TRENDS AND SUCCESSFUL
TRANSFORMATION IN MANUFACTURING

# TOWARDS A SMARTER INDUSTRY

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KAIROS FUTURE

PLM

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# EXECUTIVE SUMMARY

This report explores how manufacturing companies can maintain competitiveness amid rising global uncertainty, rapid technological advancement, and increasing operational complexity. It is based on insights gathered from industry leaders and subject-matter experts.

Multiple forces are driving the need for change. Beyond geopolitical risk and security concerns, manufacturers face tightening regulations, accelerating digital transformation, market volatility, and restructuring across global value chains. These shifts include deeper vertical integration, stricter data requirements, and the growing adoption of modular and additive manufacturing.

Internally, executives most frequently cite siloed departments, weak cross-functional collaboration, and inefficient data management as critical barriers. Long time-to-volume, persistent skills shortages, and the rising demand for hybrid 'pi-shaped' roles - those combining technical, analytical, and strategic capabilities - add further pressure. Many organisations also struggle with fragmented digital systems, heavy reliance on manual processes, and a cultural reluctance to change.

The report identifies four pillars shared by companies that have successfully transformed their operations:

- Active leadership and visible role-modelling by management
- Team-of-teams structures that replace linear hierarchies
- Integrated, system-of-systems digital platforms
- A deliberate focus on developing cross-disciplinary skills and capabilities

The findings highlight that while Agile methods are gaining traction across the sector, Lean practices remain the dominant framework for day-to-day operations.

In conclusion, thriving in a volatile, digital, and sustainability-driven landscape requires manufacturers to combine visionary strategic thinking with robust data systems, cross-functional collaboration, and future-oriented talent development. Long-term success depends less on adopting radical new tools than on leadership, cultural transformation, and systemic integration across the value chain.

This report outlines seven priorities for leaders seeking to build a more efficient and forward-leaning organisation:

1. Put the future first.
2. Empower managers as transformation leaders.
3. Embrace next-level, data-driven operations.
4. Speed up development cycles.
5. Boost efficiency and modularity through structured data reuse.
6. Adopt fit-to-standard systems.
7. Develop and secure new competencies.

Together, these actions define a roadmap for manufacturers to evolve: resilient, connected, and ready for what's next.

# KEY FORCES SHAPING THE FUTURE

To remain competitive, leaders in manufacturing must address a wide range of external trends and internal challenges.

## GENERAL TRENDS

### UNCERTAIN GEOPOLITICS AND MACROECONOMICS

The decade to date has been defined by the COVID-19 pandemic, the war in Ukraine, and heightened geopolitical instability intensified, in part, by policy shifts in the United States during President Trump's second term. There is also continuing uncertainty over whether the US will seek to replace the rules-based international order with a system oriented toward bilateral agreements, potentially weakening the multilateral institutions that manage transnational issues such as trade, health, and development (e.g. the WTO, WHO, and UN agencies).

China's future trajectory is equally unclear. Over the past decade, the country has invested heavily in green technology and industrialisation, and its next five-year plan, set to begin in 2026, may further reshape global industry. The European Union, meanwhile, is pursuing ambitious sustainability goals and efforts to strengthen supply-chain resilience, even as internal divisions persist over priorities and funding.

Taken together, these dynamics suggest that the remainder of the 2020s will be characterised by sustained geopolitical uncertainty, influencing global markets, customers, and overall investment appetite.

## INCREASING ENVIRONMENTAL REGULATION: ON DIVERGING PATHS

The effects of climate change are becoming increasingly visible, from frequent flooding to more extreme weather events. Both the EU and China are investing heavily in countermeasures designed not only to reduce emissions but also to stimulate domestic industry and economic growth. In contrast, the United States appears to be moving in a different direction, with looser federal environmental requirements and reduced incentives for a fossil-free transition. Even within the US financial sector, long a strong promoter of ESG principles, momentum appears to be slowing.

As a result, many global manufacturers now find themselves navigating diverging sustainability regimes: tightening requirements in the EU versus loosening expectations in the US.

Within Europe, regulations are tightening sharply, both in legislation and in voluntary environmental classification systems for sectors such as construction and transport. Through 2030, key changes include stricter environmental reporting (under the CSRD) and the expansion and reform of emissions-trading systems (ETS). ETS 1 is scheduled for major revision from 2027, while ETS 2 - covering buildings and road transport - is due to launch in 2026. Recently, however, concerns about EU competitiveness have prompted some slowing in the pace of certain regulatory initiatives.

Overall, environmental pressure on manufacturers continues to mount. Robust, product- and service-level data on environmental performance and sustainability are fast becoming essential to compete and comply.

## RISING SECURITY AWARENESS AND ITS BROAD IMPACT

Security concerns have intensified markedly in recent years. There is a growing recognition that hostile actors seek to undermine trust in key Western institutions and disrupt the physical infrastructure on which societies depend. Beyond physical threats, organisations are also increasingly aware of the risks posed by cyberattacks and the vulnerabilities that come with deeper digital dependency.

Overall, security has moved decisively up the corporate and political agenda. The requirement for non-US NATO members to boost defence spending and rebuild stockpiles - of ammunitions and other critical materials - will generate wide-ranging ripple effects across the economy. This shift calls for a 360-degree security mindset and a structured approach to risk management: from cybersecurity and site protection to future-proof, resilient supply chains.

## NEXT-LEVEL DIGITAL OPPORTUNITIES ARE RESHAPING BUSINESS MODELS AND PACE

In recent years, digitalisation has often been equated with artificial intelligence (AI). Yet it extends far beyond AI, continuing to transform business and society in diverse and far-reaching ways.

AI, particularly large language models, is evolving at remarkable speed, serving not only as a tool for office workers but as the backbone of new operational systems. It powers everything from autonomous machinery to neural networks that optimise energy use across built environments.

By 2025, AI agents reached mainstream adoption. Widely accessible services such as Microsoft Copilot and Google Gemini, now embedded within productivity and search platforms, exemplify this shift. This marks the beginning of a journey that will redefine how information is managed, decisions are made, and value is created through 2030 and beyond.

Digitalisation is also amplifying progress across multiple sectors. The combination of AI and advanced robotics is driving a new wave of intelligent machines and applications, accelerating materials innovation, and redefining manufacturing processes.

In the years ahead, being data-driven will evolve from an ambition into a foundational capability for every business. Value chains will be reshaped, and the pace of change will continue to accelerate. Meeting this moment requires high-quality data, clear ownership, and a strong position at the centre of value creation.

It also demands a shift from isolated data silos to integrated, system-of-systems architectures. A crucial enabler of this transformation is an operating model built around a single source of truth - a unified data core that spans the entire production chain, end to end.

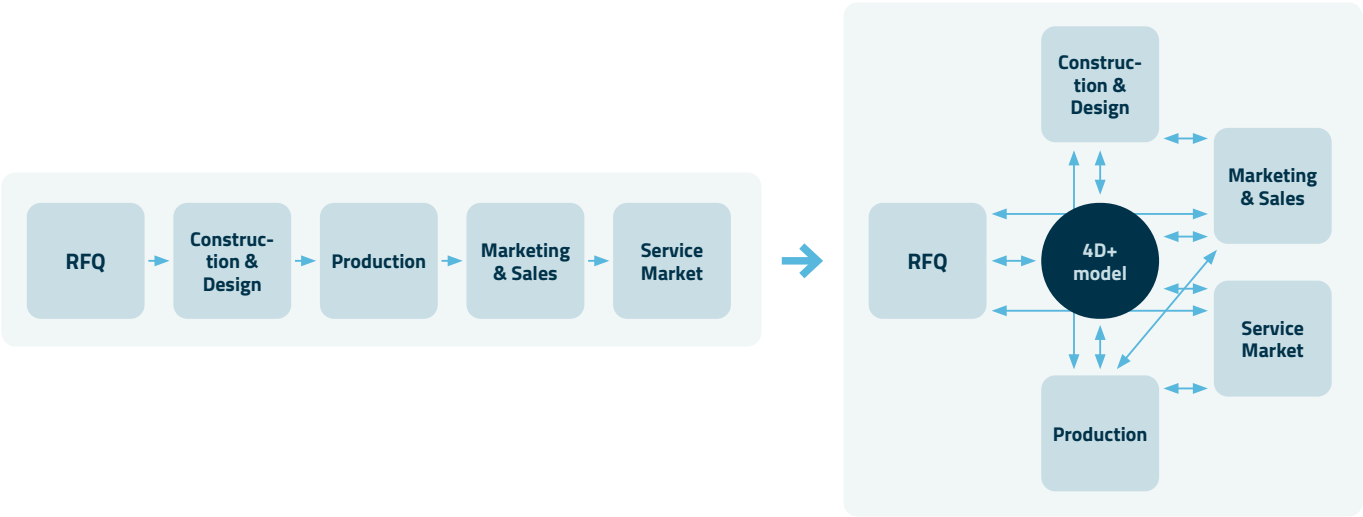



Figure 1. Manufacturing industries are going from Linear Value Chains to Connected Production Stars.

# MARKET AND INDUSTRY TRENDS

Beyond the broad societal and technological forces shaping manufacturing, a series of market- and industry-specific developments are set to impact business performance and accelerate the need for change.

## HESITANT END MARKETS

A combination of geopolitical uncertainty, the inflationary after-effects of COVID-19 government support programmes, and elevated energy prices has created a persistent, low-grade recession. This slowdown has significantly affected demand across many manufacturing end markets.

Evidence suggests this slowdown will continue for several years. Although long-term interest rates have eased since their peak in late 2023, most analysts expect them to stabilise around two percent, marking the likely end of the zero-interest-rate era. As a result, companies and consumers across much of the Western world are conserving cash, delaying major investments, and exercising caution. Even as conditions improve, it remains unclear how consumption patterns will evolve.

That said, the picture is mixed in the mid-2020s. Many segments - particularly those linked to the European automotive sector - remain under pressure. Others, such as defence, infrastructure, and energy suppliers, continue to experience robust growth and sustained demand.

## VERTICAL AND ECOSYSTEM INTEGRATION INTENSIFIES

Vertical integration within manufacturing has deepened steadily and is now extending across sub-segments and entire industrial ecosystems. Subcontractors face sustained price pressure from top-tier manufacturers, even as they are drawn into closer strategic partnerships centred

on product development, innovation, and production efficiency.

Expectations are rising. Suppliers are increasingly required not only to deliver resources, but also to align with the same operating philosophy as the primes. For example, Volvo and Scania expect their suppliers to apply Lean principles, often supported by publicly funded training programmes designed to build those capabilities.

A further dimension of this shift is the increasing importance of accurate, interoperable data. Products must now carry complete, traceable information from concept through production to the end customer. Leading manufacturers are raising the bar: all parties must either operate within the same digital systems or provide secure, well-functioning APIs that enable seamless data exchange and integration with the lead manufacturer's chosen platforms.

## FROM ENGINEER-TO-ORDER TO CONFIGURE-TO-ORDER

Manufacturers are steadily moving towards a module-based approach supported by integrated, end-to-end digital systems, commonly referred to as Configure-To-Order (CTO). Standardised platforms and modularity enable shorter lead times, both internally and to market, while improving economies of scale and overall flexibility.

That said, many sectors remain mixed-mode, combining Engineer-To-Order solutions with Configure- and Assemble-To-Order approaches. As a result, digital systems must be capable of managing 150% or '150%-plus configurable' structures with built-in rules and effectivity, rather than assuming a complete shift to CTO. In practice, this means extending product and manufacturing structures with options and constraints that guide configuration, reserving custom engineering for truly unique requirements, and reusing components wherever possible.

Successful execution requires controlled local adaptation. Production sites differ in machinery, tools, processes, and suppliers, which demands some variation in manufacturing definitions and routings - even for identical products. A major transformation now under way is the move from Engineering Bills of Materials (EBOMs) to plant-specific Manufacturing Bills of Materials (MBOMs) and routings. Historically, translating EBOMs into operations has been largely manual - time-consuming and error-prone. Today, these translations are increasingly semi-automated, saving time, reducing errors, and improving consistency across sites.

## ADDITIVE AND MODULE-BASED MANUFACTURING ARE GROWING RAPIDLY

Customer demand for tailor-made, individually configured products is increasing sharply, driving the need for small-batch, short-run production. Two complementary approaches are leading the way: additive manufacturing (often through 3D printing) and module-based production built on standardised platforms and interchangeable components.

Additive manufacturing remains the exception rather than the rule, best suited to complex, low-volume parts and rapid prototyping. By contrast, module-based production is on the verge of becoming the dominant organising model in many manufacturing segments, enabling mix-and-match configurations, faster lead times, and greater flexibility at scale.

# INTERNAL CHALLENGES DRIVING CHANGE

While external forces are reshaping manufacturing, many of the most powerful drivers of change are internal. Interviews with managers across the industry reveal a consistent set of frustrations that hinder performance - from gaps between departments and siloed ways of working, to the absence of smooth, end-to-end data handling throughout the product lifecycle.

Leaders also highlighted a series of additional internal challenges now shaping their ongoing transformation programmes.

## FOCUS ON EFFICIENCY RATHER THAN RADICAL INNOVATION

While some surveyed companies recognise the need for radical transformation in the coming years, most report that their current priority is efficiency and navigating ongoing market uncertainty. There is an urgent push for greater return on investment, making efficiency the default response to short-term pressure.

These ambitions are being pursued in several ways. Most companies are running cost-reduction programmes focused on lowering purchase costs, reducing reliance on consultants, and creating leaner organisational structures. Others are tackling the root causes of inefficiency, addressing the most critical, complex, and costly internal bottlenecks rather than working around them.

A recurring theme across organisations, large and small alike, is the persistence of an 'us versus them' mindset between departments. 'They don't understand our role', continues to undermine cross-functional collaboration and execution.

***"The biggest challenge is getting the group's different units to function as one, rather than as separate companies. There is also a need to regain momentum in product development and improve cost efficiency and digitalisation. The industry has lagged behind in innovation, but the pressure to offer digital services and connected machines is now increasing."***

CEO, FORESTRY EQUIPMENT MANUFACTURER

## A VAST NEED FOR BETTER DATA HANDLING – AND REUSE OF CONCEPTS AND DATA

A common and critical issue in manufacturing is the time and effort lost due to limited product traceability, poor data transparency, and the need for repeated backtracking - particularly when moving from the pre-production phase into full-scale production. These gaps create major inefficiencies across the internal value chain. For example, deviations and special variants are often difficult to handle, frequently requiring manual intervention to bridge gaps between systems.

Many managers and specialists express growing frustration at the lack of transparency behind key decisions, such as why certain orders are placed, which makes troubleshooting and customer communication unnecessarily difficult. They want systems that allow them to trace the rationale behind actions and track issues back up the chain when customer complaints arise.

Clearer visualisation and stronger coherence between decisions, needs, and delivery are also urgently required. For most manufacturers, this is now a top-priority challenge: they need integrated systems that can collect, explain, and present data from the design phase onward - covering elements such as component selection, service life, and pricing.

There are also major challenges around handling deviations, special variants, and manual handoffs between systems and people – issues widely recognised as costly and inefficient. As a result, there is strong demand for true data-reuse capabilities, allowing prior concepts and engineering data to be leveraged more effectively, along with next-level traceability across the value chain.

One promising way forward is to enable data reuse through configurable Bill of Materials (BOMs) with defined rules and effectivity, supported by governed libraries, disciplined sourcing practices, and variant-driven change objects.

***"The lack of seamless data structures often causes delays of six to twelve months, and budget deviations of 30–50% are common."***

CEO, HIGH-END SUBCONTRACTOR SPECIALIST

## PREDICTIVE MAINTENANCE HAS BECOME REALITY

Once considered a hallmark of the 'factory of the future', predictive maintenance has now become an operational reality. Many manufacturers already apply it as a core internal capability, and a growing number also offer it to customers - either bundled within full-service agreements or as standalone offerings.

Delivering predictive maintenance at scale requires a strong focus on the as-maintained configuration, supported by serialised traceability and structured service feedback loops that channel insights back to engineering through formal change requests.

Predictive maintenance success depends on high-quality data and reliable data flows. Some organisations link field data directly to the as-maintained digital twin, feeding issues into closed-loop quality and engineering change workflows within their Product Lifecycle Management (PLM) systems. Others attempt to embed these structures within Enterprise Resource Planning (ERP) systems - an approach that often results in higher total cost of ownership (TCO).

## TIME-TO-VOLUME AS IMPORTANT AS TIME-TO-MARKET

The race to shorten time-to-market has been under way for years, and most manufacturers are running continuous improvement programmes to address it. Increasingly, however, the ability to reduce Time-To-Volume - the speed at which production scales after launch - is proving equally critical.

Many industries encounter bottlenecks when ramping up quickly, particularly during the transition from pre-production to full production. In many cases, these stages still rely heavily on manual work, even where digital tools exist for both design and manufacturing. Because these systems often fail to communicate effectively, the manual workload remains unnecessarily high.

Scaling becomes even more complex for manufacturers operating multiple plants across different countries. Facilities are often equipped differently, meaning that manufacturing processes and underlying data structures (such as MBOMs and routings) must be adapted for each site without compromising product quality or functionality. As a result, there is a growing need for flexible PLM and ERP systems that can efficiently support production ramp-up across diverse environments.

## BRIDGING GAPS BETWEEN DEPARTMENTS

For many years, manufacturers operated within linear organisational structures that encouraged siloed behaviour, with each function optimising for its own performance. Today, there is broad recognition that true cross-functional understanding is essential across the entire value chain, from engineering and design to production, sales, and aftermarket.

Engineers need a clear understanding of how products are built and used, while production teams require insight into the underlying design intent. Closing these gaps - and integrating design, simulation, and production - is now regarded as both necessary and high priority, particularly in complex, high-specialisation industries where precision is critical.

***"Cumbersome processes and duplication of work are constant challenges. Requirements for extensive documentation in the business system (SAP) make the process slow. Employees have to create page lists in Excel to get an overview, which leads to duplication of work."***

SERVICE MANAGER

## INTENSIFIED PUSH FOR SEAMLESS DATA – BRIDGING DIGITAL GAPS

The previous challenge underscores the critical need for seamless data flows, supported by an overarching system-of-systems architecture. Companies typically adopt one of two approaches. Some position the ERP system as the system of record and process orchestrator, while others place PLM at the centre as the product-data backbone that feeds downstream functions.

Another recurring issue is that many of these processes still rely heavily on people. Employees need accurate, timely data to perform effectively, and the absence of it remains one of the most common and frustrating bottlenecks across manufacturing organisations.

***"Already from the design phase, there's a great need for systems that collect, explain, and present data - such as component selection, service life, and price."***

PRODUCTION MANAGER

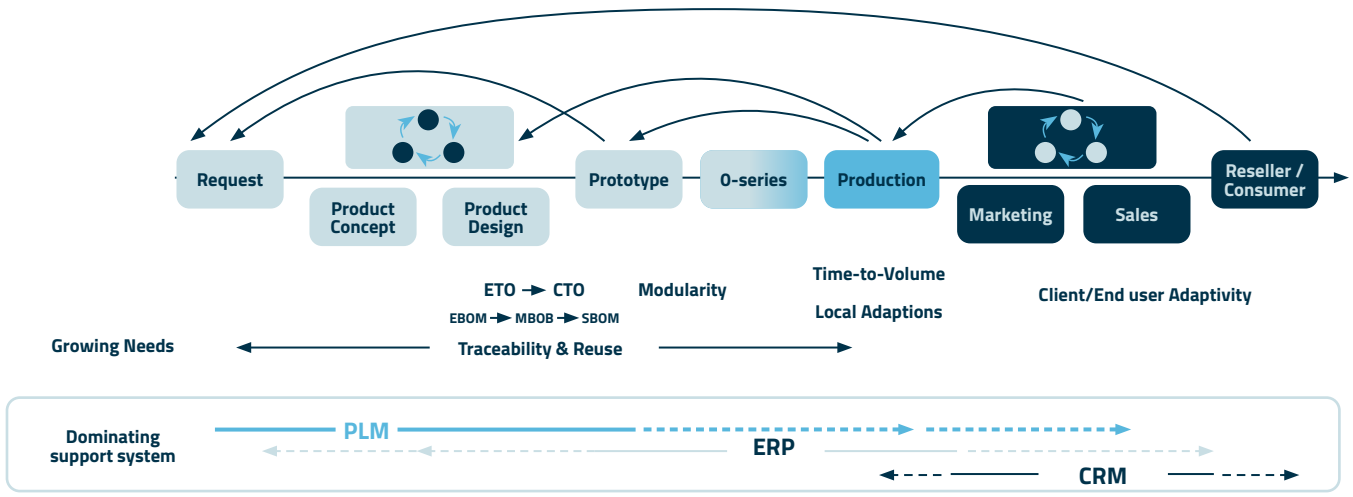
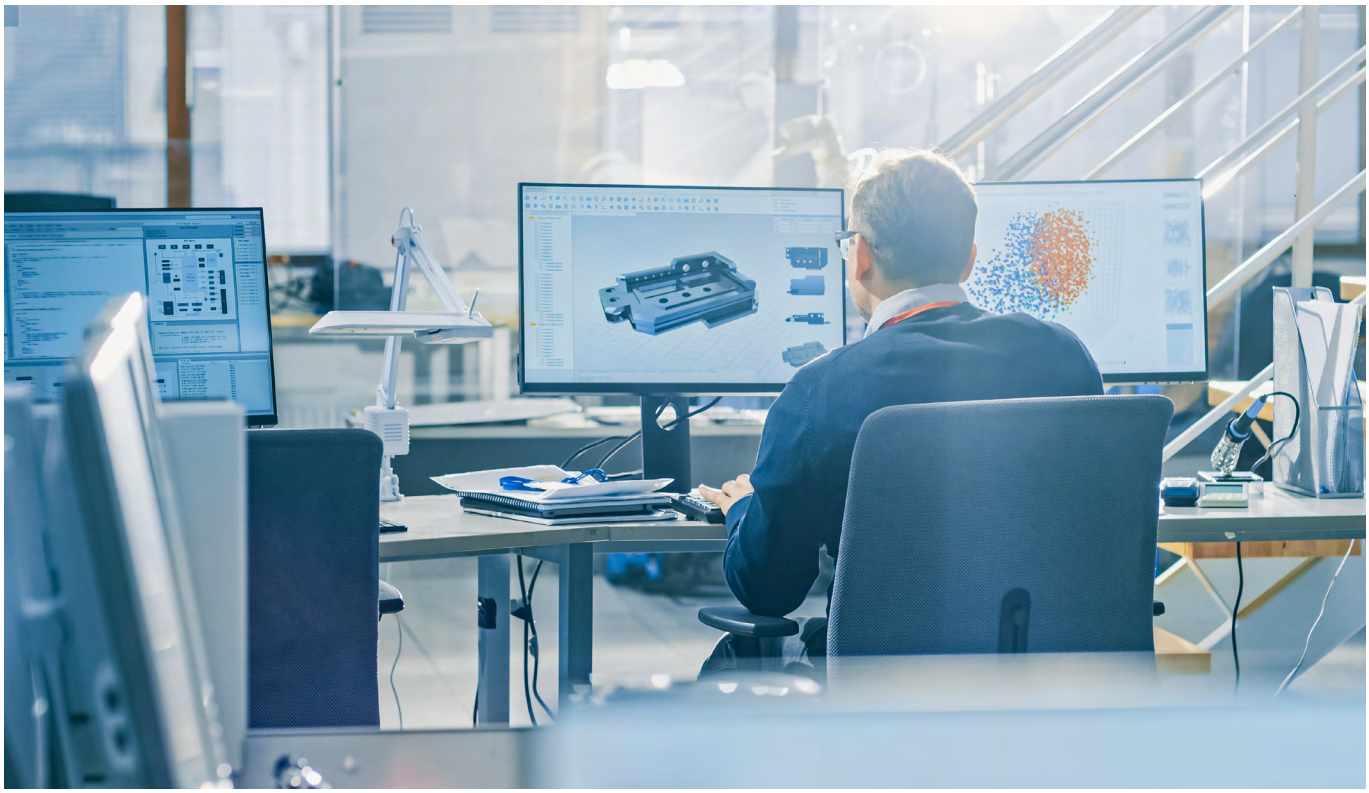



Figure 2. The growing tension between different digital systems in the manufacturing value chain



## HYBRIDISATION: COMPETENCE CHALLENGES – FROM T TO π

Manufacturing faces an increasing shortage of specialised skills. It is becoming harder than ever to recruit CNC operators, production technicians, and service technicians - and in many cases, job postings attract few or no qualified applicants.

At the same time, role requirements are expanding. A growing proportion of positions are now hybrid roles rather than single-specialty jobs. In the past, it was often enough to be T-shaped - deep in one discipline with a degree of breadth across others. Today, however, many roles must be π-shaped ('pi-shaped'): combining depth in two or more domains with strong generalist capability and flexibility.

Examples include pairing production expertise with environmental insight, or combining advanced design capability with a practical understanding of manufacturing constraints along the production chain.

## AI WON'T SOLVE EVERYTHING

Some leaders place high hopes on AI to help close talent gaps, but few believe it will fully replace people or make manufacturing human-free. Interviewees cited examples, such as Chinese battery plants, where workforce levels are far lower than in comparable Western European facilities. Even so, the prevailing view among managers is that AI will serve primarily as an assistant or co-pilot: boosting productivity and helping teams work smarter, not replacing them.

Realising this value depends on high-quality data and reliable access to it - something many organisations have yet to achieve. While AI-assisted systems that propose layouts, materials, and parts orders are emerging, most leaders see fully autonomous decision-making for complex products as unrealistic in the near term.

***"It is more important to support people with decision-making information, not replace them."***

PRODUCTION MANAGER

## FRUSTRATION – AND RELUCTANCE TO CHANGE – DRIVE CHANGE

As the saying goes, 'the only constant is change'. In a world shaped by geopolitical and economic uncertainty, environmental pressures, and rapid digital advancement, that statement feels truer than ever.

Yet even as the world changes, most people remain reluctant to change, especially in turbulent times. When conditions are uncertain, many retreat into smaller, more manageable spaces. Curiosity and the willingness to adopt new ways of working often diminish unless people can see clear, personal benefits.

One recurring driver of change, cited frequently in our interviews with managers, is accumulated frustration among employees. Fed up with inefficient organisations, opaque systems, and resistant cultures, individuals often take it upon themselves to launch initiatives with energy and resolve. The lesson: never underestimate the power of frustration.

But successful change is rarely spontaneous, it is a journey. The term 'change journey' has become common in management discussions during the 2020s, reflecting the reality that only a minority enjoy change for its own sake. Effective programmes frame change as a series of small, manageable steps towards shared interim milestones and a compelling overall vision – making a point of celebrating early wins along the way.

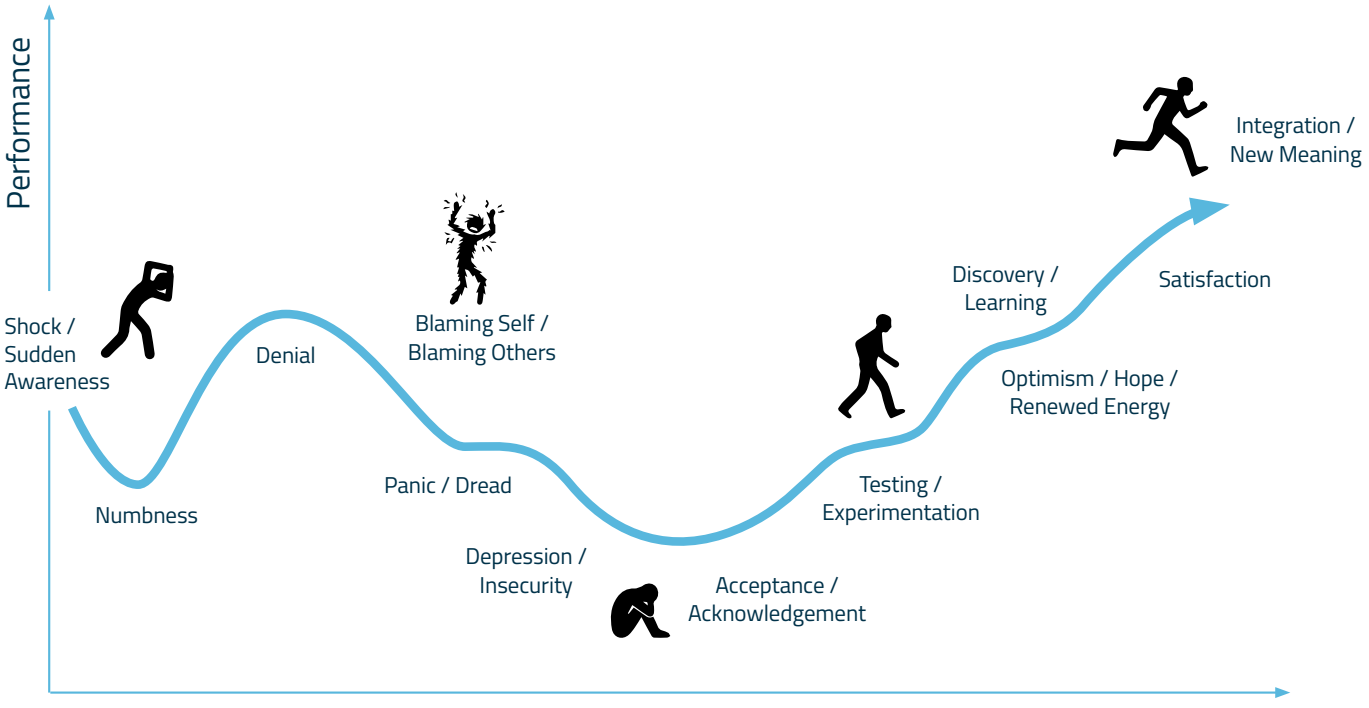



Figure 3. An illustration of the bumpy road through transitional change

# HOW SUCCESSFUL COMPANIES TRANSFORM

While every organisation finds its own path to meet rising demands and accelerate change, the research and interviews behind this report reveal a set of recurring patterns shared by companies that achieve successful transformation and improvement.

## GENERAL FINDINGS FOR SUCCESSFUL MANAGEMENT IN TURBULENT AND UNCERTAIN ENVIRONMENTS

Decades of management research highlight four broad schools of thought that, to varying degrees, influence organisational performance - particularly when past playbooks no longer provide clear answers. In practice, all four matter; it's the balance between them is often a fundamental success factor.

### 1. FORWARD-LEANING EXECUTIVE LEADERSHIP

An organisation's performance is strongly shaped by the focus and actions of its top management: how the leadership team is composed, the perspectives it brings, what it prioritises, and how it behaves day to day.

### 2. STABLE YET FLEXIBLE ORGANISATION

Differences in outcomes are also influenced by how resources and operations are structured. The ability to reallocate resources at the right time is a crucial driver of improved performance and resilience.

### 3. ROBUST PROCESSES, CULTURE, AND SUPPORT STRUCTURES

Internal processes, reinforced by enabling systems and a supportive culture, are frequently identified as key enablers of execution. Process discipline is closely linked to effective leadership and strong digital support.

### 4. FUTURE-PROOF STRATEGY

Strategy sets direction and defines choice. Without a sound strategic foundation, even the best structures and processes cannot compensate, hence the emphasis many researchers place on clear, coherent strategic intent.

Across the studies and interviews conducted for this report, these four factors consistently appeared in manufacturers that have made tangible progress in recent years.

## LEAN RULES, BUT AGILITY IS ON THE RISE

Performance improvement and transformation in manufacturing are still, in most cases, driven by versions of Lean philosophy. Lean is a way of thinking, rather than a rigid set of instructions, that is commonly framed around five guiding principles (see adjacent figure). Developed at Toyota's production sites, Lean is built on the concept of continuous improvement.

Today, companies such as Scania are often described as 'more Lean than Toyota itself'. Lean thinking now permeates much of the organisation - extending beyond the factory floor into sales, support functions, and supplier networks.

At the same time, a growing tension with R&D is evident, as many development teams advocate for more Agile ways of working to keep pace with the rapidly changing landscape. That friction is real, and its long-term outcome remains to be seen.

Most companies now operate with tailored models grounded in Lean principles - though rarely with the same ambition as Scania and other industry leaders. Over time, agility is likely

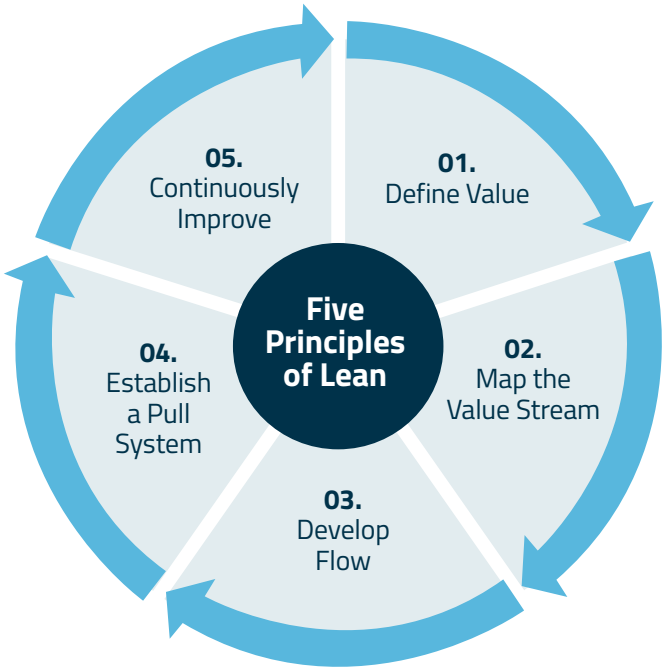



Figure 4: Overview of the Lean chain

to become more widespread, partly because many supporting digital platforms are developed by teams that already work in Agile ways, rather than through classical Lean flows.

Another reason is that it can be difficult to achieve major leaps forward with Lean alone. In such cases, Agile approaches have proven more effective in driving rapid innovation and organisational learning.

## THE IMPORTANCE OF NAMING AND FRAMING

Many interviewees said they operate with a Lean mindset, but give their programmes home-grown, forward-leaning names, often including new titles for key roles. For example, some firms have retitled local plant managers as 'change leaders', expanding the remit to emphasise leadership in transformation and alignment with strategic objectives.

This highlights the importance of not just naming, but also framing: designing the organisation, roles, and structures in ways that keep transformation on course, while ensuring the digital backbone actively supports overarching goals and the broader change journey.

## MANAGEMENT IS FUNDAMENTAL – LEAD BY EXAMPLE

All interviewees emphasised the importance of engaged, change-ready leadership with visible top-management involvement. For example, it is nearly impossible to work according to Lean principles if senior leaders are not willing to change their own behaviours and leadership practices.

***"The key to a harmonised change journey is leadership, change management, and a conscious organisation."***

CEO, MID-SIZED LEGO MANUFACTURER

This is a crucial success factor for organizational improvement. It's less about handing out guiding principles and more about living them. Successful change journeys hinge on culture-led leadership, sustained effort, and enabling processes.

This remains a critical success factor for organisational improvement. It is less about issuing guiding principles and more about living them. Successful change journeys depend on culture-led leadership, sustained effort, and enabling processes that reinforce the desired behaviours.

## TEAM OF TEAMS RATHER THAN LINEAR ORGANISATIONS

Several interviewed managers emphasised the importance of team-based execution. The shift is from isolated, siloed units to interconnected teams that collaborate, not only within their own business areas, but also upstream and downstream across the manufacturing flow.

A team-of-teams model requires carefully designed structures and support systems: robust digital tools and data flows, aligned incentives, and a culture that promotes collaboration. If you want teams to share knowledge and resources, it must be both worthwhile and recognised.

## THE ABILITY TO BECOME DATA-DRIVEN, WITH SUPPORTIVE DATA HANDLING, IS FUNDAMENTAL

Many organisations remain frustrated by the lack of well-functioning, interoperable digital systems. In response, several large corporations have invested in overarching system-of-systems architectures.
In many cases, these approaches place the ERP system at the centre of the end-to-end process, from idea to satisfied customer. However, others have found this model costly and complex, largely due to the extensive consulting effort required to adapt platforms such as SAP or Oracle to every process variant. This has deterred some companies that have yet to take the next step towards bridging the gaps among their existing systems.

***"We need more integration, transparency, and modularity rather than radically new systems."***

SYSTEM SPECIALIST, SUBCONTRACTING MANUFACTURER

A common view is that success stems from systems that enforce the right ways of working, rather than relying solely on individual discipline. Organisations that over-customise their systems to suit personal or local preferences often end up with platforms that are costly to build and cumbersome to maintain and update.

## THE LACK OF THE RIGHT COMPETENCIES

Most manufacturers report significant talent gaps, not just labour shortages, but a shortage of people who understand the end-to-end value chain. A common challenge is that many designers have limited exposure to production. The not-invented-here (NIH) syndrome is also widespread: teams often prefer to build solutions internally and stick with familiar in-house designs rather than adopt proven ideas from elsewhere, which can inhibit innovation.

Part of this issue is generational. Younger engineers sometimes have a weaker understanding of production and the aftermarket, leading to designs that are difficult to build, assemble, or service.
In contrast, more experienced designers - those who have worked closely with production - tend to bring a broader, more practical mindset.

The reverse also occurs. Production and service employees may lack sufficient understanding of design fundamentals when assembling products or performing aftermarket service. This stems partly from limited training, but also from weak feedback loops between service, production, and design - such as when improvement cards are logged in one system, but the feedback process is inconsistent or poorly governed.

Several interviewed managers identified an urgent need to develop new roles and hybrid competencies, such as Additive Manufacturing (AM) Engineers - individuals who design, optimise, and prepare parts for production, particularly in 3D printing. Overall, tighter integration between design, simulation and analysis, and production is viewed as essential to future success.

# INDUSTRY LEADER INSIGHTS & CASE EXAMPLES

## REFLECTIONS FROM AN EXPERIENCED CEO

TORD BERGGREN, CEO, SANMINA

**SANMINA**

**You've been at Sanmina for over 30 years, 20 of them as CEO. What's your general view of the internal challenges that need to be addressed and solved?**

Design and production still operate like two separate islands. The biggest issue is that designers lack knowledge of production - though in some cases, it's the reverse. The gap is widening as experienced staff retire, so the need for better collaboration is vast.

At Sanmina, the gap is especially hard to bridge because our customers own design while we handle preparation and production. Communication is often very basic. Even in the most advanced organisations, emails and Excel files remain the norm. There's no strong visual tool to document problems and feedback.

**Where do today's tools fall short?**

Design tools are lagging. Many are outdated and not adapted to current needs, which makes handovers to production unstable. Designers often lack information on lead times, component prices, and suppliers - inputs production depends on. The result is that budgets are exceeded and timelines can slip by up to a year.

Another problem is that current production systems struggle with multiple versions and change management. We need better support for implementing changes, running parallel versions, and structuring feedback among suppliers, designers, and production.

**AI and digitalisation are hot topics. Are they realistic solutions?**

Over time, yes. AI can automate tedious work, like drawings and tolerance adjustments, o designers receive ready-made documentation. But I don't think AI will replace human creativity in core design. Where I see real potential is in reducing lead times through faster prototyping, for example via 3D printing.

**If you could dream a bit, what should future systems deliver?**

Two things: rapid prototypes that let us verify core functions early, before we invest heavily in details; and standardised feedback channels from suppliers and production, so their experience informs design from the start.

**Culturally, how do we narrow the design–production gap?**

Through respect and openness. Designers need to appreciate production's practical knowledge, and vice versa. Too much information is lost in endless email threads. We need a culture that values knowledge and structures communication effectively.

**Finally, how do you view the new generation of engineers?**

They're open to new technology and eager to learn, but they lack experience. They also value work–life balance more than previous generations, they won't work themselves into the ground. That can be a strength, but it's also a challenge for the industry.

# FAST UPSCALING WITHOUT LOSING TRACK – OR EFFICIENCY

THE CASE OF NKT

NKT

## ONGOING CHANGE JOURNEY

Karlskrona-based NKT produces power cables for both short- and long-distance transmission. The company is in a strong expansion phase, planning to grow from roughly 1,800 to 2,300 employees by 2027. The main challenge is integrating a large number of new employees and roles while preserving culture and quality. Leaders describe it as 'building the aircraft while it flies'. New machines, products, and people are being introduced in parallel, placing high demands on flexibility, leadership, and cultural stewardship. The ongoing change journey comprises several programmes.

## IMPROVEMENT PROGRAMMES AND SYSTEM HARMONISATION

A major initiative is Renew Boost, a three-year programme launched in 2023 to scale the business and manage growth. The programme covers capacity expansion, skills development, and flow improvements, while acknowledging the quality risks that can arise when many changes occur simultaneously.

In parallel, NKT is upgrading and harmonising its enterprise platform across business units and sites. The goal is to create a common foundation, including standardised information models and production-planning processes that strengthen integration and efficiency.

## EFFECTIVE SYSTEM SUPPORT AND DESIGN–PRODUCTION INTEGRATION

Collaboration between engineering and production is critical. Engineering develops product concepts and production descriptions, while production makes final adjustments. Rather than relying on digital work instructions, detailed text-and-number documents still guide execution. Collaborative practices such as pre-production walks bring technicians, engineers, and operators together to identify risks and opportunities across quality, safety, and the work environment.

On the systems side, NKT recently achieved PLM–SAP ERP integration, enabling end-to-end traceability of product data throughout the lifecycle - including test and qualification data - and establishing a shared, reliable data backbone for collaboration and quality assurance.

## DIGITALISATION AND DATA-DRIVEN DEVELOPMENT

Historically, NKT has relied heavily on simulations of cables and installations, including 3D simulations to model seabed behaviour. The company is now advancing towards data-driven production and flow optimisation: analysing production and product data to improve quality, planning, and maintenance.

Management notes that substantial existing data has been underused, and a comprehensive review is underway to unlock its potential. In parallel, NKT is adding sensors to enable predictive maintenance and early process adjustments through neural networks and AI.

## FUTURE TECHNOLOGY AND AI

Looking ahead, NKT expects AI to support production-flow optimisation, quality monitoring, and safety. Automation and robotics, including bipedal (two-legged) robots for material handling and maintenance, are expected to become common within the next

10–20 years, alongside drones for site security.

At the same time, leaders stress the need for rigorous verification and quality assurance of AI outputs. Many initiatives begin locally to address specific needs, creating a risk of uncritical adoption. Building trust through continuous validation is essential.

Because product-development cycles can span 10–15 years from concept to market, innovation at NKT requires patience and a long-term lens.

## SUCCESS FACTORS AND CULTURE

Management emphasises that success depends on standardised data, robust version control, and a single source of truth to align decisions across a complex and growing organisation. Culture is equally critical, especially during rapid expansion. Actively shaping culture and safeguarding core values are essential priorities.

Finally, NKT aspires to be a learning organisation, continuously developing its people and processes to meet new demands and emerging opportunities.

# MANAGING THE BIG LEAP TOWARDS FOSSIL-FREE PRODUCTION

THE CASE OF SKF

SKF

A large share of manufacturing is grappling with the transition to fossil-free production, a challenge that is far more than technical. SKF is pursuing an ambitious decarbonisation strategy to reach net zero by 2030. This is a survival strategy: high-growth customers increasingly demand fossil-free roller bearings and services, and SKF must protect its leadership in an intensifying competitive landscape.

Beyond significant investments in energy efficiency, replacing fossil gas with renewable energy, and banning new fossil-fuel investments in its operations, SKF is engaged in research collaborations to develop fossil-free bearing steel. In parallel, the company has launched two major transformation programmes designed to make SKF both fossil-free and more competitive. These programmes aim to shift SKF from a volume-driven to a profitability-driven approach, prioritise breakthrough innovations over incremental improvements, and foster accountability and experimentation to accelerate decision-making. They also integrate sustainability and purpose across the entire value chain, while enabling more flexible resourcing, principally to free up time and capacity for the transformation ahead.

## EXAMPLES OF KEY SUCCESS FACTORS

**▪ SKF Ventures**

SKF has created an internal, independent venture structure - SKF Ventures, based in Dublin - to accelerate innovation and change. Its mandate is to catalyse radical innovation that supports the journey to net zero by 2030.

**▪ World-class manufacturing**

SKF's transformation is both AI- and digitally driven. Built on digital threads and digital twins, the strategy focuses on boosting efficiency, enhancing the product offering, and maintaining world-class performance. Having started its digital journey early, SKF remains well ahead of many peers.

Factory digitalisation focuses on streamlining production and making operations data-driven:

- The digital thread serves as a communication framework that moves the right data to the right place at the right time throughout the product lifecycle.
- SKF employs a hybrid-cloud approach, applying cloud principles locally in plants, while using public-cloud services for scalability and speed.
- Digital twins, high-fidelity virtual replicas of machines or entire plants, are used to simulate operations, visualise logistics, and automate planning.
- The overarching goal is to simplify processes and increase flexibility, for example by adapting production more quickly based on customer data.

A current challenge lies in comprehensive data capture: SKF requires sensors not only in plants (including those of subcontractors and partners) but across the entire product lifecycle. Many sensors must function where power is unavailable. To address this, SKF has established a dedicated internal start-up, supported by its venture arm.

**▪ Individual strategy acceleration plans**

Leadership at all levels has proven pivotal. To accelerate change, each leader embarks on a personal learning journey and develops an individual strategy acceleration plan, covering both personal leadership growth and business-area transformation. This creates tailored development paths aligned with each unit's market realities. Factory leaders have been retitled as 'change leaders' to underscore their transformative remit. Incentives and metrics have also been realigned to support leaders in driving the overall transformation.

# SEVEN WAYS TO RADICAL IMPROVEMENT

Manufacturing transformation is accelerating, offering lessons from both success and setback. Building on these insights, this report outlines seven ways to achieve radical improvement - actions that strengthen competitiveness, sharpen performance, and prepare organisations for the future.

## 1 SET THE FUTURE FIRST: START WITH A CLEAR AND SHARED VISION

Every performance improvement requires change, sometimes in small steps, sometimes in big leaps. Change may involve new behaviours and cultural shifts, new ways of working supported by new systems, or even entirely new business models, whether driven by external pressure or internal ambition.

The starting point is always a clear, compelling goal. This might take the form of a bold, aspirational vision or a practical roadmap of step-by-step wins. Even a simple tagline can help unify teams, though slogans alone can feel too abstract for some employees. A phrase such as 'more with less' often works well as a low-key rallying cry and guiding star for continuous improvement.

Whatever form it takes, put the future first and keep the organisation focused on the overall goal. Frame the transition as a journey - more a marathon than a sprint.

## 2 EMPOWER MANAGEMENT AS TRANSFORMATION LEADERS

Leading a change journey means setting clear, achievable milestones with a visionary end state on the horizon and, crucially, leading by example. If leaders expect employees to change, they must first demonstrate a willingness to change themselves. This is a core tenet of Lean philosophy.

A practical way to reinforce this mindset is by renaming roles to reset expectations. For example, re-titling a 'compliance officer' as a 'change manager' can help shift focus and behaviour. Of course, titles alone are not enough, real transformation requires genuine commitment, visible actions, and sustained follow-through from those leading the journey.

# 3 EMBRACE NEXT-LEVEL, DATA-DRIVEN ORGANISATION: FROM 3D TO 4D+ / DIGITAL THREADS

There is no doubt that the future of manufacturing is data-driven. AI and robotics will increasingly augment decision-making, but people remain essential. Keep human judgement and processes at the core, while giving teams the platforms and capabilities that next-level, data-driven manufacturing enables.

Modern digital architectures take decision-making and workflows to a new level of synchronisation and insight. Instead of linear, serial handovers, digital threads allow traditional queues to be short-circuited, enabling employees across the value chain to work in real time rather than being confined to disconnected, asynchronous workflows.

Emerging models now go beyond 3D to 4D+ effectively linking geometry with time, configuration, versions, and process context across the product lifecycle.

For example, production engineers and after-sales teams can now collaborate with design and engineering in real time - even through augmented reality (AR) and virtual reality (VR) - with full access to the background data and design rationale behind each assembly. They can also retrieve comprehensive materials information for every product, including quality, chemical and physical attributes, and environmental impact.

# 4 SPEED UP DEVELOPMENT CYCLES AND OVERLAP PROCESSES WITH INTEGRATED SYSTEMS AND ROLES

There is much to gain from placing a module-based, system-of-systems architecture at the centre of operations. This approach accelerates development, reduces waste through greater visibility for production teams, and gives design engineers a clearer understanding of manufacturing constraints.

Robust systems make it possible to perform digital trial runs before release - through readiness checks and virtual builds - and to maintain a clear view of the entire process: what materials are required, how much, and in what sequence assemblies occur. This helps teams make better, faster decisions.

This approach also enables shared, cross-functional processes. In addition to manual preproduction walks - or sometimes instead of - companies can conduct digital preproduction walk-downs. For example, PLM-based readiness reviews or virtual builds can confirm manufacturing definitions, routings, assembly sequences, and worker-safety considerations by simulating the build-up before release.

Manual, on-site checks should be retained where they add genuine value, but PLM should serve as the primary backbone for integration and collaboration.

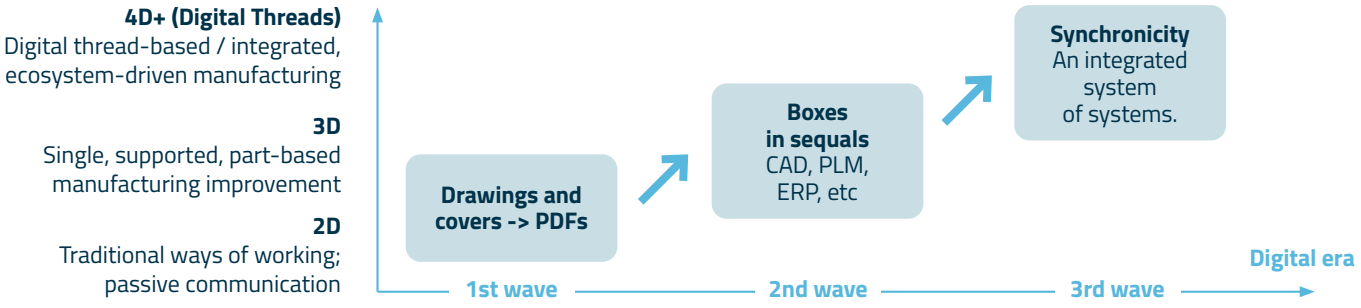



Figure 5: Towards the next level of digital supported work flows

# 5 ENHANCE EFFICIENCY AND FLEXIBILITY WITH UNIFIED DATA AND STRUCTURED DATA REUSE

Advanced approaches to data handling and reuse are rapidly gaining traction, with more companies recognising their importance for boosting efficiency and flexibility. The biggest gains come from unified, governed data, robust version control, and a shared commitment to a Single Source of Truth (SSoT).

Within one central system, teams should be able to manage:

- **Revisions** (design maturity)
- **Versions** (file iterations)
- **Baselines** (release snapshots)
- **Effectivity** (unit, date, and options)

The goal is to reduce time spent searching for the right data and to unlock systematic reuse. A genuine SSoT across the manufacturing process is particularly vital for product data, improving quality, accessibility, and traceability.

A proven approach is to place a modern PLM system at the hub, where product data is defined, structured, and maintained. Consolidate all BOMs (design/EBOM, manufacturing/MBOM, and service/SBOM) so that downstream systems - such as ERP - can extract the data they need for execution, planning, and costing.

While different systems may remain the system of record within their respective domains, the key is to establish a secure, accessible, and authoritative backbone for product lifecycle management.

# 6 FIT-TO-STANDARD RATHER THAN STANDARD-TO-FIT

When selecting digital support systems, there are two main paths. Organisations can either custom-build solutions to match every local nuance - from idea to aftermarket - or adopt standard systems and processes, training people to work effectively within them.

Both approaches have pros and cons. A fully tailor-made system may sound ideal, but it often brings high consulting costs - particularly with ERP - and can become far more expensive than anticipated. Teams unable to afford deep customisation frequently develop manual workarounds, and managers report that production tolerances and quality controls are sometimes compromised when process gaps are patched manually.

The recommendation is to favour fit-to-standard. Adopt standard PLM best practices for change, configuration, and variant management. Extend functionality through configuration and APIs, not through core code changes.

Design the organisation and culture around the principle of 'configure, don't customise', keeping any necessary extensions at the open integration/API layer. This approach reduces total cost of ownership, simplifies upgrades, and improves reliability across sites.

***"The introduction of standardised systems such as Monitor (ERP) and Salesforce (CRM) has triggered a significant change journey, requiring the organisation to work in a more uniform and transparent way. While some employees find these systems restrictive, they are expected, in the long term, to deliver clear benefits in efficiency and coordination. The focus has been on refining and standardising the supporting systems, reducing reliance on Excel, and adapting ways of working to the standard system functions rather than costly bespoke adjustments."***

CTO, INDUSTRY EQUIPMENT MANUFACTURER

## 7 DEVELOP AND SECURE NEW COMPETENCIES

Last but not least: a future-oriented manufacturer must take the lead in developing new competencies, emerging roles, and fresh insights. A number of roles will become increasingly critical, including hybrid engineers, additive manufacturing (AM) engineers, 'smooth operators' (operators who orchestrate across systems and processes), and forward-thinking leaders.

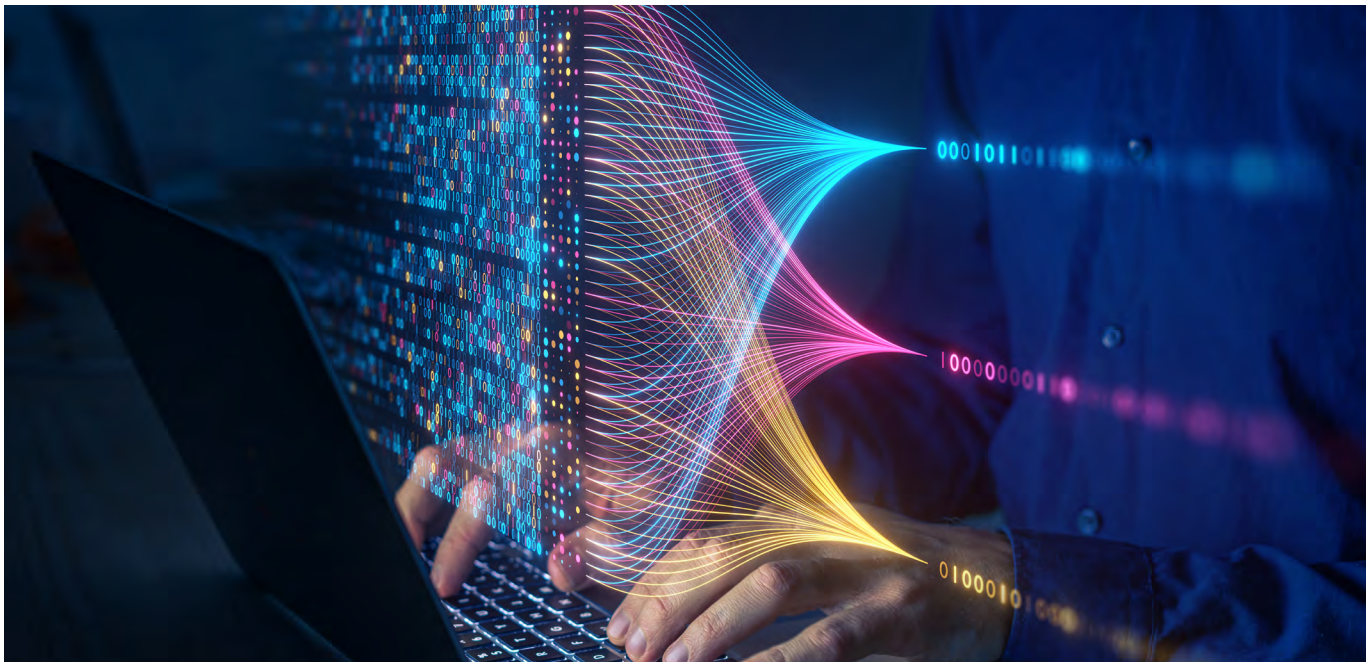
Many of these roles are not yet standardised within higher education or engineering curricula, though specialised programmes are beginning to emerge. This means industries and companies must take the initiative to build their own learning ecosystems to secure future talent. These programmes should address formal skills, but mindset and attitude will matter even more. As the old adage affirms: 'Hire for attitude. Train for skills.'

## IN CLOSING

Ultimately, the future of manufacturing will be defined not by the speed of technology, but by the pace at which people, systems, and leadership evolve together. Companies that combine clear foresight with disciplined execution, data-driven collaboration, and a culture of continuous learning will not only adapt to change, they will lead it.

# ABOUT THE REPORT

This report was produced by Kairos Future on behalf of PLM Group. It draws on desk research and in-depth interviews with approximately 20 managers and experts from the manufacturing sector, conducted in the autumn of 2025. The findings were subsequently analysed and discussed with representatives of PLM Group.



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# ABOUT PLM GROUP

PLM Group provides software solutions and expertise to support companies develop and manufacture innovative products. PLM Group customers become agile with efficient operations leading to a sustainable business model. Drawing on extensive experience across industries in Sweden, Denmark, Norway, Finland, Estonia, and Latvia, the company delivers tools that integrate all parts of a business on a single platform - creating value for stakeholders through digital continuity and supporting success throughout the entire product innovation process.

# ABOUT KAIROS FUTURE

Kairos Future is an international consulting and research firm specialising in helping organisations and business leaders understand and shape their futures. The company provides expertise in strategic foresight, trend analysis and scenario planning, innovation and strategy development, and organisational transformation. Founded in 1993, Kairos Future is headquartered in Stockholm, with representatives and partners operating worldwide.

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