Digital Manufacturing Light

Supporting SME manufacturers to take the first steps towards digital transformation

Tātaki Auckland Unlimited

AUCKLAND TĀMAKI MAKAURAU

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Contents

Foreword

Manufacturing is critical to the success of many other sectors and has a positive impact across the entire economy. When manufacturing isn't performing well, our whole economy tends to follow suit. Aotearoa New Zealand is home to a host of inventive and energetic manufacturing companies that create top-notch products, exported to customers around the world.

However, New Zealand firms produce just over half the output of similar firms in other advanced economies of comparable size, even when using the same amount of labour. And overall, productivity in New Zealand's manufacturing sector is significantly lower than in many peer countries. In 2022, the industry's productivity (measured as value added per hour worked) was US$102.40, compared with US$136.29 in Denmark and US$167.04 in Ireland.

Digital transformation can help turn this around. Globally, manufacturing is undergoing a profound revolution known as the Fourth Industrial Revolution – or Industry 4.0. Manufacturing businesses overseas and in New Zealand have demonstrated that the adoption of digital technologies boosts productivity, enhances competitiveness both locally and internationally, and opens additional exporting opportunities.

Digital transformation involves integrating digital technology across all aspects of a business. By applying digital information to enhance manufacturing processes, supply chains, products and services, small and medium-sized enterprises (SMEs) can continuously improve performance and product quality, retain knowledge and better manage uncertainty. For small manufacturers in a market the size of New Zealand's, this is particularly valuable. Implementing digital technologies allows for easier meeting of customer demands through better customisation for greater product variety, cleaner and greener products and packaging, more personalisation, faster response times and added-value services.

Recognising these opportunities, Tātaki Auckland Unlimited (TAU) identified the need for a programme to support the digitalisation of manufacturing SMEs. TAU partnered with the University of Auckland to develop this initiative, which became known as Digital Manufacturing Light (DM Light).

The DM Light initiative helps SMEs take their first steps towards digital transformation. It identifies and develops practical, cost-effective digital solutions that increase productivity with far lower risk than traditional approaches. This initiative is a key part of Tech Tāmaki Makaurau, a three-year programme led by TAU and launched in 2022. Tech Tāmaki Makaurau aims to grow Auckland's tech industry, create jobs, and attract investment and talent into the region. Over the long term, the production and process improvements enabled by DM Light solutions will contribute to lower business costs, higher turnover and increased productivity. These gains will also help manufacturers manage the ongoing challenge of labour constraints.

Effective collaboration across the wider business support ecosystem is essential to the success of initiatives like DM Light. Funding for the programme is envisioned as a blend of public and private sources, with SMEs expected to contribute part of the cost - ensuring they have "skin in the game", recognise the value of the support and solutions, and are ultimately prepared to fully fund further digital manufacturing initiatives as they grow. Central government support is justified, given the market failures that continue to limit wider uptake of digital manufacturing solutions. Local government involvement is also warranted, as the programme delivers localised benefits such as skilled job creation and stronger regional productivity. These gains come through a pipeline of more capable, digitally savvy manufacturers feeding into the broader regional economy.

Pam Ford
DIRECTOR
Economic Development
Tātaki Auckland Unlimited

[1] All figures are calculated from the OECD Productivity database.
https://data-explorer.oecd.org/vis?df[ds]=DisseminateFinalDMZ&df[id]=DSD_PDB per cent40DF_PDB_LV&df[ag]=OECD.SDD.TPS&dq=.A.GDPHRS.....&lom=LASTNPERIODS&lo=5&to[TIME_PERIOD]=false

Introducing Digital Manufacturing Light

The manufacturing sector is a key pillar of Tāmaki Makaurau Auckland's economy, contributing more than $11 billion, or 8 per cent of the region's gross domestic product (GDP). It accounts for 50 per cent of Auckland's exports and employs almost 9 per cent of the workforce (85,000 people),[2] with potential for growth.

Manufacturing in Tāmaki Makaurau Auckland:[2]

- contributes 8 per cent to the region's GDP, equivalent to $11.4 billion
- accounts for 37 per cent of New Zealand manufacturing's total GDP contribution
- makes up 50 per cent of Auckland's exports, valued at $8.9 billion
- comprises 8300 businesses, representing 34 per cent of the New Zealand manufacturing sector
- employs 85,000 people, making up 8.7 per cent of the region's workforce, and
- experienced 2.7 per cent annual growth in employment (2022–2023).

However, Aotearoa New Zealand's manufacturing productivity lags behind other advanced economies, and digital transformation can help bridge that gap. Globally, manufacturing is undergoing a profound transformation with the Fourth Industrial Revolution or Industry 4.0. By adopting digital technologies, manufacturers can boost productivity, enhance competitiveness and unlock new export opportunities.

New Zealand's manufacturing sector is largely made up of small and medium-sized enterprises (SMEs). Of the 24,360 manufacturing businesses, only 1.6 per cent employ more than 100 people, 73.5 per cent generate annual sales of less than $1.5 million, and only 5.1 per cent have a turnover of more than $10 million each year.[3] This small size and lack of resources make adopting new technologies seem expensive and unsettling, limiting organisations' ability to improve productivity through digital tools. A recent study reveals that New Zealand's manufacturing sector is reluctant to adopt digital technologies.[4] The findings indicate that New Zealand is about 10 years behind many European countries, which themselves lag behind Asia and the United States in this area.

Rationale for digital manufacturing

Key drivers:

- development and availability of new technologies
- optimising supply chains and enhancing resilience
- enhancing product and service customisation
- meeting productivity growth demands, and
- addressing sustainability demands.

Medium-term outcomes:

- increased production efficiency
- improved product and process design processes
- streamlined enterprise management
- improved and more resilient supply chain operations
- higher customer satisfaction, and
- enhanced materials and energy management.

Long-term outcomes:

- lower business costs
- higher business turnover
- strengthened and more resilient value chains, and
- greater overall productivity.

[2] 2023 prices, year to March 2023, Source: Infometrics

[3] Stats NZ. (2024). Manufacturing and production. Retrieved 13 February 2025 from https://www.stats.govt.nz/topics/manufacturing-and-production

[4] MBIE. (2018). Beyond commodities: Manufacturing into the future. https://www.mbie.govt.nz/assets/f0f81b6194/new-zealand-manufacturing-sector-report-2018.pdf

Manufacturing SMEs in Aotearoa New Zealand face significant barriers when adopting digital manufacturing (DM) – high costs, perceived risks and the complexity of implementation. Initial research at the University of Auckland (UoA) and international studies confirmed the need for a programme that provides a more accessible pathway to digitalisation.[5]

To address this, Tātaki Auckland Unlimited (TAU) partnered with the UoA in 2022 to investigate how best to support New Zealand's SME manufacturers in adopting digital technologies. This research led to the development of Digital Manufacturing Light (DM Light), a programme specifically designed to fit the needs of New Zealand SMEs and assist with the first steps into Industry 4.0.[6]

DM Light focuses on small-scale, high-impact solutions that allow manufacturers to integrate digital technologies at a fraction of the cost and risk associated with traditional Industry 4.0 approaches (Figure 1). Instead of requiring significant investment or major operational changes, the programme supports businesses in identifying and implementing practical digital tools that deliver immediate benefits while maintaining core operations.

The programme was trialled and validated by the Laboratory for Industry 4.0 Smart Manufacturing Systems (LISMS) at the UoA. The research team, led by Dr Jan Polzer (Department of Mechanical and Mechatronics Engineering) and supervised by Professor Xun Xu, worked with key industry collaborators, including Pam Ford, Marissa Brindley, Konstantin Selitskiy, Ryan Archibald and Paula Cooper (TAU), the late Andrew Gill (The Consulting Partnership Ltd, United Kingdom), and Stephen Knuckey (MartinJenkins).[7] The team aimed to ensure that the programme met the needs of New Zealand businesses and could be successfully scaled.

As part of this work, the team reviewed global initiatives that have successfully supported digitalisation in SMEs. One of the most effective models was the UK's Digital Manufacturing on a Shoestring (Shoestring) programme,[8] developed by the Institute for Manufacturing (IfM) at the University of Cambridge (UoC). The DM Light team identified Shoestring as a strong foundation and adapted its methodology to suit New Zealand's unique business environment and had support and input from the Shoestring team at IfM.

Launched in April 2022 as part of TAU's Tech Tāmaki Makaurau, a three-year initiative to grow Auckland's technology sector, DM Light has already demonstrated its value through a series of successful industry pilots. These pilots confirmed its fit-for-purpose approach and established a foundation for a national rollout.

The DM Light framework offers manufacturers an off-the-shelf solution that includes:

- a bill of materials for equipment
- open-source software specifications
- a detailed instruction manual, and
- online and in-person support to assist implementation.

This structure ensures that even non-developers can set up and integrate new technology, with a dedicated support team available for guidance.

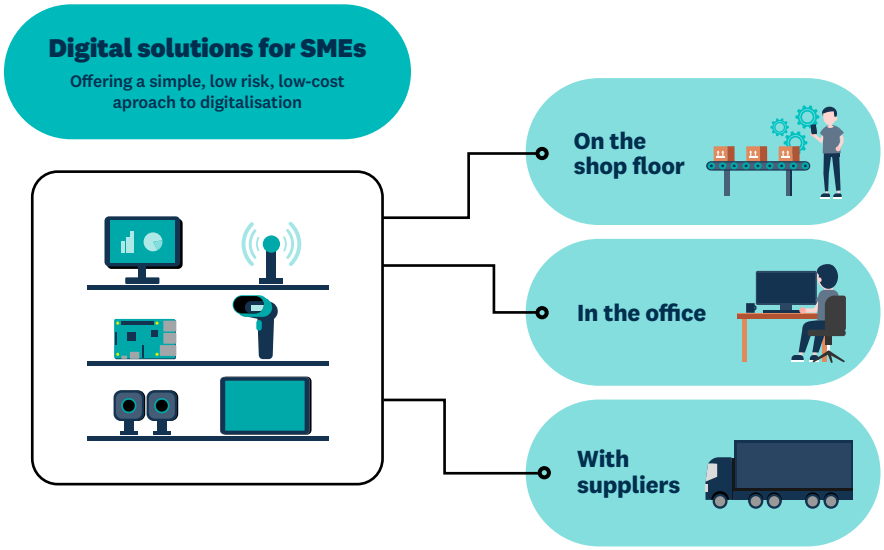

Figure 1: Digital solutions for manufacturing SMEs[9]

With its methodology now validated, DM Light is ready to be implemented across New Zealand. The programme provides a clear roadmap and framework for supporting manufacturing SMEs in augmenting existing machinery with modern digital capabilities.

This report outlines the key stakeholders, the necessary infrastructure, and the steps required to ensure a successful launch and nationwide scale-up.

[5] Hazmeh, R., Zhong, R. Y., & Xu X. (2018). A survey study on Industry 4.0 for New Zealand manufacturers. Procedia Manufacturing, 46, 49–57. https://doi.org/10.1016/j.promfg.2018.07.007

[6] Digital Manufacturing Light is modelled on the programme called Digital Manufacturing on a Shoestring, developed by the Institute for Manufacturing (IfM) at the University of Cambridge.

[7] The DM Light team acknowledges the support and impact made by other collaborators and supporters of this initiative: The IfM at the University of Cambridge, Advancing Manufacturing Aotearoa (AMA), EMA (Employers and Manufacturers Association), Callaghan Innovation, and the companies and individuals who participated in the workshops and discussions, making invaluable contributions to the initiative.

[8] © IfM, University of Cambridge.

[9] Adapted from materials published by the IfM, University of Cambridge.

Manufacturing in New Zealand and the Fourth Industrial Revolution

Industry 4.0

From the first computer numerical control (CNC) machines in the 1940s to programmable logic controllers (PLCs) in the 1970s to smart factories empowered by internet technology (IT), operational technology (OT) and artificial intelligence (AI) in the 2000s, digitalisation is an ongoing process (Figure 2). While information sectors, such as finance and media, can readily adapt to new digital technologies, rapid change is expensive and risky for industrial processes due to the large investments already made in physical machinery and plant and the potentially high costs of upgrading these.[10]

Industry 4.0, a term coined by the German Government in 2011, ushers in a new suite of technologies built on the foundations of cloud computing, the Internet of Things (IoT), Digital Twins and AI (Figure 2). The terms 'digital manufacturing' and 'smart manufacturing' encompass all emerging digital technologies within the manufacturing context and Industry 4.0 umbrella.

The University of Cambridge describes digital manufacturing as "the application of digital information from multiple sources, formats, and owners, for the enhancement of manufacturing processes, supply chains, products, and services."[11] The automation potential and new digital technologies that are based on AI have created a new wave of opportunities to enhance productivity and product quality in manufacturing.[12]

Manufacturing SMEs often struggle with lower productivity levels because they lack the scale and capabilities to fully benefit from Industry 4.0. However, many of them understand that digital applications can enhance production efficiency, address sustainability demands, optimise supply chains, improve resilience, and boost product and service customisation.

Despite this awareness, SMEs face significant barriers to adopting complex digital technologies. These include limited financial resources, fear of technological risks, and the perceived complexity of implementing and integrating these innovations.[13] A limited understanding of the value and potential applications of digital solutions further compounds these challenges.

Figure 2: Industry 4.0 and important technology development stages in digital manufacturing

1960s
Numerically controlled machine tools

1970s
PLCs as the electronic replacement for hard-wired relay systems

1980s
Computer-aided design and digital product information

1990s
Computer-aided design and manufacturing

2000s
Industrial automation empowered by IT, OT and AI

2010+
Industry 4.0, Smart Factory, Product life cycle, Value chain management

[10] Zhong, R. Y., Xu, X., Klotz, E., & Newman, S. T. (2017). Intelligent manufacturing in the context of Industry 4.0: A review. Engineering, 3(5), 616–630. https://doi.org/10.1016/J.ENG.2017.05.015

[11] McFarlane, D., Ratchev, S., Thorne, A., Parlikad, A. K., de Silva, L., Schönfuß, B., Hawkridge, G., Terrazas, G., & Tlegenov, Y. (2019). Digital manufacturing on a Shoestring: Low-cost digital solutions for SMEs (White paper). IfM, University of Cambridge.

[12] Li, Y., Dai, J., & Cui, L. (2020). The impact of digital technologies on economic and environmental performance in the context of Industry 4.0: A moderated mediation model. International Journal of Production Economics, 229, Article 107777. https://doi.org/10.1016/j.ijpe.2020.107777

[13] Polzer, J., Xu, X., Selitskiy, K., Archibald, R., & Gill, A. (2023). A systematic method for retrofitting legacy machines using the "shoestring" philosophy. In Proceedings of the Low-Cost Digital Solutions for Industrial Automation (LoDiSA 2023) (pp. 82–89). https://doi.org/10.1049/icp.2023.1738

Smart manufacturing refers to the application of digital information for the enhancement of manufacturing processes, supply chains, products and services. It has the potential to transform the manufacturing industry in New Zealand, enabling a significant increase in productivity with a myriad of knock-on benefits for workers, businesses and the economy.

Like other small, advanced economies built on SMEs, New Zealand faces these barriers to adoption for a thriving advanced local manufacturing sector. Yet if it doesn't adopt and adapt, it will struggle to be competitive internationally, risk losing opportunities in the rapidly changing global markets, and be less equipped to create a productive, low-emissions, circular economy.

As countries around the globe are impacted by the Fourth Industrial Revolution, New Zealand SMEs seek an affordable path to integrate digital technologies into existing manufacturing and industrial processes so they can be innovative and competitive, both locally and globally.

New Zealand manufacturing defined by SMEs

According to Stats NZ, more than 96 per cent of New Zealand manufacturers are SMEs with fewer than 50 full-time employees (FTEs). Indeed, 91 per cent of these SMEs are very small businesses, with fewer than 20 FTEs.

It is important to note that, overall, the business demographics in the manufacturing sectors in the UK and New Zealand are very similar, making programmes for manufacturing SMEs developed in the UK applicable to the New Zealand business environment.

What is also important is that, on average, manufacturing companies in New Zealand are even smaller than those in the UK (Figure 3).[14] More than 80 per cent of New Zealand businesses have fewer than 10 employees,[15] and firms of this small size rarely have significant capacity to do R&D or implement complex technologies.

SMEs often lack a comprehensive understanding of the value and potential applications of digital manufacturing and Industry 4.0.[16] Additionally, businesses frequently face a shortage of internal expertise to implement and integrate digital technologies into manufacturing processes.[17] Securing funding to cover the associated costs can also be challenging, compounded by a lack of management time to dedicate to the implementation of digital manufacturing.

In New Zealand factories, many businesses continue to operate 20-year-old (and older) machines that are mechanically functioning and (mostly) still producing high-quality output. However, this equipment lacks the capabilities – and business benefits – offered by modern data collection, connectivity and automation. Operated manually or semi-automatically, many production lines:

- require a high level of human oversight and intervention, and
- make it hard to collect meaningful data for process planning.

Furthermore, when quality relies on human oversight, businesses face obstacles to achieving optimal quality due to keeping staff engaged on often mundane tasks.

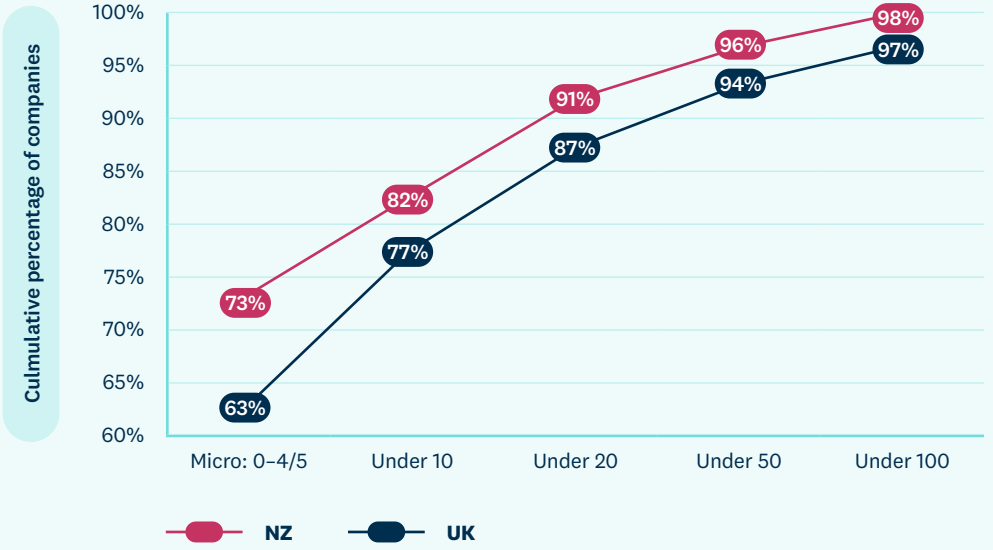

Figure 3: A comparison of the size distribution of manufacturing companies in the UK versus New Zealand[18]

[14] Stats NZ. (n.d.). InfoShare. Retrieved April 2024 from https://infoshare.stats.govt.nz/

[15] Stats NZ. (n.d.). InfoShare. Retrieved April 2024 from https://infoshare.stats.govt.nz/

[16] There are also views that some of the terms used, such as Industry 4.0 or AI, can alarm people or not resonate with them, and there is a need to position the technologies into the language and perspective of manufacturers and staff. (Source: Knuckey, S. (2022). Innovation in New Zealand and targeted sectors. Report 1 of the Review of R&D, Innovation and Business Development Support. Ministry of Business, Innovation & Employment.)

[17] Hazmeh, R., Zhong, R. Y., & Xu X. (2018). A survey study on Industry 4.0 for New Zealand manufacturers. Procedia Manufacturing, 46, 49–57. https://doi.org/10.1016/j.promfg.2018.07.007

[18] The chart uses 2020 and 2023 'all company' statistical data from the UK and New Zealand, respectively. Source of data for the UK: Office for National Statistics. Business activity, size, and location. Retrieved April 2024 from https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation. Source of data for New Zealand: Stats NZ. (n.d.). InfoShare. Retrieved April 2024 from https://infoshare.stats.govt.nz/

A programme for New Zealand

As part of the development phase of the DM Light programme, TAU surveyed members of the Employers and Manufacturers Association (EMA), confirming that the key barriers to implementing new digital solutions include cost (identified by 61 per cent of respondents), a lack of time and resources (54 per cent), and challenges associated with existing or legacy systems (52 per cent).

The DM Light programme is designed to help SMEs overcome these barriers by offering (Figure 4):

- a low-cost approach
- a non-core system approach, and
- a requirements development approach.

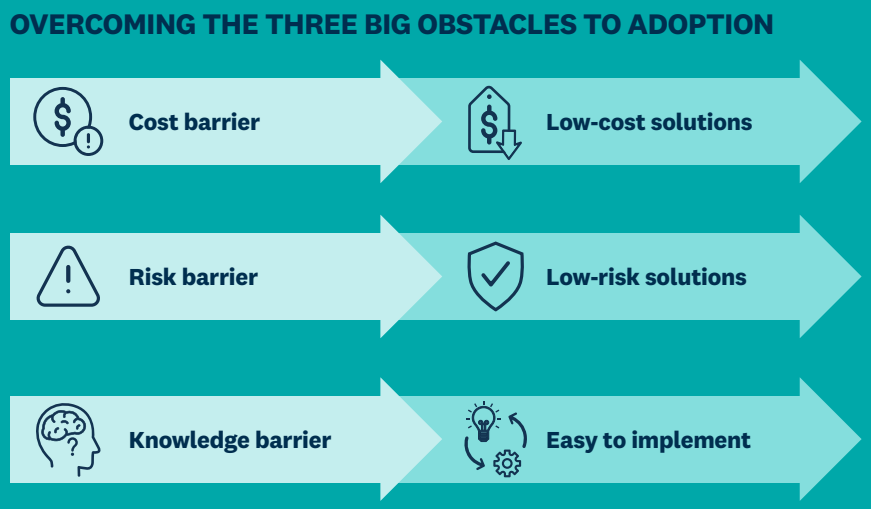

Figure 4: How a DM Light approach can overcome the three main barriers to digital adoption

A pioneering approach: Digital Manufacturing Light

The DM Light initiative has been designed to help companies "dip their toe in the water", build confidence and enhance both technology and workforce capabilities, while also addressing key barriers to adoption.

The programme seeks to enhance businesses' awareness of the value of external advice and the broader importance of developing business capability.

While modelled on Shoestring, DM Light will have differences at the solutions level. Both programmes follow agile engineering design processes, but New Zealand has its own unique array of industries and businesses which are overall smaller in size, with differing priorities. This will lead to a unique combination of starter solutions developed by the IfM in the UK and those developed locally for local needs.

DM Light Auckland pilot timeline

The LISMS team has been studying the UK's Shoestring approach for well over three years, assessing and adapting it for local application through workshops and industry pilot projects. Auckland pilots have enabled the team to test the Shoestring approach and the solution kits from the UK, demonstrating effectiveness within the New Zealand context (Figure 5).

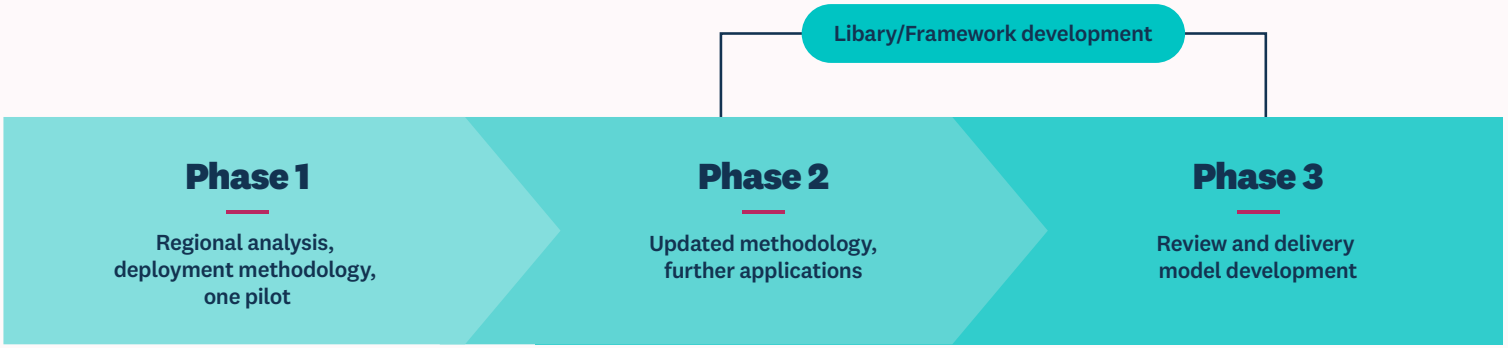

Figure 5: DM Light Auckland pilot timeline

PHASE 1

Phase 1 was successfully completed in 2022 and involved regional analysis, deployment methodology and conducting one implementation project. The results and findings from Phase 1 received highly positive feedback from stakeholders, including small businesses, EMA, BusinessNZ, New Zealand Trade and Enterprise (NZTE), Callaghan Innovation, Make | NZ and the IfM at the University of Cambridge.

PHASE 2

Phase 2 was completed in 2023 and included updating the DM Light methodology (based on local learnings and capabilities), implementing further deployments supported by partner organisations (see the section New Zealand pilot projects for details), defining the development framework and further developing a library of solutions. Phase 2 received positive feedback from the companies involved and various stakeholders.

PHASE 3

The objective of Phase 3 was to review Phases 1 and 2, develop and validate the delivery model, and disseminate knowledge from research to date to promote DM Light within the New Zealand manufacturing sector. This included engaging with key stakeholders, particularly Advancing Manufacturing Aotearoa (AMA) and the Minister of Commerce's Manufacturing Productivity Advisory Group (MPAG).

DM Light concept and key features

DM Light offers a step-by-step approach to digitalisation, leveraging off-the-shelf technology to deliver low-cost, low-risk solutions. By implementing small-scale digital solutions one at a time, SMEs can gain immediate benefits without disrupting core operations. This approach makes digital manufacturing accessible, helping businesses adopt affordable technologies, build skills and understand the impacts firsthand – all without significant costs or risks.

Designed for businesses unsure of where to begin or hesitant to commit to substantial digital budgets, this hands-on method enables companies to explore the benefits of digitalisation while building internal digital competencies. The programme facilitates a distributed and repeatable approach to developing specific solutions, allowing organisations to develop, implement and upgrade solutions incrementally, benefiting from earlier deployments while remaining easy to scale across New Zealand.

Figure 6: Key principles of the DM Light approach to digitalisation

Key principles of the programme

- **Affordable for SMEs**
  Off-the-shelf starter solutions (hardware and software) cost no more than NZ$2000. Implementation and integration costs can vary depending on the solution and level of tailoring required.
- **Focus on in-house deployment**
  Solutions can be implemented by staff without specialised technical expertise, fostering learning and digital adoption.
- **Building confidence in digital adoption**
  Helps SMEs to see a clear pathway to digital transformation.
- **International collaboration**
  Encourages the co-development of new solutions across borders.
- **Comprehensive support**
  Provides an online troubleshooting forum, technical training with expert support, and access to an extensive network and community of practice.

Features of DM Light solutions

- Solutions can be built and deployed **in-house** by company staff, not developers
- Solutions come with comprehensive instructions, training and **support** by experts
- Solutions are based on **affordable electronic components** available from major retailers
- Solutions include **open-source software** to create easy-to-understand dashboards
- Solutions promote **community** building through peer-to-peer assistance

Figure 7: Features of DM Light solutions

Each solution kit includes a detailed list of affordable electronic components, all of which can be purchased online from major retailers. Solutions also include the necessary open-source software to connect the components and create easy-to-understand dashboards. Additionally, the approach promotes peer-to-peer assistance through a community of practice (Figure 7).

The DM Light method leverages affordable digital devices from non-industrial sectors – such as sensors, barcode readers, Wi-Fi cameras and game controllers – combined with open-source software to create cost-effective industrial solutions.[19] Figure 8 and Figure 9 illustrate how low-cost technologies, including cloud computing, Raspberry Pi micro-computers, IoT devices and open-source software enable the development of modular, reliable digital solutions for manufacturing. This framework supports continuous performance improvement, knowledge retention and better uncertainty management, using commercially available technologies for mobile computing, sensing, micro-processing, communication and AI.

Importantly, these digital solutions employ the application of industry automation standards providing for future-proof solutions and serve as a foundation for further adoption of Industry 4.0 applications.

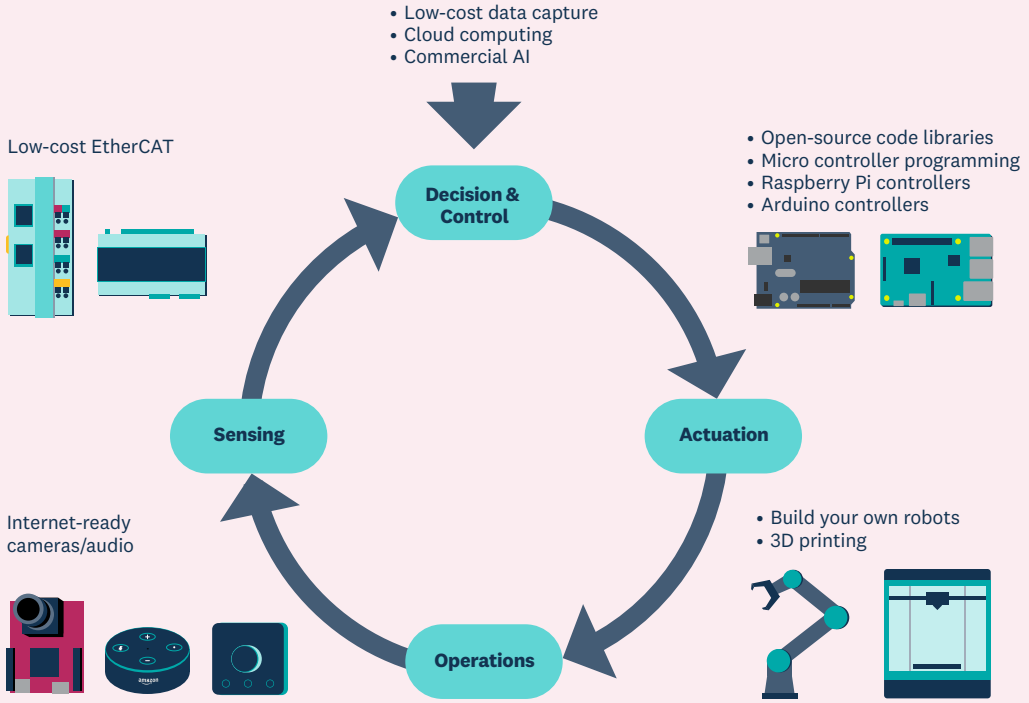

Figure 8: Low-cost technologies for digital manufacturing[20]

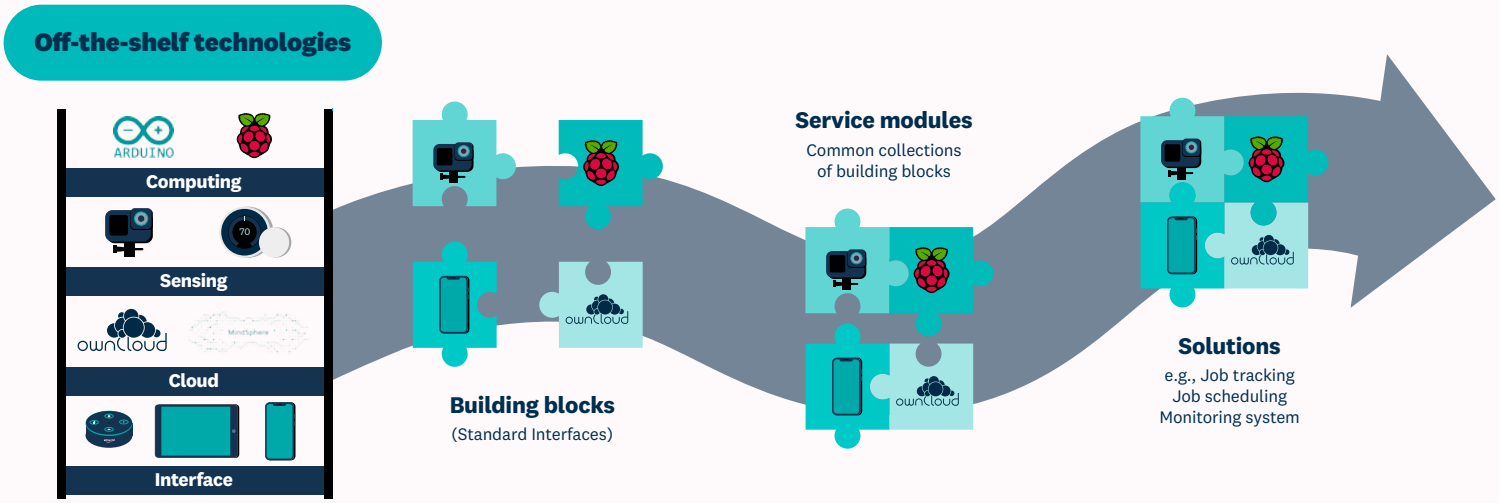

Figure 9: DM Light/Shoestring concept

[19] McFarlane, D., Ratchev, S., de Silva, L., Hawkridge, G., Schönfuß, B., & Terrazas, G. (2022). Digitalisation for SME manufacturers: A framework and a low-cost approach. IFAC PapersOnLine, 55(2), 414–419. https://doi.org/10.1016/j.ifacol.2022.04.229

[20] McFarlane, D., Ratchev, S., Thorne, A. K. Parlikad, A. K., de Silva, L., Schönfuß, B., Hawkridge, G., Terrazas, G., & Tlegenov, Y. (2020). Digital manufacturing on a shoestring: Low cost digital solutions for SMEs. In T. Borangui, D. Trentesauax, P. Leitău, A. G. Boginno, & V. Botti (Eds.), Service Oriented, Holonic and Multi-agent Manufacturing Systems for Industry of the Future: Proceedings of SOHOMA 2019 (pp. 40–51). Springer.

How DM Light concept works in practice

Identifying priority areas for SMEs

The Shoestring programme built an initial catalogue of digital solution areas based on numerous academic and non-academic case studies, then surveyed more than 200 small companies in the UK and abroad to identify priority areas for small manufacturers. It identified more than 50 'Digital Solution Areas'.[21]

To concentrate efforts in priority areas, the IfM team then developed the top 10 solution areas. Despite differences in the products they produce, small manufacturers share similar digitalisation needs which low-cost solutions can address.

To assess the relevance of these priorities for SMEs in New Zealand, the UoA team, in partnership with TAU, conducted workshops at EMEX 2022 and two more in collaboration with EMA in 2023 and 2024, augmenting this work with a comprehensive survey on SME needs and preferences.[22] The findings confirmed that New Zealand manufacturers have largely the same priorities as UK counterparts, with job tracking, digital job cards, process monitoring and lead-time monitoring forming the top four in New Zealand (Table 1).

While some New Zealand SMEs identified unique needs not mentioned in the UK study, all the workshop participants found relevant digital solutions within the top-priority digital solution areas list, reinforcing the applicability of the Shoestring model for the New Zealand context.

	Needed digital manufacturing solution	Presence in UK Top 10
1	Digitised work instructions, photos and assembly procedures	Y
2	Real-time digital tracking of internal jobs	Y
3	Capacity monitoring (human and machine resources)	Y
4	Internal lead times monitoring	Y
5	Monitoring of occupational health and safety	N
6	Digital job cards	Y
7	Digitally assisted product quality monitoring and inspection	N
8	Process monitoring (speed, vibrations, energy, temperature)	Y
9	Customer and demand data gathering and analysis	Y
10	Waste and emissions monitoring	N

Table 1: Digital Manufacturing Light top-10 digital solutions areas (DM Light workshops and survey results)

[21] Schönfuß, B., McFarlane, D., Hawkridge, G., Salter, L., Athanassopoulou, N., and de Silva, L. (2021). Digital manufacturing on a shoestring: Low-cost digital solutions for manufacturing SMEs: A catalogue of digital solution areas (White paper). IfM, University of Cambridge.

[22] A survey of 80 EMA members, conducted by TAU during the development phase of the DM Light programme, confirmed strong interest and demand for digital manufacturing solutions, with around 80 per cent of respondents expressing the intention to investigate and potentially adopt new digital solutions and technologies.

DM Light process and digital solutions development

To maintain affordability, DM Light provides a pre-developed library of digital solutions sourced from the Shoestring programme and developed locally in New Zealand. These solutions use off-the-shelf non-industrial components and open-source software, allowing SMEs to integrate digital technologies cost effectively and incrementally.

The programme also offers a distributed and repeatable method for developing specific solutions. Organisations can independently develop, implement and upgrade solutions as needed, benefiting from earlier deployments. There are four key principles of DM Light's solutions development (Figure 10):

1. A pre-developed library of priority digital solutions for New Zealand SMEs.
2. A module-based architecture, allowing basic data and services to be shared between applications.
3. Use of low-cost, commercially available components (e.g., off-the-shelf hardware and software) for easy integration and maintenance.
4. A systematic building-block approach that enables companies to upgrade solutions incrementally.

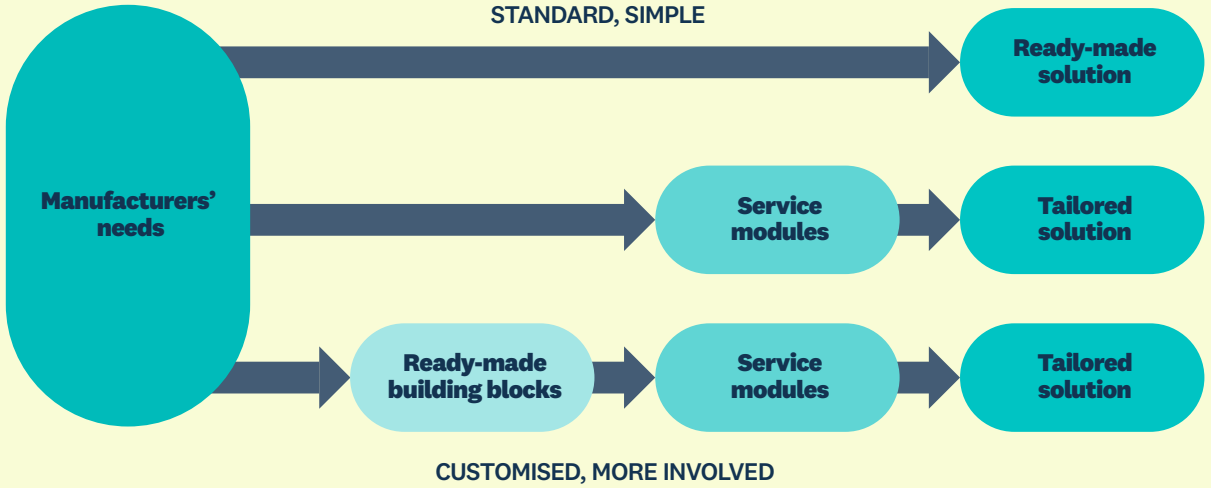

Figure 10: DM Light solutions development framework[23]

Existing digital solutions library

Through partnership with IfM and its recently established Shoestring Ecosystem and Regional Programme, DM Light will leverage the existing library of Shoestring Starter Solutions and collaborate on developing new ones. Accordingly, DM Light will follow Shoestring's proven methodology for deployment.

Step 1: Identify the company's digital needs through an assessment with senior leadership.

Step 2: Select an appropriate digital solution from the library.

Step 3: Adapt the solution design to the specific company requirements.

Step 4: Implement the solution in the company with step-by-step instructions and access to support.

[23] Based on the Shoestring solutions development framework; see: McFarlane, D., Ratchev, S., de Silva, L., Hawkridge, G., Schönfuß, B., & Terrazas, G. (2022). Digitalisation for SME manufacturers: A framework and a low-cost approach. IFAC PapersOnLine, 55(2), 414–419. https://doi.org/10.1016/j.ifacol.2022.04.229

The DM Light new solutions development framework

When an SME requires a solution not available in the existing library, one of the existing solutions can be modified or adapted, or a new solution can be developed. This can be achieved through:

- collaboration with system integrators, offering flexibility in timing but at a higher initial cost, or
- engagement with universities through student projects, a more economical option but with time constraints.

The initiation of new solutions and starter kits stems from two primary sources:

1. by demand, when multiple companies identify the same solution need, or
2. by SME request, when a specific requirement is brought to the DM Light team.

In both scenarios, all new developments follow a common development framework (Figure 11), ensuring capitalisation on existing modules and maintaining the scalability and sustainability of the solution. This avoids isolated solutions and fosters a cohesive ecosystem.

The long-term success of DM Light relies on seamless compatibility of solutions with professional automation technologies.

To achieve this, the DM Light team collaborated with system integrators, gathering insights that informed the programme's rollout and development roadmap.

By adhering to industry automation standards, DM Light ensures future-proof solutions that support further broader Industry 4.0 adoption by involved companies. This approach aligns with the Industry 4.0 framework established by AMA, Callaghan Innovation and partners, enabling manufacturers to digitalise incrementally and with minimal risk. (See Part Five: Rolling out DM Light in New Zealand for more details.)

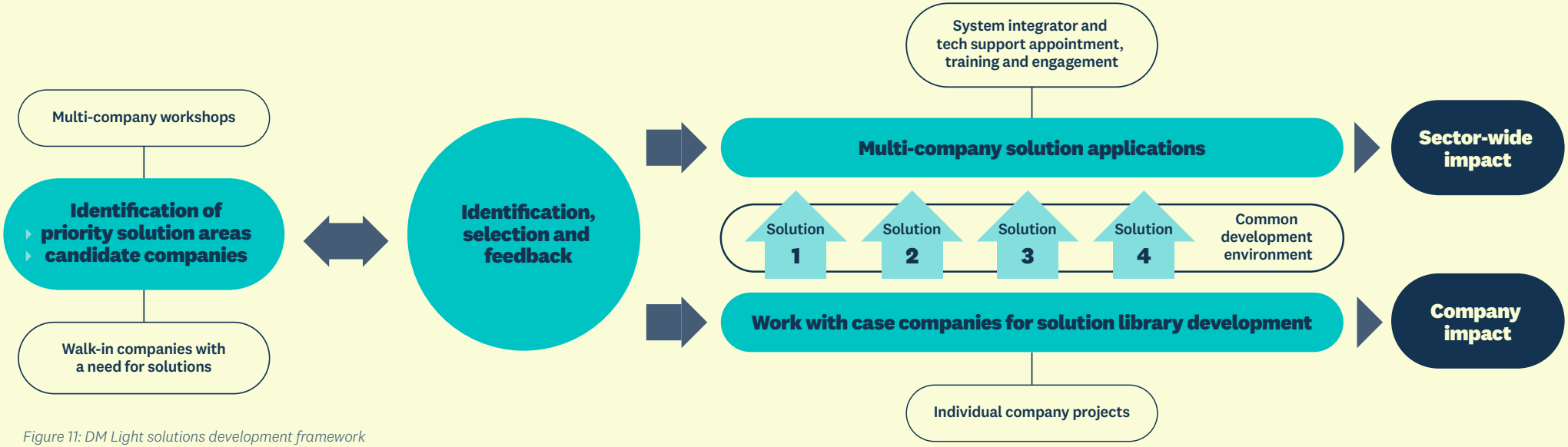

Figure 11: DM Light solutions development framework

DM Light in the New Zealand context - pilot projects

To assess the viability of the DM Light philosophy in the New Zealand context, the UoA, with material support from TAU, conducted research and pilot projects involving student work. The research began with students testing starter solution kits developed by the IfM Shoestring team and exploring how these could be adapted. Building on this work, two DM Light pilot projects were carried out with Auckland-based companies, Spiraweld Stainless and ABB New Zealand, where the UoA team developed and implemented tailored solutions based on the DM Light approach. Each pilot aimed to enhance productivity in a key factory process.

Student research project

Job- and product-specific FTE cost tracking in manufacturing for SMEs

The initial student project tested and expanded the capabilities of the original Shoestring Job Tracking Starter Kit, enabling factory managers to access a digital dashboard that displays labour utilisation on the shop floor. Based on its job-tracking capability, the dashboard provides detailed information about the number of employees on the shop floor, the workstations they are assigned to, and the total time worked by everyone during the shift.

Pilot projects

Pilot project one: Spiraweld Stainless (tube and pipe fabricators)

Productivity improvements in the core process used by Spiraweld Stainless Ltd were achieved by upgrading legacy pipe welding machines with cost-effective, commercially available components based on the DM Light methodology.[24] As a result of this project, rather than observing and manually adjusting the welding torch for several hours per pipe, the plant operator can now attend to other tasks while the machine welds automatically. This project immediately increased productivity and improved quality. (See a detailed case study in the appendix.)

Pilot project two: ABB New Zealand (digital technologies)

This project (sponsored by ABB) developed a portable, cost-effective and automated quality inspection system for SMEs.[25] Manual quality inspection of parts is time consuming and prone to errors. The newly developed automated system inspects features on all sides of a part, requiring minimal staff training for implementation. Built with low-cost materials and 3D-printed components, it accommodates a wide range of part dimensions and can be integrated at any stage of the production process.

The system was designed specifically for SMEs using the Shoestring methodology. Its total cost is approximately NZ$2500, making it significantly more affordable than existing market solutions. This affordability addresses the cost barrier that often prevents SMEs from adopting digital solutions. The risk barrier is mitigated by implementing the system in non-critical manufacturing processes and enabling manual inspection processes to run in parallel with the automated inspection system. The complexity barrier is reduced by providing an easy-to-use and easy-to-train machine vision system.

The two pilot projects summarised above have demonstrated positive outcomes, including improved efficiency, enhanced product quality and reduced waste. This success has led both the participating companies to express interest in digital manufacturing and consider implementing additional digital solutions.

[24] Polzer, J., Xu, X., Selitskiy, K., Archibald, R., & Gill, A. (2023). A systematic method for retrofitting legacy machines using the "Shoestring" philosophy. In Proceedings: Low-Cost Digital Solutions for Industrial Automation (LoDiSA 2023) (pp. 82–89). IET. https://ieeexplore.ieee.org/document/10324424

[25] Sun, H., Teo, W.-T., Wong, K., Dong, B., Polzer, J., & Xu, X. (2024). Automating quality control on a shoestring: A case study. Machines, 12(12), Article 904. https://doi.org/10.3390/machines12120904

Next steps

TAU and UoA have collaborated with AMA, EMA, MartinJenkins, manufacturers and system integrators to workshop the implementation process of DM Light. With input from these industry stakeholders, the project team has developed a process map for the DM Light programme (Figure 12) and a proposed roadmap for its rollout – first to Auckland manufacturers, then nationwide. This roadmap leverages New Zealand's existing industry support ecosystem and builds a community of best practice, driving the expansion of the digital solutions library.

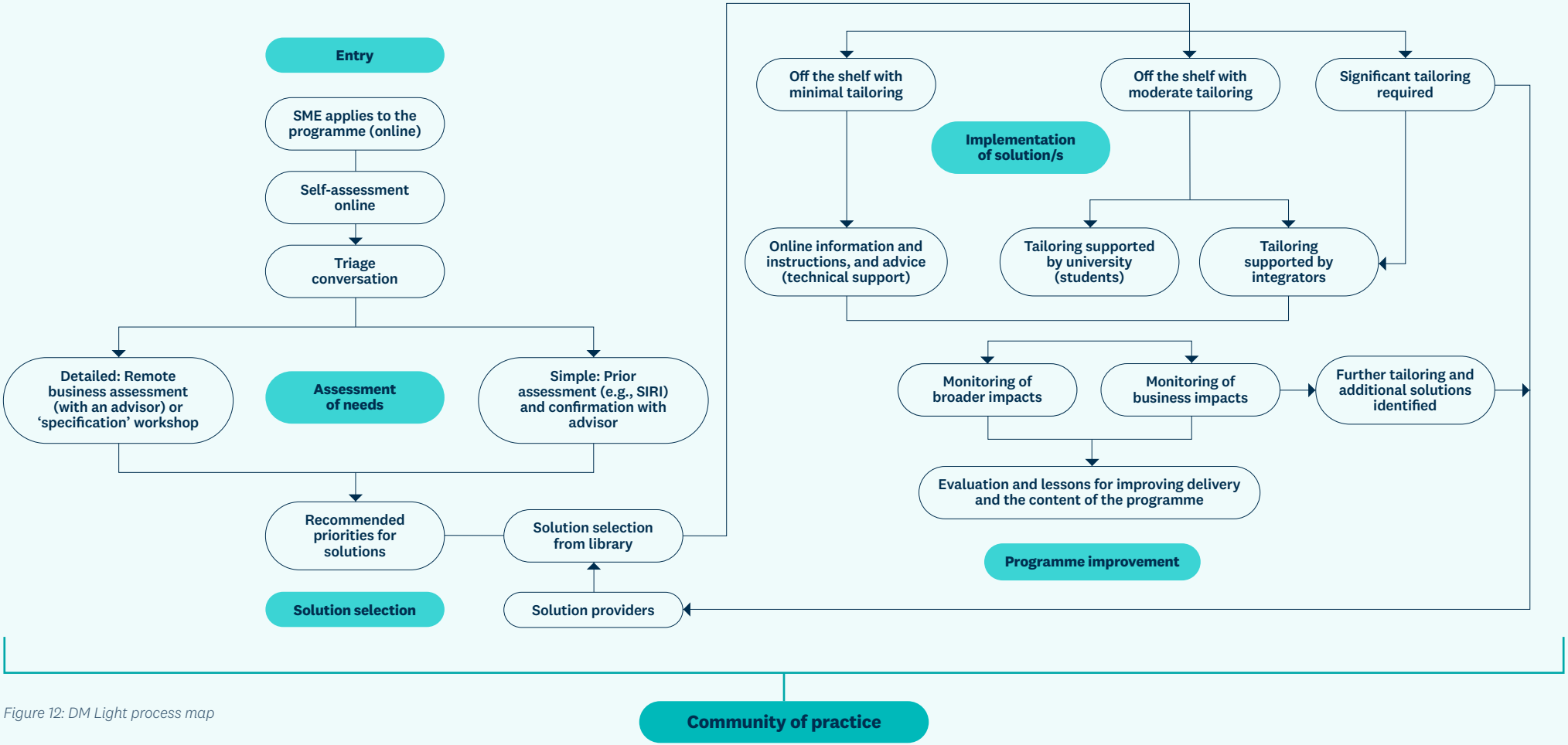

Figure 12: DM Light process map

Who will benefit from this programme

DM Light is designed for SMEs with fewer than 50 FTE employees, particularly those looking to advance beyond current capabilities and benefit from productivity gains through digital manufacturing.

For businesses that have already completed a Smart Factory Assessment (previously known as the Smart Industry Readiness Index [SIRI] assessment) with Callaghan Innovation, identifying digital opportunities is just the first step. However, implementing the recommended solutions can be challenging.

DM Light bridges this gap by providing a swift, structured and cost-effective pathway to digital transformation. With ready-to-use starter kits and the flexibility to create bespoke solutions, it offers step-by-step guidance for selecting and deploying digital tools. This hands-on approach enables businesses to achieve immediate workplace efficiencies, making it an ideal starting point for SMEs embarking on a digital transformation journey.

Programme ecosystem

It is anticipated that DM Light will be managed and administered by AMA in collaboration with the UoA's LISMS.[26,27] AMA is a nationwide, cross-sector industry body dedicated to advancing New Zealand's manufacturing sector. LISMS, the first Industry 4.0 learning factory in New Zealand, fosters interactions and collaborations between industry partners and researchers.

The programme can be marketed through existing AMA media channels and industry associations such as EMA, as well as the Regional Business Partner (RBP) Network and the Industry 4.0 demonstration network or its successor.

SMEs will apply to join the programme and will then be triaged and further assessed by qualified assessors. Depending on the outcome of the triage, applicants will either participate in the specification workshop or undergo a simplified assessment, particularly if they have already completed a SIRI/Smart Factory Assessment or Digital Manufacturing Challenge.

Other members of the ecosystem are outlined in the table (Table 2).

DM Light stakeholders	Ecosystem players	Functions
AMA	Lead DM Light organisation	Lead the programme rollout; facilitate industry engagement, funding and licensing; and coordinate support
Shoestring by IfM, UoC, UK, UoA LISMS	Library holder(s)	Library of digital solutions
EMA, Make | NZ, HERA, etc. TAU, ChristchurchNZ, etc.	Industry bodies/organisations, regional economic development agencies	Champion the programme
IfM, UoA, AMA, others	University, industry bodies, integrators	Assessments workshops and training of deployers and trainers
LMAC, NZ Controls, Motion Design, Wyreframe, Thred, etc.	Deployers and system integrators (selected by AMA in consultation with the UoA)	Deployment and engineering support
Regional Business Partner (RBP) Network	Central government-funded (MBIE) programme	Provide support framework, advisers and funding model
UoA, AMA, EMA, Make | NZ, other New Zealand universities	Universities, industry bodies	Education and training
IfM, UoA, system integrators, other New Zealand universities	Universities and system integrators	New digital solutions development; solutions validation
AMA and partners	Industry bodies	Build a community of practice
Pilot companies	End users	Pilot the rollout

Table 2: Potential DM Light ecosystem

[26] https://www.amanz.nz/about
[27] https://lisms.auckland.ac.nz/About/

A global Shoestring partner

Shoestring solutions have been deployed in more than 100 companies across the UK, helping businesses improve productivity, reduce waste and energy usage, and enhance the digital skills of staff.[28] The initiative is also expanding internationally: a regional rollout pilot has commenced in Western Australia for the food and beverage sector; a scoping pilot has been completed in Scotland; a scoping study has been launched in Egypt; and, most recently, Shoestring has expanded into the Australian Capital Territory and surrounding regions through its partnership with the University of New South Wales Canberra.[29]

DM Light has established strong collaborative relationships with IfM at the University of Cambridge and can initiate the programme rollout in New Zealand by becoming a global Shoestring partner through the recently established 'Shoestring Ecosystem and Regional Programme'. In 2024, this collaboration expanded with the formation of 'Shoestring ANZ', an alliance comprising the University of Auckland, University of Western Australia, UNSW Canberra and the Western Australian state government. The IfM Shoestring team attends these alliance monthly meetings. By joining this alliance, DM Light will leverage the existing library of Shoestring Starter Solutions while actively contributing to new developments and participating in peer learning across New Zealand and Australia.

DM Light will deliver solutions from the existing Shoestring library under licensing agreements that include software, kit lists, access to relevant guidelines and training materials, case studies, Q&A support and more.

This framework for international collaboration offers significant benefits for DM Light; for example, implementing existing solutions via a licensing agreement, while also developing a domestic implementation model and support network, adapting solutions to local requirements, and developing new solutions that would augment the existing library.

As highlighted by the survey of EMA members, among the top DM priorities were real-time digital tracking of internal jobs, capacity and utilisation monitoring, and process monitoring (temperature and power). Digitalisation starter solutions for these areas are already developed and available from Shoestring.[30] Each of these starter kits is priced at £800 or less than NZ$2000.

Over time, it is expected that more solutions will be developed locally and added to the library. Local vendors will receive a licence fee whenever a solution they developed is used. This enables businesses to experiment, learn how to operationalise the solutions, and continuously improve productivity by integrating further innovations.

In a fully developed DM Light programme, depending on each business's requirements and capabilities, solutions can be implemented in one of the following ways:

- off-the-shelf, taken directly from the library with minimal tailoring required
- off-the-shelf, with a moderate level of tailoring and testing to align with the business's production processes, or
- custom-built, requiring significant tailoring or the development of a new solution, followed by extensive testing to fit with the business's production processes.

Timeline of the potential rollout

Year one	Year two	Year three
The programme will begin by delivering at least three off the-shelf solutions from the existing Shoestring library, with the goal of supporting 20–30 manufacturing SMEs in the Auckland region and potentially in Waikato. The first cohort of companies can be drawn from those that have already completed a Smart Factory Assessment.	The solution set will be expanded to at least five solutions, with delivery reaching 60–75 manufacturing SMEs across New Zealand's main manufacturing regions: Auckland, Waikato, Canterbury and Wellington.	Delivery will expand to all major regional manufacturing centres. The number of solutions will continue to grow incrementally, supporting up to 150 SMEs annually.

Table 3: Potential rollout timeline

Intended outcomes and benefits

1. Short-term outcomes (1–12 months):
   - increased awareness of digital manufacturing benefits
   - greater interest in adopting digital solutions, and
   - enhanced capabilities to implement digital solutions.
2. Medium-term (1-2 years) outcomes:
   - increased production efficiency
   - improved product and process design processes
   - streamlined enterprise management
   - improved and more resilient supply chain operations
   - higher customer satisfaction, and
   - enhanced materials and energy management.
3. Long-term benefits:
   - lower business costs
   - higher business turnover
   - strengthened and more resilient value chain, and
   - greater overall productivity.

[29] University of Cambridge. Shoestring News. Retrieved 22 January 2025 from https://www.digitalshoestring.net/news/
[30] https://digitalshoestring.net/our-digitalisation-solutions/

The expected outcomes of DM Light align with the priorities identified by businesses surveyed during its development. According to the survey, the key benefits SMEs anticipate from implementing digital solutions include:

- improved productivity and efficiency – 78 per cent
- real-time insights into production performance – 63 per cent
- reduced production costs – 60 per cent
- improved product quality – 57 per cent
- enhanced customer service – 48 per cent
- increased staff capability – 48 per cent
- better job satisfaction and staff engagement – 47 per cent
- reduced waste – 47 per cent, and
- increased profit – 47 per cent.

These findings reinforce the programme's focus on delivering practical, high-impact digital solutions tailored to SME needs.

Conclusion

Through tests and pilot projects, the DM Light programme has validated the suite of solutions developed by the Shoestring unit at the Institute for Manufacturing at the University of Cambridge in the UK and augmented at the University of Auckland. The programme is now ready to be put into effect in Aotearoa New Zealand. It has the knowledge and capability to support SME manufacturers in augmenting existing machinery with digital technology and smarter processes.

The programme is designed to boost productivity and add value to the manufacturing sector, particularly in today's economic climate where rising input and labour costs make efficiency gains essential. By adopting these digital solutions, businesses can enhance competitiveness, improve resilience, and drive long-term sustainability and growth.

Case study Spiraweld Stainless Ltd

Retrofitting legacy machines at Spiraweld Stainless (tube and pipe fabricators) using the DM Light approach[31]

Many manufacturing SMEs, such as Spiraweld Stainless, operate older but mechanically functional machines that require manual or semi-automatic operation, demanding significant staff attention and hindering productivity. Spiraweld, a manufacturer of spiral welded pipes, faced these challenges with its semi-autonomous welding process. To address this, the UoA team applied a five-stage method, originally designed by the Shoestring programme and further refined by UoA, to automate Spiraweld's welding process (Figure 13).

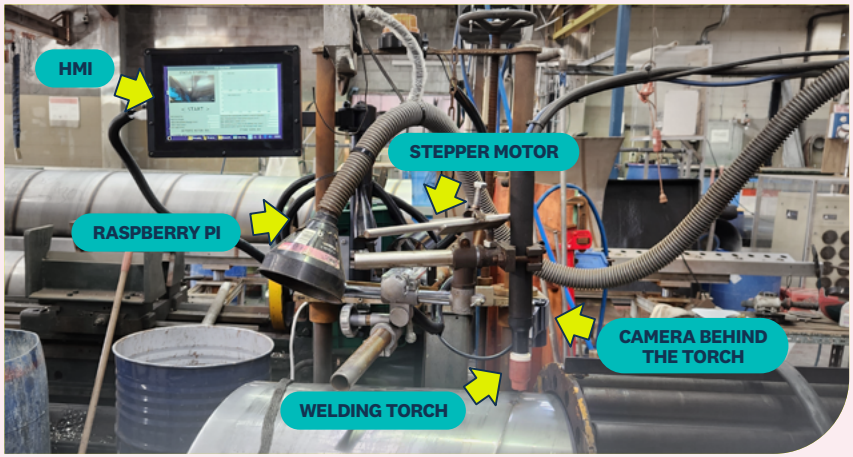

Figure 13: Retrofitted pipe welding system at Spiraweld Stainless Ltd

STAGE I: Digital manufacturing needs assessment

The team analysed Spiraweld's production process to identify automation opportunities. Together with the company leadership, it prioritised automating the pipe welding process to improve productivity and quality.

STAGE II: Solution specification and development

The team developed a solution concept and identified missing hardware components: a camera for computer vision to measure the welding gap, a stepper motor (an actuator) to rotate the welding rig knob, a Raspberry Pi microcomputer as a controller, and a touch screen. The team designed and built necessary frames and modifications for these components.

STAGE III: Procurement, installation and testing

The team gathered process data during manual operation and tuned the new automation concept based on this data. The hardware costs were below NZ$1000, and development costs were around NZ$5000. The team ensured minimally invasive onsite integration and safe testing.

STAGE IV: Training

The production manager, plant operator and CEO were trained on the new system using the 'see one, do one, teach one' approach.

STAGE V: Operation and maintenance

The new system was integrated into daily production. Maintenance involves cleaning the camera lens and fan annually. Spare parts should be kept in stock due to the low-cost components' shorter lifespan.

Project benefits and impact on employees

The digital retrofitting provided four main benefits:

- improved efficiency
- better product quality
- less waste, and
- marketing advantages.

For Spiraweld, the primary benefit of this digital retrofit was the ability to weld pipes automatically, freeing the operator to perform other tasks and improving productivity. This boost in productivity is crucial for Spiraweld's long-term survival against international competition. Enhanced welding quality through closed-loop control reduced waste and improved the company's brand image, offering marketing benefits by assuring customers of consistent high-quality pipes.

Given that the system is constructed from low-cost components, it is unreasonable to expect the same lifespan in industrial use as one would from more expensive, industrial-grade components. Therefore, to avoid prolonged system failures, all components that cannot be procured quickly should be kept in stock as spare parts.

[31] Polzer, J., Xu, X., Selitskiy, K., Archibald, R., & Gill, A. (2023). A systematic method for retrofitting legacy machines using the "shoestring" philosophy. In Proceedings of the Low-Cost Digital Solutions for Industrial Automation (LoDiSA 2023) (pp. 82–89). https://doi.org/10.1049/icp.2023.1738

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