McKinsey
& Company

Global Lighthouse Network

Insights from the forefront of the 4th Industrial Revolution

January 2020

Executive summary

The latest findings from the Global Lighthouse Network, an ongoing research collaboration between McKinsey & Co. and the World Economic Forum, show that industrial leaders in applying Fourth Industrial Revolution (4IR) digital technologies are benefiting from a head start to generate even more value across the entire enterprise, and not just within factories

This brief summary examines what the 44 Lighthouse manufacturers do differently; crucial insights for the vast majority of manufacturers that aren't yet competitive with the leaders

At least 70 percent of manufacturers are languishing in "pilot purgatory," unable to bring manufacturing innovation to scale; they're at higher and higher risk of falling permanently behind the leaders

A detailed look at Lighthouse success cases reveals organizations that are driving outsized improvement in productivity, sustainability, operating cost, and speed to market

A common thread across Lighthouses is that the digital journey begins with the transformation of the plant's system of operations and is then propelled through 6 key scale-up enablers

End-to-End (E2E) Lighthouses in particular are using technology to drive value for the enterprise in three ways: customer-centered design, seamless connectivity across functions, and continuous connectivity beyond organizations

Transforming manufacturing from sourcing to delivery increases complexity and shifts stakeholder incentives as digital connectivity expands; addressing these changes requires breaking down internal divisions, sharing data externally, and building new capabilities, demonstrating the importance of the human element in successful technology application.

Adoption of 4IR technologies affect tasks performed and the ways in which people work together. Lighthouses are preparing their workforce through 6 common actions to maximize the potential of workers.

The Global Lighthouse Network includes 44 sites where 4IR technology is successfully deployed at scale

1. **Zymergen** — Biotechnology, US
2. **Fast Radius with UPS** — Additive manufacturing, US
3. **Johnson & Johnson vision care** — Medical devices, US
4. **Groupe Renault** — Automotive, BR
5. **MODEC** — Oil and gas, BR
6. **Johnson & Johnson DePuy Synthes** — Medical devices, IR
7. **GSK** — Pharmaceuticals, UK
8. **Schneider Electric** — Electrical components, FR
9. **Groupe Renault** — Automotive, FR
10. **Tata Steel** — Steel products, NL
11. **Henkel** — Consumer goods, DE
12. **Phoenix Contact** — Industrial automation, DE
13. **AGCO** — Agricultural equipment, DE
14. **Rold** — Electrical components, IT
15. **Bayer** — Division pharmaceuticals, IT
16. **BMW Group** — Automotive, DE
17. **Procter & Gamble** — Consumer goods, CZ
18. **Sanvik Coromant** — Industrial tools, SE
19. **Nokia** — Electronics, FI
20. **Arcelik A.S.** — Home appliances, RO
21. **Petkim** — Chemicals, TR
22. **Ford Otosan** — Automotive, TR
23. **Saudi Aramco** — Gas treatment, SA
24. **Unilever** — Consumer goods, UAE

Legend:
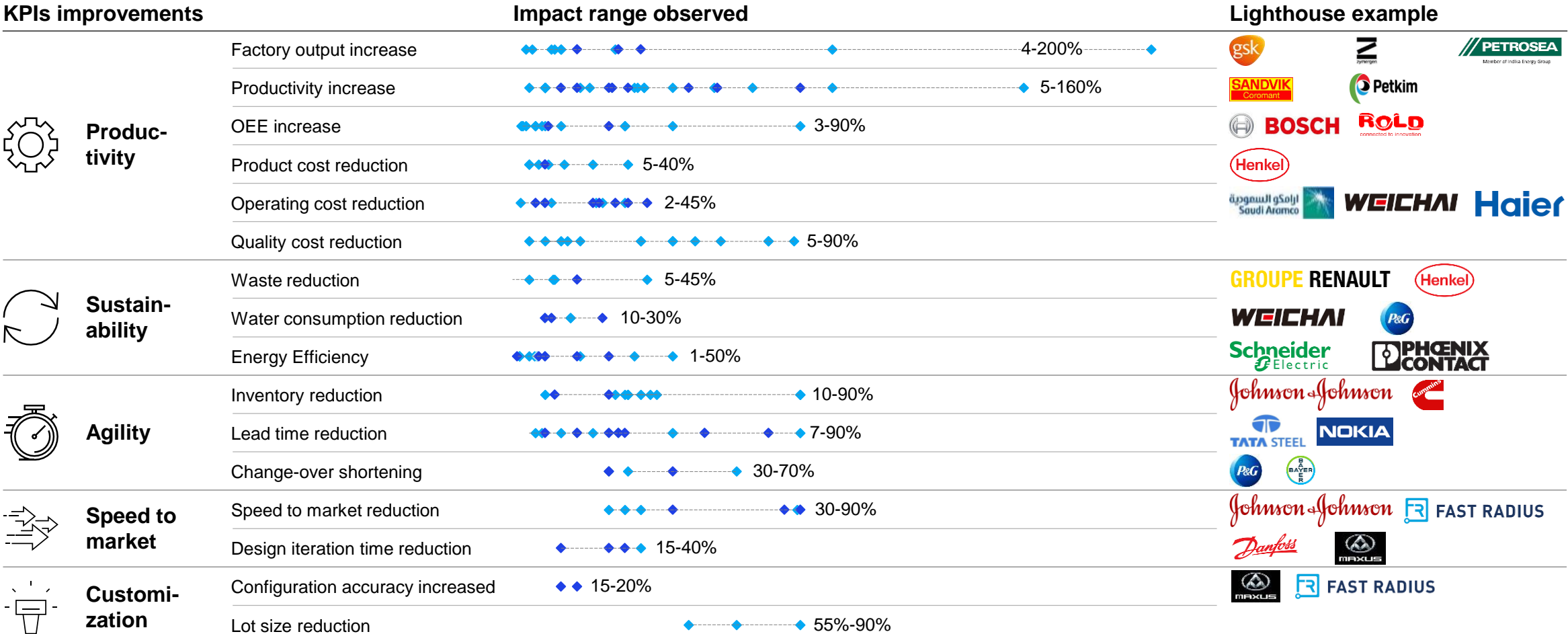- End-to-end connected value chain Lighthouses
- Four-wall factory lighthouses

37. **Johnson & Johnson DePuy Synthes** — Medical devices, CN
38. **Bosch** — Automotive, CN
39. **Procter & Gamble** — Consumer goods, CN
40. **Boashan Iron & Steel** — Steel products, CN
41. **Haier** — Appliances, CN
42. **POSCO** — Steel products, KOR
43. **GE Healthcare** — Healthcare, JP
44. **Hitachi** — Industrial equipment, JP

25. **Tata Steel** — Steel products, IN
26. **Siemens** — Industrial automation products, CN
27. **Infineon** — Semiconductors, SG
28. **Schneider Electric** — Electrical components, ID
29. **Micron** — Semiconductors, SG
30. **Petrosea** — Mining, ID
31. **Foxconn Industrial Internet** — Electronics, CN
32. **FOTON Cummins** — Automotive, CN
33. **Danfoss** — Industrial equipment, CN
34. **Weichai** — Industrial machinery, CN
35. **SAIC Maxus** — Automotive, CN
36. **Haier** — Home appliances, CN

Lighthouses demonstrate what's possible with measurable improvements in operations

◆ E2E Lighthouses   ◆ Factory Lighthouses

KPIs improvements		Impact range observed	Lighthouse example

Productivity

	Range
Factory output increase	4-200%
Productivity increase	5-160%
OEE increase	3-90%
Product cost reduction	5-40%
Operating cost reduction	2-45%
Quality cost reduction	5-90%

Lighthouse examples: gsk, Zymergen, PETROSEA, SANDVIK Coromant, Petkim, BOSCH, ROLD, Henkel, Saudi Aramco, WEICHAI, Haier

Sustainability

	Range
Waste reduction	5-45%
Water consumption reduction	10-30%
Energy Efficiency	1-50%

Lighthouse examples: GROUPE RENAULT, Henkel, WEICHAI, P&G, Schneider Electric, PHOENIX CONTACT

Agility

	Range
Inventory reduction	10-90%
Lead time reduction	7-90%
Change-over shortening	30-70%

Lighthouse examples: Johnson & Johnson, Cummins, TATA STEEL, NOKIA, P&G, BAYER

Speed to market

	Range
Speed to market reduction	30-90%
Design iteration time reduction	15-40%

Lighthouse examples: Johnson & Johnson, FAST RADIUS, Danfoss, MAXUS

Customization

	Range
Configuration accuracy increased	15-20%
Lot size reduction	55%-90%

Lighthouse examples: MAXUS, FAST RADIUS

Lighthouses are deploying 92 use cases with some focusing within the manufacturing site and others on connecting the E2E value chain (1/2)

Manufacturing

Digital assembly & machines

Real-time locating system (RTLS) for key manufacturing components

Cycle time optimization through big-data analytics on lines PLCs

Light-guided assembly sequence

Mixed reality to enable digital standard work/trainings

Advanced IIoT applied to process optimization

Artificial Intelligence-powered process control

Digital lean tools
(e.g., eKanban, eAndon, eSpaghetti)

Artificial intelligence guided machine performance optimization

Digitally enabled variable takt time

Digitally enabled modular production configuration

Digital maintenance

Cost optimization Of heavy operations through sensor analysis

Machine alarm aggregation, prioritization and analytics enabled problem solving

Predictive maintenance aggregating data based on historical and sensor data

Real-time pipeline cost optimization based on edge sensors

Remote assistance using augmented reality

Analytics platform for deviation root-cause identification

Digital performance management

Analytics platform for remote production optimization

Digital dashboards to monitor OEE performance

Digital twin for remote production optimization

Enterprise Manufacturing Intelligence system to upgrade operations management

Integration platform to connect machine-level data with enterprise-software

Real-time asset performance monitoring
and visualization

Sensor-based manufacture KPI reporting

Digital tools to enhance a connected workforce

Digital recruitment platform tailored to shop floor

Digital twin of sustainability

Digitally enabled man-machine matching

Digital quality management

Scanning to replace and improve performance for high cost CMM (scans)

Automated in-line optical inspection to replace end-product manual inspections

Digital work instructions & quality functions

Digitized standard procedures for line operations with integrated workflow

Mixed reality glasses to guide operators in the end-of-line inspection

Field quality failures aggregation, prioritization and advanced analytics enabled problem solving

IoT enabled manufacturing quality management

Digital quality audit

Quality improvement by predictive analytics

Digitally enabled sustainability

Energy optimization by predictive analytics

IIoT real-time energy data aggregation and reporting dashboard

Sensor-based data collection for energy management

Lighthouses are deploying 92 use cases with some focusing within the manufacturing site and others on connecting the E2E value chain (2/2)

End-to-end value chain

Supply network connectivity

Aggregate demand across end-to-end supplier network

Should-cost modeling to support make versus
buy decisions

Analytics driven procurement supported by spend intelligence & automated spend cube

End-to-end real-time supply chain visibility platform

Supplier and materials quality tracking

Part traceability from unique digital tag based on surface scanning

Digital supplier performance management

Artificial Intelligence to accelerate scaling of digital applications across sites

Joint data analytics with equipment OEM for process optimization

E2E product development

3D printing for rapid design prototyping

3D simulations / digital twin for product design and testing

Testing automation

Advanced analytics for performance management across the idea
to market

Product development using robotics

Big-data / AI enabled product design and testing

Virtual reality supported prototyping

Digital thread implementation through product development lifecycles

Rapid outsourced prototyping

Crowd-sourcing & competitions to develop digital solutions

E2E planning

Predictive demand forecasting

Real-time S&OP

Real-time inventory management (internal / extremal)

Dynamic production scheduling with digital twin

Dynamic network optimization

Predictive inventory replenishment

Analytics for dynamic warehouse resource planning and scheduling

Dynamic simulation for warehousing design

No-touch master planning (allocation to the plants)

Digital integrated business planning

Closed loop planning

End-to-end real-time supply chain visibility platform

Advanced analytics to optimize manufacturing and distribution footprint

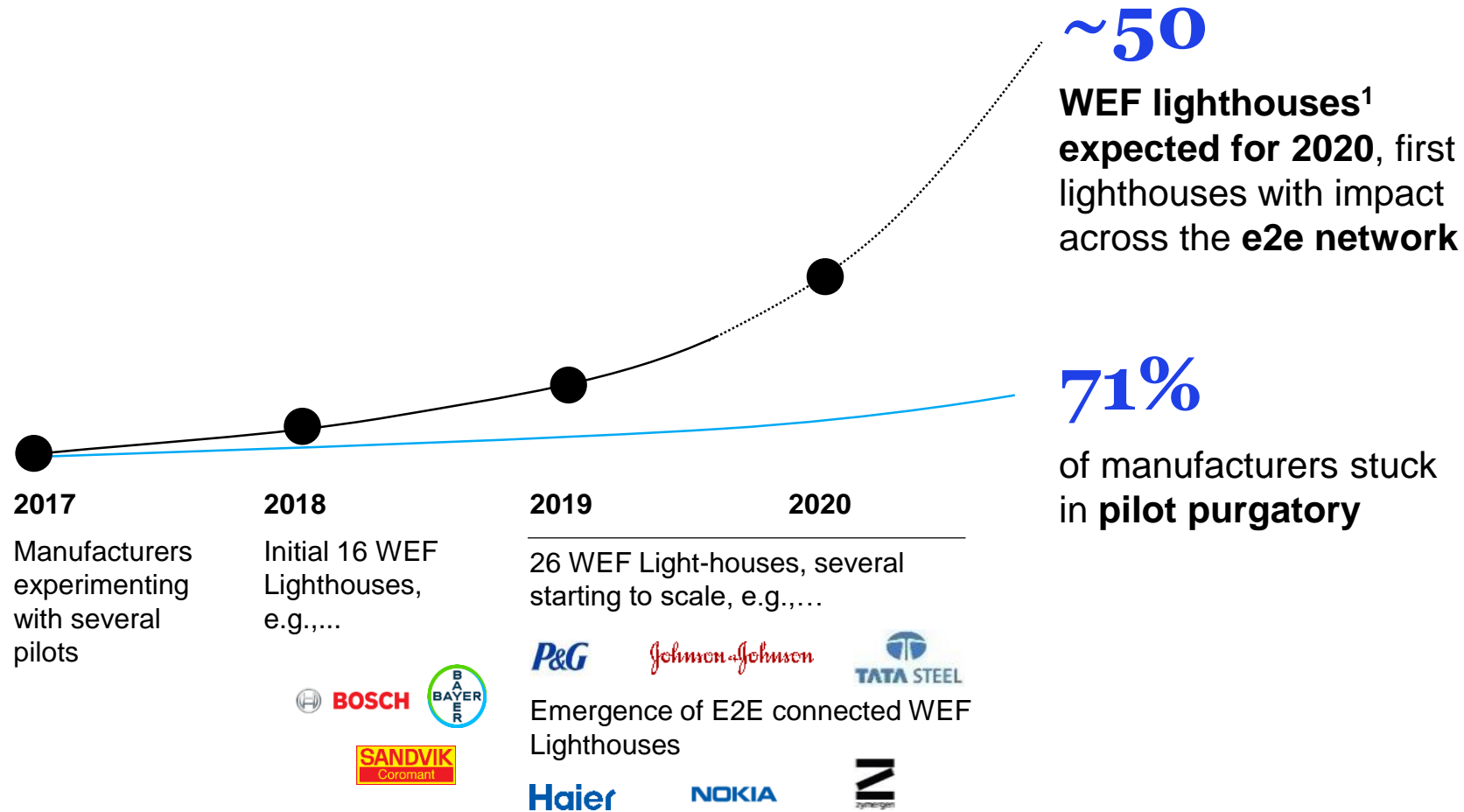Production planning optimized by advanced analytics

E2E delivery

Dynamic delivery optimization

Robotics enabled logistics execution

Digital track and trace

Asset utilization and yard management for logistics

No touch order management

Digital enabled picking and transport

Predictive maintenance in fleet assets

"Uberization' Of transport

ATP based on real-time constraints

Digital logistics control tower

Customer connectivity

Connected devices to track and measure consumer behaviors

Mass customization and B2C online ordering

Delivering to customers wherever they are through new delivery solutions

Customer end-user interface to configure and order a product, and track delivery

Smart / intelligent packaging

Customer analytics enabled by RFID

Online communities for customer insights

GPS based map and customer location

3D printing

Connected devices to track and measure product performance

Digital Twin of Customer System

The gap between the frontrunners and the majority continues to grow

~**50**

WEF lighthouses[1] expected for 2020, first lighthouses with impact across the **e2e network**

71%

of manufacturers stuck in **pilot purgatory**

Only a handful vanguards went from pilot to lighthouse and are starting to scale network-wide

Secret formula for scaling business impact decoded

2017

Manufacturers experimenting with several pilots

2018

Initial 16 WEF Lighthouses, e.g.,...

BOSCH

BAYER

SANDVIK Coromant

2019   **2020**

26 WEF Light-houses, several starting to scale, e.g.,...

P&G   Johnson&Johnson   TATA STEEL

Emergence of E2E connected WEF Lighthouses

Haier   NOKIA   Z symega

1. Estimated based on pipeline of applications to the WEF

To escape pilot purgatory, Lighthouses become the scale-up vehicle for the entire company

Scale-up architecture

Lighthouses as scale-up vehicles

One — **Company operating system**
New way of working across value chains, people, assets and sites

Few — **Lighthouses**
Integrated 20+ use cases that together innovate a value chain or factory and allow to build the infrastructure to scale

50+ — **Use cases**
Digital innovations that change how business/process is conducted

500+ — **Deployments**
Local transformations that innovate the way we work across the organization

1. Minimum viable product
2. Future of work

Scale-up Unit

Lighthouses create an MVP[1] of the company wide IIoT operating system

Augmented-reality operators, robotics, and leaned-out, automated processes are simulated and optimized using digital twin methodology

Upskilled workforce with FoW[2] ready profiles via an IIoT academy. Agile operating model fostered through agile digital studio

IIoT/Data systems

Business process

Management systems

People systems
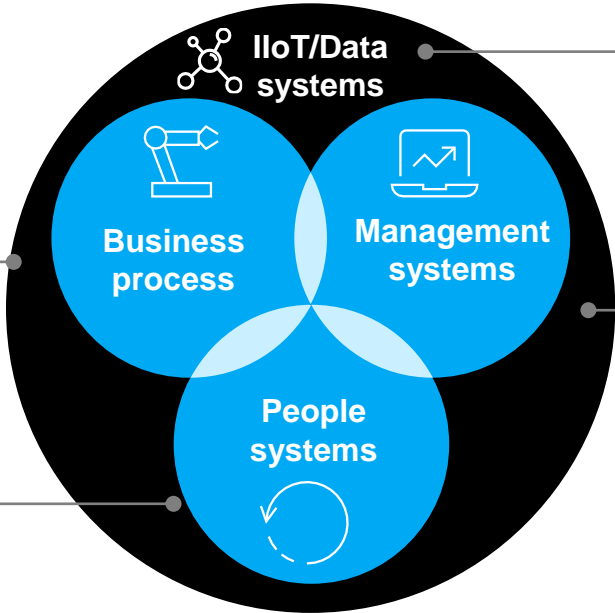
Modernized IIoT stack & data model allow cyber connection between reality (eg, shop-floor sensors) and IT systems, and agility to add use cases in matter of weeks (technology democratization)

Digital performance management—with AI-powered, personalized dashboards and alerts—creates one source of truth and eliminates waste in decision making

Scale-up enablers

Lighthouses build the infrastructure to scale

Agile approach	IIoT stack	IIoT academy
Agile digital studio	Tech ecosystem	Transformation office
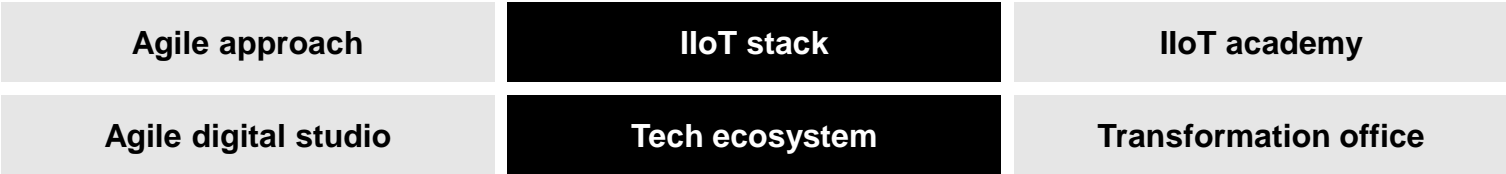
Key enablers are the secret sauce to scaling fast

Scale-up enablers

Lighthouses build the infrastructure to scale

|		
	Agile approach	Lighthouses iterate quickly, fail fast, and learn continuously. Create minimum viable products (MVPs) in two-week sprints, and bundle use-cases for fast transformations This agile approach stands in stark contrast to year-long pilots that are designed for perfection
	Agile digital studio	To be agile, co-location of translators, data engineers, ERP systems engineers, IIoT architects, and Data Scientists is key, as is direction by product managers and an agile coach, who make sure that results are delivered in sprints and iterated fast
	IIoT stack	Lighthouses are preparing existing IT systems to design & modernize the next generation of technology capabilities, ensuring that selected IIoT architecture is sufficiently adaptable and future proof
	Tech ecosystem	Relationships supported by mutual exchange of large amounts of data and collaboration on technology platforms to facilitate the exchange and consumption. This is a notable shift from the age-old idea of safeguarding technology solutions and data as a competitive advantage
	IIoT academy	Given the need to reskill and upskill the workforce at scale, the development of effective learning methods focused on technology becomes critical. Examples include gamification, digital learning pathways, VR/AR learning, and AR and digital custom real-time work instructions
	Transformation office	Lighthouses that achieve scale have established governance models to support best practice exchange and prioritization with a focus on impact and solutions, as opposed to focusing principally on technology

Though Lighthouses have a common set of value drivers - E2E leaders deliver value in 3 distinct ways

Value drivers across both areas

Technology democratization and augmenting the operator

Technology on the shop floor is transforming ways of working, as operators develop their own apps and solutions to facilitate and automate their tasks.

Big data decision-making

Decisions are not hypothesis-driven, but rather are based on big data deciphered by pattern recognition – and not by humans.

Process and business model innovation

Fourth Industrial Revolution technologies enable the lighthouses to develop new business models that complement and/or disrupt the traditional business and value chain.

Value drivers in E2E Lighthouses

Customer centricity

By placing customers at the center of process design and operations, organizations are improving the initial purchase experience as well as use over the product lifetime

Seamless connectivity across functions

Seamless data exchange and transparency across functions reduces friction, allowing for more efficient decisions and reduction of redundant communications

Continuous connectivity across organizations

4IR technologies enable unprecedented data collection, exchange, and processing; this allows organizations to create new ecosystems in the manufacturing space

Lighthouses

SAIC 上汽集团 SAIC MOTOR | MAXUS 迈克萨斯

Haier

FAST RADIUS

NOKIA

zymergen

PHŒNIX CONTACT

Haier

FAST RADIUS

Lighthouses are taking common actions to prepare their workforce for change

Transforming the ways in which people work together as part of the 4IR transformation is essential

Lighthouses are successfully navigating these changes through 6 common actions to maximize the potential of workers.

Lighthouses have invested in people
Keeping people at the center, empowering them to realize their full potential alongside that of digital technology, demonstrates that true 4IR innovation is directly entwined with people and that the Fourth Industrial Revolution is, after all, a human enterprise

Empowering the front line to innovate, using technology and data

Proactively building capabilities, both technical and soft, and managing talent

Adjusting the organizational structure to enable Fourth Industrial Revolution transformation

Implementing new ways of working such as agile and increased transparency

Improving day-to-day assembly and operating tasks through automation and technology

Increasing levels of problem solving and collaboration on the front line

"From-To" illustrates these common actions impacting front-line workers' daily work and engagement (1/2)

	Example lighthouses	From	To
Empowering the front line to innovate, using technology and data	P&G Schneider Electric FORD OTOSAN	Innovation in my production line is generated from the top	I own innovation in my production line—we all come up with ideas
		I always see scorecards measuring the same KPI—but with different numbers	All our scorecards are based on data from a single source that now we all use to make decisions
		I spend my time confirming data accuracy and inputting it into multiple report templates	My data is tracked automatically from hundreds of sources and feeds real-time into scorecards
Proactively building capabilities, both technical and soft, and managing talent	P&G PETROSEA	I learn the basics to perform my job, but have limited opportunities to develop other skills	I have a customized reskilling program, adjusted for my abilities with digital technologies and accelerated multiskilling
		My company relies on our internal knowledge and experience to train our team, and it is limited to the first week on the job	My company uses innovative external methodologies for training, blending on-the-job coaching, rotations, augmented reality, and virtual stations or a digital learning center
		The talent-management system is one-size-fits-all, relying on expertise	Partnerships with universities and other companies offer new learning opportunities to learn from others, as part of an online platform with an individual training journey
Adjusting the organizational structure to enable 4IR transformation	BAYER BOSCH Invented for life NOKIA arçelik Schneider Electric	I see many silos between IT functions and operations	We have new cross-functional team focusing on digital deployment
		My team is production only—we only focus on running equipment	My team merges production and maintenance, with technicians and operators running automated operations

"From-To" illustrates these common actions impacting front-line workers' daily work and engagement (2/2)

|	Example lighthouses	From	To
Implementing new ways of working such as agile and increased transparency	arçelik NOKIA FORD OTOSAN BOSCH Invented for life	Solution development is finished outside of our operations before being tested	To develop a fit-for-purpose product, the agile team involves us early in minimum viable product (MVP) development, though sprint review
		My discussion with my supervisor is based on the last hour or day with limited data that does not help us problem solve—so its mostly just a review	My discussion with my supervisor uses real-time and relevant data for the losses we are having, so we can diagnose root causes and make decisions quickly
Improving day-to-day assembly and operating tasks through automation and technology	Danfoss PHOENIX CONTACT	More than 90% of my shift tasks are repetitive and manual	For basic tasks, I have help from automation and cobots
		I rely on few support tools, mostly paper standard operating procedures (SOPs)	I have digital tools for real-time help (electronic SOPs, augmented reality)
		I can only manage a few machines since they have frequent breakdowns, and I have to make adjustments based on my experience	My machines are self-learning with automated centerlining and other settings, which eliminates most breakdowns and allows me to track more machines in parallel
Increasing levels of problem solving and collaboration on the front line	arçelik FOXCONN Schneider Electric	I spend most of my time gathering data, yet most sessions lack all relevant data	I have relevant data available in a centralized source to use when needed
		Decisions in my line typically are based on experience, not data	My team relies on self-diagnosing machine-based data to make decisions

Appendix – Case studies

Scale-Up enablers

Agile digital studio

Agile approach

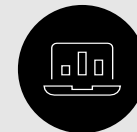IIoT stack
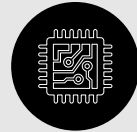
Tech ecosystem

IIoT academy

Transformation office

Value Drivers

Technology democratization and augmenting the operator

Big data decision-making

Process and business model innovation

Customer centricity

Seamless connectivity across functions
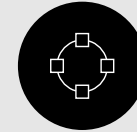
Continuous connectivity across organizations

Digital technology improves connectivity throughout the value chain allowing organizations to minimize the effects of deviations in production

Schneider Electric in Batam has created a platform for stakeholders to monitor and adjust to anomalies within its manufacturing processes

One Communication Portal
used by all suppliers to communicate operational capabilities enabling better supply chain planning

IIOT Platform

Monitors and transfers real-time data to supplier informing any variations in production

Supplier Portal

Communicates demand forecasts to suppliers facilitating more efficient inventory planning at the suppliers' locations

QR Code

Aids company and suppliers to effectively track and trace inventory throughout the value chain

Key Impacts

+70% Supplier service rate

-85% Administration time

+40% On-time delivery

The right portfolio of interconnected technologies enables operational agility while minimizing efficiency costs

VR

Flexible Robotics

Automated Internal Logistics

Virtualization of R&D

Lessens time to market and helps identify quality issues early

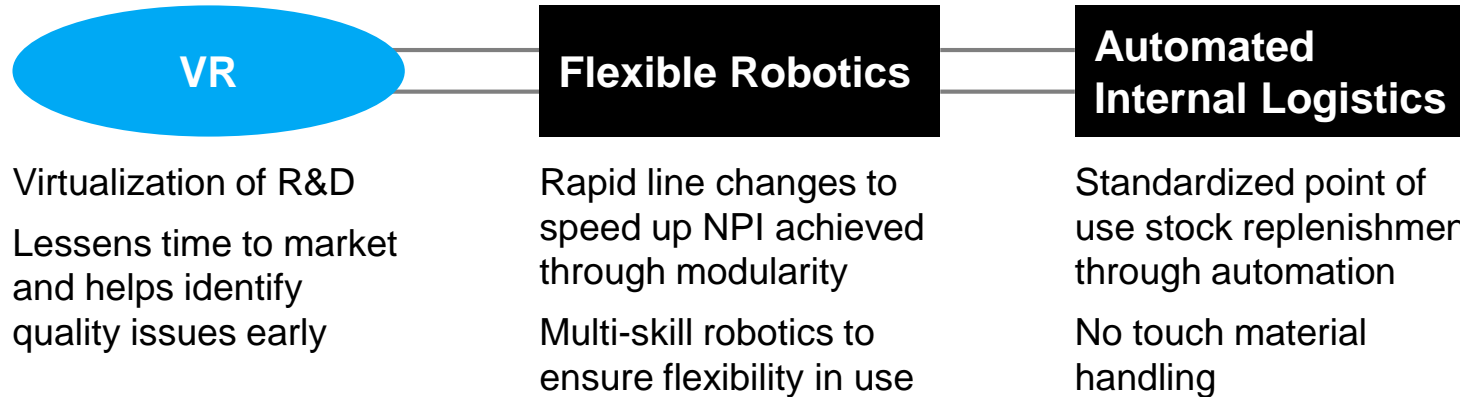Rapid line changes to speed up NPI achieved through modularity

Multi-skill robotics to ensure flexibility in use

Standardized point of use stock replenishment through automation

No touch material handling

Wireless network & cloud infrastructure

Robust private cellular network infrastructure allows for all machines to be upload and download data seamlessly
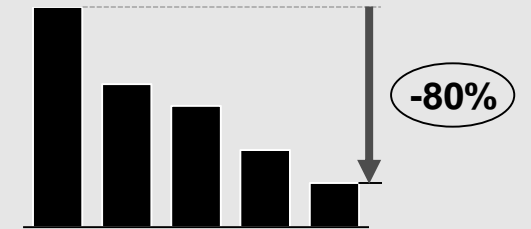
Enables plug and play of machines without rewiring LAN

Data from the cloud is inputted into analytics platforms to identify inefficiencies and correct those through planning
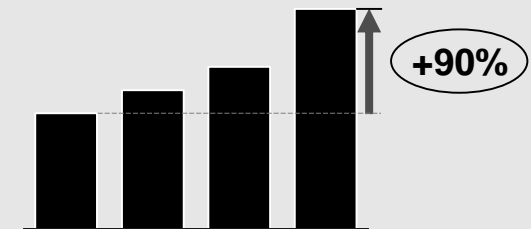
Ex. Impact on KPIs

Production lead-time

-80%

Standard unit per FTE

+90%

Process quality (PPM)

-50%

2016   17   18   2019
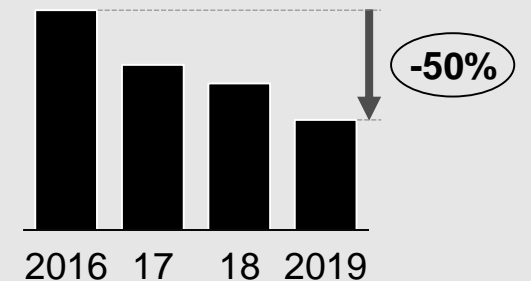
Digital planning overcomes inefficiencies by leveraging total data transparency across functions to make holistically efficient decisions

Design 〉 **Testing** 〉 **Production** 〉 **Shipment**

Digital Twin for Remote Production

Production can be viewed across all sites

Allocates job to the site while solving for logistics and capacity of the sites

Analytics platform captures data throughout the process

Analytics platform utilizes multiple machine learning algorithms to provide specific feedback to all segments of the value chain

- Empowers root cause problem solving across all functions by utilizing the feedback to work on the deficient areas

The platform is enabled by an open communication protocol between all of the factory's sensors in the line and the central cloud data storage

Reduced amount of quality issues and rework based on improved design from data feedback loop

Key Impacts

-36% inventory reduction

-90% time to market

Organizations place customer experience at the core of their strategy and utilize technology to establish a link with performance management

Haier's air conditioning unit is achieving its transformational goal of moving from a one-time customer mindset to a **lifetime user mentality** by utilizing digital technology to connect customer experience with daily operations

Real-time Data Monitor

Customer PM analyzes unit performance data and any deterioration in performance is reported

Customer Complaint

Product Purchase

Using interactive platform, customer customizes and places order

Customer calls with any issues and the data engine retrieves the performance data from unit serial number

Team/Dept.

Issue Solved

Lessons Applied

With the data provided from the system, the root cause of the customer's issue can be addressed

If production worker error caused the fault, the appropriate individual's record will be updated in the shop floor bonus system accordingly

- If part error, parts will be examined to determine appropriate course of action

Key Impacts

+21% quality improvement

+63% in labor productivity

-50% customer PM FTE

-33% lead time

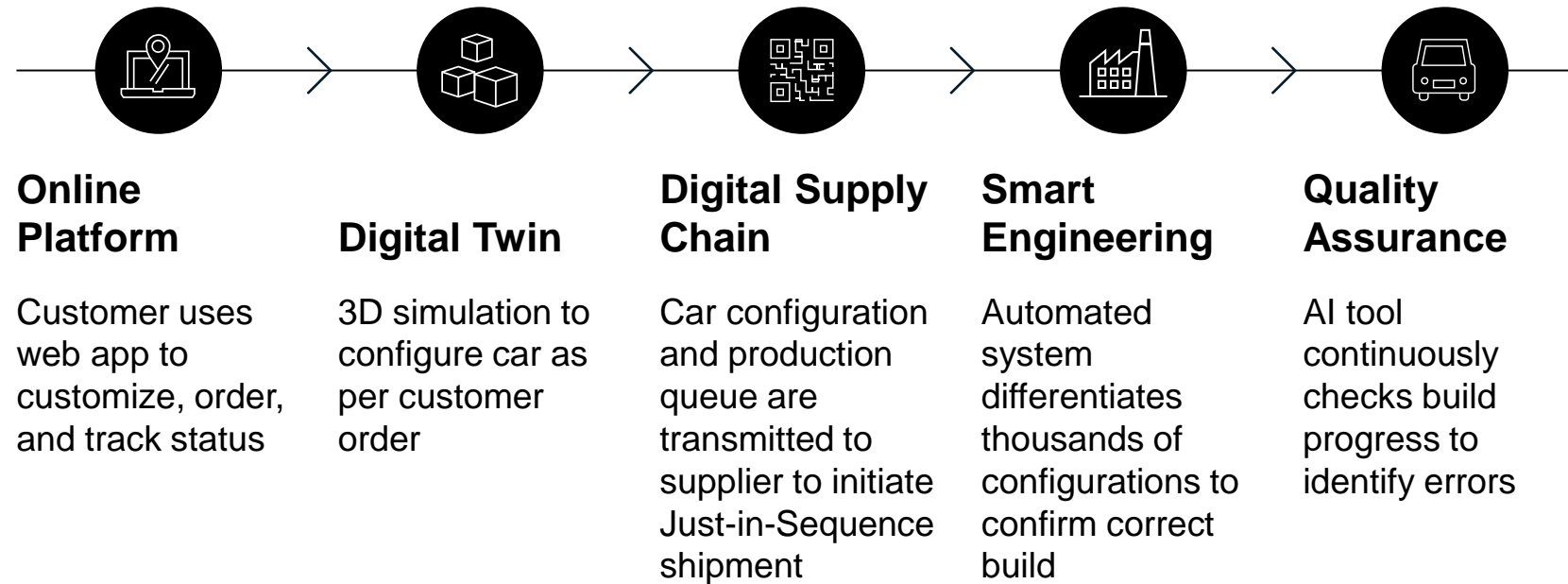# E2E Lighthouses continue to generate value outside the four walls by creating solutions that enable a differentiated customer centric experience

SAIC Maxus is utilizing digital solutions to revolutionize the **mass production of mass customized** vehicles to provide unprecedented service to the customers

Online Platform

Customer uses web app to customize, order, and track status

Digital Twin

3D simulation to configure car as per customer order

Digital Supply Chain

Car configuration and production queue are transmitted to supplier to initiate Just-in-Sequence shipment

Smart Engineering

Automated system differentiates thousands of configurations to confirm correct build

Quality Assurance

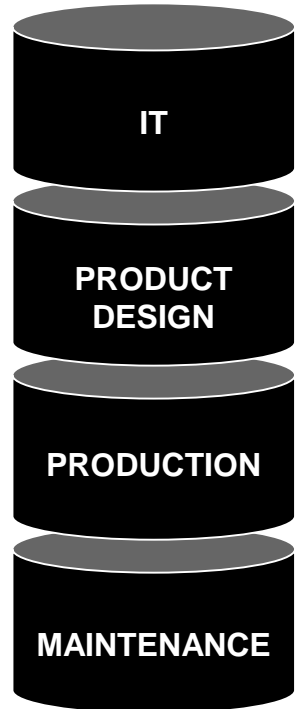AI tool continuously checks build progress to identify errors

Key Impacts

-35% Time to market

-20% Production lead time

99.8% Configuration accuracy

-30% Tooling and changeover

As organizations foster cross function collaboration, they are able to achieve impact at scale rapidly

Siloed Teams

Enabled by "transformation group leader"

Integrated cross-functional teams

IT

PRODUCT DESIGN

PRODUCTION

MAINTENANCE

Transformation group was composed of participants from every function ensuring collaboration throughout the transformation
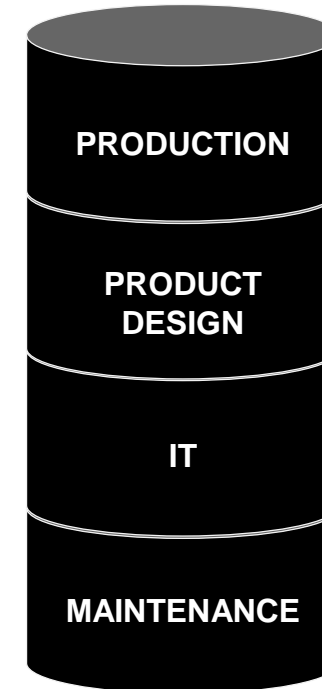
Collaboration is enabled by a universal technology platform, EcoStruxure, with custom app development that can be plugged-in to the ecosystem

Change management program effectively leveraged the collaboration to establish

Quick pilot to scale-up cadence

PRODUCTION

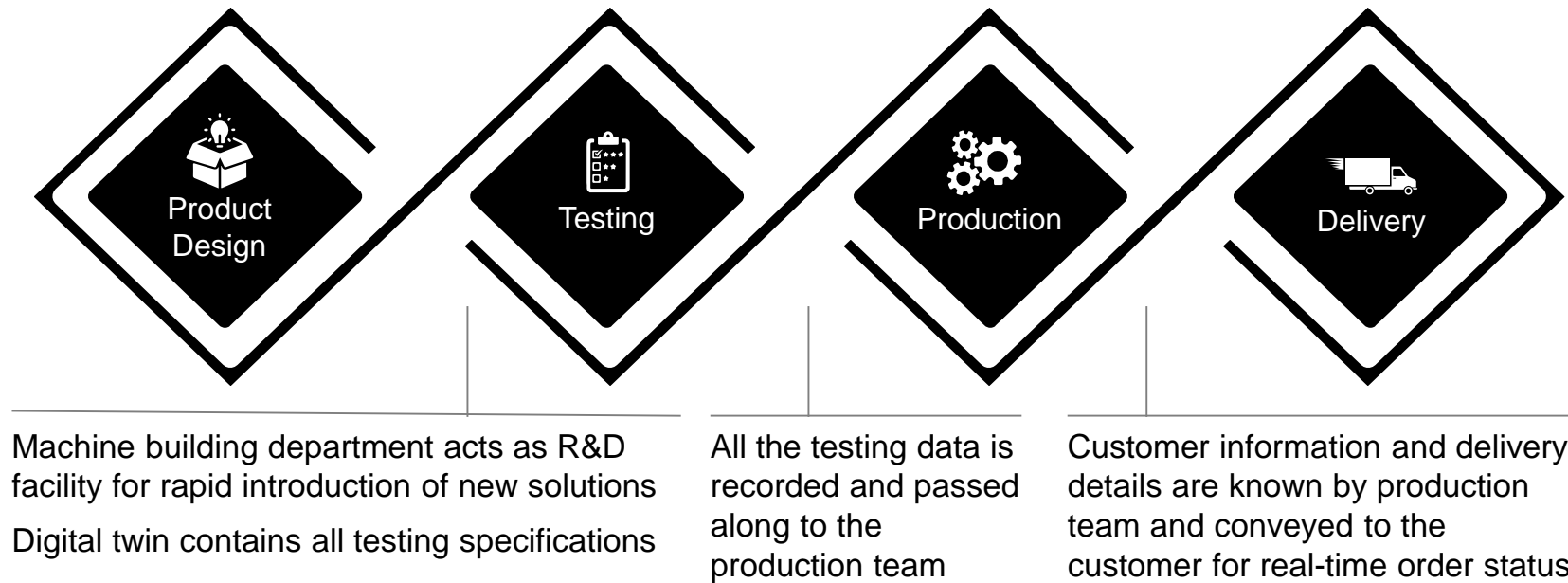PRODUCT DESIGN

IT

MAINTENANCE

Key Impacts

+12% operational efficiency

-44% machine downtime

Digital connectivity enables an integrated and transparent operating model that results in value creation greater than the sum of each step in the value chain

Phoenix Contacts uses **RFID** tags that carry information ensuring transparency and accessibility of data to all steps of the process

Product Design

Testing

Production

Delivery

Machine building department acts as R&D facility for rapid introduction of new solutions

Digital twin contains all testing specifications

All the testing data is recorded and passed along to the production team

Customer information and delivery details are known by production team and conveyed to the customer for real-time order status
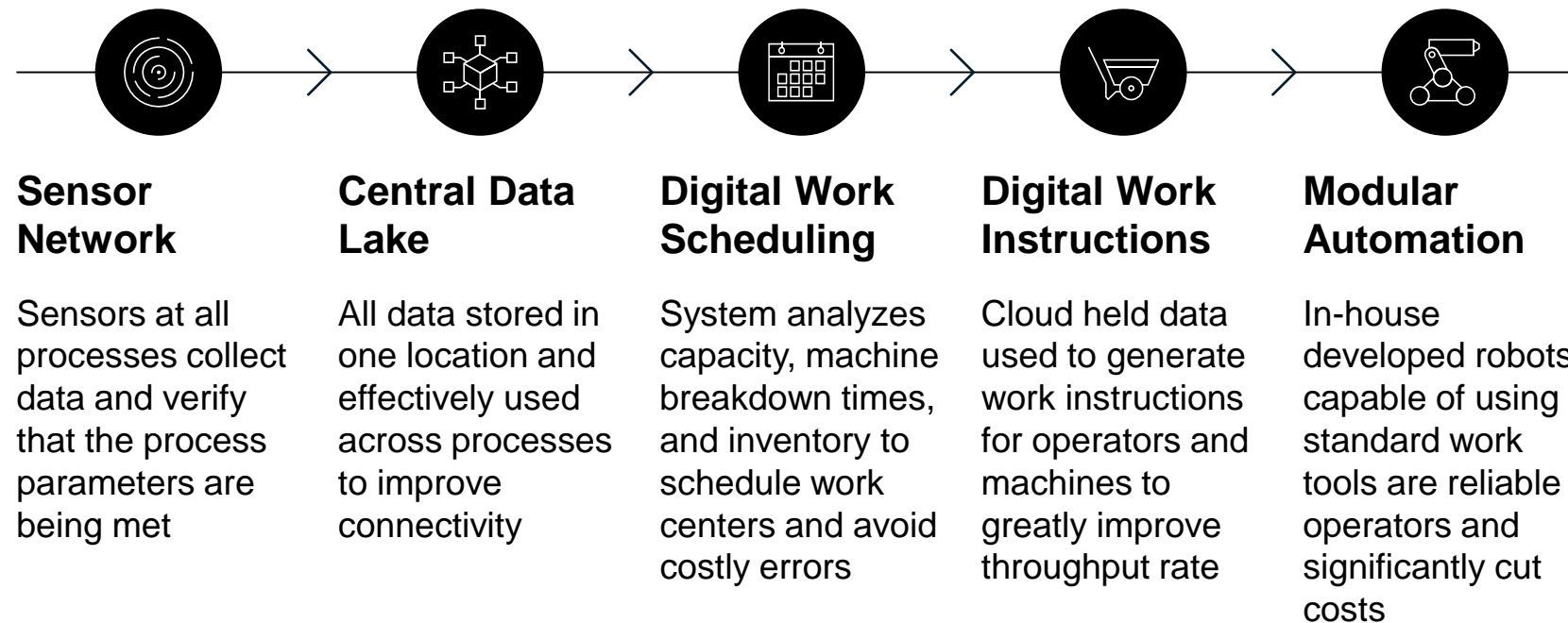
Key Impacts

24/7 running of the line

+40% performance

Up to -30% production time

Unique products at cost of mass production

When utilizing a single repository of data, analytics and big data can effectively plan across functions and contribute to connectivity

Zymergen is employing **advanced analytics** and **automation** to digitize the traditional method of performing lab works

Sensor Network

Sensors at all processes collect data and verify that the process parameters are being met

Central Data Lake

All data stored in one location and effectively used across processes to improve connectivity

Digital Work Scheduling

System analyzes capacity, machine breakdown times, and inventory to schedule work centers and avoid costly errors

Digital Work Instructions

Cloud held data used to generate work instructions for operators and machines to greatly improve throughput rate

Modular Automation

In-house developed robots capable of using standard work tools are reliable operators and significantly cut costs

Key Impacts

+46% labor efficiency

-42% operating cost

-50% lead time

+40% line yield

The Global Lighthouse Network

The Global Lighthouse Network is a community of production sites and other facilities that are world leaders in the adoption and integration of the cutting-edge technologies of the Fourth Industrial Revolution (4IR).

Lighthouses apply 4IR technologies such as artificial intelligence, 3D-printing and big data analytics to maximize efficiency and competitiveness at scale, transform business models and drive economic growth, while augmenting the workforce, protecting the environment and contributing to a learning journey for all-sized manufacturers across all geographies and industries.

The Global Lighthouse Network is a World Economic Forum project in collaboration with McKinsey & Co, and the factories are chosen by an independent panel.

Find out more: https://www.weforum.org/projects/technology-and-innovation-for-the-future-of-production

Want to learn more?

Read the summary report at
https://mckinsey.com/business-functions/operations/our-insights/industrys-fast-mover-advantage-enterprise-value-from-digital-factories

Read the full report at
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