WORLD ECONOMIC FORUM

Global Lighthouse Network: Rewiring Operations for Resilience and Impact at Scale

WHITE PAPER

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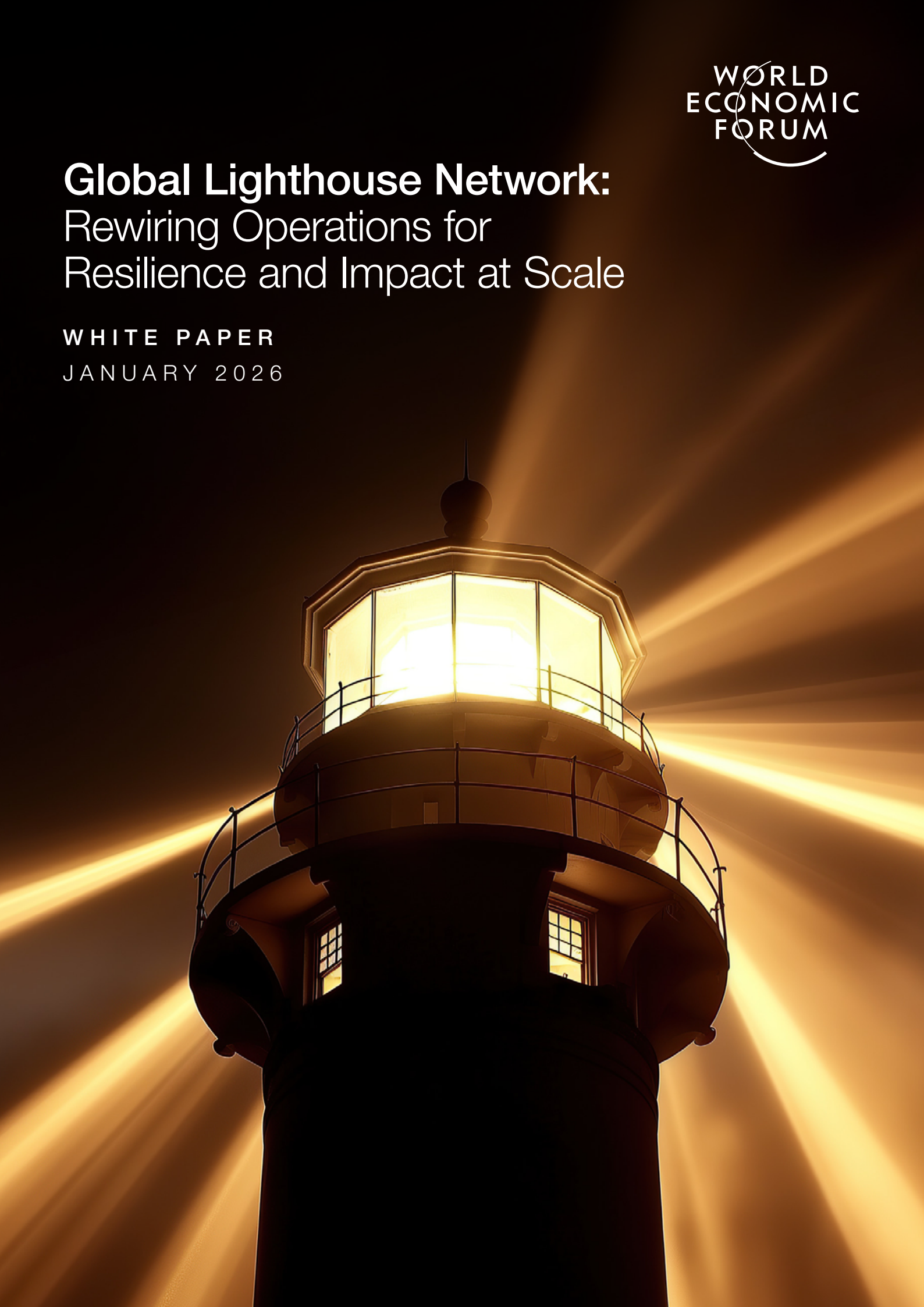

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The Global Lighthouse Network (GLN) is the leading industry movement celebrating the world’s top-performing production and operations sites. Network members showcase proven performance increases and achieve operational excellence across five categories: productivity, supply chain resilience, sustainability, customer centricity and talent. GLN is a World Economic Forum initiative co-founded with McKinsey & Company and counselled by an advisory board of industry leaders, including Aramco, Foxconn Industrial Internet, Koç Holding, McKinsey & Company, Schneider Electric and Siemens.

Foreword

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Biological evolution teaches that survival and progress depend not on speed, size or strength alone, but on the capacity to adapt. The same is true of industrial operations, where evolution is ceaseless. To survive, let alone thrive, players across the value chain must find the courage, will and agility to adapt their operations amid ongoing change – that is, to *rewire*.

Such adaptation is no small feat, yet it has always been the engine of progress. Each industrial revolution was powered by transformative technology that demanded new ways of working. Adoption, often hard-won, unlocked the innovations that shaped each new era. But technology alone has never been enough. It has always been people who drive lasting transformation, with a willingness to take risks, adapt, learn, reskill and collaborate.

However, even with the most engaged workforce, industrial operations remain deeply physical systems. Transforming them at scale involves contending with complex, capital-intensive assets – machines, materials and production lines – that require considerable effort and precision to evolve. Unlike technology firms that move at the speed of software, industrial operators must master the coupling of digital and physical at scale.

That's where Lighthouses come in. Since the inception of the Global Lighthouse Network eight years ago, it has illuminated the path forward for transformative operational rewiring. Lighthouses are unlocking more value from artifical intelligence (AI) than most of their peers and in ways that strengthen both human capability and system performance. With the Network now 223 members strong, its blueprint for scaling-up has never been more important.

The Global Lighthouse Network remains true to its vision: to light the way forward towards a more adaptive, human-centred and tech-empowered future of operations.

Executive summary

This white paper celebrates eight years of GLN as the leading learning community for achieving world-class operational performance at scale.

The Global Lighthouse Network (GLN) continues to showcase leaders across the manufacturing and supply chain ecosystem making measurable impacts on people, planet and performance. Having expanded from 16 factories to 223 sites across more than 30 countries and 40 industries, the Network remains at the forefront of holistic, scalable performance transformation. In 2025, two new award categories were introduced: **customer centricity** and **talent**, alongside the existing pillars of **productivity**, **supply chain resilience** and **sustainability**.

This report highlights three major themes fundamental to the success of all Lighthouses: operational resilience in a new era of disruption, adopting AI to build cognitive networks and scaling-up from pilots to enterprise-wide impact.

Operational resilience in a new era of disruption

This year's Lighthouses are redefining resilience for a new era. Confronted by persistent volatility, from geopolitical instability to tariffs and inflation, Lighthouses have moved beyond risk mitigation to actively shaping strategy in the face of disruption. Their investments focus on three priorities: building foundations for network agility and scale, empowering people to thrive in a digital world and amplifying impact through collaboration and purpose. They distinguish themselves by mastering critical trade-offs – balancing speed and standardization, autonomy and visibility, connectivity and cybersecurity – to anchor every decision in business value.

Adopting AI to build cognitive networks

Lighthouses are moving beyond pilots to enterprise-level deployment, with analytical AI and machine learning now embedded in nearly 62% of their top-5 use cases and generative AI (GenAI) embedded in 23% – up from 9% in 2024. By focusing on vertical, domain-specific applications, they are overcoming the "GenAI paradox", turning experimentation into tangible performance gains. As they evolve from "smart factories" to "cognitive networks", Lighthouses are pioneering hybrid human-AI workforces and intelligent agent ecosystems that enable agile, autonomous decision-making.

Scaling-up from pilots to enterprise-wide impact

Adoption alone does not guarantee impact. The goal is to claim the enormous advantages that come from scale; but this remains one of the toughest challenges in operations. Even within GLN, only a select few have rewired operations enterprise-wide. Those that succeed follow the same blueprint that made their Lighthouse pilots successful: strategic roadmaps, agile operating models, talent, technology and data, ecosystem collaboration and adoption programmes. The 2025 Lighthouse cohort placed particular emphasis on three enablers – well-defined transformation roadmaps, agile teams and global ecosystem partnerships – as levers to accelerate innovation, embed agility across networks and turn localized success into sustained enterprise-wide impact.

Lighthouses are illuminating the way out of the "scaling slump" identified in earlier GLN reports, aligning their transformation approach with the maturity of the enterprise.[1] They employ **three scaling-up archetypes**:

1) **Centre of excellence**

2) **Workforce capability building**

3) **Technology integration**

Each combines structural, cultural and technological elements that drive expansion and continuous innovation.

In an age defined by disruption, Lighthouses remind us that transformation is not a destination but a capability, one that turns volatility into advantage and vision into value. The next era of operational progress will belong to those who act with purpose, scale up with discipline and keep people at the centre.

1 Celebrating eight years of the Global Lighthouse Network

GLN showcases leaders across the manufacturing and supply chain ecosystem making positive, measurable impacts on people, planet and performance.

The Global Lighthouse Network is a World Economic Forum initiative recognizing best-in-class operational sites and value chains that have achieved exceptional performance in productivity, supply chain resilience, sustainability, customer centricity and talent. The initiative was co-founded with McKinsey & Company and is counselled by an advisory board of industry leaders working together to shape the future of global manufacturing.

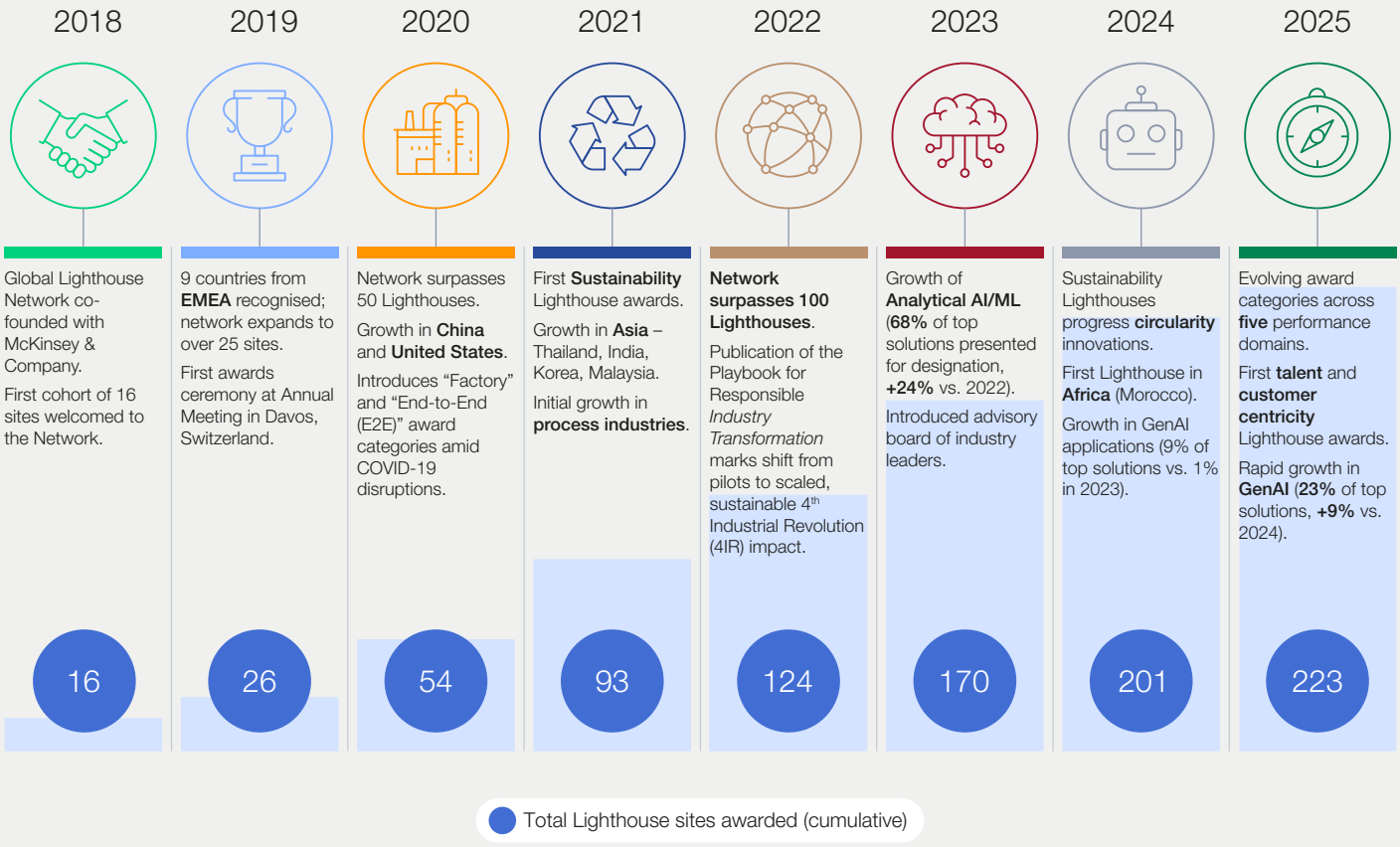
Sites and value chains that join the network are designated by an independent panel of experts. Since its founding, GLN has demonstrated the transformative power of digital innovation in a rapidly evolving industrial ecosystem. Growth has been a constant over the past eight years, from an initial cohort of 16 sites to 223 Lighthouses, each recognised for its approach to adapting ways of working with new technologies to drive lasting value.

1.1 Continuous evolution of the Network

GLN has consistently amplified its influence, assembling an advisory board with representation from industry leaders including Aramco, Foxconn Industrial Internet, Koç Holding, McKinsey & Company, Schneider Electric and Siemens.

These organizations have been instrumental in steering the Network's future direction. Continuous evolution is at the heart of GLN and it has expanded in both scope and composition (see Figure 1).

FIGURE 1 | **Celebrating eight years of the Global Lighthouse Network**



Note: EMEA = Europe, Middle East and Africa.

Source: Global Lighthouse Network.

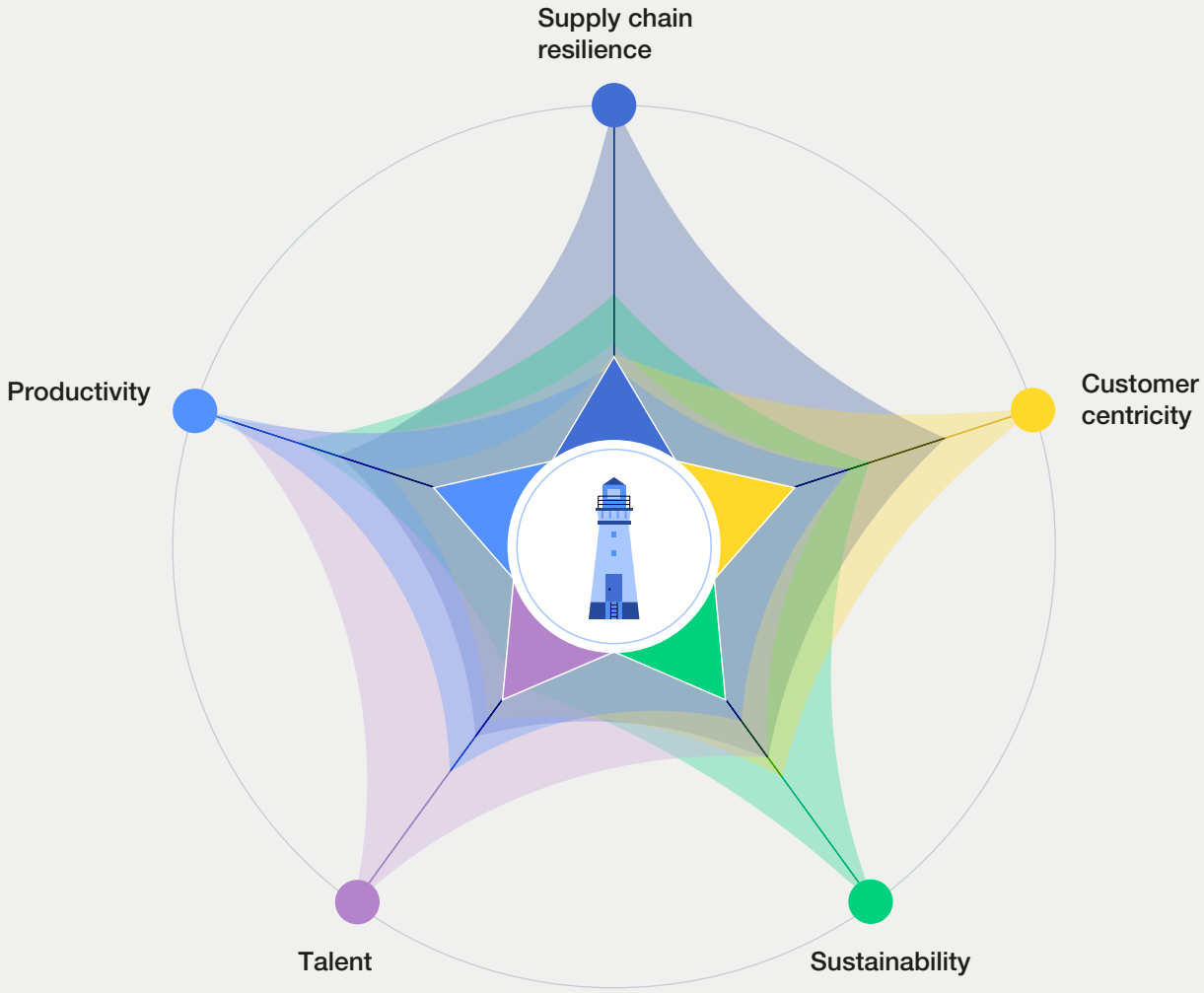
Growing from 16 to 223 sites across more than 30 countries and 40 industries, Lighthouses remain at the forefront of holistic, scalable performance transformation.

Today, the GLN is focused on demonstrating how productivity and digital advancements are just part of a broader transformation journey. The 2025 cohort joins the Network at an exciting juncture as it expands to five award categories. Along with productivity (formerly 4IR), **supply chain resilience** (formerly E2E) and **sustainability**, GLN now includes **customer centricity** and **talent** categories. Lighthouses demonstrate outstanding performance across all categories, but are recognised for exceptional impact in at least one.

The customer centricity category recognises excellence in speed-to-market and customization, while the talent category – established in collaboration with the World Economic Forum's Frontline of the Future Initiative – is awarded to leaders at the intersection of people and operations.

This paper presents the latest Lighthouses from the 2025 application cycles, detailing the transformative journeys that earned them recognition in one of the five award categories (see Figure 2). By sharing their stories, GLN aims to inspire change, foster collaboration and shape a better future for all players in the production ecosystem.

FIGURE 2 | **2025 Lighthouse award categories**



Productivity
Cost & quality
+18 awardees in 2025

Exceptional performance in cost and quality through technology-enabled transformation, improving asset utilization, worker enablement and resource management

Supply chain resilience
Service & agility
+6 awardees in 2025

Exceptional performance in service and agility through supply chain transformation (e.g. planning, fulfillment, logistics), enhancing transparency and working capital management

Customer centricity
Speed to market & customization
+4 awardees in 2025

Exceptional speed-to-market and customization through tech-enabled design and procurement, optimizing batch size, lead time, product cost and performance

Sustainability
Circularity & decarbonization
+5 awardees in 2025

Industry-leading reductions in energy, emissions, water and waste through advanced solutions in pursuit of a holistic set of net-zero, decarbonization and circularity goals

Talent
Workforce empowerment & stability
+3 awardees in 2025

Transformative impact on the workforce through advanced solutions in work design and safety, talent planning, attraction and onboarding, development and effectiveness

Lighthouse site types
The GLN includes a diversity of sites across the production ecosystem, including:

Source: Global Lighthouse Network.

1.2 Global expansion of the Network

Lighthouses have showcased more than

1,150

solutions

offering a blueprint to achieving holistic performance transformation across sectors and regions.

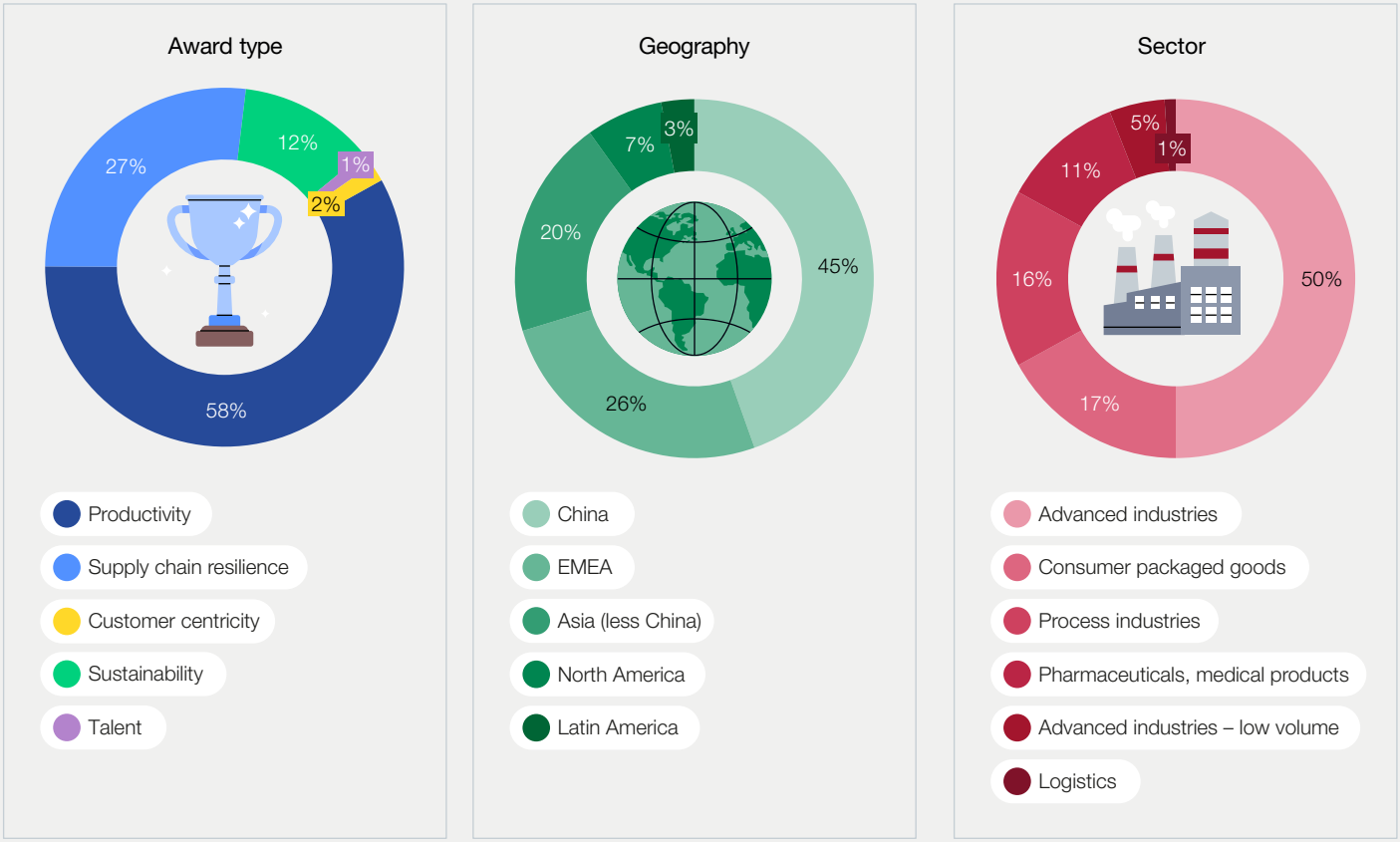
The GLN initially identified factories that had deployed cutting-edge technologies to elevate performance and escape "pilot purgatory". These pioneering sites and value chains presented early examples of how digital could drive transformative impact for people, planet and performance. As explored in the World Economic Forum's white paper *Global Lighthouse Network: Adopting AI at Speed and Scale*, they offered inspiration for millions of potential "fast followers" eager to replicate validated solutions, adapting them to local contexts to accelerate their own transformations while minimizing risk.

Today's 223 Lighthouses comprise more than the vanguard of performance – they represent a paradigm shift in operational excellence, one that scales up transformation with purpose by infusing sustainability, workforce empowerment and innovation into daily operations.

In 2025, GLN proudly welcomed an additional 34 Lighthouses, spanning 11 countries, including newcomers from Qatar and Azerbaijan. The Network now encompasses 1,150+ solutions from more than 40 industries in seven sectors and over 30 countries, offering a proven playbook for scaling-up transformation within sites and across production networks.

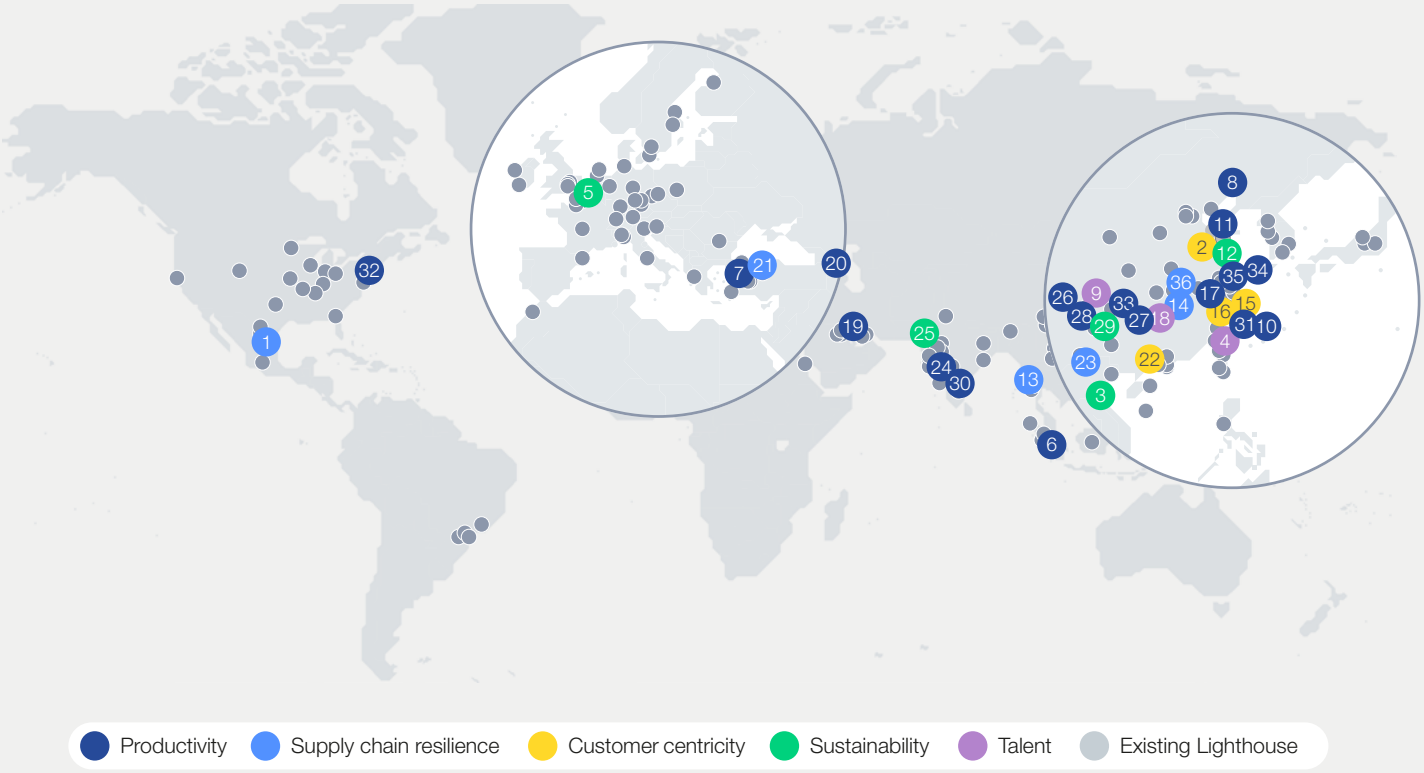
FIGURE 3 **Global Lighthouse Network composition (January, 2026)**

Total Lighthouse sites, by award type, geography and industry (%)



Source: Global Lighthouse Network.

FIGURE 4 | **New Lighthouses in 2025**



New Lighthouses in 2025

Electronics

1 **Lenovo**
Monterrey, Mexico

2 **Hisense Visual Technology**
Qingdao, China

3 **Foxconn Industrial Internet (FII)**
Bac Ninh, Vietnam

4 **AUO Corporation**
Suzhou, China

Fulfilment centre

5 **Schneider Electric**
Evreux, France

Semiconductors

6 **Global Foundries**
Woodlands, Singapore

Automotive

7 **Ford Otomotiv**
Kocaeli, Türkiye

35 **Faurecia**
Yancheng, China

Tyres

8 **Michelin**
Shenyang, China

Home appliances

9 **Haier**
Chongqing, China

10 **Haier**
Shanghai, China

11 **Haier**
Qingdao, China

12 **Hisensehitachi**
Qingdao, China

13 **Midea**
Si Racha, Thailand

14 **Midea**
Wuhu, China

Industrial equipment

15 **Eaton**
Changzhou, China

16 **Mettler Toledo**
Changzhou, China

Industrial products

17 **Siemens Numerical Control**
Nanjing, China

18 **Schneider Electric**
Wuhan, China

Oil and gas

19 **Qatar Shell**
Ras Laffan, Qatar

20 **SOCAR Carbamide**
Sumqayit, Azerbaijan

21 **Tüpraş**
İzmit, Türkiye

Medical lenses

22 **Carl Zeiss Vision**
Guangzhou, China

Personal care products

23 **Yunnan Baiyao**
Kunming, China

24 **Unilever**
Pondicherry, India

25 **Unilever**
Gandhidham, India

36 **Unilever**
Hefei, China

Renewable energy

26 **Tongwei Solar**
Meishan, China

Batteries

27 **EVE Energy**
Jingmen, China

28 **HiTHIUM Energy Storage Technology**
Chongqing, China

29 **CATL**
Yibin, China

Films and packaging

30 **ACG Packaging Materials**
Shirwal, India

31 **Kunlene Film Industries**
Suzhou, China

Biologics

32 **Bristol Myers Squibb**
Devens, Massachusetts, United States

Fabrics

33 **Huafon Spandex**
Chongqing, China

34 **Yueda Textile**
Yancheng, China

Source: Global Lighthouse Network.

FIGURE 5 | **Highlights from the 2025 cohort**

Award categories	Site and location	Standout use cases

A — Productivity
Cost & quality

Site and location: Shirwal, India
Cost leadership and agility in a competitive packaging market

Standout use case: In-house development

ML-powered precision setup for legacy machines

Manual setup of parameters on 60-year-old machines for 5k+ SKUs with tight tolerances was significantly impacting yield, lead time and quality. The solution uses ensemble ML models trained on 2+ years of golden batch data to prescribe optimal machine settings. Operators transfer these first-time-right settings directly to the machine programmable logic controller (PLC) system and a continuous ML pipeline refines models based on desired outcomes and operator feedback.

- **+37%** First pass yield
- **-43%** Quality setup time
- **-13%** Production lead time

B — Supply chain resilience
Service & agility

Site and location: Hefei, China
Factory-to-customer agile model for e-commerce growth

Standout use case: Joint-development

AI agents for warehouse performance management

Where fragmented, high-volume data previously delayed action, an AI agent now streamlines performance management by automating issue detection, root cause analysis and resolution workflows. Leveraging LLMs for self-learning and knowledge standardization, it integrates data from 12+ systems to trigger real-time alerts, generate reports and govern the PDCA cycle. A GenAI copilot enhances decision-making with advanced reasoning.

- **-80%** Issue fixing time
- **+40%** Throughput (parcels/hour)
- **+6%** Online store satisfaction rating

C — Customer centricity
Speed to market & customization

Site and location: Changzhou, China
Agile design & fulfilment of complex ETO customer requirements

Standout use case: Joint-development

Simulation and genetic algorithm (GA)-based workstation reconfiguration for ETO

Floor scales have millions of configurable variants and engineered-to-order (ETO) solutions, with 66% one-piece orders processed daily. Through multi-system integration, discrete event simulation (DES) and GA, modular cluster workstations are dynamically reconfigured via real-time scheduling, supporting complex line-balancing and scalability constraints and improving reliability.

- **+38%** Productivity (UPPH)
- **+13%** Manufacturing on-time delivery
- **-54%** Cycle time

D — Sustainability
Circularity & decarbonization

Site and location: Qingdao, China
Emissions and resource efficiency across product lifecycle

Standout use case: Joint-development

AI-enhanced R&D testing optimization for energy efficiency

A neural network automates optimal plans for product testing to address energy inefficiencies, while a deep learning model refines plans using historical data. Multi-constraint optimization determines ideal test sequence and reinforcement learning allocates lab capacity efficiently. A load calculation model and a PLC system maintain precise control, including fine tuning for temperature accuracy.

- **-20%** Testing cycle time
- **-32%** Energy consumption in new product testing
- **-32%** Scope 1 & 2 emissions in new product testing

E — Talent
Workforce empowerment & stability

Site and location: Wuhan, China
Digital apprenticeships and integrated, AI-enabled upskilling

Standout use case: In-house development

Intelligent workforce orchestration for demand volatility

To address fluctuating demand (up to 200%) and limitations of experience-based planning, a deep learning-powered system enables skill-based matching and dynamic workload balancing via real-time dashboards. The system integrates upskilling into task allocation, aligning with training programmes to provide exposure to new skills while leveraging existing expertise. An AI assistant delivers recommendations and generates 12-month training and hiring plans to promote workforce readiness.

- **-7.4p.p.** Vacancies
- **-51%** Overtime per employee per week
- **+6.8p.p.** On time delivery

Notes: LLM = large language model, ML = machine learning, PDCA = plan-do-check-act, SKU = stock keeping unit.

Source: Global Lighthouse Network.

2 Operational resilience in a new world era

Lighthouses don't just adapt – they build resilience to thrive amid macro-environment disruption, demographic shifts and technological transformation.

GenAI could lift the productivity growth rate tenfold –

3%

annually through 2030 compared to 0.3% annually in a business-as-usual scenario.

The past year has been defined by volatility. Tariffs, geopolitical instability and inflation have shocked global markets, reshaping competitive dynamics and posing risks to global growth. According to the World Economic Forum report, *Chief Economists' Outlook: May 2025*, 82% of surveyed economists reported "very high" levels of uncertainty, signalling ongoing pressure on trade and investment.[2] After dominating risk perceptions earlier in 2025, trade policy concerns receded by year's end.[3] As confidence improved, leaders shifted focus towards geopolitical risks and company-specific priorities, bringing renewed attention to the internal operational constraints that now define competitiveness.[4]

Operations leaders face an array of challenges, including ageing legacy equipment and a younger, less experienced workforce than in prior decades. The support ratio, which measures the number of working-age people for every person over 65, was at 6.8 at the turn of the century – but in 2025, dropped in "first wave" industrialized regions to 3.9 (4.9 in China, 3.8 in both North America and Europe).[5] Moreover, by 2030, the manufacturing sector has projected a 23% labour deficit in the United States, a 31% deficit in China and a 10% surplus in India.[6] Maintaining agility and resilience amid these challenges demands fit-for-purpose, locally-grounded strategies and effective management of both assets and people.

Value chain reconfiguration and resource constraints have intensified the pressure to raise productivity without jeopardizing operational continuity.[7,8] In this context, resilience has become the foundation for capturing the full promise of GenAI. A study published in May 2024 estimated that, when paired with agile operating models and proactive workforce redeployment, GenAI could lift the productivity growth rate tenfold – 3% annually through 2030 compared to 0.3% annually in a business-as-usual scenario.[9] Yet a recent report by MIT Nanda revealed that 95% of enterprise GenAI pilots today fail to achieve measurable outcomes, with only 5% realizing strong return on investment (ROI).[10] The challenge is not a lack of technological potential, but the absence of stable operating conditions required to translate that potential into durable, enterprise-level value.

Lighthouses in 2025 illustrate what it takes to close this gap: they align investment in core capabilities and enablers to build adaptive operations and technology foundations, empower people for the future and scale with innovation and purpose (Figure 6).

FIGURE 6 | **Lighthouse capabilities and enablers for resilience in 2025**

How Lighthouses build resilience	Build foundations for network agility and scale		Empower people to thrive in a digital world		Scale impact with collaboration and purpose	
	1 **Operational agility** Managing volatility & complexity	2 **Network modernization** Building a scalable digital backbone	3 **Workforce transformation** Developing future-ready talent	4 **Human-centric AI** Making innovation accessible	5 **Ecosystem collaboration** Amplifying value chain impact	6 **Embedded sustainability** Transforming resource efficiency
Capability	**Digital twins for value-chain reconfiguration** enables planning, production and logistics to adapt dynamically	**Unified IT/OT architecture** connects shopfloor, enterprise and planning systems through seamless data flows	**Digital-first talent models** redesign roles and workflows around new technologies, tools and data	**Frontline-built digital solutions** allow operators and engineers to adapt AI for the shopfloor	**End-to-end planning alignment** synchronizes demand, supply and execution across the value chain	**Circular resource operating models** manage materials, energy and waste through closed-loop systems
	-83% Delivery lead time	3-6 months Time to design, train & deploy new solutions	-6p.p. Key role vacancies	~1.6m setup options Managed via no-code energy platform, scaled to five other sites	~36% Share of customer and supplier endpoints connected to IIoT platform	-43% Scope 3 emissions (absolute)
Enabler	**Predictive risk modelling** provides forward-looking scenarios that guide rapid operational decisions	**Standardized data foundations** ensure consistent models, connectivity and governance across systems	**Embedded digital technologies** across onboarding and training bridge experience gaps and chart career paths	**Business-led use-case prioritization** focuses AI development on clearly defined operational value	**Shared knowledge ecosystems** connect suppliers and customers through data and practices	**AI and IIoT-driven resource optimization** supports predictive control of energy and materials use and emissions
	+6 weeks Planning time horizon visibility	50+ Solutions deployed at scale	-74% Frontline leaders' turnover rate	60% Share of solutions developed in-house	~10+ Ecosystem partnerships enabling the transformation	-18% Energy consumption (absolute)
Lighthouse examples below	SIEMENS Nanjing, China	Ras Laffan, Qatar	Tüpraş İzmit, Türkiye	Haier Chongqing, China	AUO Suzhou, China	SOCAR Sumqayit, Azerbaijan	EATON Changzhou, China	Yunnan Baiyao Kunming, China	Schneider Electric Evreux, France

Notes: IIoT = industrial internet of things, IT/OT = information technology/operational technology.

Source: Global Lighthouse Network.

2.1 Building foundations for network agility and scale

Relentless disruption means companies must be able to pivot quickly – changing production rhythms, rerouting supply chains and redeploying assets in real time. Research shows that supply chain disruptions cost, on average, 45% of one year's cash profit.[11] Companies recognise the risk: an estimated 86% of business leaders surveyed in 2024 said they are investing in supply chain transformation, but only about a quarter of supply chain professionals believe their companies have completed it.[12]

Lighthouses, having set a strategic mandate for network-wide resilience, are equipping frontline teams with tools for bottom-up innovation so they can respond dynamically to risks and opportunities. In doing so, they model a replicable, scalable approach to building lasting operational resilience and agility.

Operational agility: rapidly adapting to volatility and complexity

Operational agility has become a critical differentiator in today's volatile macroeconomic environment. A 2024 survey of business leaders showed that two-thirds of organizations have redesigned their operating models in the past two years.[13] Companies are investing in flexible digital systems, real-time data analytics and adaptive supply chain strategies that support faster, data-driven decisions. Focusing on localized, impact-driven solutions allows Lighthouses to scale up technologies efficiently while anticipating disruption and adapting dynamically across value chains.

Dynamic value chain reconfiguration with digital twins

As factories become increasingly connected, the dynamic reconfiguration of value chains has emerged as a defining capability for resilient operations, one increasingly enabled by digital twins. These virtual replicas of physical systems can simulate, predict and optimize performance, accelerating decision-making by up to 90%.[14] Yet adoption remains uneven: a 2024 McKinsey survey found that while 86% of companies view digital twins as relevant, only 44% have implemented them and just 15% plan to do so.[15]

Even with strong technical foundations, digital twin initiatives often falter because they demand new ways of working. For example, because digital twins both gather and send data to physical assets, their bi-directional nature introduces cybersecurity and latency risks that can make operators hesitant. **Siemens Numerical Control** in Nanjing, China mitigated these risks through an interconnected manufacturing operations management (MoM) system that governed data exchange between physical and virtual environments, validating simulations and process adjustments before deployment to production. Thus, digital twins could be used to safely test process changes, reduce cycle times and automatically rebalance production lines, unlocking capacity in a highly customized, discrete manufacturing environment (Figure 7).[16]

FIGURE 7 | **Siemens' digital twin for continuous cycle time optimization**

Siemens Numerical Control

Nanjing, China

+50% Units per hour

-12% Cycle time

-83% Delivery lead time

Digital twins for cycle time optimization and line re-balancing

Facing market volatility and growing demand for customization, the site integrated 10+ digital twin technologies with lean methodologies. Using 3D layout planning and simulation, digital twins create models incorporating key parameters such as cycle time, labour and process time to identify optimal designs for flexible production. Plan-do-check-act (PDCA) cycles support closed-loop improvement with real-time deviation analysis and standard refinement.

In-house development

Design Layout planning simulation

Realize Physical line setup

Optimize Closed-loop cycle time optimization

Lean OpEx

Call design fundamentals

- Output
- Total effective equipment performance (TEEP)
- Target cycle time
- Operator efficiency
- Machine utilization
- Floor space
- Technology enablers

Digital twin

Operations simulation

- Operator balance
- Machine utilization
- Operator walking distances
- Actual cycle times
- Output

Digital cycle time

Closed-loop optimization through PDCA

1. Establish line operation standards
2. Monitor and identify deviations
3. Analyse deviations
4. Continuous improvement

Digital data platform | Visualization tools | Digital twin platform

Augmented reality / virtual reality (AR/VR) | Wearables

Note: OpEx = operating expenses.

Source: Global Lighthouse Network.

86%

of business leaders are investing in supply chain transformation, but only about a quarter believe their companies have completed it.

Proactive risk management with advanced scenario planning

With volatility now the norm, traditional forecasting models are losing their predictive power. To stay ahead, Lighthouses are embedding dynamic risk modelling, what-if simulations and intelligent alerts and escalations into daily operations. Building a longer predictability horizon is no simple task. It requires a structured, forward-looking approach to risk management – one grounded in data-driven fundamentals.[17]

Tüpraş in İzmit, Türkiye offers a compelling example. Following the commissioning of an upgraded plant, the company faced growing operational complexity, siloed planning and losses due to manual forecasting that hindered market responsiveness. Tüpraş deployed a suite of risk management solutions, including digital twins, AI-powered demand forecasting and advanced analytics to optimize crude selection, scheduling and logistics, which collectively unlocked working capital and predictive, scenario-based decision-making across the crude-to-product value chain (Figure 8).[18]

Qatar Shell's gas-to-liquids facility in Ras Laffan, Qatar faced early challenges with siloed systems, fragmented data and scarce local capabilities in a highly technical industry. Recognizing the criticality of its assets, the site invested in solutions such as real-time, physics-based structural health monitoring and AI-enhanced corrosion prediction to improve asset reliability. Real-time integrity insights are used to prioritize repairs and schedule maintenance during planned downtimes, supporting operational continuity at reduced cost (Figure 8).[19]

By integrating financial, demand and supply risk factors into a unified supply chain "control tower", Lighthouses anticipate vulnerabilities before they materialize and calibrate interventions based on live operational data, bridging planning and execution into a single decision loop. Achieving this level of responsiveness requires rethinking legacy systems and processes for continuous, data-driven adaptation.

Network modernization: reimagining legacy systems, processes and mindsets

For established organizations, scaling-up transformation across brownfield sites – typically ageing facilities with entrenched systems and processes – presents obstacles. Legacy systems, often optimized for sustaining current operations, can stifle innovation and stall digital efforts. Lighthouses align systems, processes and – critically – *mindsets* around the mission and vision, building a transformation engine capable of persisting under ceaseless change.

Systems integration and IT/OT optimization

Integrating information technology (IT) and operational technology (OT) is now foundational to modernizing sites, where legacy systems often block data flow and hinder transformation. Lighthouses bridge these gaps by building unified IT/OT architectures that connect, on average, 85% of production and logistics endpoints, unlocking end-to-end visibility, early risk detection and rapid response (Figure 9). An integrated backbone supports predictive maintenance, automated recovery and cybersecurity for operational continuity. Through cloud-hybrid deployments and close collaboration with ecosystem partners, Lighthouses localize development to accelerate solution rollout and sustain impact.

FIGURE 8 | **Tüpraş and Qatar Shell have prepared their sites for a volatile world**

Qatar Shell

Ras Laffan, Qatar

-90% Engineering cost

-98% Response time to system upset

Automated condensate optimization informed by live data feed from offshore wells

With gas feed capped, daily manual choke adjustments for offshore wells limited condensate production. Now, an AI system optimizes valve settings for each well every 30 minutes. A compositional integrated network (CIN) and physics-based models simulate hydrocarbon flow and calculate optimal settings to inform an advanced process control (APC) system's real-time adjustments, eliminating manual intervention.

In-house development

Qatar Shell

Ras Laffan, Qatar

+6 years Critical equipment lifetime

-64% Annualized CapEx

Real-time, physics-based AI for asset integrity and performance

Pressurized steel integrity challenges can lead to downtime, safety risks and reduced operational efficiency. By combining structural mechanics with real-time operational data, physics-based AI delivers ultra-fast simulations of stress and fatigue for critical assets, far surpassing traditional methods. These insights empower proactive maintenance and operational decisions, extending asset life and enhancing reliability while significantly reducing costs and risks.

Joint-development

Tüpraş

İzmit, Türkiye

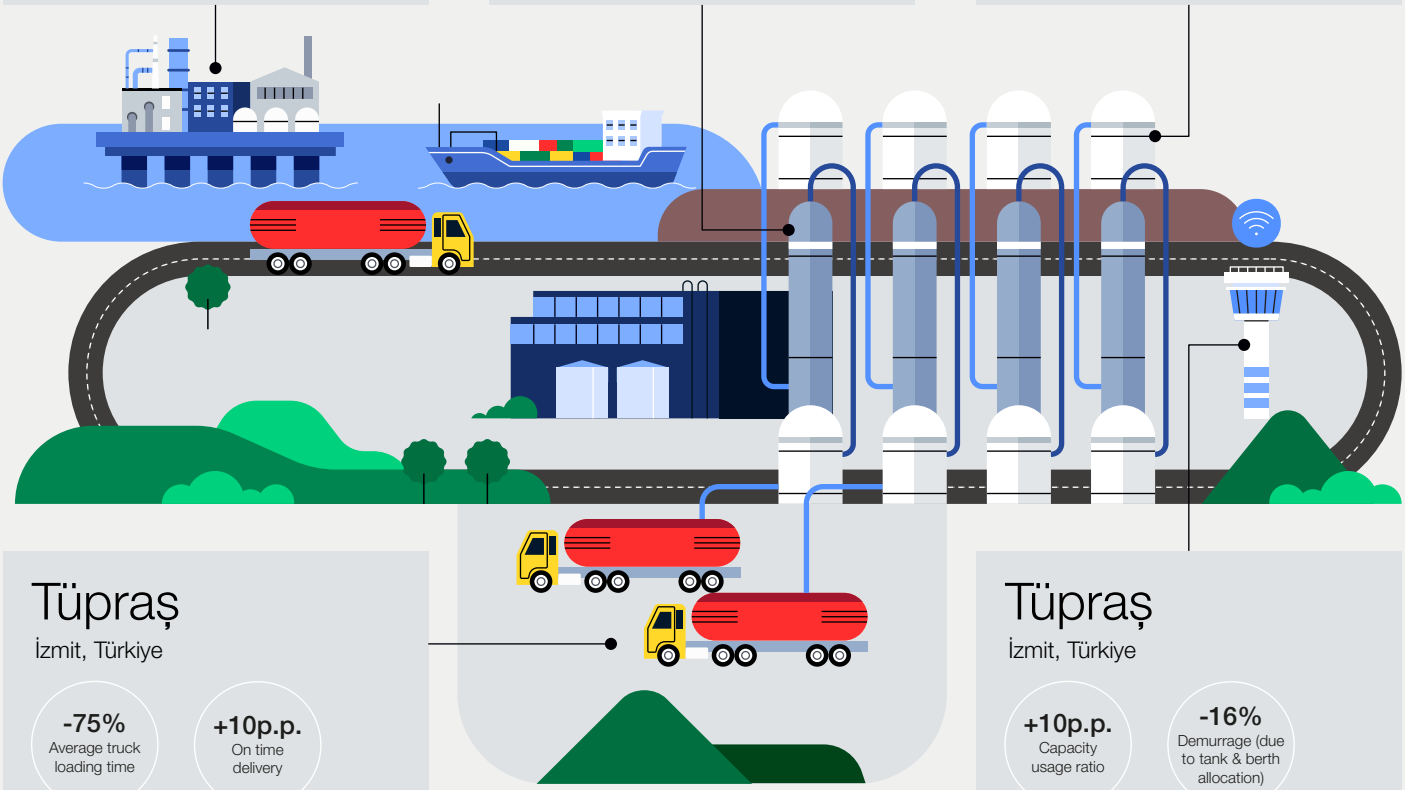
-5% Inventory levels

+6 weeks Planning time horizon visibility

AI-driven crude supply chain synchronization

Manual processes and siloed planning caused delays, excess inventory and higher costs. An AI-driven system now optimizes crude procurement, production scheduling and logistics in real time. The crude slate layer evaluates cargo impacts months ahead using simulations, the product slate aligns production with demand forecasts, while Aspen PIMS optimization and the logistics slate synchronize transport with real-time tank levels and disruptions.

In-house development



Tüpraş

İzmit, Türkiye

-75% Average truck loading time

+10p.p. On time delivery

Integrated platform for product distribution and logistics excellence

Manual dock scheduling was causing long delays, high demurrage and lower on-time delivery. A self-developed driver hub platform integrates ERP, terminal automation system (TAS), IoT sensors and RFID with an AI orchestration engine. It unlocks real-time appointment-to-exit planning and dynamic slot optimization, reducing manual work and enabling 30 FTEs to be redeployed to analytics roles.

In-house development

Tüpraş

İzmit, Türkiye

+10p.p. Capacity usage ratio

-16% Demurrage (due to tank & berth allocation)

Intelligent crude blending and refinery optimization

To ensure optimal crude blend quality and maximize yield, the site built a 3-layer optimization system. Petromix dynamically adjusts blending strategies based on live data such as crude quality and vessel schedules, while a refinery-wide optimization layer leverages digital twins and soft sensors to recommend hourly setpoints. Integrated with Aspen PIMS and IoT analytics, the system runs 10,000+ simulations to align operations with market conditions.

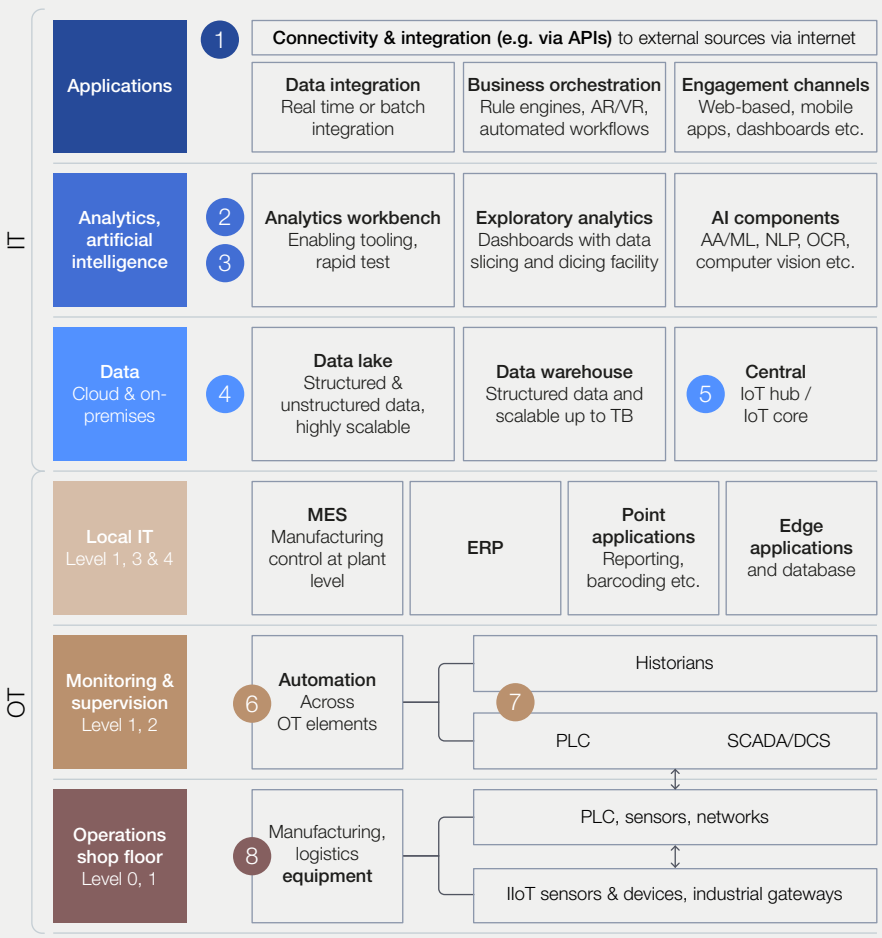
Joint-development

Notes: ERP = enterprise resource planning, FTE = full-time equivalent (worker), PIMS = pipeline integrity management system, RFID = radio frequency identification. Demurrage is a charge payable to the owner of a chartered ship on failure to load or discharge the ship within the time agreed.

Source: Global Lighthouse Network.

FIGURE 9 | **Lighthouses modernize IIoT architectures to unlock end-to-end value chain impact**

Generic best-practice IIoT architecture



Lighthouse IT/OT integration and performance

3-6 months
Time to design, train and deploy new solutions

Share of solutions developed
60% In-house
25% 3rd party on-premises
15% 3rd party SaaS

<1 day
Speed to onboard new assets to IoT platform

Connected to IoT platform
85% End points[2]
35% Customers
37% Suppliers

50%
Share of data stored enterprise level (vs. 25% locally on edge, 25% at the site)

Hosting of digital solutions
35% In cloud
50% On-premises
15% On edge

Trends and examples from 2025 Lighthouses

1. **Cyber-security, especially around AI, is top of the agenda**
   Cybersecurity best practices are key when deploying LLMs to secure intellectual property (IP)

2. **Stability at the core enables application flexibility**
   Stable core architectures enable flexible integration of fast-developing elements such as LLMs through standardized protocols and interfaces

3. **Lighthouses collaborate extensively with the tech ecosystem**
   Lighthouses collaborate extensively with one partner of each pillar (e.g. academia, startup, tech vendors, hyperscalers)

4. **World-class systems can be cloud-enabled or deployed on-prem**
   Depending on the in-house development capabilities and hardware available data can be stored on-premises or on the cloud

5. **Core IoT systems are born onsite and highly customized**
   Lighthouses are localizing IoT development capabilities. IoT infrastructures are increasingly fully owned E2E by sites

6. **Lighthouses succeed in connecting ~85% of end-points to the stack**
   Big-data and AI-enabled use-cases require scaled connectivity to enable insights

7. **Lighthouses leverage all types of data to drive business impact**
   Data can be structured, unstructured and semi-structured

8. **Best-practice IoT architectures can be deployed in brownfield environments**
   Retrofit with smart sensors, IoT gateways and/or industrial PCs to obtain data from legacy machines

Notes: 1. According to ISA 95 standard; 2. e.g. machines, utilities, workstations. AA/ML = advanced analytics/machine learning, API = application programming interface, DCS = distributed control system, E2E = end-to-end, MES = manufacturing execution system, NLP = natural language processing, OCR = optical character recognition, PLC = programmable logic controller, SaaS = software-as-a-service, SCADA = supervisory control and data acquisition, TB = terabyte.

Source: Global Lighthouse Network.

“What distinguishes Lighthouses is their ability to navigate critical trade-offs: speed versus standardization, local autonomy versus global visibility and cybersecurity versus connectivity.

Steering organizations through technological transformations, whether integrating legacy systems or migrating to the cloud, can be challenging. What distinguishes Lighthouses is their ability to navigate critical trade-offs: speed versus standardization, local autonomy versus global visibility and cybersecurity versus connectivity, calibrating each choice to the specific demands and constraints of their operations.

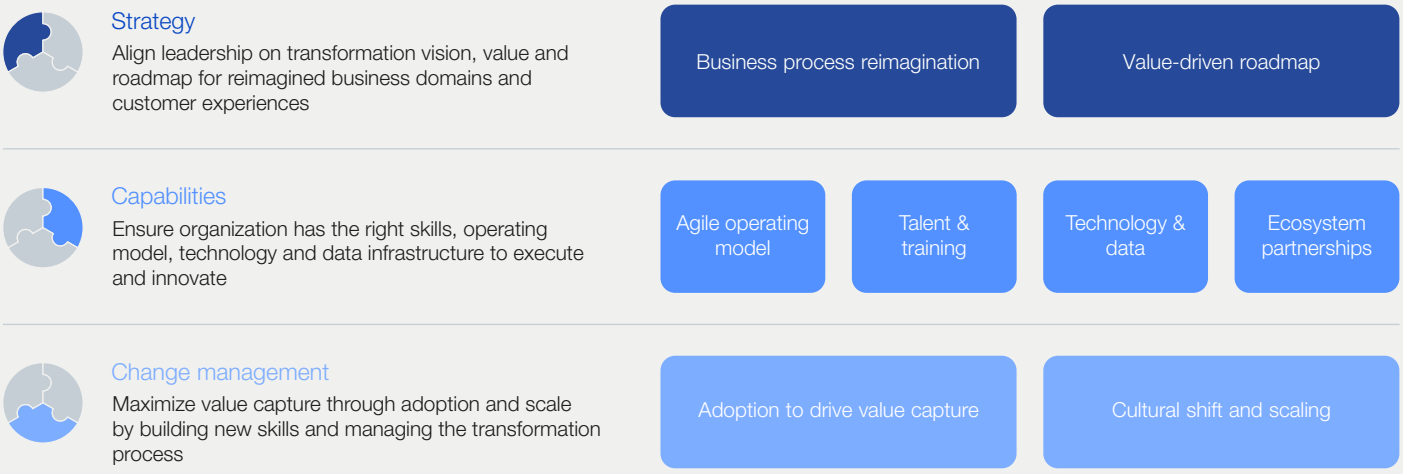
Rewiring beyond technology: reimagining processes and mindsets

Scaling-up transformation across a network demands more than infrastructure upgrades – it requires holistic rewiring that aligns business priorities, operating models and technology infrastructure. Yet most organizations struggle to translate digital ambition into measurable results. In McKinsey’s March 2025 report The state of AI, more than 80% of executives reported their organizations have not yet realized a tangible earnings before interest and taxes (EBIT) impact from GenAI.[20] The same survey found that, among 25 transformation attributes tested, workflow redesign had the single largest effect on whether organizations achieve EBIT impact from GenAI.

Lighthouses excel at holistic integration of strategy, capabilities and change management to drive and reinforce technology adoption with clear governance, cross-functional collaboration and workforce commitment (Figure 10). For example, **Tüpraş** upskilled over 1,500 employees in analytics, forecasting and digital tools through structured training programmes and aligned commercial, technical and operational teams under shared governance.[21] Similarly, **Qatar Shell** placed people at the core of its transformation, pairing investment in a full-scale data platform and digital twin with hackathons and bootcamps that engaged employees and local startups to co-develop over 150 use cases.[22]

By equipping teams with a shared purpose, the right tools and a culture of accountability, Lighthouses show that even large, complex production sites can move as one. Chapter 4 revisits this topic, detailing how Lighthouses operationalize strategy, capabilities and change leadership to sustain transformation at scale.

FIGURE 10 **Lighthouse approach to holistically rewiring operations**



Source: Global Lighthouse Network, framework adapted from McKinsey Operations Practice (August 2025).[23]

2.2 Empowering people to thrive in a digital world

Recognizing that – for the first time – five generations are working side by side in production environments, Lighthouses are deliberate about engaging a multigenerational workforce. Each generation brings distinct expectations, skills and perspectives, while each site's geographic context introduces unique challenges such as turnover, talent scarcity and local wage competitiveness. To address these realities, Lighthouses are designing employee journeys that dynamically close skill gaps and evolve with individual career aspirations.

Lighthouses signal to younger, digitally native talent that their sites are truly tech-forward by equipping all current and future employees with the skills needed to thrive in the future of work. They are embedding digital and AI tools across the end-to-end employee lifecycle – from attraction and hiring to onboarding, training and retention – creating a holistic, data-driven view of each employee's needs.

Workforce transformation: empowering a multi-generational and digitally native workforce

> Attracting younger talent demands a digital-first approach that speaks to a generation fluent in technology. With information just a click away, candidates can quickly gauge whether a company is a tech leader.

As baby boomers retire and younger employees enter manufacturing roles, Lighthouses face the dual challenge of bridging the experience gap while attracting talent to sites often located far from urban centres. Unlike many organizations struggling to adapt, Lighthouses are overcoming these challenges by reimagining training and development programmes that empower employees new to operations environments.

Attracting and retaining talent with digitally-enabled employee journeys

Attracting younger talent demands a digital-first approach that speaks to a generation fluent in technology. With information just a click away, candidates can quickly gauge whether a company is a tech leader through its partnerships, ecosystem presence or industry recognition. To stay competitive, Lighthouses must make their commitment to innovation visible and credible.

Haier in Chongqing, China has implemented a suite of digital solutions to manage a particularly young and seasonal workforce. Located in an industrial park alongside other factories, Haier's system provides visibility into employee skills from the moment of onboarding. New hires undergo fair and rapid skills assessments, enabling targeted upskilling programmes that accelerate time to proficiency. This system supports flexible reassignment to production lines based on customer demand and an employee's skills and schedule preference (Figure 11).[24]

Addressing skill gaps strategically with data-driven interventions

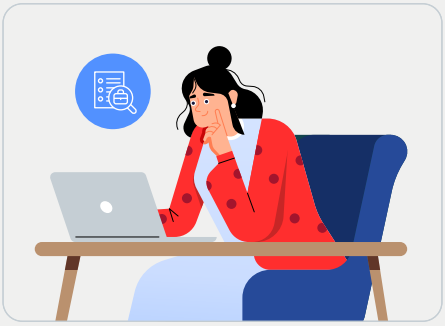
The current generation often joins the shopfloor with limited experience, making transparent, equitable and accessible people management systems critical. Yet with an average employee tenure of six years, growing 25% over the course of the transformation, Lighthouses design solutions for a demographic mix.[25] They digitize skills matrices, develop web-based apps to track progress, incorporate gamification and incentives and provide employees with a clear sense of career progression. They also design solutions such as adaptive ergonomic workstations that make jobs more accessible.

AUO Corporation in Suzhou, China uses machine-learning-enabled decision engines to analyse data from over 25,000 employees, integrating "stability scores" and cultural fit with clear, explainable outputs to better assess new candidates. AI-based interviews evaluate motivation, flexibility and openness to shift work, while vision-based tools evaluate movement and ergonomics. This approach promotes objective, data-driven hiring and reduces early attrition by aligning candidates' capabilities and preferences with operational needs (Figure 12).[26]

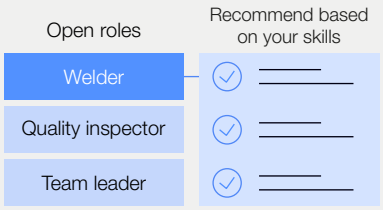
By embedding digital across the employee journey, Lighthouses attract talent, retain knowledge and build a workforce capable of meeting today's demands and thriving amid future change.

FIGURE 11 | **Haier's employee journey is designed for a digitally native workforce**

1 **Attraction**



2 **Matching**



-6p.p. Key role vacancies

-40% Promotion cycle duration

AI-powered key talent identification and career development platform

To address a 12% key role vacancy rate and inefficient career planning, the AI-driven platform uses a two-dimensional competency model and 12 talent metrics to create dynamic profiles. It matches employees to roles and learning resources based on career goals, optimizing a 3-tier succession pipeline, ensuring alignment of talent with organizational needs.

Joint-development

3 **Onboarding**

-50% MTTR

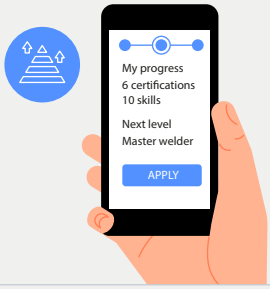
+16p.p. Proportion of high-skilled talent

GenAI maintenance & repair assistant

A GenAI assistant integrates a multi-dimensional knowledge graph using extensive data from IoT signals, equipment manuals and maintenance records. Large language models (LLMs) diagnose faults, generate repair plans and recommend personalized training. Real-time guidance and structured learning accelerate upskilling for transitions from operator to engineer roles.

In-house development

4 **Retention**



+28% Average FTE tenure

+43% GenZ satisfaction rate

Proactive-service employee stability prediction & improvement

A unified platform integrates HR and satisfaction data to track 14 employee need indicators (e.g. pay, career growth) through dynamic profiling. Using gradient boosting decision tree (GBDT) algorithms, it predicts attrition risks and recommends tailored interventions such as training, role adjustments, or compensation changes.

Joint-development

Note: MTTR = mean time to repair.

Source: Global Lighthouse Network.

AUO Corporation

Suzhou, China

-81% Attrition in first 90 days

-63% Recruiting lead time

-75% Interview waiting time

AI-powered interview optimization with predictive stability modelling

To address labour shortages and turnover, AUO Corporation deployed an AI-managed queue for e-resume submission, identity verification and multimodal resume analysis. It incorporates psychocultural assessments and AI interviews, utilizing gradient boosting models trained on 25k+ records with 13 key factors to predict job stability in real time.

In-house development

Application initiation

- Applicant completes initial application
- Applicant's profile is created based on ID

AI-based interview

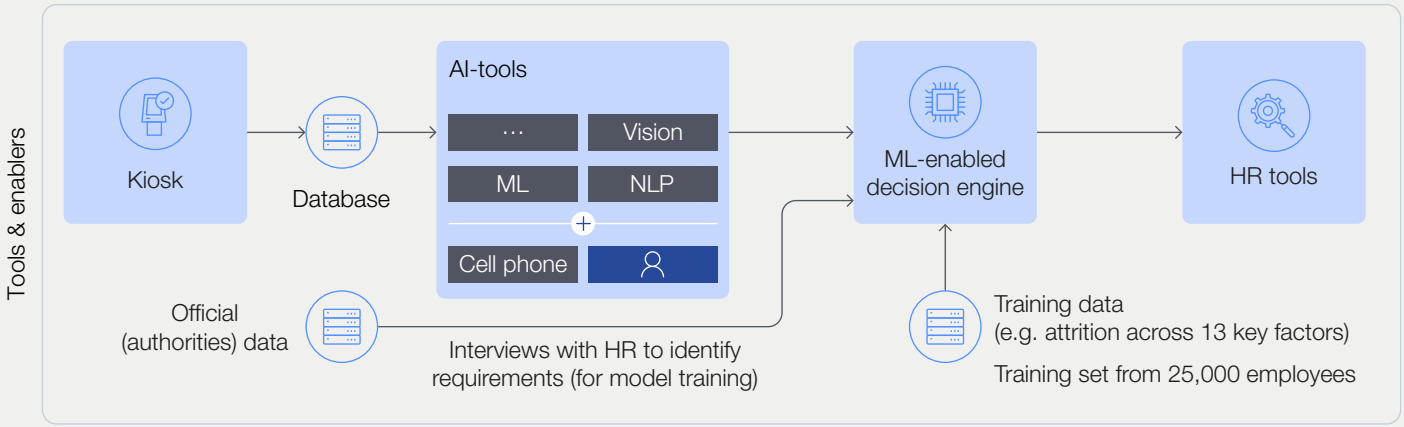
- AI agent interviews applicant
- Basic questions about motivation, career, plans, skills, education, openness to work in shifts etc.
- Vision-based ergonomic movement & flexibility controls (e.g. arm movements)

Candidate selection

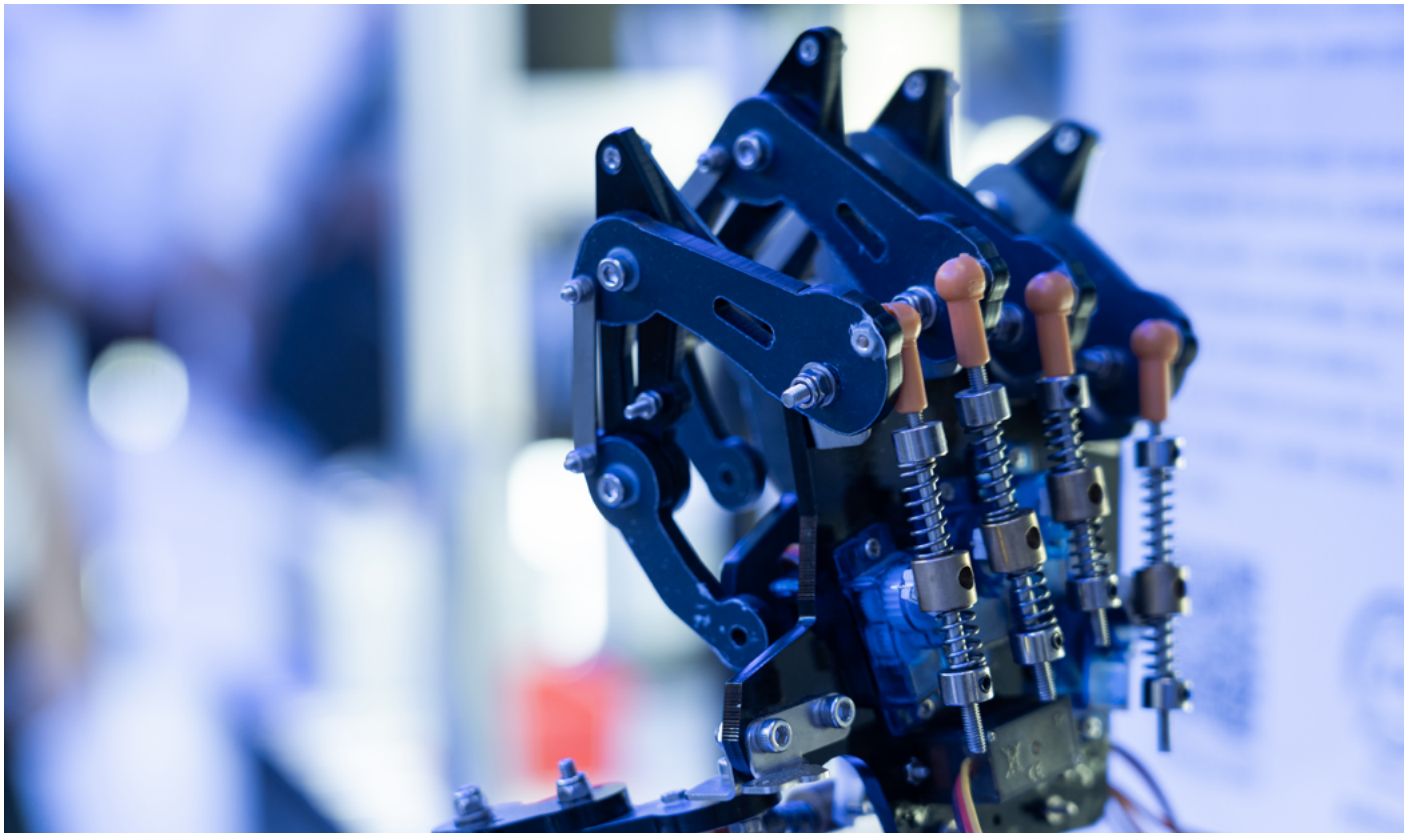
- AI scores application and proposes contract in case of high fit probability
- "Stability score" with explanations

Initial onboarding

- Contract is created and offered
- Information with next steps is shared (targeted training courses, potential development area)



Source: Global Lighthouse Network.



Leveraging AI democratization: scaling-up innovation through accessible technologies

AI models are becoming more efficient – smaller models now match the performance of their larger predecessors while being faster, easier to deploy and cheaper to scale up.[27] Between November 2022 and October 2024, inference costs – the computing resources and cloud or server fees involved in training AI models – dropped 280x, hardware costs declined by 30% per year and energy efficiency improved by 40%.[28] AI systems have also achieved rapid gains in sustained reasoning and workflow orchestration, achieving more with fewer parameters.[29]

These advances are redefining what work looks like on the factory floor. As AI shifts from automating tasks to orchestrating decisions, frontline and logistics operators are moving from "doing" to "overseeing". Recognizing that skills in this new era evolve as quickly as the tools themselves, companies are shifting from reactive consumers to co-producers of talent, partnering with educational institutions and regional ecosystems to collaborate in defining the next generation of digital skills.[30]

As AI evolves, new tools are putting problem-solving power directly in the hands of frontline teams – leveraging democratized innovation to strengthen enterprise resilience. Lighthouses show how this shift draws in a new generation of digital-native talent while reinvigorating experienced employees with technologies that elevate and redefine their work.

Low/no-code tools and platforms enable innovation directly from the shop floor

The democratization of AI is changing both the tools of innovation and the hands that wield them. For example, low- and no-code tools and large language model (LLM)-enabled tools can reduce development costs by up to 70%, while enabling "citizen developers" (frontline workers without specialized coding knowledge) to spearhead innovation.[31] The role of citizen developers is already dominant at Lighthouses – responsible for 58% of solutions in 2025.[32]

At **SOCAR**'s Carbamide plant in Sumqayit, Azerbaijan, a no-code platform empowered frontline operators without analytics expertise to optimize energy use and reduce emissions in gray urea production. Designed as a scalable, self-service product, the solution integrates a machine learning-based power and steam optimization engine with an intuitive interface, enabling rapid control logic customization by non-technical users. The platform has already been scaled up to three other sites (Figure 13).[33]

When operators can design and deploy their own digital solutions, agility becomes embedded in the organization's DNA. For Lighthouses, this is what resilience looks like in practice – a workforce empowered to solve problems and incubate new ideas from the shop floor up.

SOCAR

Sumqayit, Azerbaijan

-18% Energy consumption

-22% Scope 1 emissions

-19% Water consumption

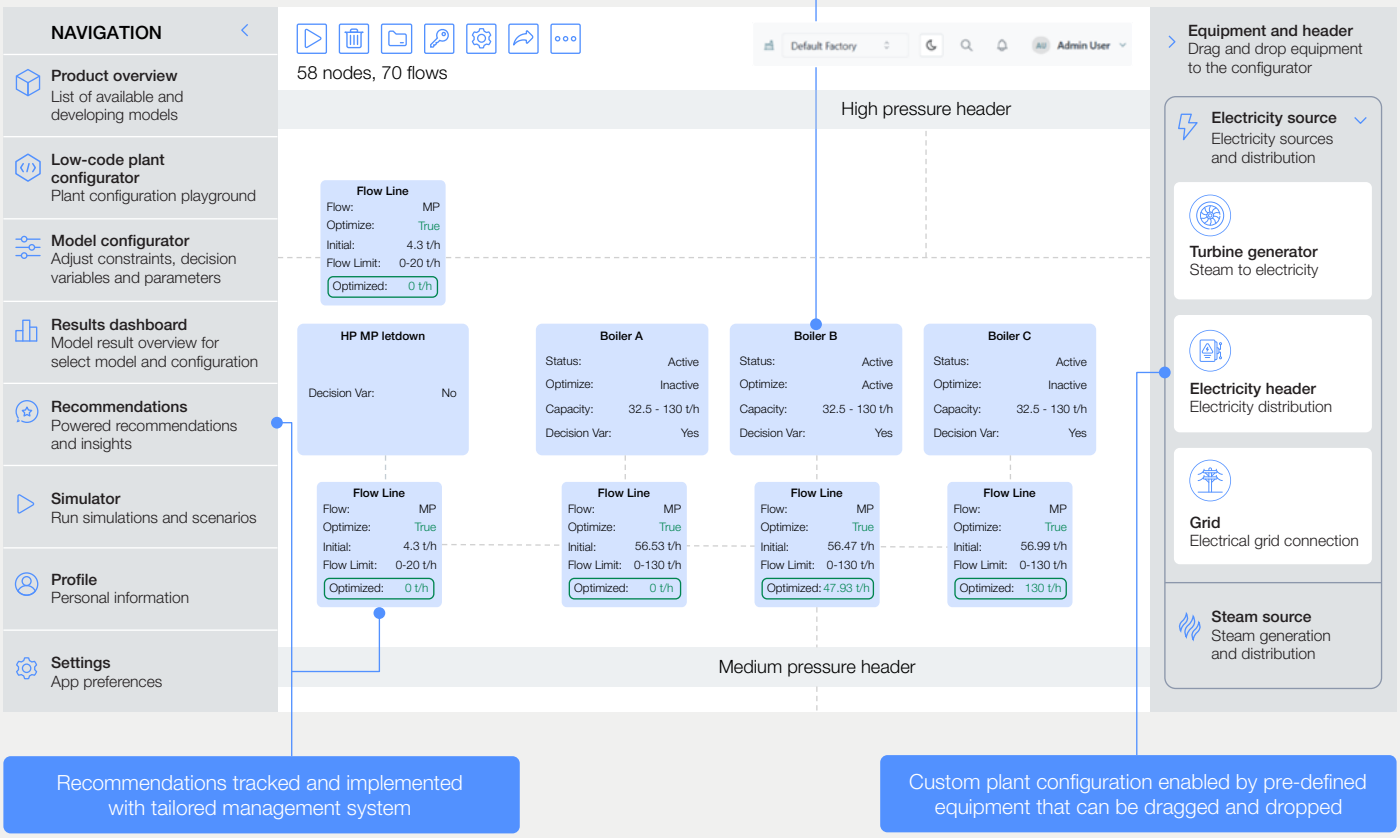
Dynamic energy optimization with ML-enabled no-code platform

Gray urea production is emission-intensive, driven by natural gas in power and steam generation. To achieve net-zero commitment and reduce costs, an energy network enabled by ML optimizes power and steam supply by analysing 156 IoT sensors and adjusting 35 parameters closed-loop and in real time. Operators use a no-code platform to re-configure solutions, run what-if simulations and scale the model to other sites.

In-house development

Equipment characteristics and sensor-level energy calculations defined by user from control panel

No-code configuration and simulation platform[1]



Recommendations tracked and implemented with tailored management system

Custom plant configuration enabled by pre-defined equipment that can be dragged and dropped

Note: 1. All datapoints in this figure are illustrative only.

Source: Global Lighthouse Network.

FIGURE 14 | **AUO Corporation's virtual supervisor assistant for task orchestration**

AUO Corporation

Suzhou, China

-74% Frontline leaders' turnover rate

-71% Frontline leaders' admin workload

+200% Frontline leaders' coaching time

AI-enabled virtual supervisor assistant

GenAI transforms supervisor roles from "doers" to "orchestrators". Virtual assistants reduce reporting, planning and analytics workloads, with a human-in-the-loop for precise decision-making. Instead of a generalized AI, specialized systems optimize performance for specific tasks, addressing computing power constraints. Virtual teams receive performance evaluations, feedback and "promotions" to maintain team cohesion.

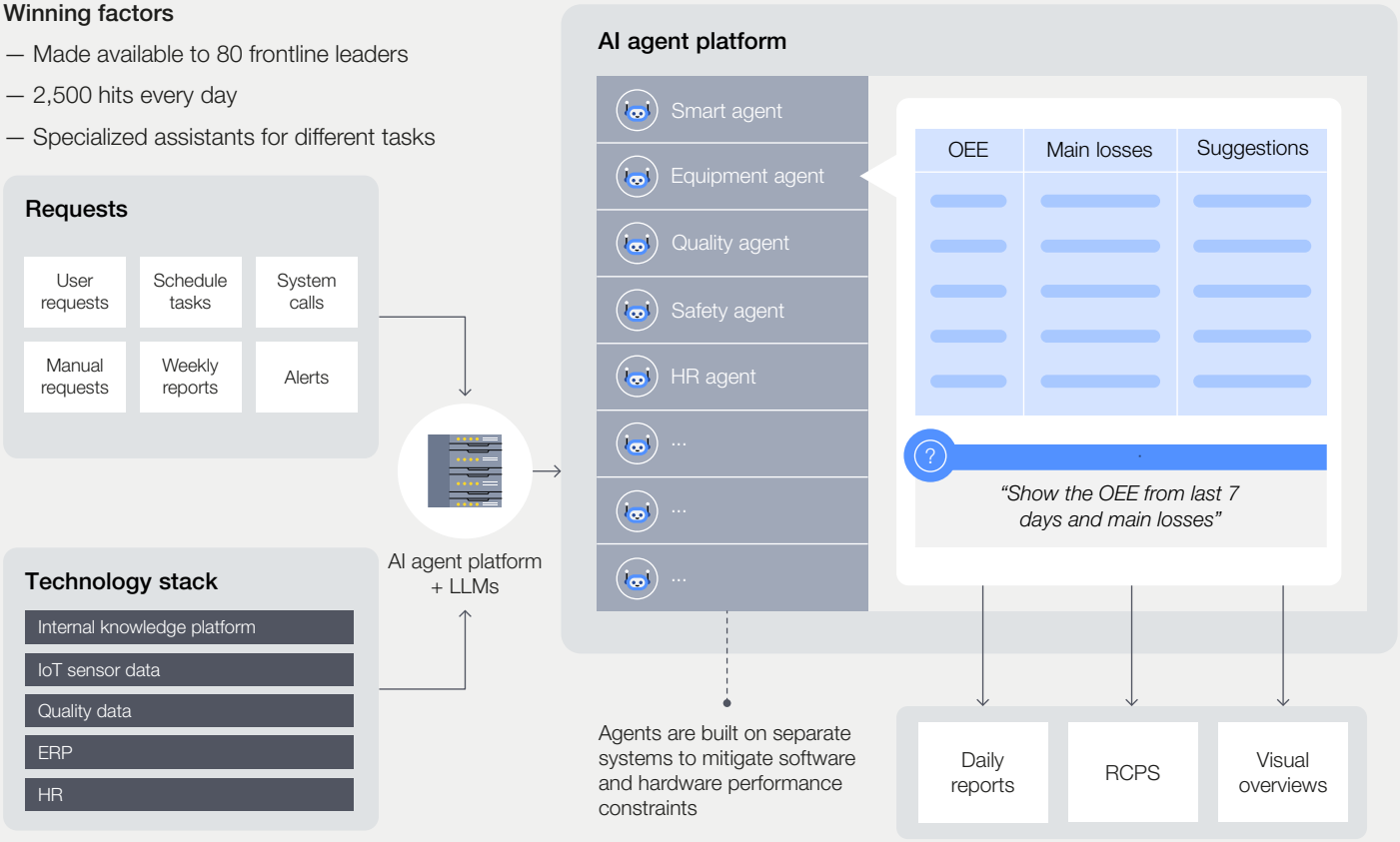
In-house development

Winning factors

— Made available to 80 frontline leaders

— 2,500 hits every day

— Specialized assistants for different tasks



Notes: OEE = overall equipment effectiveness, RCPS = resource-constrained project scheduling.

Source: Global Lighthouse Network.

Business-backed innovation to resist shiny objects

The rapid advancement of AI is inspiring Lighthouses to think strategically about how they rewire their operations. Though inference costs are dropping, the cost of training AI models has skyrocketed – from a few hundred dollars for early models to tens or even hundreds of millions for today's large foundation models. To stay competitive, Lighthouses are reserving larger, more expensive models for critical tasks with direct business impact.[34]

AUO Corporation deployed an AI-enabled virtual supervisor assistant to free up valuable time, now dedicated to frontline coaching and complex problem-solving (Figure 14). The "AgentX" platform integrates LLMs and retrieval-augmented generation (RAG) to support intelligent assistants across key areas, including quality, equipment and safety. The platform monitors production data in real-time and automatically generates anomaly alerts, task assignments and resolution recommendations.[35]

The rise of AI-enabled "virtual assistants" shows how technology can amplify the human core of operations. By automating repetitive monitoring and administrative work, these systems free frontline leaders to focus on coaching, problem-solving and continuous improvement – the very levers of resilience. Lighthouses demonstrate that when AI

augments human judgment, rather than replacing it, organizations achieve greater agility and make decisions with more confidence and trust.

Lighthouses distinguish themselves by going beyond adoption of advanced technologies. With a keen eye to scalable impact, they rethink how to derive optimal solutions for their most pressing challenges and stay hyper-focused on practical, impact-driven innovation. They prioritize purpose-built designs that address specific pain points, such as manual data entry or complex user interfaces.

With many operational leaders wondering about the practical applications and ROI of humanoids,[36] **Eaton** in Changzhou, China offers a timely example. The site faced a 300% increase in wiring complexity for control boxes, requiring inspection of 30,000 wires daily. Instead of pursuing a fully humanoid robot, Eaton deployed an autonomous mobile robot (AMR)-supported torso, with a dual-hand, camera-guided platform optimized for wiring inspections, which improved inspection accuracy to nearly 100% (Figure 15).[37]

This focus on function over form reflects a core Lighthouse principle: prioritizing business challenges over implementing technology for its own sake. By doing so, Lighthouses avoid the resource allocation trap that often leads companies to overinvest in innovations that maintain status quo rather than those that drive true transformation.

FIGURE 15 **Eaton's approach to piloting humanoids**

Eaton

Changzhou, China

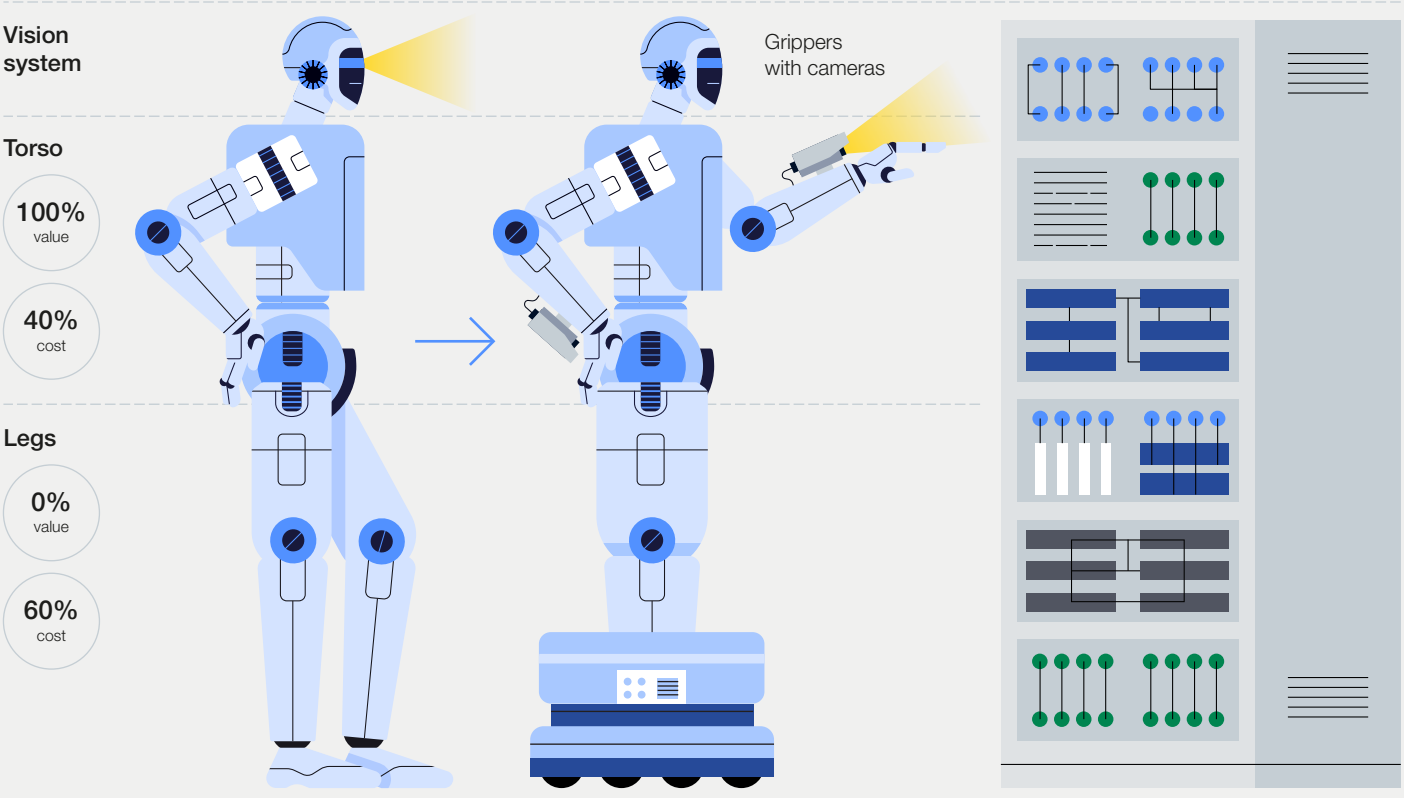
99.8% Inspection accuracy

-90% Trouble-shooting time

Humanoid-powered inspection optimization to reduce wiring defects

As wires in control boxes increased by 300% (30k wires for inspection daily), manual methods led to high defect rates. Wiring errors accounted for over half of yield loss, with long detection times. Troubleshooting took 50 hours monthly and training inspectors took 6 months, creating skill gaps. Eaton piloted humanoid robots with computer vision machine learning (CVM) technology to identify wiring errors and improve trouble-shooting efficiency.

Joint-development



Robot's value lies entirely in the torso, which houses the dual-hand system and **camera-guided vision system** designed for high-precision inspections.

Autonomous mobile robot (AMR)-supported torsos are easily adapted for various tasks (e.g. quality control audits, routine shop floor tours) enhancing operational flexibility.

Source: Global Lighthouse Network.

2.3 Scaling-up impact with collaboration and purpose

The potential for further digitalization across supply chains remains significant, with much of the value still untapped. Even after years of disruption that exposed the cost of blind spots, more than 40% of organizations still lack visibility into tier-1 supplier performance, suggesting that while intent is high, achieving true end-to-end transparency remains elusive.[38] Meanwhile, Lighthouses on average have onboarded roughly 36% of their customers and suppliers onto their IoT platforms, marking a move from localized efficiency to collaborative networks that create mutual value and resilience.[39]

Lighthouses demonstrate that true digital leadership extends beyond factory walls to supply chains. By cultivating partnerships grounded in transparency, mutual capability building and long-term value creation, they are also reducing waste, improving traceability and accelerating decarbonization.

Ecosystem collaboration: amplifying impact across the value chain

Lighthouses are capable of translating early digital wins into system-level impact because they have managed to effect an essential shift from transactional to transformational collaboration across the value chain. With shared standards, data trust and aligned incentives, Lighthouses activate entire value chains whereas most companies stall at the enterprise boundary.

Knowledge sharing and capability building

Lighthouses collaborate across their end-to-end value chains to proliferate knowledge and drive network-wide scale. By sharing insights and best practices with suppliers, peer sites within the organization and end-customers alike, they turn individual achievements into enablers for system-wide impact. This ripple effect strengthens the entire network.

Yunnan Baiyao in Kunming, China actively seeks to amplify capabilities across its end-to-end value chains. The company's Welkin AI Platform provides enterprise-level LLM and agent capabilities, with users generating 30+ low code and 20+ AI-enabled applications. By partnering with universities, the site created a robust talent pipeline supported by project-based learning. The site trained 170+ suppliers on environmental, social and governance (ESG) practices and engaged 200+ small and medium enterprises (SMEs), while supporting small farmers with an IIoT and GenAI-enabled digital platform focused on improving agricultural practices (Figure 16).[40]

End-to-end supply chain synchronization

Another distinction of Lighthouses is their ability to synchronize the full value chain, translating data connectivity into coordinated action. Rather than optimizing in silos, they integrate planning, production, logistics and customer demand signals in near-real time. This seamless flow of information breaks down geographic and organizational barriers, enabling joint decision-making with suppliers and customers.

For example, **Yunnan Baiyo**'s satellite remote sensing and AI-powered yield forecasting and procurement of herbs improved yield prediction accuracy by 23 percentage points and reduced inventory levels by 35%. The integration of high-resolution satellite images and AI models enabled precise monitoring of crop health and growth, ensuring stability and supply chain resilience. This approach also improved raw material quality, leading to better product outcomes (Figure 16).[41]

Embedded sustainability: transforming resource efficiency and circularity

Through purposeful ecosystem collaboration, Lighthouses turn operational gains into network-wide impact, driving productivity, sustainability and resilience across the value chain. Resource efficiency provides a clear example: amid sharp price increases in commodities such as fertilizer, aluminium, coal and steel, Lighthouses have demonstrated greater stability by minimizing exposure to global logistics and overseas production. While supply chains and commodities tend to correct over time, recurring mid-term disruptions underscore the value of these resilient models and are fuelling new interest in circular business approaches that reclaim products and materials for reuse.[42]

FIGURE 16 | **Yunnan Baiyao builds capabilities of its key partners across the value chain**

Satellite remote sensing & AI empower yield forecasting & herb procurement

Herbal toothpaste's active ingredients come from plants of 3-year growth and from widespread areas, challenging yield-forecasting & supply stability. Using high-resolution satellite images & weekly remote sensing over 400,000 km², AI algorithms precisely map cultivation areas. Based on historical yield records and regional characteristics, annual yield is forecasted, enabling county-level procurement planning.

+23p.p. Yield prediction accuracy

-35% Inventory levels

In-house development

Internal capabilities

-0.6p.p. Turnover rate

Digital roles

9 digital roles created including AI, data & IoT engineers, software developers and translators

94% Engagement

Development

70% project-based,10% formal training and 20% mutual learning; Baiyao Academy

91% Internal succession rate

Progression

8 predefined career tracks and PDCA-based performance management

94% Key role retention rate

Progression

Competitive compensation, equity incentives and personalized benefits

Value chain capabilities

University partnerships

10+ universities fulfill majority of high-skill needs and provide pipeline of interns

SMEs

>200 small farmers engaged

Suppliers

170 trained on ESG; 80% of supplier base

Tech partners

Alibaba Cloud
Cloud, AI and collaborative tools

SIEMENS
Factory planning & process innovation

Midea
Digital factory operations & energy management

Schneider Electric
Predictive maintenance

VélkhAi
Enterprise-scale AI platform

Digital cultivation platform and multimodal LLM to improve good agriculture practices (GAP) adoption

Bad cultivation practices cause excess pesticide, mould & loss of actives. A multimodal LLM, fine-tuned on 100k+ planting, processing and GAP regulation entries guides farmers on planting area, timing, quantity by Q&A and identifies pests and diseases based on uploaded photos. Four automated lines available to farmers & partners for cleaning, slicing and drying use AI image recognition for sorting and grading, ensuring high quality and timely material processing.

-26p.p. Premium raw material ratio

-5p.p. Ratio of returns to farmers

+19% Farmers' income

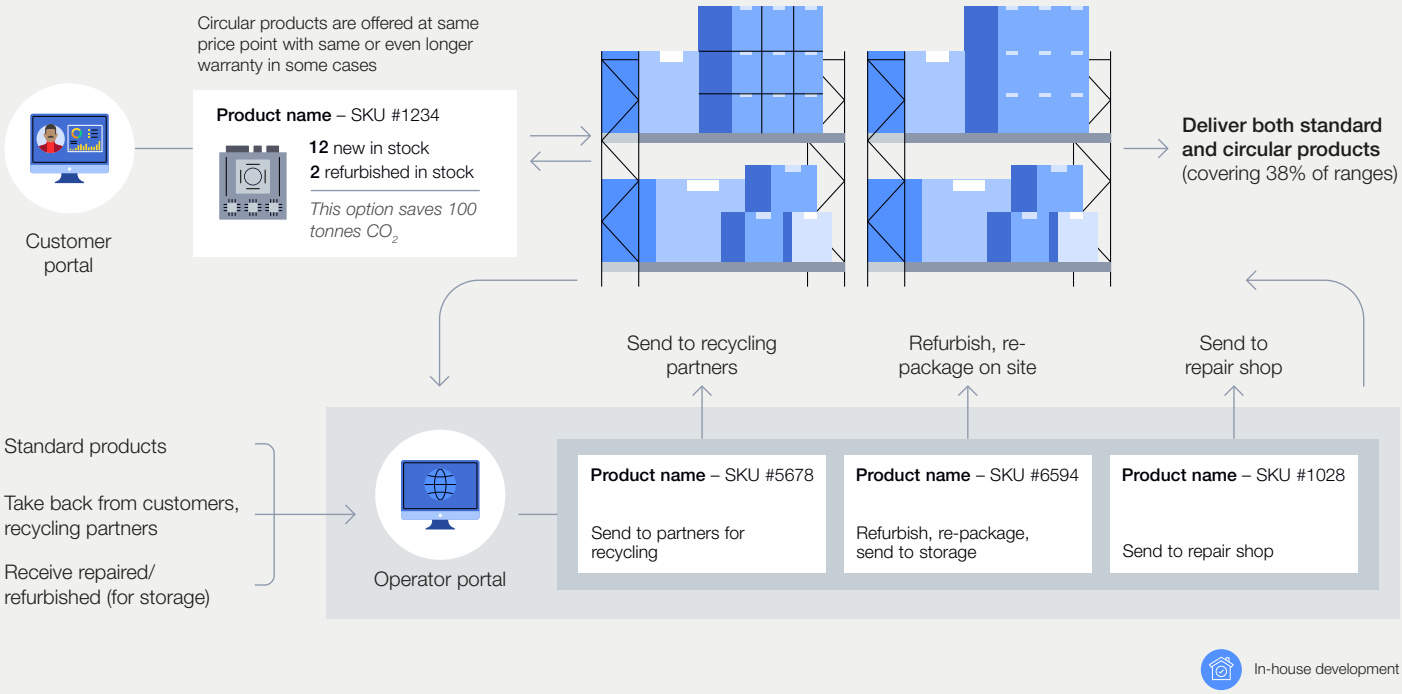
In-house development

Source: Global Lighthouse Network.

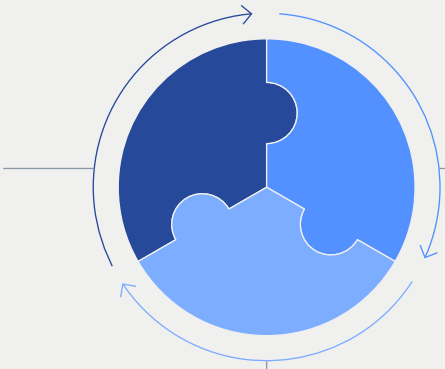
Circular economy for resource efficiency and supply security

To shift from a linear "take-make-waste" to a circular "use better, longer and again" model, **Schneider Electric**'s distribution centre in Evreux, France mobilized its supplier ecosystem and in-house expertise to transform its operating model with circularity at the core. The site integrated data, financial and physical systems to secure new sources of critical raw materials such as copper, silver and rare earths, expanding its circular product offering to 38%. In two years, the Evreux distribution centre reduced scope 3 emissions by 43%, single-use plastic by 40% and energy consumption by 18%, contributing to enterprise-wide goals to lower carbon footprints across 50% of its product ranges and inspiring rollouts to other network sites (Figure 17).[43]

FIGURE 17 **Schneider Electric transformed its fulfilment centre for a circular future**



Circular model enabled by aligning strategy, capabilities and change management:



Strategy

- **Redefined financial strategies** to consider customers as suppliers
- **Enabled total cost assessment** of product transformation via reverse logistics and circular operations
- **Established legal entities** for new circular roles

Capabilities

- **Integrated two SAP instances to manage linear and circular products** within the same warehouse management system
- **Utilized integrated data from full product lifecycle tracking** and circular catalogues for inventory management, displaying real-time counts on customer-facing web platforms

Change management

- **Deployed transformation governance** to oversee circular flows, including order, stock and product state monitoring, as well as demand and supply reviews
- **Established a dedicated management team** to coordinate circular supply chain activities and ensure operational alignment

Source: Global Lighthouse Network.

3 Trends in technology: Lighthouses and the agentic revolution

Lighthouses are leading the shift from digital enablement to AI-native enterprises, embedding agentic intelligence across factories and value chains

Lighthouses are leading in AI deployment, boosting integration of analytical AI and machine learning across top use cases and rapidly adopting generative AI. They are also pioneering the shift from “smart factories” to self-learning, adaptive and autonomous “cognitive factories” powered by advanced AI technologies, including AI agents. Furthermore, they are redefining global value chains, evolving from digitally-native to AI-native organizations operating as “cognitive networks”.

3.1 Mastering AI adoption: from hype to scalable assets

Navigating the S-curve of AI adoption

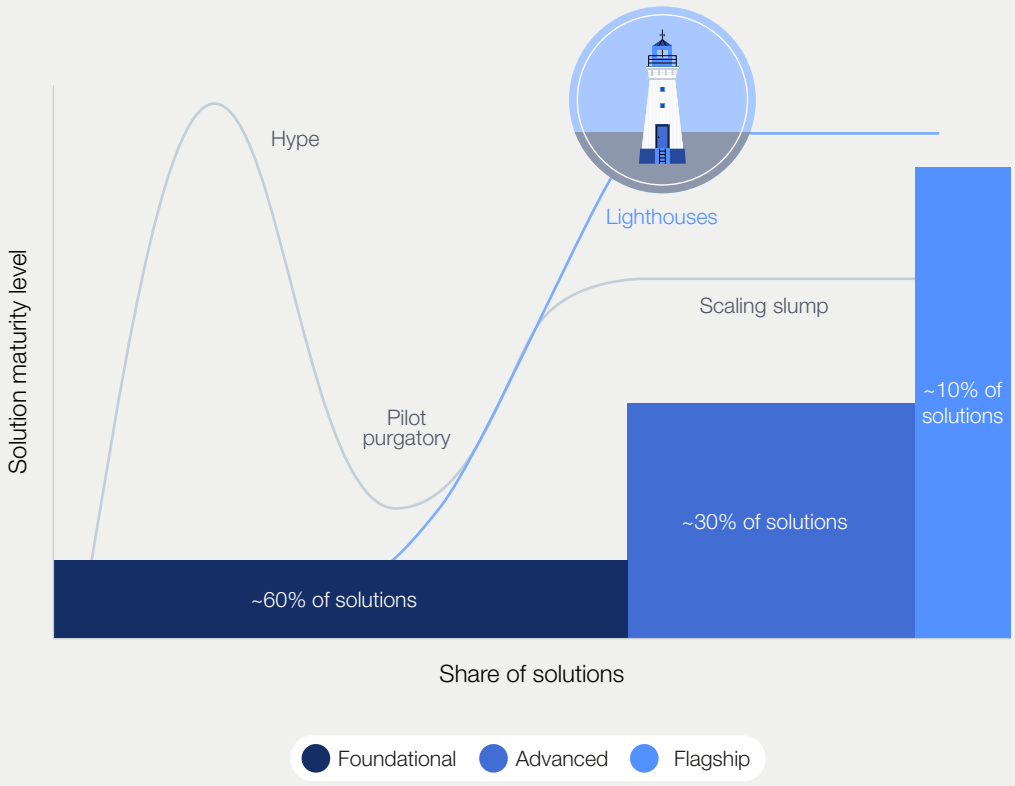
Lighthouses remain at the forefront of AI deployment, with a growing share of their top-five use cases powered by advanced AI capabilities. Under an updated classification methodology, analytical AI and machine learning account for roughly 62% of Lighthouse solutions in 2025, reflecting continued deep adoption across core operations.

At the same time, the use of GenAI has accelerated sharply, reaching 23% of top-five solutions in 2025, up from 9% in the prior year. AI agents are also beginning to emerge, enabling 5% of solutions in 2025 (Figure 19). Despite the inherent costs and complexities, Lighthouses are adeptly navigating the S-curve of AI adoption – a journey from initial hype, through a valley of uncertainty, to the reality of sustained value.

Lighthouses build from a foundation of hyper-connectivity, developing advanced AI solutions on top of optimized processes and information flows. As feedback loops are closed and capabilites advance, Lighthouses deploy flagship solutions, such as autonomous process control, where technology safely manages higher-risk tasks (Figure 18). Starting domain-first, typically with two to three focus areas, they manage change, capture synergies and uncover value aligned to risk. As process AI tools mature, implementation accelerates, giving organizations deeper visibility into workflows and intervention points.

By embedding generative AI directly into core workflows, Lighthouses achieve measurable gains in speed, accuracy and efficiency. This shift to AI-native systems shows the power of technology when it is designed to augment, not replace, the people at the heart of operations.

FIGURE 18 | **Lighthouses cut through new technology hype with a value-backed roadmap**



Lighthouses typically deploy up to 50+ solutions at scale with 5-10 flagship

- **Hyper-connectivity**
  AGV/AMR logistics automation, IoT-based OEE dashboards, robotics/co-bot integration, digital performance management, condition-based maintenance
- **AI-assisted systems**
  Vision-based quality inspection, open-loop parameter optimization, NLP/chatbot-enabled reporting, AI-enabled predictive maintenance
- **Closed-loop, autonomous**
  Self-optimizing process control (root cause analysis, scheduling), parameter optimization (e.g. energy consumption), agentic decision systems

Notes: AGV = automated guided vehicle, AMR = autonomous mobile robot.

Source: Global Lighthouse Network.

Lighthouses treat technical decisions as business-critical

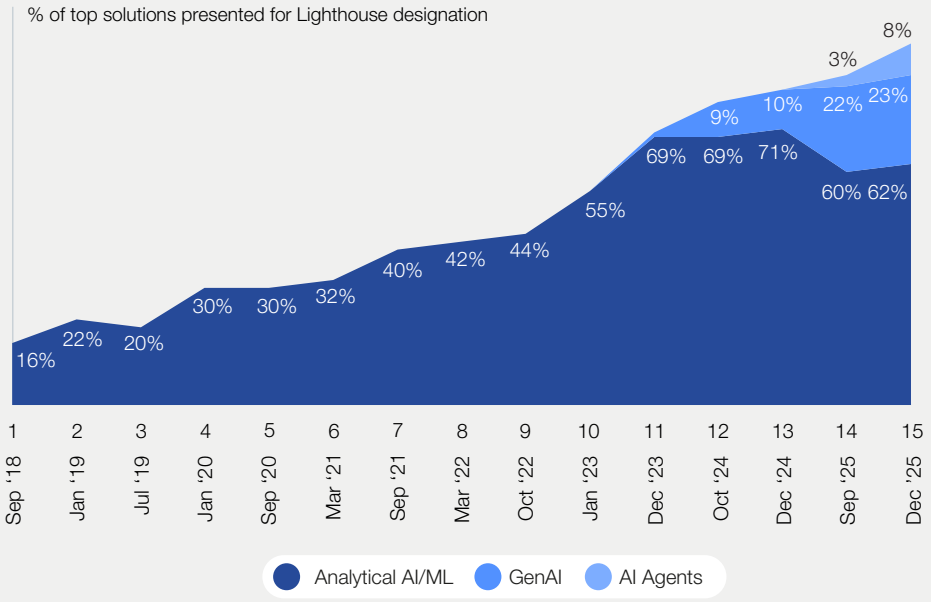
Each new technology wave is as new to Lighthouses as to anyone else, but they stay ahead by steadily building capabilities that matter. As tools become more accessible, in-house teams move quickly, prototyping and refining solutions tailored to local operational needs.

Figure 19 compares development approaches, ranging from in-house builds to third-party solutions, across three AI technologies: analytical, generative and agentic. The variation reveals a deeper shift: technology choices are now strategic levers for value creation, not just implementation details. As decisions move from IT to the C-suite, Lighthouses weigh not only cost and speed, but also how each approach builds differentiated capabilities and resilience across the enterprise.

Lighthouses treat make-versus-buy not as a binary choice, but rather as a dynamic capability, building internal fluency while maintaining an open ecosystem of partners. As AI and analytics become standardized modules within enterprise resource planning (ERP) and other vendor platforms, this dual model enables agile in-house development alongside partner-driven scale, preventing technology fragmentation and keeping AI anchored in business value.

FIGURE 19 | **Evolution of artificial intelligence (AI) at Lighthouses**

Analytical AI/ML and GenAI solutions, by Lighthouse cohort



Development approaches in 2025

	In-house developed (%)	Cost ($K)	Speed to deploy (months)	ROI[1]
Analytical AI/ML	69%	680	12	4.2
GenAI	71%	370	7	1.4
AI agents	88%	228	7	1.3

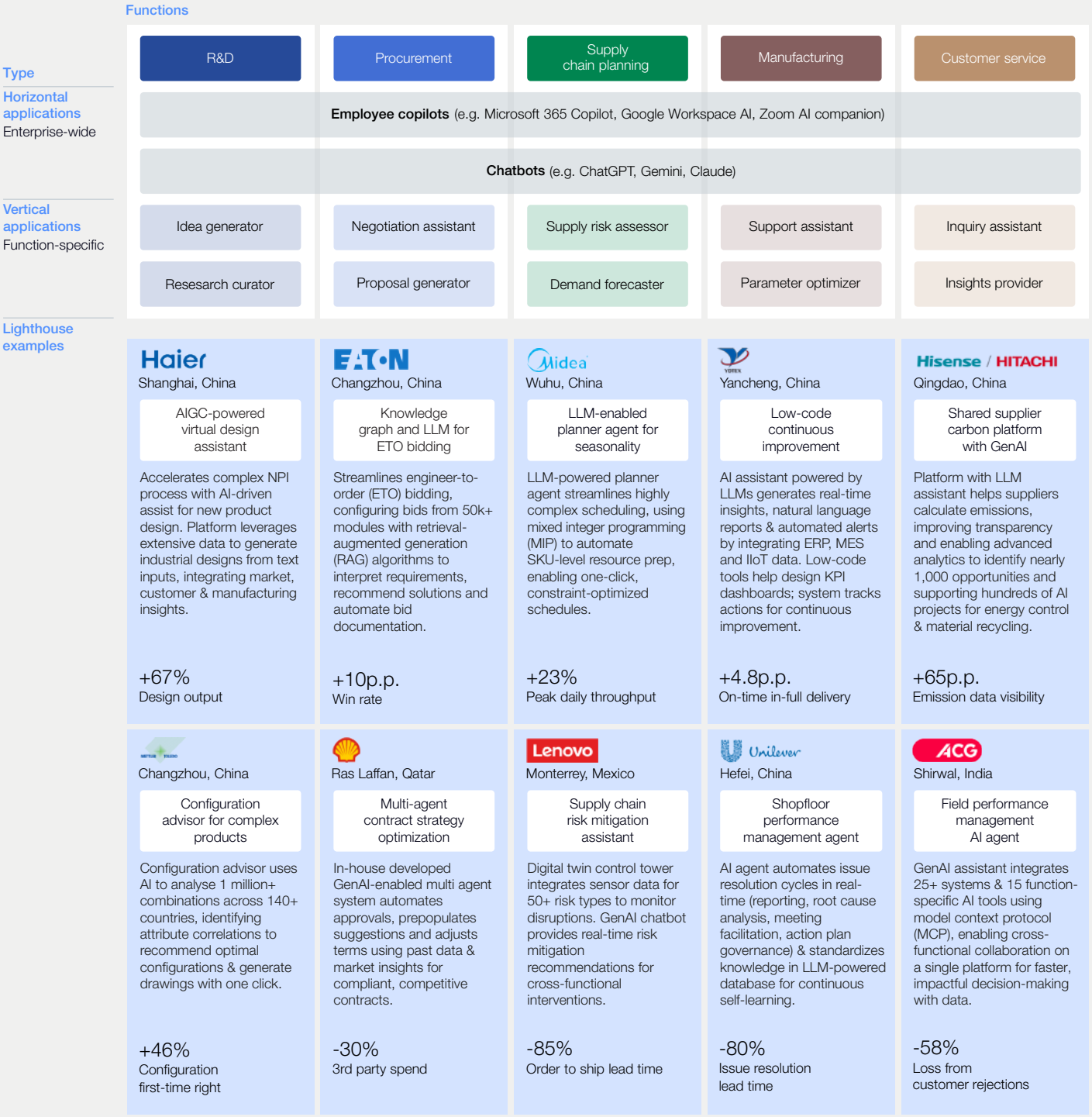
Notes: 1. ROI calculation: total investment divided by total financial benefit (to date, at time of application).
Source: Global Lighthouse Network.

Overcoming the "GenAI paradox" by focusing on high-impact vertical applications

Nearly eight in 10 companies have deployed GenAI in some form, yet about 80% report no significant impact on earnings – a phenomenon McKinsey calls the "GenAI paradox".[46] The gap stems from over-investing in horizontal applications and under-investing in vertical ones. Horizontal applications, such as chatbots, improve productivity but deliver incremental value. Vertical applications, by contrast, are function-specific and transformative: because they directly influence pricing, demand, risk and asset utilization, vertical applications are more likely to drive measurable revenue uplift, margin expansion and cost reduction than horizontal applications. However, vertical applications are harder to implement, as they require deep integration with existing systems and domain-specific data (Figure 20).

Lighthouses are breaking through by focusing on high-impact vertical applications which, when assetized[47] as enterprise capabilities, provide a competitive edge. For example, those competing on customization or speed to market, such as **Haier** in Shanghai, China and **Eaton** in Changzhou, China, deploy GenAI for idea generation, research curation and sales enablement. Rather than adding operational complexity, AI streamlines it, transforming data and design inputs into first-time-right prototypes that compress the time from ideation to industrialization (Figure 21).

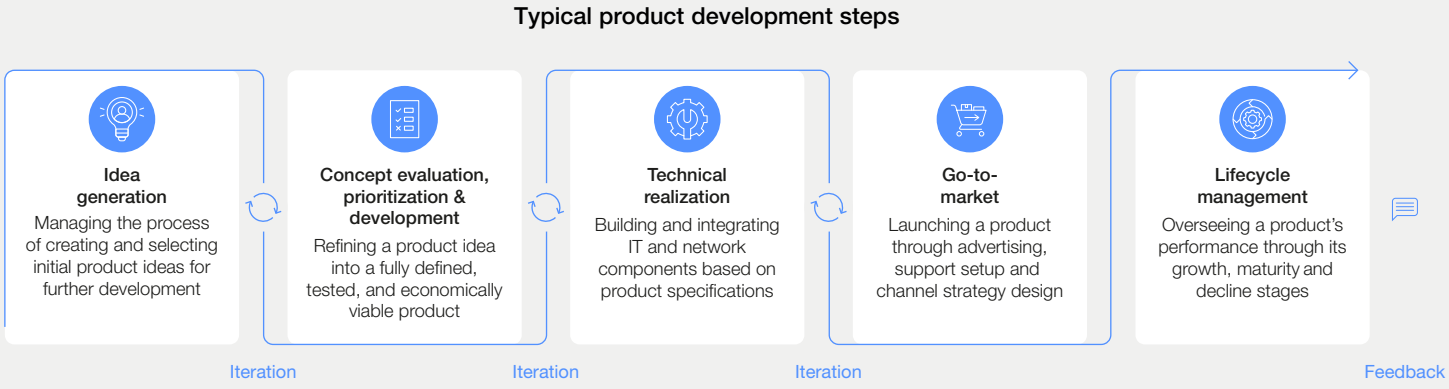
FIGURE 20 | **High-impact vertical AI applications deployed at Lighthouses**



Note: NPI = new product introduction.

Source: McKinsey & Company, examples from 2025 Lighthouse cohort.[45]

FIGURE 21 | **AI applications to meet growing demands for speed, customization and innovation**



Vertical, functions-specific applications

Idea generator, research curator

Haier

Shanghai, China

-50%	+13p.p.	+67%
Time to insight	First-pass drawing approval rate	Design output per month

AIGC-powered virtual design assistant

Haier addressed the challenges of a highly complex new product introduction (NPI) process, characterized by frequent customer requirement changes, by deploying an AI-generated content (AIGC)-powered virtual design assistant.
The solution, called the co-designer platform, leverages market and social media data, as well as technical and manufacturing data, to generate designs. Backed by expert design assets and customer preference data, the platform processes multimodal inputs to run a domain-specific text-to-image model, generating multiple industrial renderings from text descriptions.

In-house development

Negotiation assistant, risk assessor

Eaton

Changzhou, China

+10p.p.	-52%	+55%
Win rate	Bidding & customized order design cycle	Design output per year

Knowledge graph and LLM-powered smart bidding system

Eaton tackled the complexities of engineer-to-order (ETO) bidding, which involves diverse specifications, implicit requirements and rapid-response needs by deploying a knowledge graph (KG) powered by large language models (LLMs). The system intelligently configures bids based on over 50,000 modules, efficiently handling complexity and accelerating bid specification preparation. LLMs, integrated via retrieval-augmented generation (RAG), accurately interpret customer requirements and provide recommendations. Automated documentation further streamlines the process by generating customized bids.

Joint-development

Insights provider, customer service assistant

Eaton

Changzhou, China

+73%	+66%	-39%
Production efficiency	Drawings/ FTE	Order-to-ship lead time

AI-enabled simulation for cabinet performance optimization

Eaton deployed an AI-enabled simulation platform to optimize cabinet performance and reduce delivery cycles. The solution includes a cloud data portal and a KG-based smart design platform, where engineers input variables to automatically generate module-drawing changes. Simulation-enabled computer-aided engineering (CAE) achieved one-click wiring design and accuracy checks, while AI-powered computer-aided manufacturing (CAM) optimized production paths and material usage.

Joint-development

Source: Global Lighthouse Network.

The modular design of GenAI systems enables them to be easily adapted across contexts and requirements, enabling large-scale deployment of vertical applications. Once trained on a specific task or dataset, a model can be fine-tuned for new product lines without starting from scratch. By investing early in data infrastructure and targeted AI capabilities, Lighthouses elevate GenAI from a tool to a true co-collaborator.

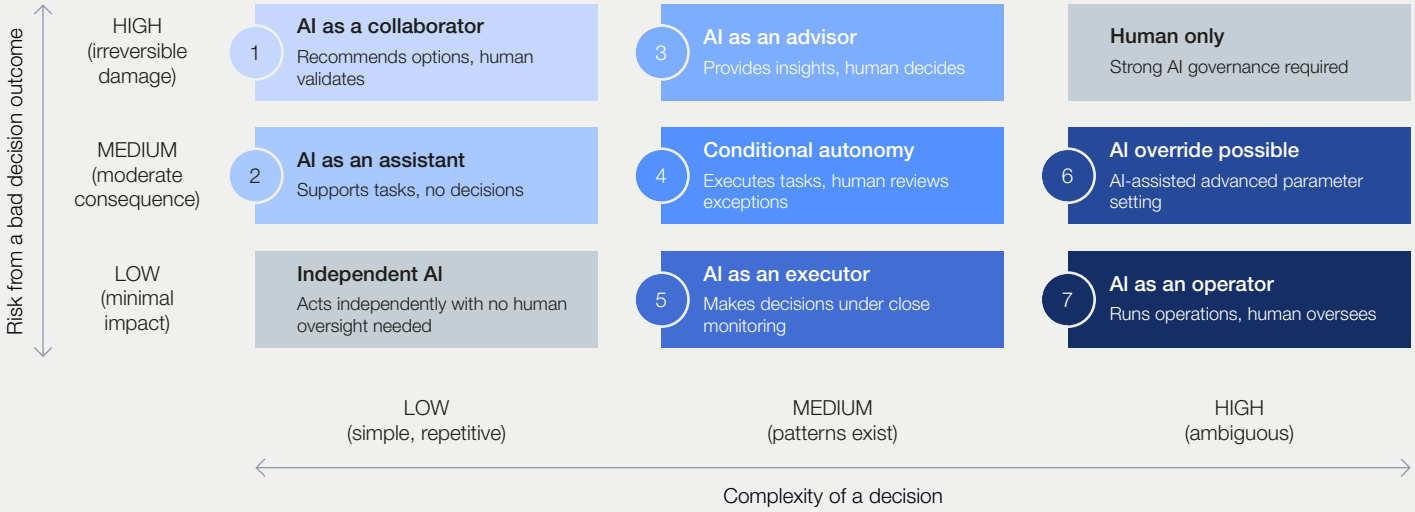
3.2 Cognitive factories: staying value-backed with human-centric AI

Lighthouses are driving the shift from “smart” to “cognitive” factories – sites with self-learning, adaptive and increasingly autonomous operations. Powered by advanced AI applications such as AI agents, these factories enable a single operator to oversee multiple systems that are increasingly capable of making real-time decisions for core processes. Drawing on deep process expertise and rich data ecosystems, Lighthouses are building AI-enabled “brains” that orchestrate entire operations with speed and precision.

Human-in-the-loop decision making: balancing automation with oversight

AI applications demand robust safety and governance, but agentic AI – where systems act as active collaborators – requires even greater rigour. Lighthouses embed human oversight as a core design principle, moving beyond passive “human-in-the-loop” models. As agents begin managing other agents, it becomes critical to pinpoint moments for human intervention and define accountability. Fairness audits, explainability frameworks and continuous governance loops are now table stakes for maintaining trust as automation scales up, ensuring AI decisions are transparent and that leaders understand not just what the system decides, but *why* (Figure 22).

FIGURE 22 | **How Lighthouses adapt AI oversight to decision-making contexts**



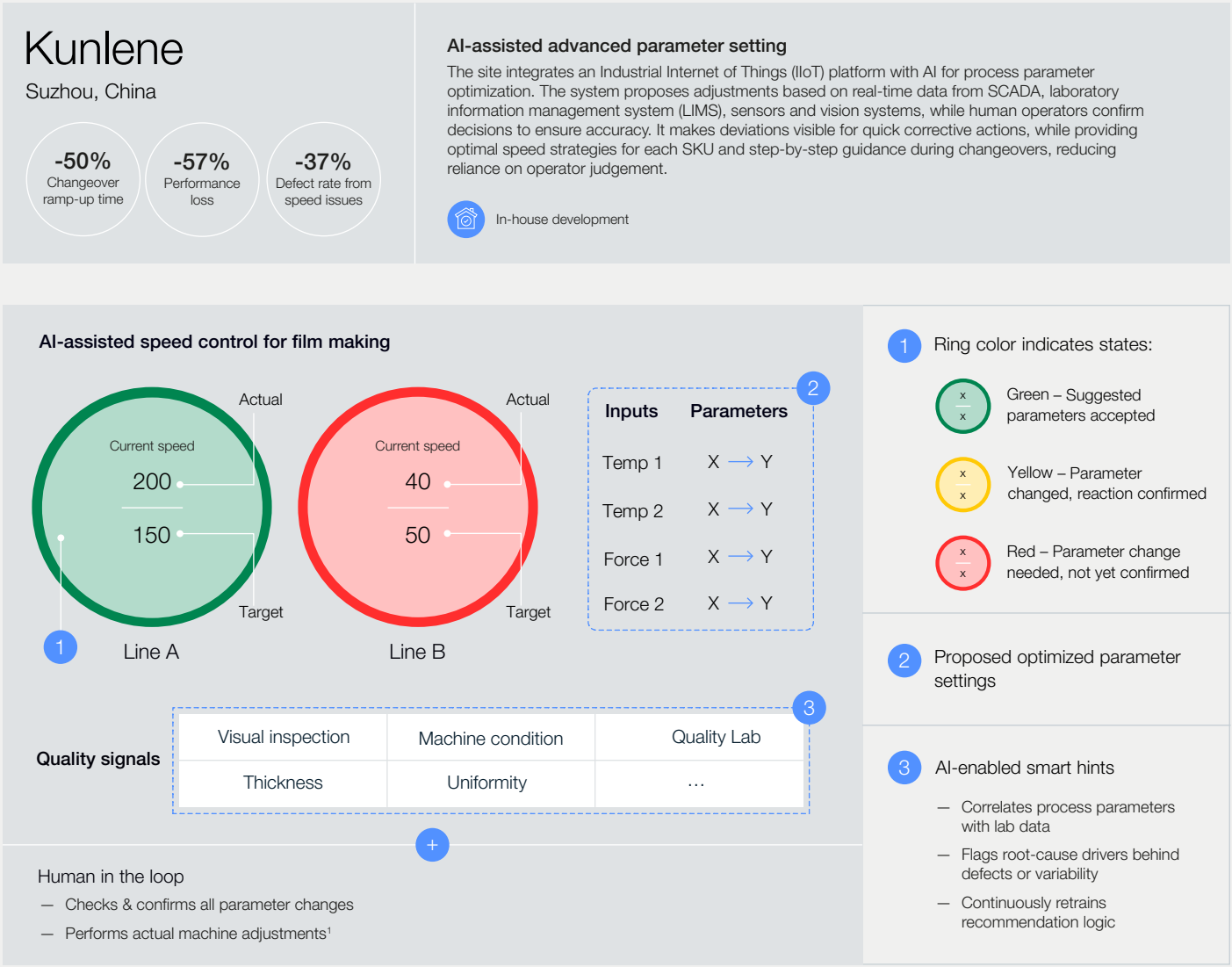
Lighthouse examples

1	Lenovo Monterrey, Mexico	Digital twin-enabled supply chain control tower	To address frequent order delays caused by supply chain disruptions, a digital twin-based control tower integrates data from 50+ sensors (e.g. internal systems, public news) and 40+ risk types (e.g. natural disasters, regulatory changes). Users receive real-time risk mitigation recommendations from a GenAI chatbot powered by LLMs.	-85% Order lead time
2	Schneider Electric Wuhan, China	Technical competency for NPI acceleration AI agents	Surge in new products and market expansion increased new product introduction (NPI) complexity, requiring broader technical competencies and longer lead times (3-year ramp-up). AI platform with 21 agents automates 50% of tasks (e.g. data collection, document generation), enabling teams to focus on process optimization and machine design.	-67% NPI lead time
3	YDTEX Yancheng, China	AI-based self-diagnostic equipment management	To improve maintenance efficiency and reduce downtime, AI-based self-diagnosis platform collects sensor and machine data every 5 seconds. CNN algorithms detect faults and trigger alerts, while LLMs provide actionable advice, such as adjusting pallet jack speed and optimizing maintenance plans. LSTM models predict remaining part life with precision, enabling proactive maintenance and stabilizing machine performance.	-58% Maintenance cost
4	METTLER TOLEDO Changzhou, China	Simulation-based cluster workstations reconfiguration	Floor scales provide millions of configurable variants and engineered-to-order (ETO) solutions, with 66% one-piece orders processed daily. Traditional rigid production lines hinder delivery agility. Through multi-system integration, discrete event simulation (DES) and genetic algorithm (GA) modular cluster workstations are dynamically reconfigured via real-time scheduling, resolving complex line-balancing and constraints.	+13% Manufacturing on-time delivery
5	Haier Shanghai, China	Multi-objective optimization for injection moulding	Manual tuning of injection moulding parameters led to inefficiencies, quality issues and energy waste. Multi-objective optimization model with dynamic compensation and analysis of real-time data from 500+ parameters identified top factors. This approach, leveraging historical data and advanced algorithms, enabled intelligent recommendations and self-adaptive optimization.	-15% Cycle time
6	Midea Wuhu, China	AI-enabled E2E exception-driven supply chain controls	Managing 100k+ daily small batch orders across many control points resulted in slow root cause analysis. Site-built E2E supply chain control tower integrates 10+ systems, providing real-time visibility across all order nodes for intelligent alerts. A 13-layer decision tree model with AIGC automates root cause analysis and generates optimal solutions for fast resolution.	-39% Delivery lead time
7	ACG Shirwal, India	First-time-right production enabled by IIoT and ML	With 5,000+ SKUs and manual setup of 70+ parameters on 60-year-old machines, operations faced challenges in yield, lead time and defect rate. ML models trained on 2+ years of golden batch data now prescribe optimal settings, directly transferred to machine PLCs. A continuous ML pipeline retrains models using outcomes and operator feedback, improving quality and efficiency.	+37% First pass yield

Notes: AIGC = artificial intelligence-generated content, CNN = convolutional neural network, LSTM = long short-term memory.

Source: Global Lighthouse Network.

FIGURE 23 | **Kunlene's AI-assisted advanced parameter setting**



Note: 1. Machine parameters not directly adjustable.

Source: Global Lighthouse Network.

When decision risk is high but complexity is moderate, AI collaborators are ideal. For example, **Kunlene** in Suzhou, China deployed an AI-assisted parameter-setting platform to dynamically propose machine adjustments for maintaining consistent film quality during high-speed production and autonomously handling specific workflows, with human oversight limited to edge cases (Figure 23).[48] For moderate decision risk and complexity, conditional autonomy is more effective, as with **Kunlene**'s closed-loop parameter adjustment system. It uses smart robotics to maintain uniform film thickness in food-grade recyclable films, reducing safety incidents in high-temperature zones and reliance on operator's technical expertise (Figure 24).[49]

FIGURE 24 | **Kunlene's closed-loop parameter adjustments with smart robotics**

Kunlene

Suzhou, China

-25%
Time to stabilize thickness

-53%
Downgrade due to thickness variance

-25%
Scrap rate

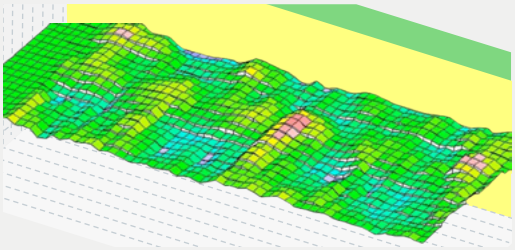
Closed loop parameter adjustment with smart robotics

Film production requires uniform thickness, challenging to achieve with limited access to machine parameters or unavailable interfaces. By retrofitting smart robotics and using AI-enabled parameter setting, Kunlene's integrated IIoT platform processes real-time data to dynamically adjust machine parameters. Human operators kept in the loop maintain transparency, observing robots' actions (e.g. turning bolts) making impact of AI visible.

In-house development

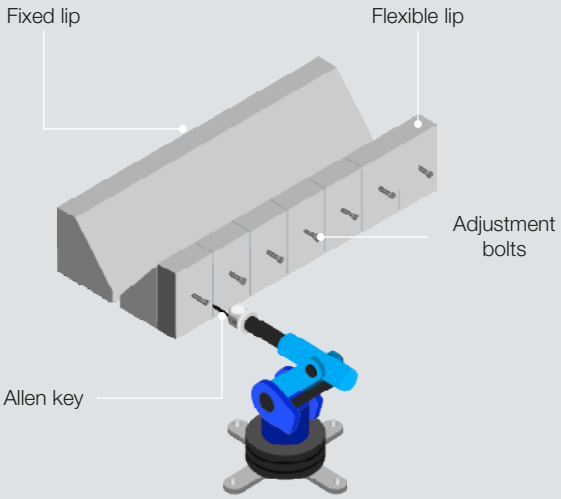
5-step approach for closed-loop parameter adjustment

1. Analyse material thickness profile across ~700 positions



2. Translate thickness profile into 43 sections across the material width
3. Incorporate additional parameters into the calculation to determine drivers
4. Adjust bolts upstream using smart robotics and fine-tune other process parameters (e.g. temperature, speed)
5. Implement continuous improvement and AI model training for ongoing optimization

Technical implementation



- 43 bolts to adjust 43 sections
- Robot with allen key to mimic human intervention

Source: Global Lighthouse Network.

From task execution to AI supervision: new roles in AI-driven operations

Some Lighthouses are pushing the boundaries of autonomy. **Haier** in Shanghai, China deployed a self-adaptive welding programming agent that helps manage the complexity of thousands of configurations. Previously, a robot had to be taught to perform a specific work cycle by physically guiding it through each desired position. Today, an agent equipped with reinforcement learning algorithms identifies and recommends optimizations to its own programming, cutting programming time from 16 hours to 1 hour while maintaining high welding accuracy (Figure 25).[50]

While fully autonomous agentic AI remains theoretical in the production context, Lighthouses are leading the way in managing hybrid human-agent workforces. Rather than simply placing humans in oversight roles, they design systems that define when and where intervention is required.

FIGURE 25 | **Haier's self-adaptive welding programming agent**

Haier

Shanghai, China

+2.3p.p. First pass yield

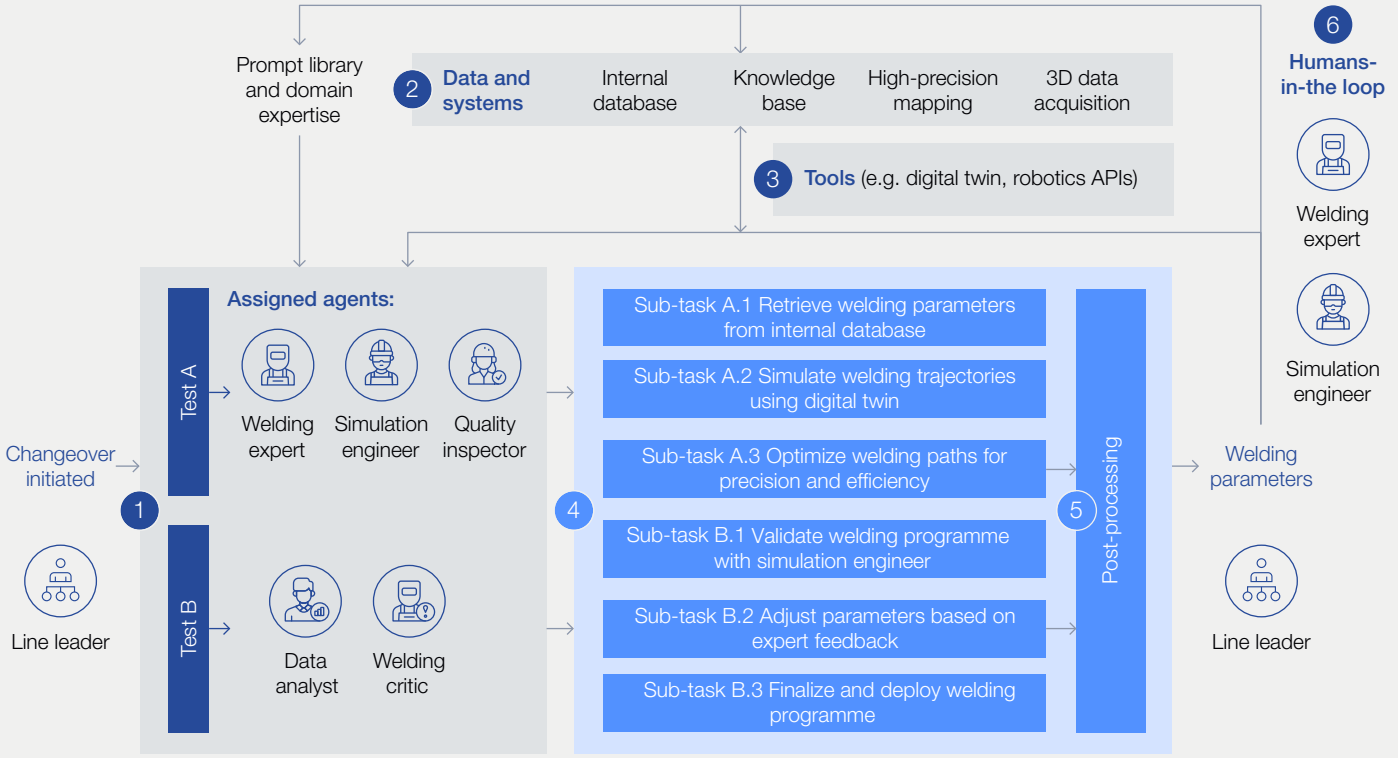
-0.2p.p. Grade mis-classification rate

-45% Quality down-grading loss

Self-adaptive welding programming agent

The site faced challenges in meeting the demand for high-end, customized washing machine frames, where traditional manual teach-in programming for welding robots was time-consuming and inefficient. A reinforcement learning-driven self-adaptive programming agent was deployed to automate the process, reducing deviations from 2 to 0.5 millimeters across eight welding robots.

Joint-development



1 Prompt engineering	2 Data and systems	3 Tools	4 Tools	5 Post-processing	6 Human-in-the-loop
Codify the expertise of welding engineers and programming requirements of high-end washing machine frames	**Organize data and IT systems** to provide context for the AI agent (i.e. sensors and interface protocols to collect data)	**Enable the AI agent to interact** with the real world (i.e. digital twins, robotics kinematics to simulate 6-axis motion)	**Agents continuously learn from domain experts to self-organize** and break down tasks into subtasks and execute	**Agents evaluate welding results** against predefined standards, and structured data models generate executable robot code	**Engage welding engineers** and other experts to validate the agents' outputs and provide feedback for improvement

Engineered by… A human AI agents

Source: Global Lighthouse Network.

3.3 Cognitive networks: orchestrating value chains with AI

Lighthouses are redefining global value chains by embedding AI across every layer of operations, evolving from digitally native to AI-native organizations that form cognitive networks.

This shift enables seamless collaboration between humans, AI agents and robots, fostering new levels of operational performance.

From zero to one: stand up the first supply chain "brain"

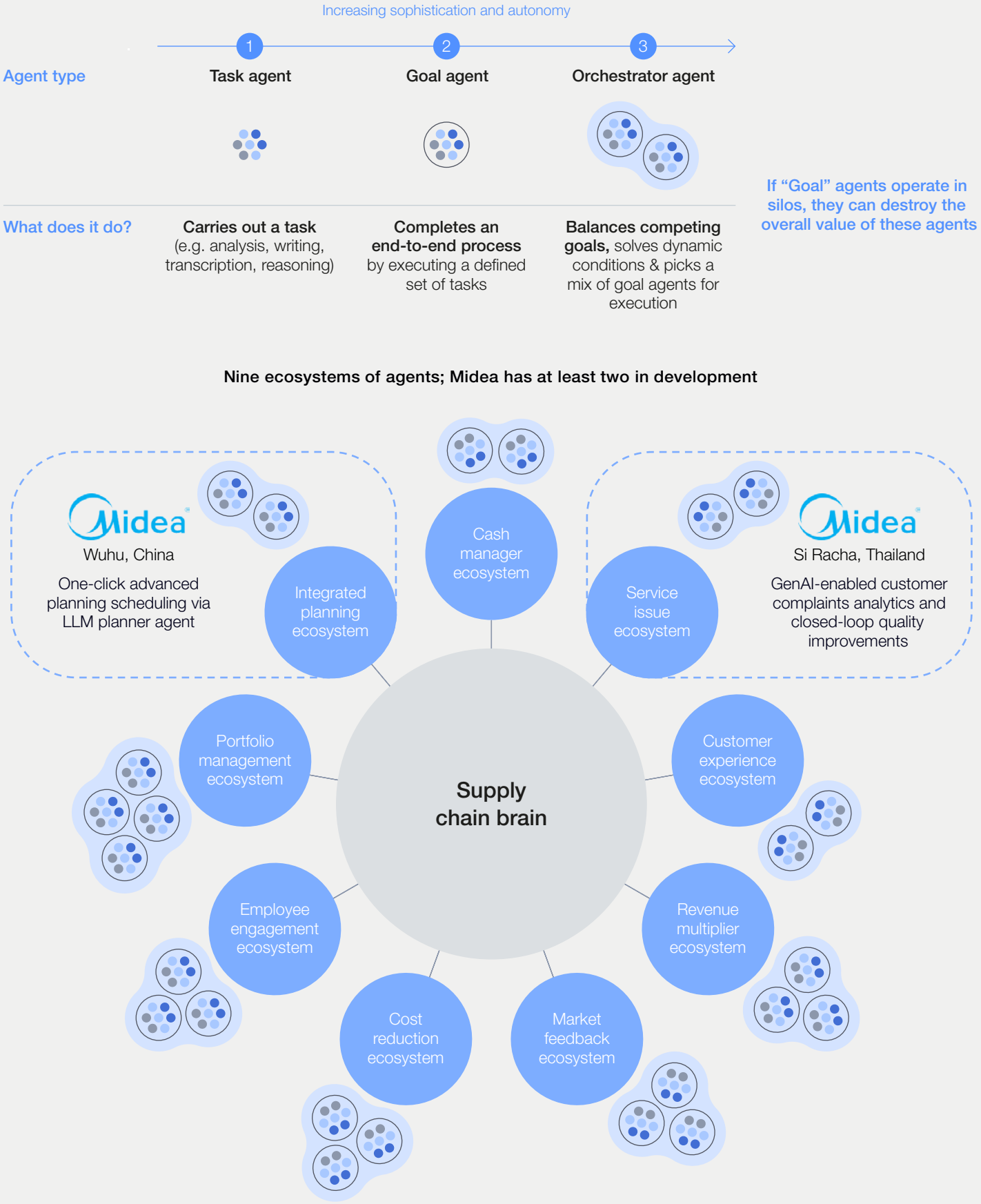
In the progression from cognitive factories to cognitive networks, the first challenge is building the initial "brain" – a core intelligence layer to which future sites and ecosystem partners can connect. This foundation unlocks future agentic ecosystems capable of cross-site visibility and coordinated decision-making. As task-orientated agents proliferate, value increasingly comes from "orchestrator agents" that reason, decide and act autonomously (Figure 26).

Isolated task agents alone rarely create value. The aim is to reconfigure the supply chain network to make data-driven, real-time decisions through aligned people, processes and technology.

Lighthouses develop orchestrator agents that coordinate goal- and task-specific agents, integrated with existing technology stacks (e.g. AI models, robotic process automation or RPA, query systems), balancing competing priorities and executing complex, sector-specific operational constraints with greater speed and consistency than manual teams.

Each orchestrator must be tailored to the customer context, drawing on deep knowledge of trade-offs and business priorities to deliver lasting impact. That is why Lighthouses start with one or two agent ecosystems, proving value before scaling-up across domains.

FIGURE 26 | **Lighthouses are laying foundations for agentic orchestration**



Source: Global Lighthouse Network. Framework adapted from McKinsey Operations Practice (September 2025).

Closing the loop: turning customer feedback into autonomous quality improvement

As suppliers and manufacturing nodes become more connected, transformation extends beyond operations into customer experience. When faced with challenges in managing customer complaints and quality improvements across global operations, **Midea** in Si Racha, Thailand, implemented an AI-driven system that automates its end-to-end voice-of-customer (VOC) to voice-of-process (VOP) workflow. Customer feedback is captured through a centralized platform and linked to the quality management system (QMS), forming a closed data loop. Graph-matching algorithms and traceability data identify responsible units, while LLMs infer root causes validated by engineer chatbots and auto-generate corrective action recommendations (Figure 27).[51] By connecting customer signals directly to production response, Lighthouses are turning feedback into foresight, closing the loop between data and action.

FIGURE 27 **Midea's quality of VOC (voice of customer) to VOP (voice of process) in seven steps**

Midea

Si Racha, Thailand

1 day
Quality issue to action plan lead time

-32%
Customer complaints rate

-43%
Defect rate

GenAI-enabled customer complaints analytics and closed-loop process quality improvements

Quality engineers faced delays resolving 1,000+ annual complaints from 800 service centres across 10+ countries, with manual processes taking 60+ days. Limited experience (only 20% with 3+ years) led to reliance on judgement. A knowledge base with 3,000+ expert inputs, AIGC and AI algorithms (e.g. clustering, decision trees) automated the seven-step VOC-to-VOP process, cutting resolution time from 3 months to days. The solution uses NLP to structure descriptions, analyse root causes and recommend actions via LLMs and case libraries, driving continuous improvement despite limited expertise.

Joint-development

User	Step		Enabled by AI
Aftersales engineer, quality engineer	1 Quality risk identification	**Critical component** Category: Evaporator Fault cause description: Evaporator leakage	**Classify the category of key components** — Market repair records, historical breakdowns & quality issues — Multi-lingual translation, intent recognition & clustering
	2 Process risk identification	**Responsibility issue** Classification: Leakage defect Responsibility distribution: Process	
	3 Confirmation of risk units	**Responsible unit** Workshop: WK01 Line: RACWK10002 Team: B Shift	**Relate key components to accountable root location** — Accountable department, plant/line/shift and process step — Decision tree logic informed by procedure, malfunction & accountability data
Quality engineer	4 Confirmation of risky processes	**Position name** Welding	
	5 Root cause analysis	A. Welding equipment nozzle wear and ageing B. Operator actions C. Welding materials	**Identify top-3 root causes of quality issue** — Quality issue expert knowledge library — Chatbot interaction to finalize root causes
	6 Intervention recommendations	A. The welding process requires maintenance or replacement of the welding nozzle every two months B. Need to add overdue maintenance warning function for error prevention and control	**Recommend remedies of quality issue**
Shift leader, inspector, process engineer	7 Standard changes are implemented	Short-term measures: Process control Short-term measures: Morning meetings Long-term measures: Project events	**Close loop through execution task order** — Morning meeting "one-pager" — Process control centre warning — Long-term quality project

Source: Global Lighthouse Network.

4 Rewiring operations for Lighthouse levels of performance at scale

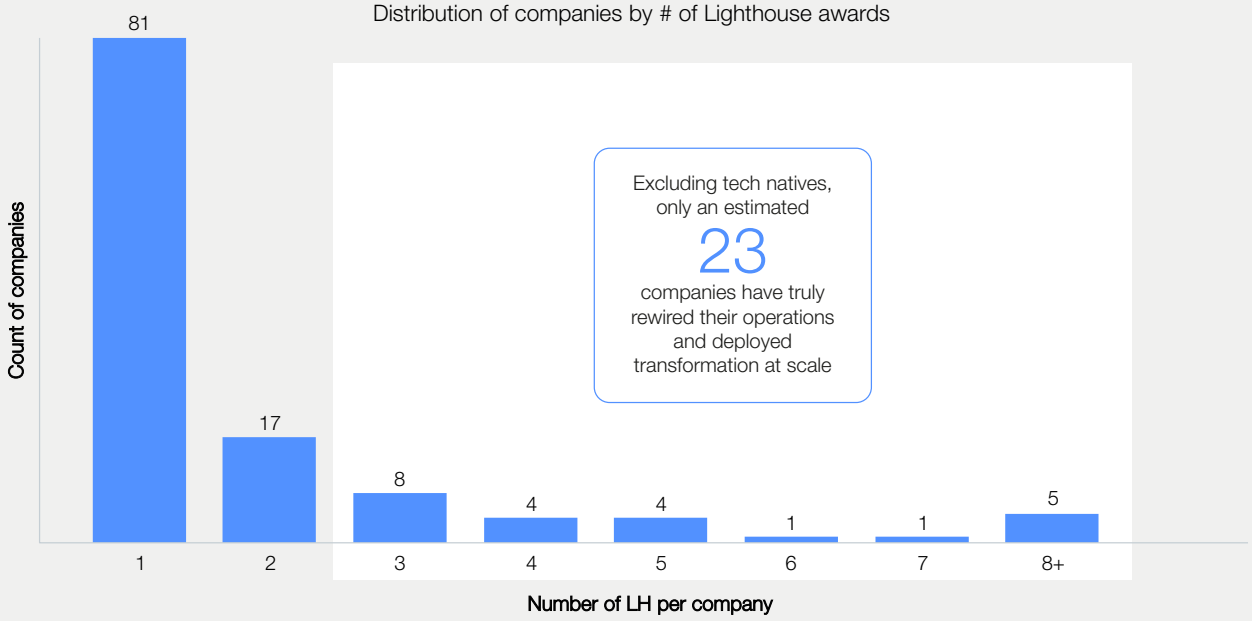
Lighthouses know that scaling-up transformation requires fundamental changes to operations and investment in capabilities that equip the workforce and breed grassroots innovation.

Despite its many advantages, scaling-up remains one of the toughest challenges in operations, even for leading companies. Among the ranks of the Global Lighthouse Network, only 23 organizations have successfully expanded their rewiring efforts to three or more sites (Figure 28).

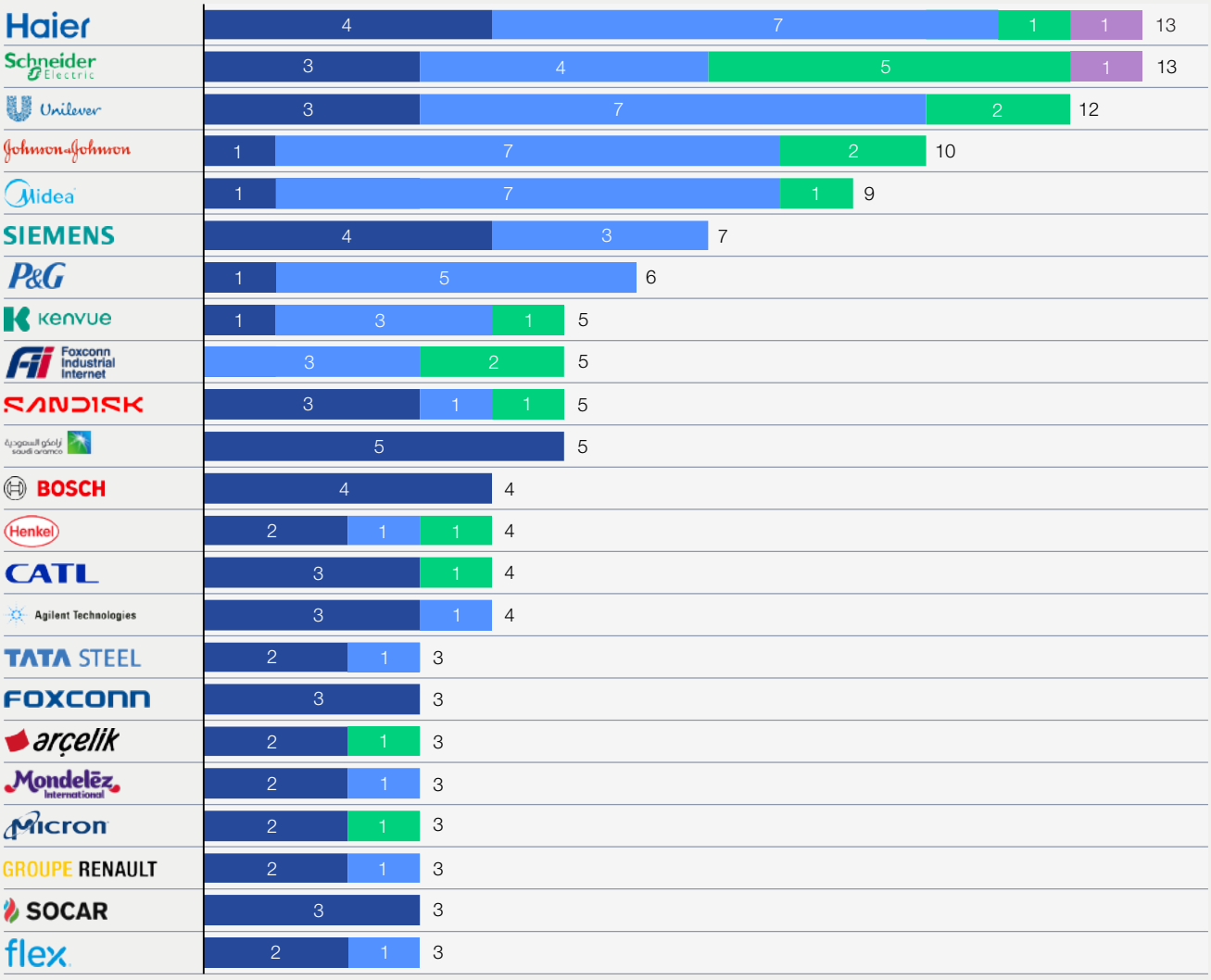
Effective scaling-up is not about deploying every technology everywhere; it is about building the capabilities that matter most. Lighthouses focus resources on high-impact enablers – talent, operating model, technology and data – treating rewiring as an ongoing journey rather than a one-time event. Lighthouses successfully scale up by first designing roadmaps that channel investment towards innovation with minimal distraction. Then, agile teams work closely with frontline users and ecosystem partners such as vendors and universities to co-develop, test and rapidly deploy solutions that deliver measurable impact. This disciplined approach allows local innovations to spread across networks, turning isolated successes into system-wide change.

Over time, Lighthouses turn these scaling-up capabilities into organizational “superpowers”, accelerating their move up the S-curve with each wave of technology innovation.

Companies scaling information,
Distribution of companies by # of Lighthouse awards



Top Lighthouse scalers
Companies ranked by # of Lighthouse awards



Source: Global Lighthouse Network.

4.1 Accelerating digital transformations network-wide: core enablers of the Lighthouse blueprint

Mechanics of scaling-up: how Lighthouses realize network impact with focus and agility

“ All successful scaling-up stories start small. For Lighthouses, the first site marks the beginning of a transformation journey with impact spanning the entire organization.

Lighthouses possess six core enablers fundamental to successful Fourth Industrial Revolution scaling-up:

- Strategic roadmaps
- Agile operating models
- Talent and training
- Technology and data
- Ecosystem collaboration
- Adoption and cultural shifts

The importance of each enabler remains consistent across every stage of a transformation journey, starting with design, through implementation and site-level scaling-up, all the way to full network-wide rewiring. This range is evident among Lighthouses. While they present only their top five solutions for GLN evaluation, 63% of these have been scaled up to three or more sites. Overall, the organization deploys more than 50 solutions on average.

While all six enablers are essential to any transformation, the 2025 cohort of Lighthouses leaned most heavily on three enablers to achieve scale in a fast-moving, disruptive market landscape:

1. **Well-defined transformation roadmaps** with governance and tracking mechanisms that stay value-focused as they evaluate, prioritize and allocate resources.
2. **Agile operating models** that co-develop solutions to address frontline needs during design and development of prototypes.
3. **Global ecosystem partnerships** that enable implementation and adoption to scale up local innovations, sharing and sustaining best practices across sites and partners.

Figure 29 illustrates how Lighthouses leverage all six core enablers to rewire operations for holistic performance and scalable impact – applying a proven blueprint for transformation.

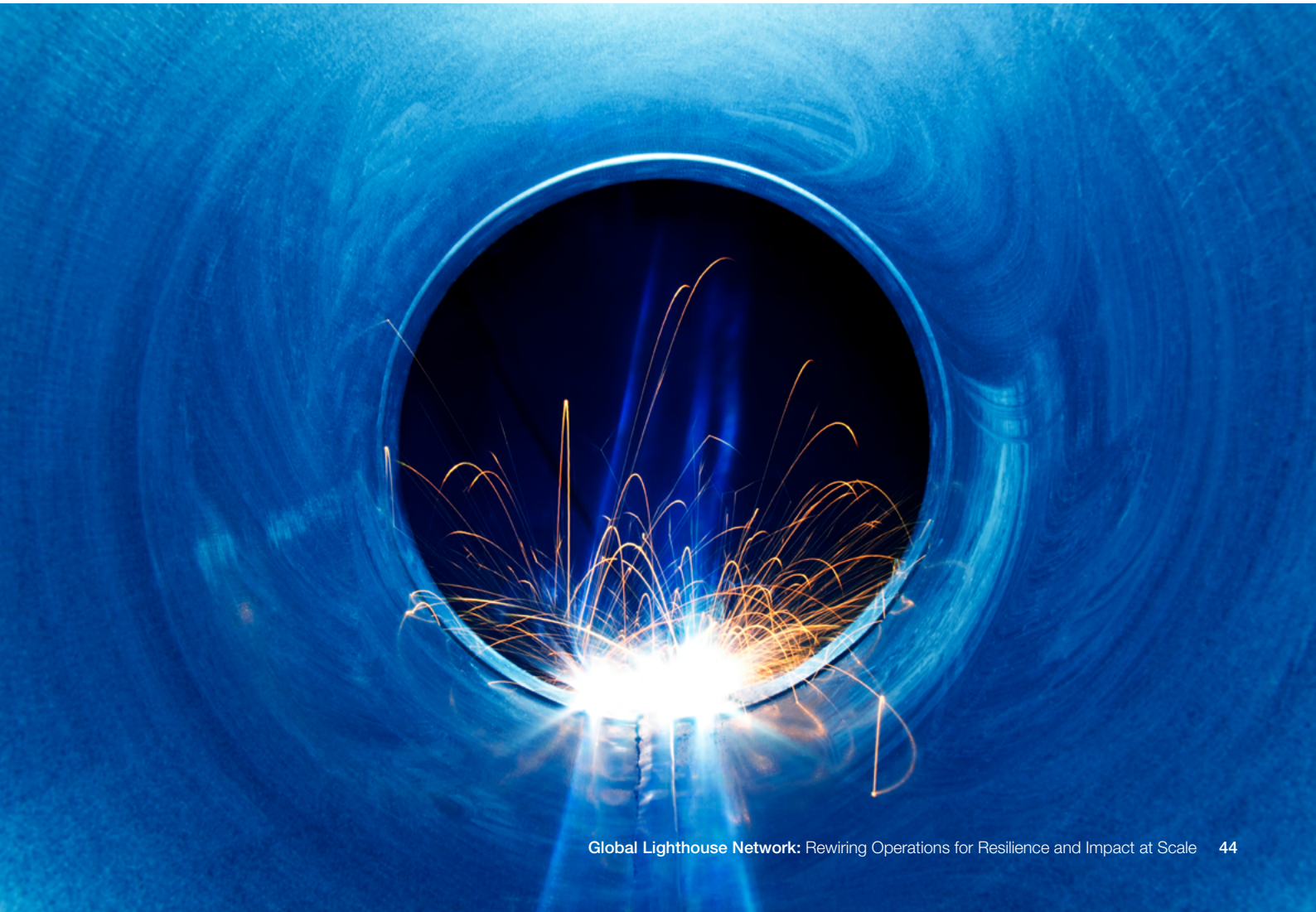
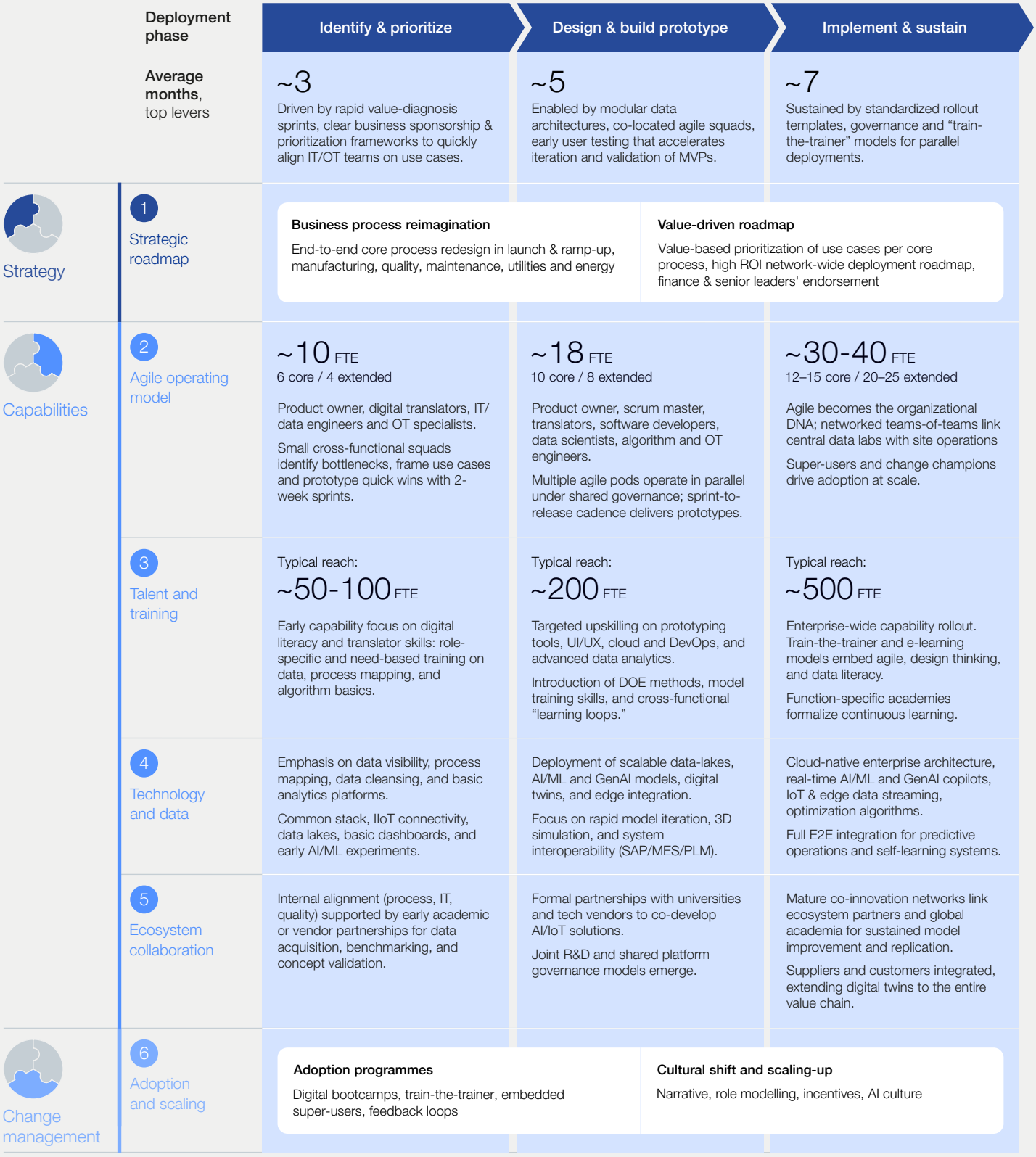


FIGURE 29 | **Lighthouse blueprint: six core enablers for high-impact and scalable transformations**



Notes: DOE = design of experiments, MVP = minimum viable product, PLM = product lifecycle management, UI = user interface, UX = user experience. DevOps combines software development (Dev) and IT operations (Ops) to shorten the software development lifecycle and deliver applications and services at a high velocity.

Source: Global Lighthouse Network.

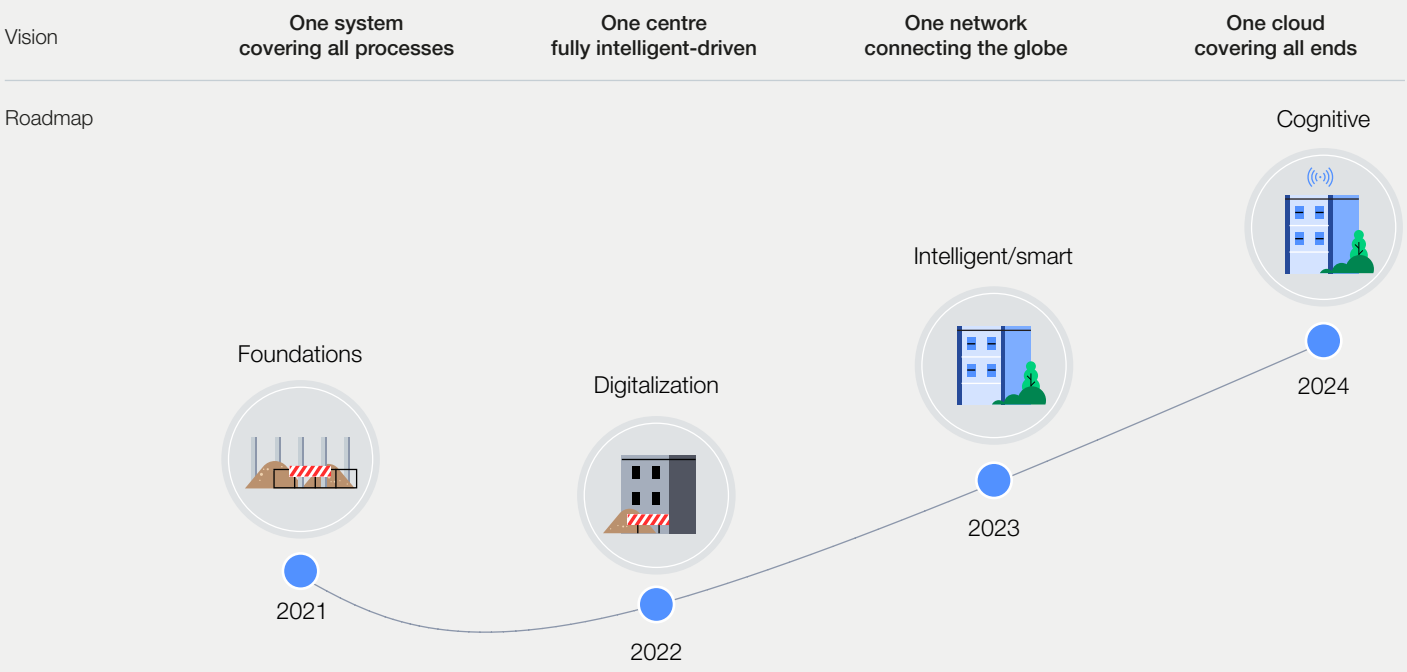
Well-defined transformation roadmaps: mobilizing the organization towards a vision

To chart a course of innovation and maintain steady progress, the Lighthouse journey always begins with an intentional decision about the destination. How to get there will change, of course. Over the next few years, for example, the proliferation of AI-enabled task agents offered by hyperscalers and enterprise platforms alike is expected to drive commoditization at the application layer.

Lighthouses lay out a transformation roadmap that frames the vision and direction for the leadership at an industrial site. They set an aspiration, often so ambitious as to seem unattainable, but then determine interim milestones realistic enough to motivate and compel progress. Lighthouses do not waste time on questions such as "Should we even try this?" or "Which of these hundred vendors do we choose?" Instead, they spend 45% of their solution development time on implementation and adoption – seven months on average – alongside five months for design and prototype build and three months for ideation and resource planning. A clearly articulated vision for all sites enables leadership teams to quickly evaluate potential investments in new technologies or partnerships.

Tongwei Solar in Meishan, China has a roadmap that has stood the test of time. The company first drafted it in 2020 during the pandemic, driven by urgency around digital adoption. By focusing on strategic milestones specifically tied to business priorities, Tongwei provided the site with ambitious goals and a structured pathway to achieving them (Figure 30).[52]

FIGURE 30 **Transformation vision and roadmap at Tongwei Solar**



Source: Global Lighthouse Network.

Agile operating models: forming and constantly evolving teams of knowledge

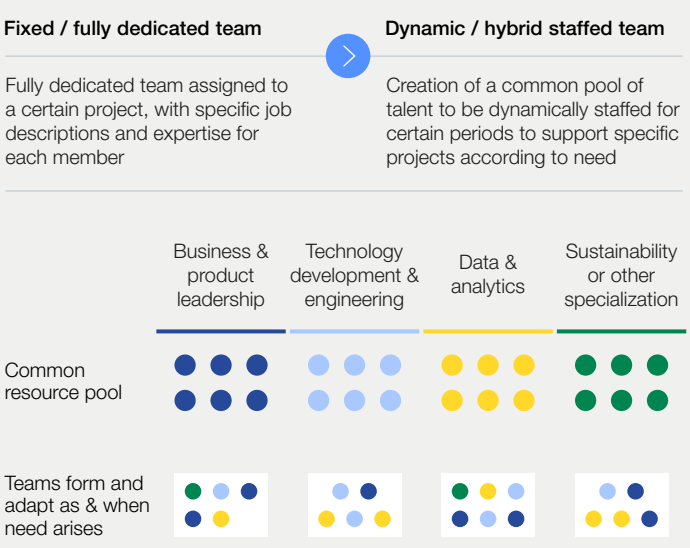
Technical and operational teams at Lighthouses are highly agile, capable of uniting expertise from across the organization to rapidly develop, test and iterate solutions for the frontline workforce. This agility accelerates the early phases of solution identification and design, allowing resources to focus more on feedback and iteration in implementation.

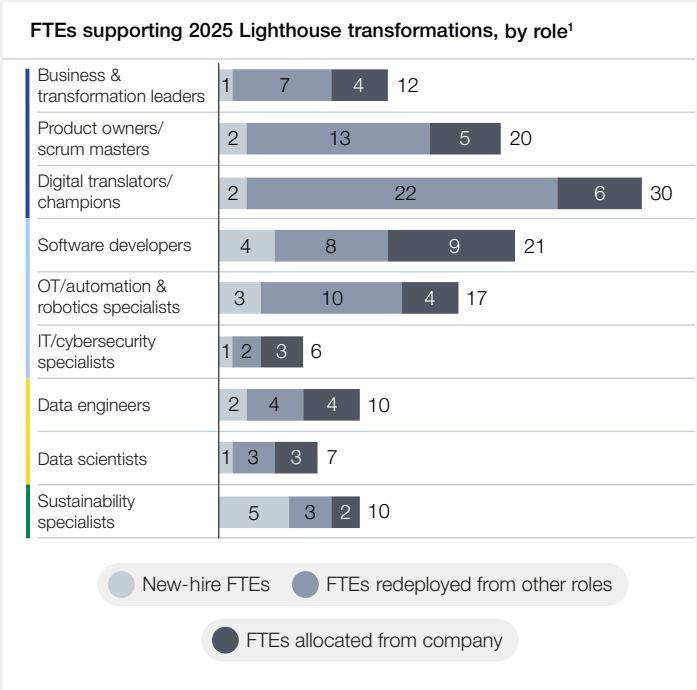
Increasingly, adopting a "best of breed" platform approach for technology stacks has emerged as a key enabler, with 61% of Lighthouses in the 2025 cohort reporting this strategy, compared to 39% using a "full stack" approach.[53] These Lighthouses take advantage of optionality – rather than being tied to a single provider, they select the most effective solutions from various vendors, evaluating trade-offs on costs such as integration and scalability in each case.

Building AI solutions in-house for customization and control underscores the need for a new operating model approach. All projects will require bringing in domain experts to inform the right architecture and setup, but the level of support needed may shift over time and varies across projects. Lighthouses structure their operating model to support this fluidity, transitioning from fixed, fully dedicated teams to a dynamic hybrid staffing model that pulls from a common pool of talent according to specific project needs (Figure 31).

Lighthouses learn hard-won lessons during their pilot transformations – how to structure teams, empower people and build frameworks for success. They carry these insights forward when scaling-up best practices and solutions across their networks. Over time, their focus expands beyond individual sites towards strengthening the broader ecosystem, helping partners across the value chain to share in the benefits of transformation.

FIGURE 31 **Dynamically staffed teams at Lighthouses leverage broad, flexible expertise**





Note: 1. Normalized for a 500-FTE production or logistics site.

Source: Global Lighthouse Network.

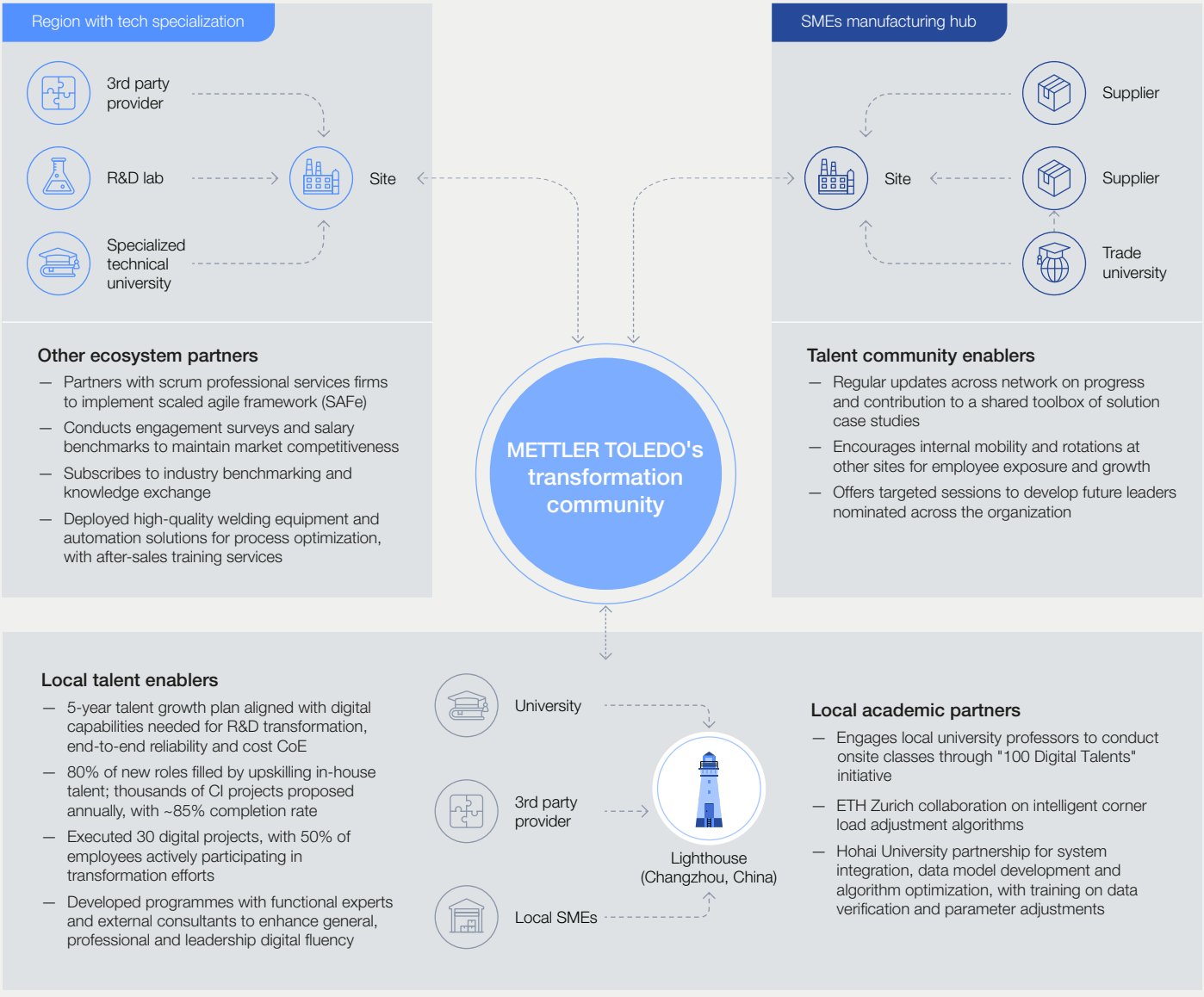
Global ecosystem partnerships: building transformation communities of practice

Lighthouses maintain open channels for knowledge transfer and information sharing across their networks so that solutions can scale up rapidly across transformation communities. Initiatives such as reward platforms incentivize cross-functional collaboration, while direct application programming interfaces (APIs) accelerate the sharing and adaptation of solutions. Consequently, individual solutions scale up easily: Lighthouses typically report up to five partners supporting their transformation efforts, with 63% drawn from existing Lighthouse sites, demonstrating how shared learning fuels continuous, network-wide improvement.[54]

Lighthouses rarely develop solutions in isolation, understanding that the best solutions often require collaboration across a variety of ecosystem partners. Facing intense local competition for talent and customers, **Mettler Toledo** in Changzhou, China, shifted its business model to prioritize customer value and cost leadership for a competitive edge. This required the agility to enter new segments quickly while exiting old ones. This inspired the site to leverage its community – including internal talent, network sites, academic partners and other ecosystem collaborators – to scale up the transformation to six additional sites worldwide (Figure 32).[55]

The success of Lighthouses lies in their ability to foster a culture of collaboration and continuous learning. By leveraging their networks and communities, they can rapidly adapt and deploy innovations. As they continue to refine their strategies and share best practices, Lighthouses illuminate the path for others seeking to achieve transformative scale.

FIGURE 32 **Illustrating Mettler Toledo's transformation community**



Notes: CI = continuous improvement, CoE = centre of excellence.

Source: Global Lighthouse Network.

4.2 Three archetypes of successful scalers: illuminating a way out of the "scaling slump"

Lighthouses treat the full rewiring of their operations as a journey. They begin with a clear vision of the end state, yet continually reassess their context, ambitions and progress to determine how much change to pursue at each stage. As they become more cross-functional, Lighthouses evolve through successive models, moving steadily away from traditional organizational structures. This is not change for its own sake, but an intentional shift from the limitations of legacy systems – whose hierarchical, siloed processes often hinder the adoption of new digital technologies and the flow of knowledge across sites.

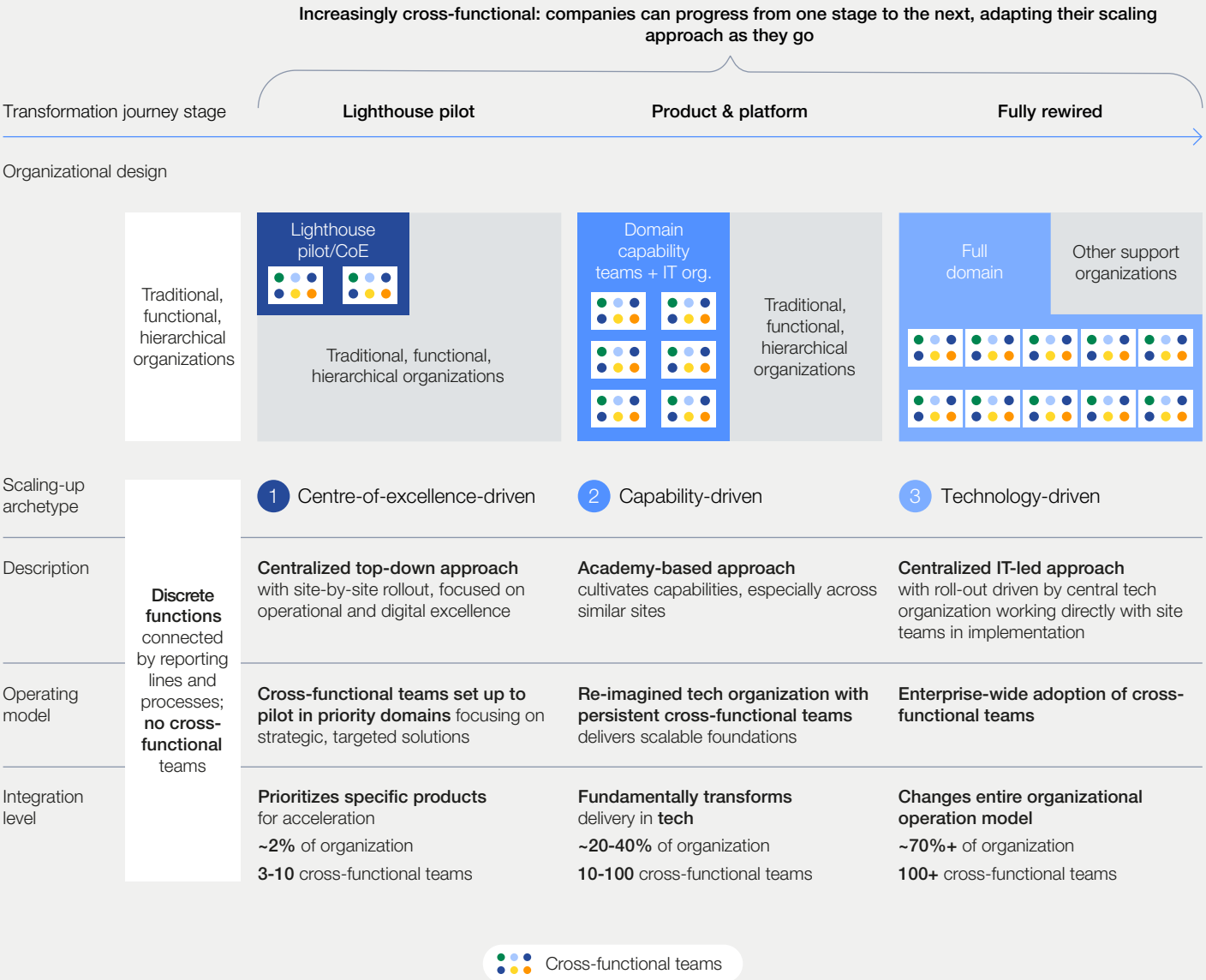
Many organizations experience a "scaling slump" – the point at which early transformation momentum stalls as pilots fail to replicate beyond a few sites.[56]

Lighthouses overcome this barrier by progressing through three scaling-up archetypes that reflect increasing levels of transformation maturity (Figure 33):

1. **Centre-of-excellence (CoE)-driven:** Centralized expertise, deployed locally
2. **Capability-driven:** workforce capability and upskilling programmes
3. **Technology-driven:** standardization and integration of technology

While each archetype can stand on its own, Lighthouses typically advance from one to the next as capabilities deepen and strategic ambitions broaden.

FIGURE 33 **Organization structures for various transformation phases and company strengths**



Source: McKinsey & Company (rewired framework).[57]

Lighthouse factories unlock CoE-driven scale

At the Lighthouse pilot stage, companies often pursue a CoE-driven model, characterized by a centralized, top-down transformation approach. A transformation office or CoE orchestrates roll-outs site by site, ensuring operational consistency and performance tracking. Cross-functional teams are typically deployed in a limited number of priority domains – focused on high-value use cases that accelerate time-to-market and improve quality for strategic products.

Data architecture is often built with external partners, supported by agile governance to maintain quick decision cycles. The centralized CoE codifies business rules, harmonizes metrics and standardizes reporting, although implementation remains relatively light-touch at the site level through rapid pilots led by local champions. This model prioritizes speed and replicability over autonomy – allowing organizations to quickly prove value and establish foundational digital capabilities before broader scaling-up efforts. **Tongwei Solar** demonstrates a CoE-driven model through a CIO-sponsored transformation office coordinating 250+ full-time equivalent jobs (FTEs) across 15 digital use cases (Figure 34).[58]

FIGURE 34 **Transformation journeys at Lighthouses scaling-up network-wide**

Scaling archetype	1 Centre-of-excellence-driven	2 Capability-driven	3 Technology-driven
Examples from the 2025 cohort	TW SOLAR	Schneider Electric	Midea
Transformation journey stage	**Lighthouse pilot**	**Product & platform**	**Fully rewired**
Case for change	Rising customer expectations, stricter quality standards and cost pressures from market oversupply	Meet rising customer demand for sustainable solutions, secure critical raw materials and comply with regulations	Long lead times for core materials from 800 overseas tier 1/2 suppliers across 35 supply chain nodes
Impact	**Deployed >50 4IR solutions** (64% with AI), enabling -41% quality defects; -37% conversion cost; upskilled 500+ engineers (15% FTE)	**Achieved a fully circular product flow** of 220,000 products, enabling customers to purchase lower CO_2 footprint product	**Delivered $7.1 million annualized financial impact** through 72 digital solutions; integrated 4k+ new employees from Thailand, Myanmar, China
Capabilities			
Agile operating model	**CIO-sponsored transformation office** with 258 cross-functional FTEs for parallel development of 15 digital use cases	**Catalyst model for leadership** exemplarity, transparent communication for collective ownership	**Cross-functional agile teams** with 20+ product owners, 50+ translators, 100+ developers, 30+ architects, 160 group experts
Talent and training	**Talent pipeline** by collaborating with 200+ universities for R&D and curriculum integration	**Partnered local organizations** (e.g. IMPAQT) to develop sustainability skills	**Partnered with universities** to co-cultivate 70+ digital talents and 200+ interns annually
Technology and data	**Tongwei Cloud IoT platform** and hybrid data architecture to process 450 GB of real-time data daily	**Dual SAP & WMS system** to manage linear and circular flows, integrated IoT and cloud for real-time data	**Integrated 11 supply chain systems** via a cloud-edge IIoT architecture and 10 AI agents for business scenarios
Ecosystem collaboration	Dassault, Foxconn, NetEase H3C for low-code platform, GenAI, unified data products, IoT infrastructure	Packaging suppliers, forwarders, and equipment providers; Renault, Decathlon for innovation, benchmarking	Microsoft, Tencent and HAI Robotics for AI, training and automation solutions, universities, logistics partners
Change management			
Adoption programmes	**Digital bootcamps**, hackathons, demo days and performance-linked incentives	**Employee engagement programmes** such as suggestion cycles and group surveys	**Clear career paths** for 87 job types, incentives for multi-skilled/lingual employees

Note: WMS = warehouse management system.

Source: Global Lighthouse Network.

Product and platform investments unlock capability-driven scale

As digital maturity advances, organizations evolve towards a capability-driven model that emphasizes workforce enablement and platform-based collaboration. Here, the focus shifts from central governance to developing enduring, cross-functional capabilities within domain teams – often through digital academies or hub-and-spoke learning networks.

Persistent cross-functional teams become the engine of scaling-up, combining IT and operational expertise to deliver solutions that can be adapted across diverse production sites and supply chains.

The "hub" consolidates scarce digital talent and accelerates innovation, while "spokes" replicate proven solutions through a structured train-the-trainer approach. This archetype is especially effective for networks with heterogeneous equipment and process landscapes, where human capability, not technology uniformity, determines scaling-up speed. **Schneider Electric** exemplifies a capability-driven model by embedding circularity and talent transformations into its academy-based, hub-and-spoke capability-building programme (Figure 34).[59]

Fully rewired enterprises are capable of technology-driven scale

At full maturity, technology-driven scaling-up defines the fully rewired enterprise. Here, transformation becomes systemic rather than programmatic, with enterprise-wide adoption of cross-functional teams and tightly integrated digital architectures. A centralized IT or "intelligent manufacturing department" drives deployment, working directly with business owners and digital translators to embed solutions into daily operations.

The focus shifts towards technology standardization, interoperability and data quality – unlocking seamless integration across MES, ERP and cloud systems. Platforms are unified, analytics are democratized and feedback loops between sites enable continuous improvement. This model fundamentally changes how the organization operates, aligning business and IT to deliver resilience, scalability and real-time decision-making. **Midea**'s technology-driven model is defined by enterprise-wide system integration and cross-functional agile teams – over 20 product owners, 50+ translators, 100+ developers and 160 experts – operating on a unified cloud-edge IIoT architecture (Figure 34).[60]

Conclusion

In keeping with its name, it has always been the vision of the Global Lighthouse Network to serve as a guide, beacon and inspiration. But as inspiring as it might be, its impact would indeed be limited if it were merely symbolic of possibilities. Rather, the Network has always maintained a commitment to matching the aspirational with the practical, demonstrating how real world innovations are transforming the industrial landscape and yielding visible, tangible impact.

Eight years since its founding, GLN's light is brighter than ever, illuminating new frontiers of possibility with the transformative power of today's latest innovations, including the ongoing evolution of AI. As the gears of production turn steadily towards intelligent factories and value chains linked as cognitive networks, Lighthouses remain anchored by the same core principle: transformation succeeds when people, systems and technology evolve together.

Additional information

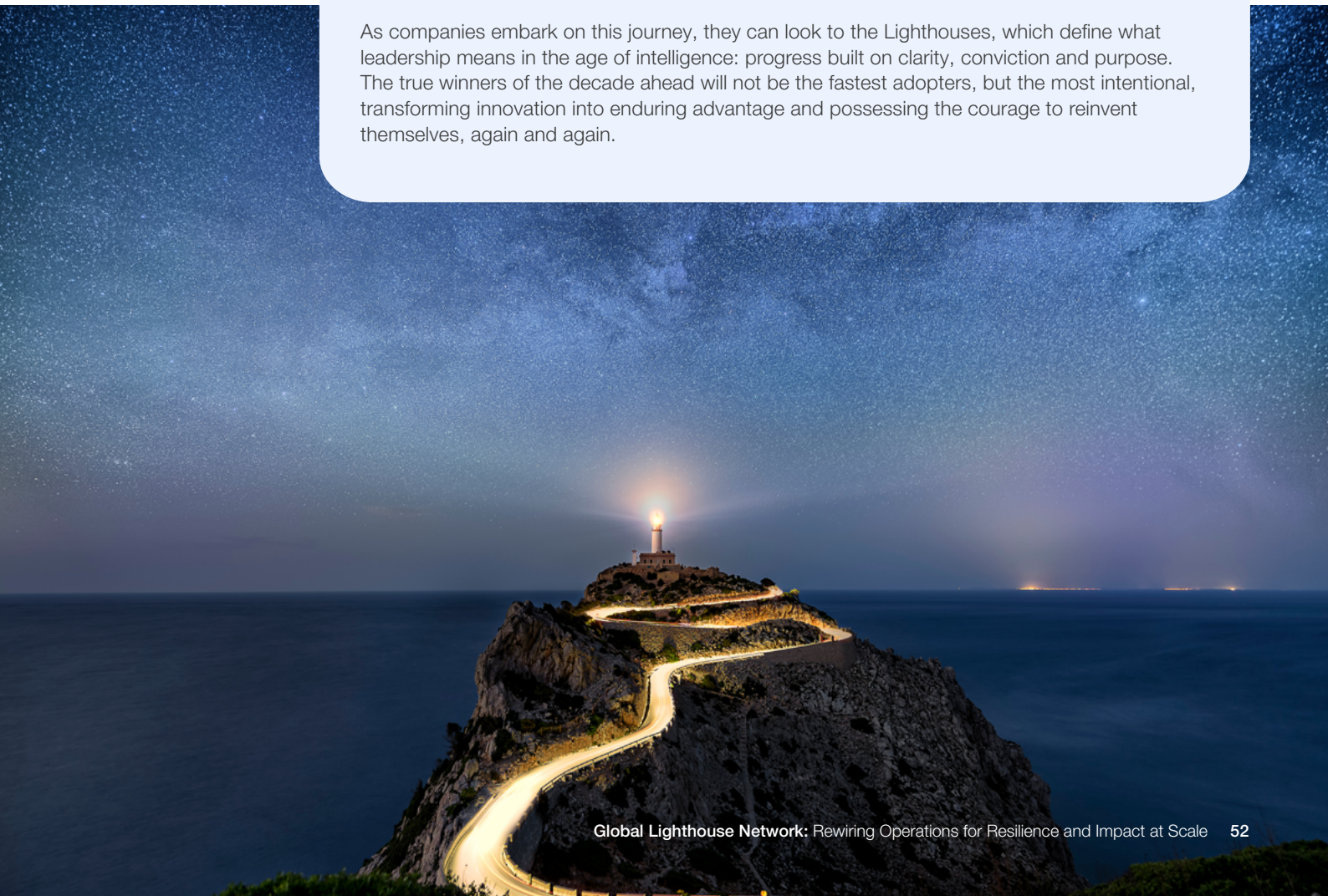
Organizations aspiring to join this community of transformation leaders are encouraged to apply for application Wave 16 by 2 February 2026 or Wave 17 by June 2026. For details on eligibility, selection criteria and upcoming deadlines, visit the Global Lighthouse Network homepage.

For additional resources and information on all Lighthouses and examples introduced in this report, please see this PDF.

Calling all aspirational scalers: learn from the Global Lighthouse Network community

Scaling-up requires balancing localized innovation with standardized infrastructure. A re-wired approach – one that unites technology with capability-building – propels organizations beyond isolated pilots to enterprise-wide transformation.

As companies embark on this journey, they can look to the Lighthouses, which define what leadership means in the age of intelligence: progress built on clarity, conviction and purpose. The true winners of the decade ahead will not be the fastest adopters, but the most intentional, transforming innovation into enduring advantage and possessing the courage to reinvent themselves, again and again.



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49. Based on 2025 Global Lighthouse Network site visit.
50. Based on 2025 Global Lighthouse Network site visit.
51. Based on 2025 Global Lighthouse Network site visit.
52. Based on 2025 Global Lighthouse Network site visit.
53. "Best-of-breed" means choosing the individual tools or systems that are considered best in class for a specific function (e.g. customer relations, analytics, manufacturing execution system etc.). "Full stack" means using a fully integrated suite of tools from one vendor (or from only a few), even if each individual tool might not be the most optional one if considered in isolation.
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