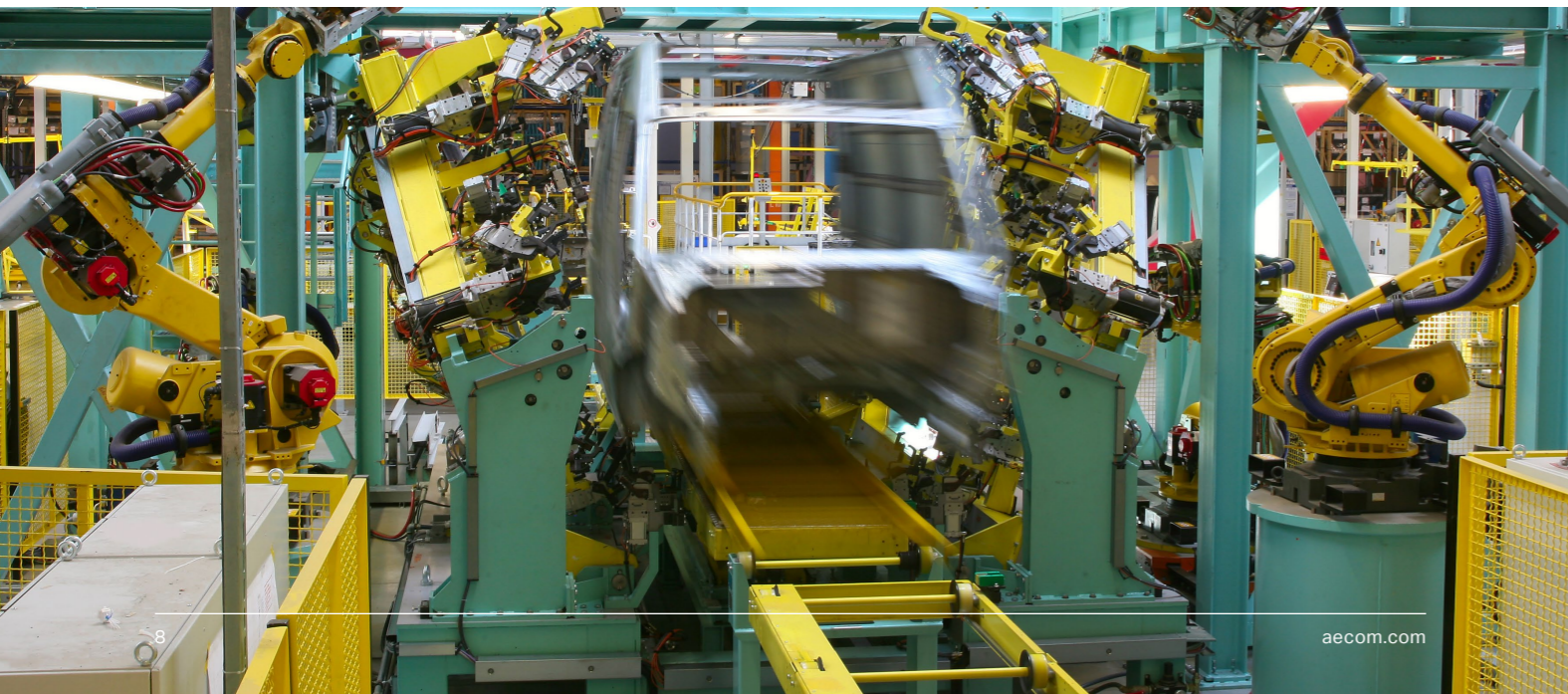
Making lean leaner

What is lean manufacturing?

Lean manufacturing involves using tools and techniques to identify and remove waste such as time spent waiting between production stages or during product transportation, with the ultimate aim of creating more value for customers.

For manufacturers and service providers, applying a lean approach to business operations essentially makes production more efficient throughout the entire value chain to increase overall productivity and margins. Lean asks businesses to ask themselves: how can we improve the way we make our products? How can we provide customers a better service?

The Lean Enterprise Research Centre suggests 60 per cent of production activities do not add value to the end product or customer. Process and automation engineers **Robert Davies** and **Stephen Mounsey** look at clever tools and techniques that reduce wasteful parts of systems, and how coupling them with digital processes can drive improved production.



THE EIGHT TYPES OF WASTE

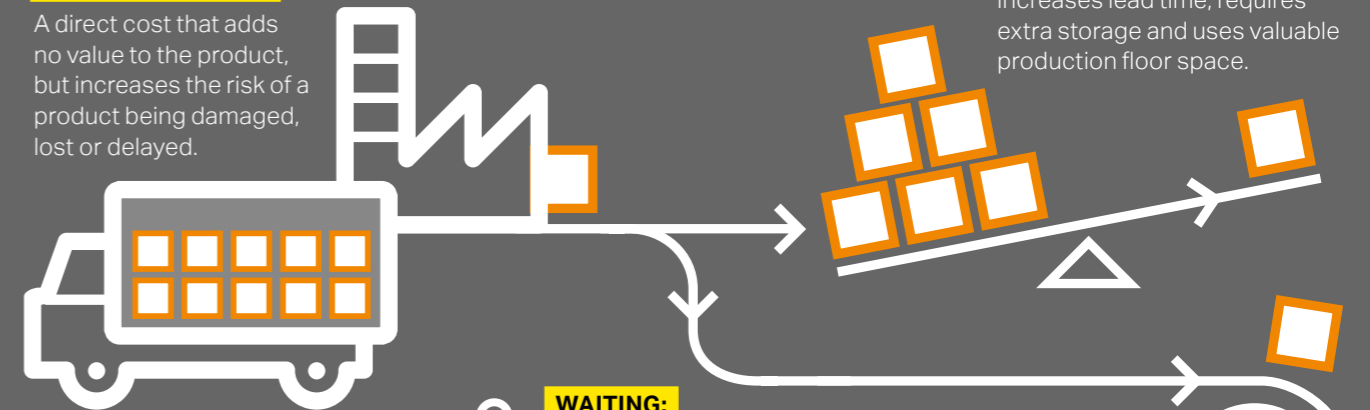
Waste is defined as any activity in the production process that consumes resources but creates no value.

INVENTORY:

A capital outlay that, if not processed immediately, produces no income. Holding excess inventory tends to hide other production problems such as transportation delays, increases lead time, requires extra storage and uses valuable production floor space.

TRANSPORTATION:

A direct cost that adds no value to the product, but increases the risk of a product being damaged, lost or delayed.



WAITING:



When products aren't moving or being processed, disrupting production flow. Idle staff and resources don't add value, either, and can occur from overproduction or excess distance between work stations.



OVERPRODUCTION:

Larger batches or more products being made than required. Overproduction affects production material flow, leads to higher storage costs and reduces productivity and quality.



OVER PROCESSING:

When more work is done than needed to produce a product, or when tools are more complex, precise or more expensive than necessary.



DEFECTS:

Losses from reworking or replacing sub-standard products. Defects directly disrupt production, are responsible for a high percentage of manufacturing costs and reduce profitability.



UNDERUTILISATION OF PEOPLE:



Limiting employee responsibility, empowerment, enthusiasm and ingenuity.

MOTION:

Excess and unnecessary movement of people, equipment and parts such as bending, stretching, walking, lifting and reaching that lead to repetitive stress injuries and unforeseen accidents.

Who created lean?

Lean thinking can be traced back to Henry Ford who, in 1913, introduced the Powered Assembly Line, where machines used to build the Ford Model T were arranged in the correct production sequence to create flow, from the collection of raw materials through to car delivery, bringing great efficiencies.

By the 1930s, Ford's work had revolutionised both American and European manufacturing and led directly to the development of the Toyota Production System, which shifted the focus from mass production to gain economies of scale to creating linked efficient production processes that produce goods at the rate of customer demand.

Since then, hundreds of publications have been written about lean thinking, most significantly Daniel Roos, Daniel T. Jones, and James P. Womack's *The Machine that Changed the World*, published in 1990.

Today, lean approaches are used not only across manufacturing but the construction, aerospace, ship building, administration and health industries.

People, not just process

Lean manufacturing isn't just about making individual parts of a process quicker or more efficient; a truly lean business works to reduce waste in every part of the organisation from accounts to logistics.

People play a big part in making lean work — if employees don't understand lean, why it's important and how it works, it will be difficult to implement it within any business. Communication and encouraging lean thinking through training is a good place to start.

Our lean training helps managers understand the benefits of applying lean to the workplace by tailoring the training to their company.

We work directly with organisations to understand their concerns with their current operations, analyse their processes and then use this information as the central case study in the training. Our bespoke approach helps our clients understand the potential benefits of lean in relation to their specific business operations and needs.



How do you apply lean on the ground?

There are a number of lean tools and techniques that can be used to identify and eliminate production waste and optimise manufacturing processes. We explain four of them in more detail below.

ROOT CAUSE ANALYSIS

A process that identifies the underlying cause of a problem to prevent it from happening again, rather than fixing it each time.

KAIZEN (CONTINUOUS IMPROVEMENT)

A strategy where employees work together proactively to achieve regular, incremental improvements in manufacturing processes.

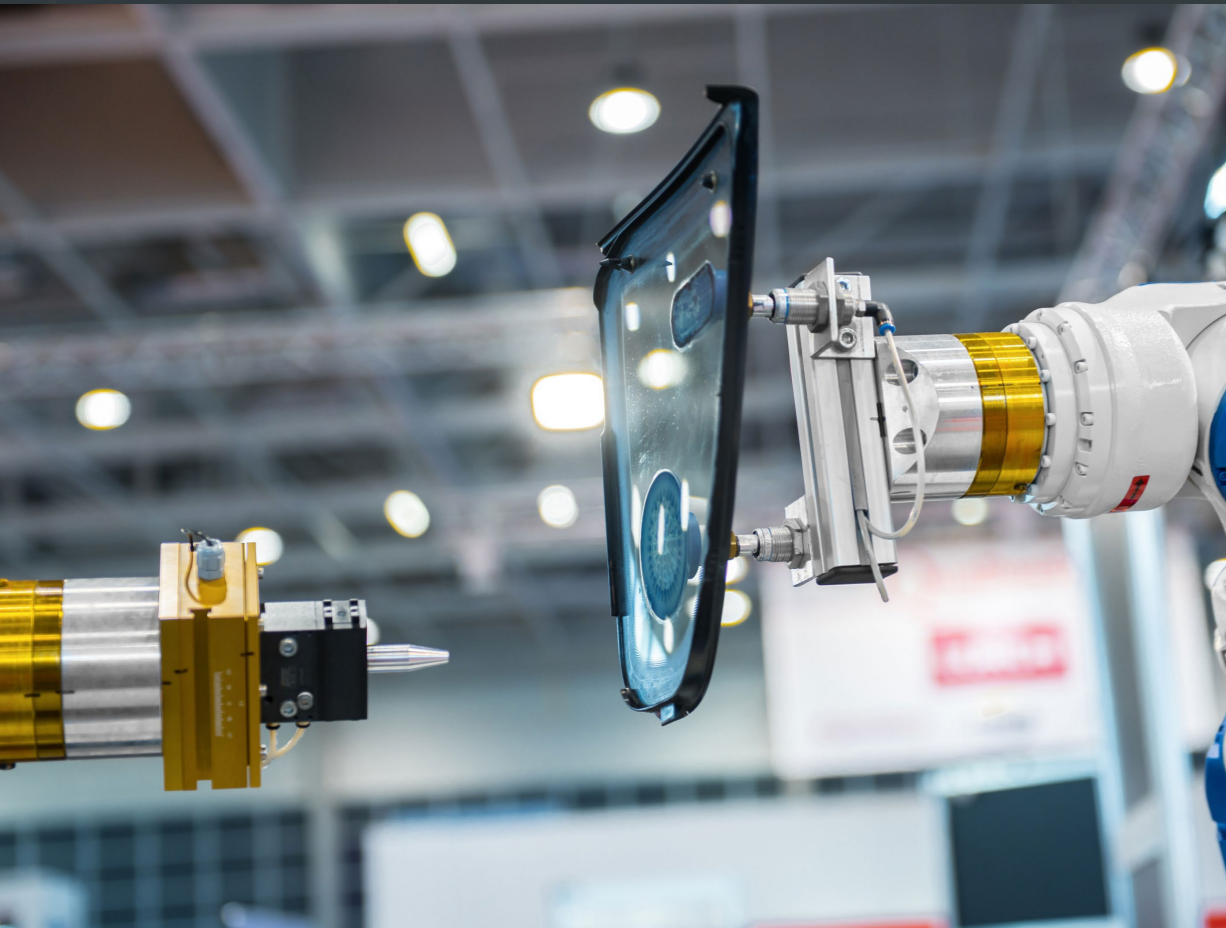
VISUAL FACTORY

The use of visual tools such as photographs and graphics to communicate information about a process such as how to use it and help drive efficiency.

MISTAKE PROOFING (POKA YOKE)

Simple methods for eliminating errors in product design and manufacturing processes through error detection to achieve zero defects.

HOW DOES INDUSTRY 4.0 ENHANCE LEAN?



The use of smart, digital processes such as simulation and automation, which we're seeing with Industry 4.0, are all part of the lean evolution; both lean and Industry 4.0 set out to make industrial processes faster and more efficient and produce higher-quality products using fewer resources.

The digital revolution has for the first time enabled the real-time capture and seamless input of customer data

into product and service design, shrinking production time from concept to delivery.

Smart technologies give manufacturers and service providers greater control over their processes. Sensors built in to production equipment gather real-time data, speeding up the transfer of vital process and product information, detecting potential production

problems immediately, which can then be resolved sooner, reducing process down time. Increased data and digital connectivity can also directly control inventory levels, materials and transportation flows to match the rate of production, eliminating overproduction and extra processing.

A SMART WAY TO CUT TIME AND ADD VALUE

We're using lean thinking and process simulation to help our marine client refurbish and refit their customer's ships, taking two and a half years per vessel instead of three.

Through detailed process analysis we've identified that the heavy lifting equipment they use to move ship parts to storage on a dry dock before they're sent off for refurbishment, is needed for just five per cent of the items. The remaining parts weigh fewer than 10 tonnes and require a much smaller, lower tonnage lift and conveyor system, with the current system taking an unnecessary amount of time to move the items from A to B, causing delays and bottlenecks, adding no value to process or our client's customer.

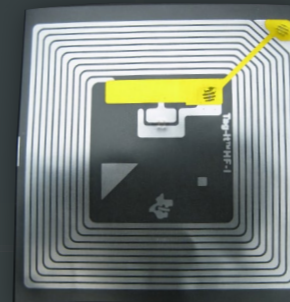
To ensure the new lifting and conveyor system works as efficiently as possible, we modelled the equipment flow through the dockyard using Lanner's WITNESS simulation software. The simulation pinpoints if anything could potentially interfere with the process and slow things down or cause congestion such as the location of storage areas on the dockyard, and things like how many fork lift trucks are needed to move the equipment around the dockyard.

By reducing and removing waste from the process, we're helping the client cut their refurbishment programme by around 15 per cent, or six months, as originally set out, bringing the ships back into service sooner.

This not only saves the customer enormous sums of money but adds value too.

By incorporating smart technologies and RFID (Radio Frequency Identification) tags into the process, the customer can also digitally identify, track and locate the items, giving them more control throughout the entire refurbishment process.

With six more ships due for refurbishment over the next 20–25 years, more efficient equipment flow across the dockyard will save the customer time, resources and money well into the future.



The power of smarter

Energy use is one of the biggest ongoing considerations and costs for the industrial sector. Power and energy specialist **Martin Land** explains how, through smart on-site power generation, and by carefully looking at energy use across facilities and sites, businesses can make their energy supply more flexible, resilient, sustainable and affordable.

Renewable energy generation technologies and emerging energy storage techniques, coupled with the drive to reduce carbon emissions, are motivating us all to develop better and smarter ways to control our energy use. What does this mean for industrial businesses and how can greater digital connectivity help?

Connected efficiencies

New process and building technologies mean factories of the future will be increasingly modular, have more flexible production and even the option to be 'packed up'

and moved to different locations to suit new markets. New production technologies such as advances in 3D product printing will see mini factories grow as satellites from hub factories located closer to consumers.

Industry 4.0 will play a massive part in ensuring these factories stay efficient and optimised. Interconnected computer systems provide tremendous opportunities for businesses to generate, analyse and exchange production, scheduling and energy use data across systems and entire industrial businesses and supply chains. This data can be used to spot areas of opportunity for improvement or poor or inconsistent energy performance across manufacturing facilities.



Extended optimisation Detection through connection

The data that is now available allows businesses to manage and control their manufacturing systems much more widely. We have a system-wide approach to energy optimisation that not only considers a process but the energy that feeds it.

By considering energy use beyond just the process and facility to include infrastructure, offices, workshops, administration buildings and lorry parks, it is possible to understand the wider cost of a business's energy use across an entire site, country or even internationally.

Greater data connectivity will increase real-time traceability of how energy is used and its costs, and create decision-making opportunities with the potential to trim levels of demand.

Currently, businesses generally look at their energy costs on a daily or weekly basis. Through the use of digital technologies and processes it is possible to monitor energy costs continually and at 48 different price periods of the day; every half hour it's possible to make a choice on what energy to use based on the price of energy at that specific time, and even sell energy to the network at times of high prices. This can really drive down wider portfolio operational costs.



Going off-grid

We believe that all new factories should look to create their own low carbon energy solutions and install energy assets paired to the capacity of the facility. This approach can provide more sustainable solutions and also helps increase energy resilience and security.

Increasing resilience and ensuring security of supply, so that essential production and process data can't be lost, are reasons enough for businesses to consider generating their own energy, particularly through renewable assets such as wind turbines and solar power, which minimise the need for and cost of fuel.

Power protection

One of our clients, a research facility in England, was left without power for more than three days due to severe weather and flooding at an electricity substation some distance away from their premises. The unforeseen and prolonged interruption in energy supply meant they lost vast amounts of irreplaceable research data.

To mitigate the impact to future business, we've introduced wind turbines for local generation, and identified a combination of solar panels and battery storage so the organisation can operate as an 'island' away from the grid and be confident that their operations and data will not suffer the same losses again.



New markets, new locations

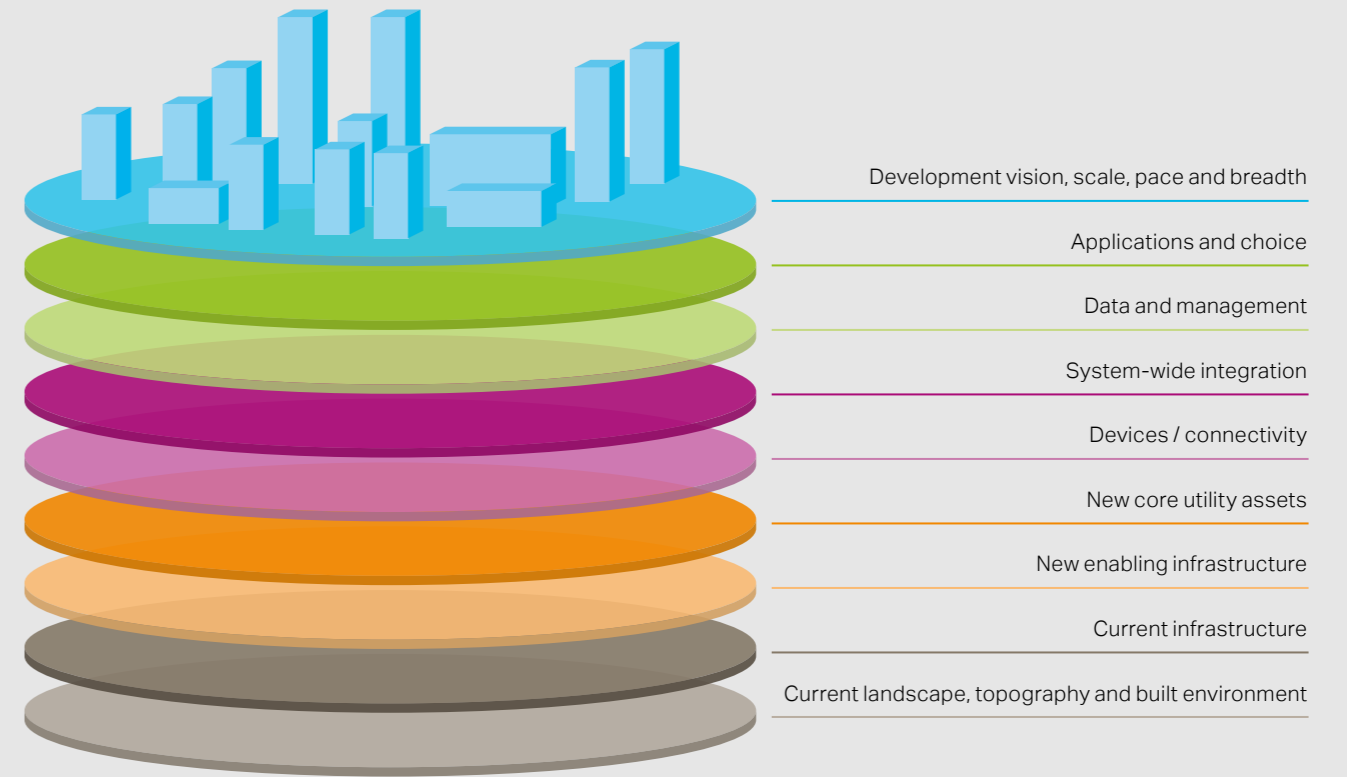
In locations where demand for industrial and fast-moving consumer goods is growing rapidly, such as we're seeing in Africa, the availability of reliable power at new factories can be problematic. Smart off-grid solutions are likely to be less expensive overall and can be delivered in time, meeting production and sustainability objectives.

Smarter, more sustainable

Local, smart-enabled energy solutions include a combination of low power assets and sensory devices to adjust operation across the wider site. In the future this will extend to electric vehicles with the potential for staff and businesses to share storage across fixed assets and the vehicles, even in the facility car park.

Renewables are a big part of the future industrial energy landscape, especially in meeting sustainability targets, and when coupled with storage and combined heat and power units, intensive users will not only be doing their part for the planet but helping control their future access to affordable power.

Configuring for the future



Our engineering and environmental teams partner with industrial businesses to help them manage and optimise their future energy use and utilities, including electricity, heat, chill, water, gas and emissions. Under our Energy Estate offer, we look at all aspects of our clients' energy infrastructure and site assets and suggest ways that increased digital connectivity can drive efficiencies across their entire industrial processes and buildings.

Through this approach, it's possible to assess how businesses can progressively harness more data and use emerging digital platforms to better integrate their energy infrastructure and site assets to drive efficiencies and make better decisions around energy generation, use and storage.

Overall, our Energy Estates approach means we can optimise our clients' energy capacity and load requirements and reduce initial infrastructure investment and operating costs.

STANDARDISE TO OPTIMISE

Standardised building design can make factories more flexible and reduce the time it takes to upgrade an existing facility or build a new one, adding real value to manufacturing businesses, writes building engineer **Andrew Burrell**.



The rate of technological and digital change in the industrial world is getting faster every day.

Greater customer demand for made-to-order products that can be bought and delivered anytime, anywhere, and expansion into new markets and locations, means smart businesses are already thinking about how to design and build new or more efficient and adaptable facilities.

What's it all about?

Standardised design allows businesses to design and construct facilities that meet their specific needs, provides a baseline for future designs, reduces build time and frees up capital so that businesses can do more with it. Through standardised design, it's possible to simplify procurement and enhance cost accuracy by knowing what works best.

The real benefit of this approach is the ability to build a new facility or adapt an existing one with

speed, allowing businesses to respond as quickly as possible to customer demands; for today's industrial clients, speed to market is everything.

It's through Industry 4.0 that businesses can also collect and store building data better than ever before and use it to generate and analyse standardised designs to understand and identify how their entire portfolio could be optimised.

Think about tomorrow

Future expansion and flexibility can be included in standardised designs from the very start. We're working with a logistics provider to develop a standard design for their new frozen foods facility. As part of our role, we've put together a technical design guide that includes vital information including how the facility works and strategies for future expansion and development. This means that as their business expands, their facilities will be able to grow quickly and easily without disruption.



Enhance opportunities

Vital process, operational and business data can be gathered and fed into standardised designs throughout the project life cycle; it's through Industry 4.0 that these processes are being made possible.

By utilising this information, it's possible to create optimised facilities for both current operations and future developments or expansions, and identify what needs to be maintained such as the size of a facility, and what needs to be improved such as ventilation, to create designs that bring the most benefits.

By looking at what already works well for one of our industrial clients — and where things could be improved — we've found them suitable sites more quickly and have completed early stage facility design work 20–25 per cent faster than usual. This has helped them meet challenging sales deadlines which wouldn't have been possible using a more traditional design approach.

Turn to tech

To realise the full benefits of standardised design, the use of technology is also important. We've developed a simple-to-use, excel-based tool kit for a client that allows us to feed in design specifications such as the height and size of their buildings, to produce concept designs and accurate cost estimates in minutes, saving the client money and time spent on early design and business planning, all at the click of a button.

People power

Standardised design can optimise facilities and make them more fit for the future, but this ultimately depends on people's understanding of the benefits it can bring. In the long term, buy-in and uptake across a business is needed to produce buildings that really work for a business into the future.

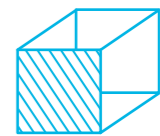
FOUR-LEVER APPROACH TO OPTIMISE BUILDING DESIGN

We've developed a building model that shows ways to save money and time when designing buildings; building standardisation is one of them.

We use the model to help clients as much or as little as they need, from looking at how their business and processes work to developing strategies to enhance procurement.

On one project we've used the approach to reduce early stage design time by 35 per cent, saved the client 20 per cent in construction costs and improved cost accuracy by 20 per cent.

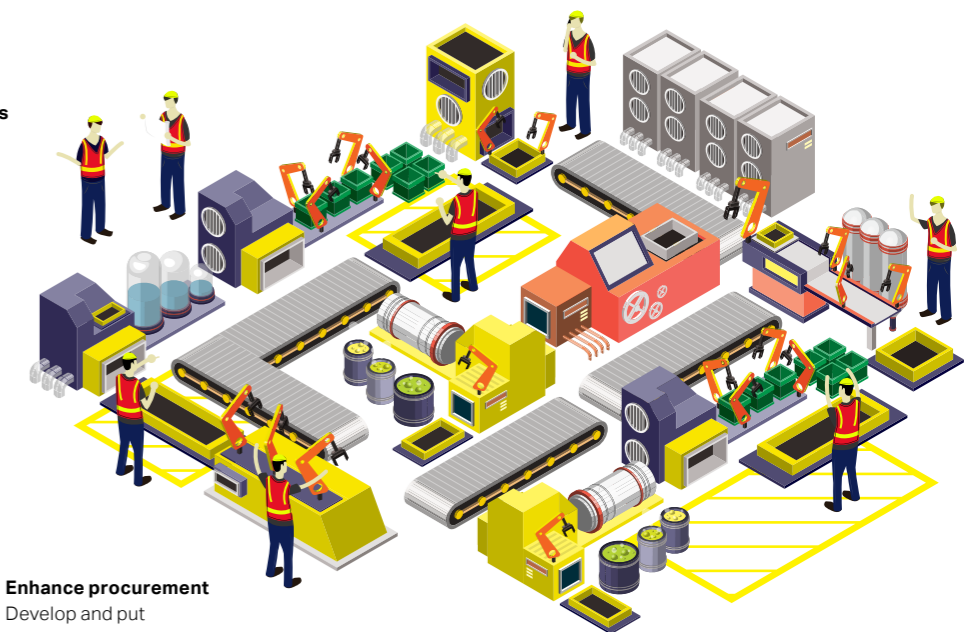
Applying all stages of our approach to a project will bring the greatest results. However, applying them one by one to small-scale projects will also bring measurable improvements.



02 Develop standardised designs
Develop holistic building designs that bring the best value and meet a business's key operational requirements



01 Look at how the business and its processes work
Assess a business's various workflows to remove blockages, ease pressure and improve project performance



03 Enhance procurement
Develop and put strategies in place to reduce lead times, maximise economies of scale and ensure operations continue to run effectively



04 Perform cost management and cost production
Capture data and compare it to benchmarks to improve accuracy of cost estimates and maximise use of capital

About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A *Fortune 500* firm, AECOM companies have annual revenue of approximately US\$18 billion. See how we deliver what others can only imagine at aecom.com and [@AECOM](https://twitter.com/AECOM).

Our See Further series is now available on the Apple App Store and Google Play Store.

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