

THE PRIORITISATION MATRIX

Catalysing the transformation of manufacturing

Singapore Economic Development Board (EDB), a government agency under the Ministry of Trade and Industry, is responsible for strategies that enhance Singapore's position as a global centre for business, innovation, and talent. We undertake investment promotion and industry development, and work with international businesses, both foreign and local, by providing information, connection to partners and access to government incentives for their investments. Our mission is to create sustainable economic growth, with vibrant business and good job opportunities for Singapore.

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Foreword

Since the inception of the term **Industrie 4.0** in 2011, the global manufacturing community has come a long way. The conversation around Industry 4.0 has evolved from learning about its key concepts and benefits to exploring how to best implement transformation roadmaps.

Today, more companies are aware of Industry 4.0, and fewer doubt that the benefits are real. Instead, they are asking a new set of questions around implementation: **How can I start? Where should I focus on?** As companies acquire knowledge about Industry 4.0, it is evident that there is a struggle to progress towards implementation.

In 2017, we launched the Smart Industry Readiness Index (“SIRI”) to help manufacturers learn about the key tenets of Industry 4.0. We also introduced an Assessment Matrix to allow manufacturers to evaluate the existing state of their facilities and assess their Industry 4.0 readiness levels. SIRI has helped many companies kick-start their Industry 4.0 journey over the last two years. Looking ahead, we realised that we needed to do more to help companies better design and execute their transformation roadmaps.

Developed with the support of Industry 4.0 thought leaders McKinsey & Company, SAP, Siemens, and TÜV SÜD, this new Prioritisation Matrix serves to guide manufacturers – in Singapore and globally – towards identifying the Industry 4.0 areas that will yield the greatest benefit to them. We believe that the ability to prioritise key areas will alleviate some of the long-standing uncertainties that manufacturers face and be the needle-mover in accelerating the pace of Industry 4.0 transformation.



Dr Beh Swan Gin
Chairman
Singapore Economic Development Board

Executive Summary

Over the last few years, manufacturers’ understanding of Industry 4.0 and its potential value has grown steadily, yet many have been unable to translate their acquired knowledge to actionable transformation plans. According to a 2018 McKinsey survey of manufacturing companies, while 75 per cent of respondents recognised that Industry 4.0 solutions could improve business performance, only 13 per cent had embarked on Industry 4.0 initiatives. Many manufacturers that had completed the Smart Industry Readiness Index (“SIRI”) Assessment Matrix also reflected the same uncertainty regarding next steps.

This gap between awareness and implementation is usually due to companies lacking an overall Industry 4.0 roadmap. **Prioritisation** is a critical undertaking for companies in order to formulate an effective Industry 4.0 roadmap as it helps identify focus areas that will generate the greatest value. This drives both informed decision-making and effective resource allocation. Yet, despite the importance of prioritisation, there has been little assistance and guidance available for manufacturers – big and small – that want to embark on this process in a robust and comprehensive way. This whitepaper is a deliberate attempt to help companies approach prioritisation in a systematic fashion that is both robust and comprehensive.

TIER: A Holistic Framework for Prioritisation

The TIER Framework provides a conceptual framework which underscores the four key principles that companies must factor into consideration for a holistic prioritisation.

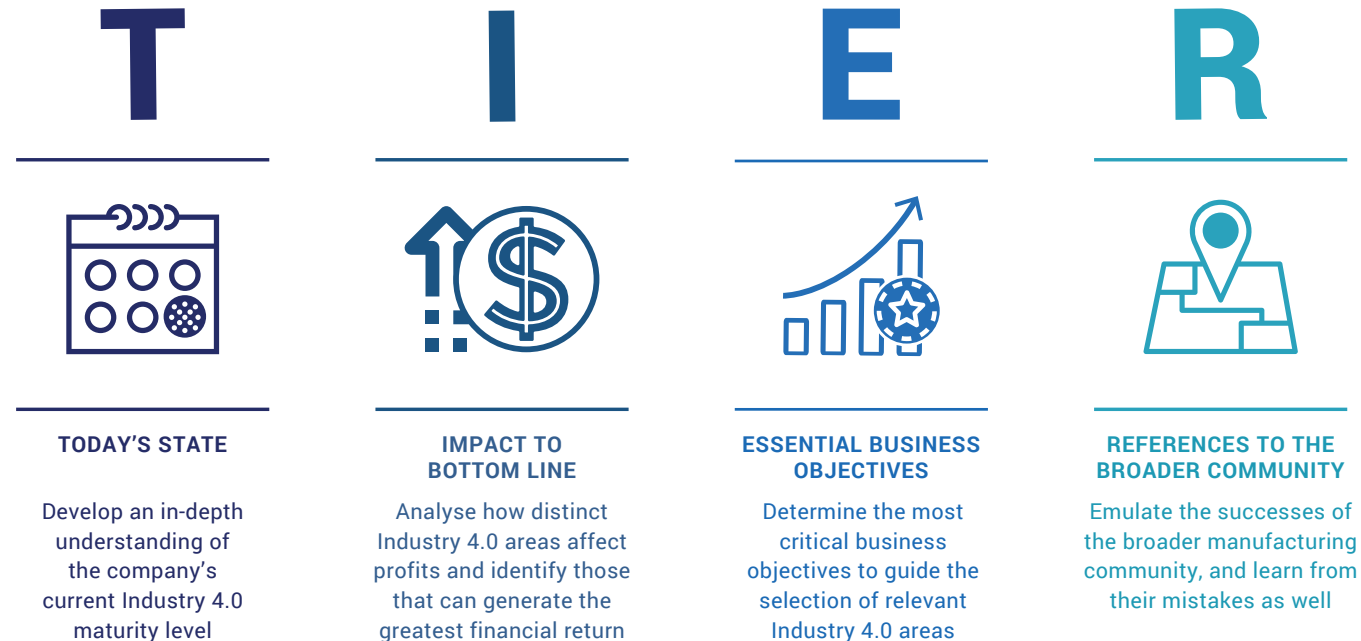
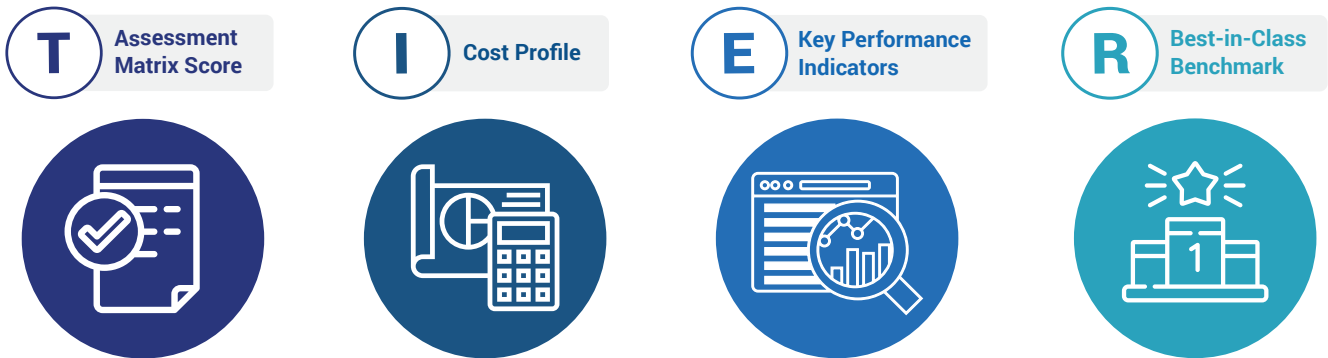


Figure 1: The TIER Framework

The Prioritisation Matrix

To help companies translate the four principles into practice, the Prioritisation Matrix was developed with the support of knowledge partners Fraunhofer Institute, McKinsey & Company, SAP, Siemens, and TÜV SÜD. Designed as a management planning tool, the Prioritisation Matrix aims to assist companies in quantitatively identifying the high-priority SIRI Dimensions in which improvements will bring the most benefit, by comparing the Impact Values across the different SIRI Dimensions.



THE PRIORITISATION MATRIX FORMULA

$$\begin{aligned}
 \text{Impact Value of SIRI Dimension } i &= \text{Weighted Cost Factor } i + \text{Weighted KPI Factor } i + \text{Weighted Proximity Factor } i \\
 &= W_c \cdot \text{Cost Factor } i + W_k \cdot \text{KPI Factor } i + W_p \cdot \text{Proximity Factor } i \\
 &= W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC - AMS}]_i
 \end{aligned}$$

AMS: Assessment Matrix Score

DOR_c: Degree of Relevance (Cost)

W: Weightage assigned to the factor

BIC: Industry Best-in-Class Benchmark

DOR_k: Degree of Relevance (KPI)

Figure 2: The Prioritisation Matrix Formula

The Way Forward

Together, the TIER Framework and Prioritisation Matrix offer a holistic approach to help ensure that companies move in the right direction as they forge ahead with their Industry 4.0 transformation roadmaps.

Introduction

Industry 4.0 Transformation Journey: The LEAD Framework

The transformation and upgrading of a manufacturing facility is not a one-off exercise. Rather, it is a continuous and iterative process. This is encapsulated in the LEAD Framework – a continuous four-step process that all manufacturers can adopt in their approach towards Industry 4.0 transformation.

- 1 **LEARN** key concepts and build a common language for alignment;
- 2 **EVALUATE** the current Industry 4.0 maturity levels of existing facilities;
- 3 **ARCHITECT** a comprehensive transformation strategy and implementation roadmap; and
- 4 **DELIVER** impact and sustain transformation initiatives



Figure 3: The LEAD Framework

Background: The Smart Industry Readiness Index (2017)

The Smart Industry Readiness Index (“SIRI”) was created by the Singapore Economic Development Board (“EDB”), in partnership with a network of leading technology companies, consultancy firms, and industry and academic experts. SIRI comprises a suite of frameworks and tools to help manufacturers – regardless of their size and industry – start, scale, and sustain their manufacturing transformation journeys.

The SIRI Framework comprises three layers. The topmost layer identifies three fundamental building blocks of Industry 4.0: Technology, Process, and Organisation. All three building blocks must be considered to harness the full potential of Industry 4.0. Underpinning the building blocks are eight pillars, which represent critical aspects that companies must focus on to become future-ready organisations. The third and final layer comprises 16 dimensions that companies should reference when evaluating the current Industry 4.0 maturity levels of their facilities.

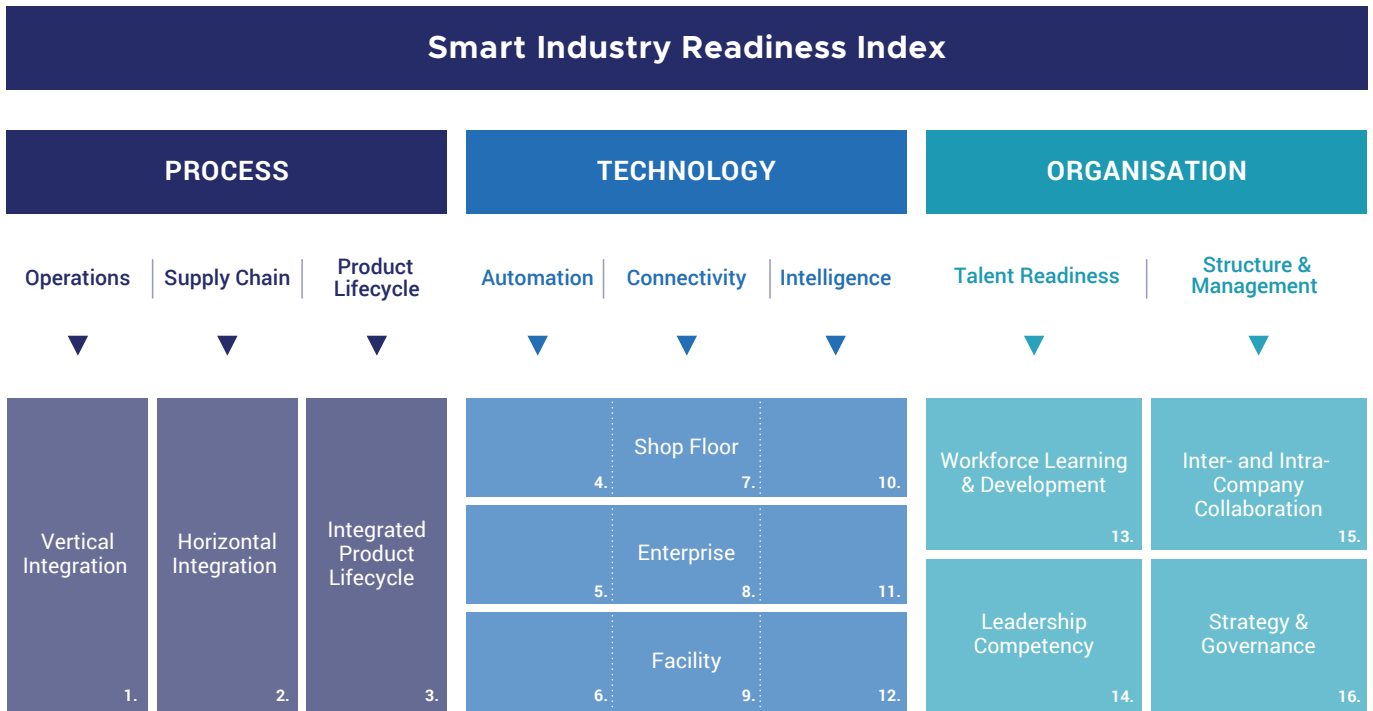


Figure 4: The SIRI Framework

The Assessment Matrix

Launched in tandem with the SIRI Framework, the Assessment Matrix is the world's first self-diagnostic Industry 4.0 tool. The Assessment Matrix is validated by a global advisory panel of industry experts and is designed to strike a balance among technical rigour, usability, and relevance. Companies can refer to "The Smart Industry Readiness Index" whitepaper published in November 2017 for the complete Assessment Matrix.

Within the Assessment Matrix, there are six bands, in ascending order, tied to each of the 16 SIRI Dimensions. Each band describes a specific state within that dimension. Identifying a manufacturing facility's bands across all 16 dimensions therefore presents a snapshot of the manufacturing facility's current Industry 4.0 maturity level. This is referred to as the facility's **Assessment Matrix Score**.

A Perennial Challenge: Moving from Awareness to Implementation

Since its launch, SIRI has helped many companies better understand Industry 4.0 and its potential value to their manufacturing facilities. Despite the increased knowledge, many firms have remained noncommittal about developing and executing action plans, exposing a significant gap between awareness and implementation of Industry 4.0 solutions.

This observation is also echoed by various global consultancy reports and surveys. For example, in a 2018 McKinsey survey of over 200 manufacturing

companies across six ASEAN markets, 75 per cent of respondents recognised that Industry 4.0 technologies and concepts could improve business performance, yet only 13 per cent had embarked on Industry 4.0 initiatives.

Referencing the LEAD Framework, it is apparent that manufacturers continue to be apprehensive in moving from the Evaluation phase to the Architecting phase of their digital transformation journey.

The Gap from Awareness to Implementation

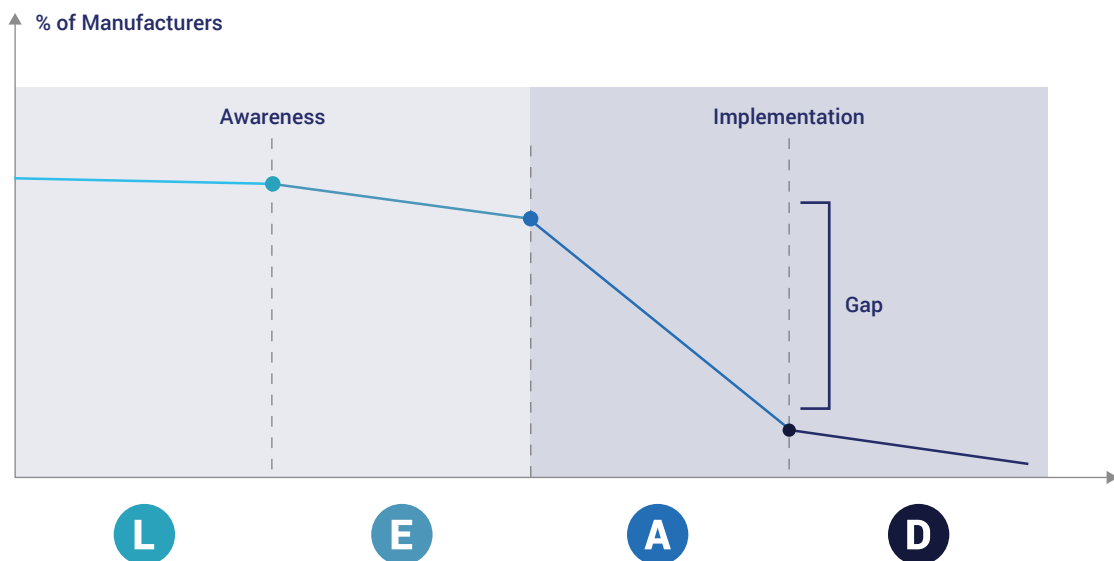


Figure 5: The Gap from Awareness to Implementation

“The overarching objective of SIRI is to help manufacturers leverage Industry 4.0 technologies and concepts to stay relevant and competitive in an increasingly digital age. As more companies develop a good understanding of their manufacturing facilities’ Industry 4.0 maturity level, we must work more closely with them to translate their knowledge into action. Prioritisation is an important step to achieve that.”

– Mr Lim Kok Kiang, Executive Vice President, EDB

Prioritisation: A Key Exercise to Bridge the Awareness-Implementation Gap

There are many reasons why companies have been slow to adopt Industry 4.0 solutions despite high levels of awareness. One of the most cited barriers is the lack of an effective strategy. In a world of scarce resources, information overload, and pressures to deliver short-term results, a clear Industry 4.0 vision is essential for companies to push beyond small-scale pilots and embrace real transformative projects.

Prioritisation is a critical exercise for any company formulating an Industry 4.0 strategy and roadmap. It also plays an important role in closing the awareness-implementation gap. Prioritisation enables companies to identify focus areas that will generate the greatest value, which drives informed decision-making and effective resource allocation.

Yet, despite the importance of prioritisation, there has been little assistance and guidance available for manufacturers – big and small alike – that want to embark on this process in a robust and comprehensive way.

This whitepaper thus aims to provide a conceptual framework and an accompanying tool to help the global manufacturing community unlock the power of prioritisation. It is an attempt to support companies in Architecting their digital transformation and progressing towards implementation and Delivery.

“Prioritisation is important for companies to gain clarity on the right Industry 4.0 areas to focus on, but it has to be carried out in a rigorous manner to drive the right outcomes. The TIER Framework, and Prioritisation Matrix, is a first of its kind reference to catalyse the digital transformation of manufacturing sectors.”

– Mr Raimund Klein, Executive Vice President & Head, Digital Industries, ASEAN, Siemens

The 4 Principles of Prioritisation

TIER: A Holistic Prioritisation Framework

Companies may find it challenging to prioritise their Industry 4.0 focus areas. One of the most common mistakes is failing to factor in all necessary considerations for a holistic prioritisation, resulting in suboptimal outcomes.

What are the key elements that companies should consider? How should companies approach a prioritisation exercise in a systematic fashion?

To answer these questions, this whitepaper establishes four key principles of prioritisation.

These four principles – collectively known as the TIER Framework – will help manufacturers home in on the Industry 4.0 areas where improvements made will deliver the greatest value. This will enable companies to start, scale, and sustain their Industry 4.0 transformation journeys in the right direction.

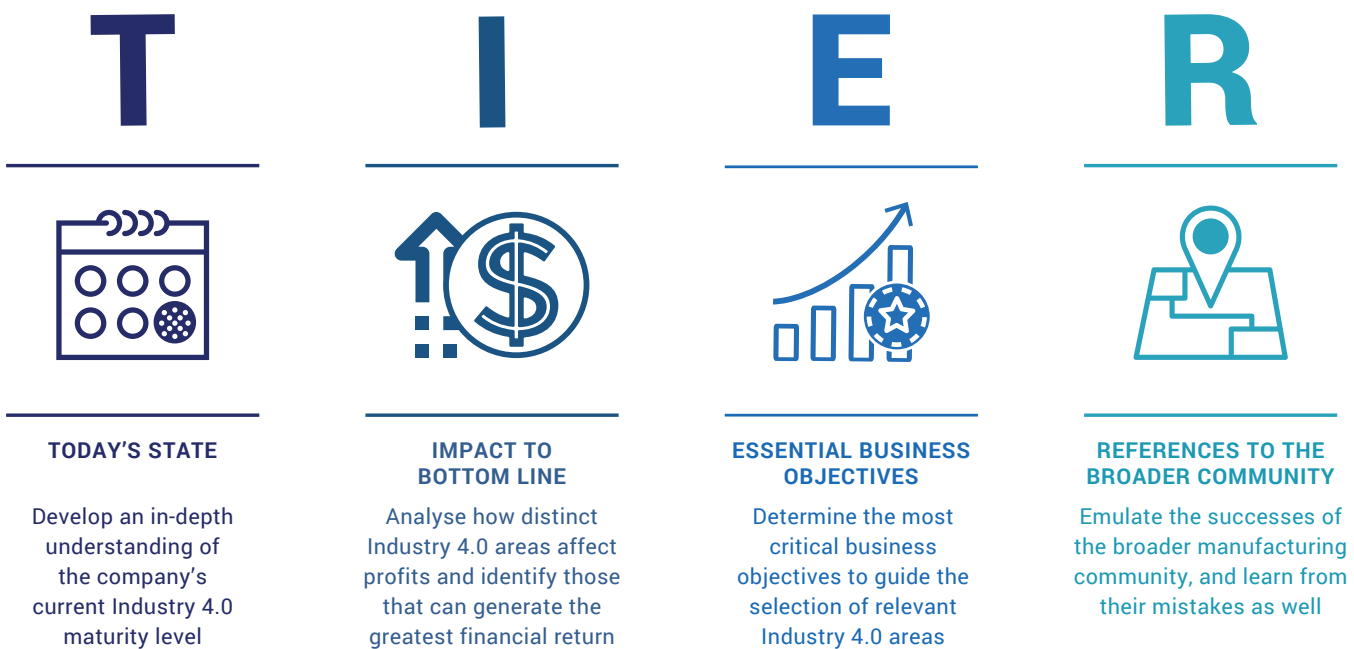
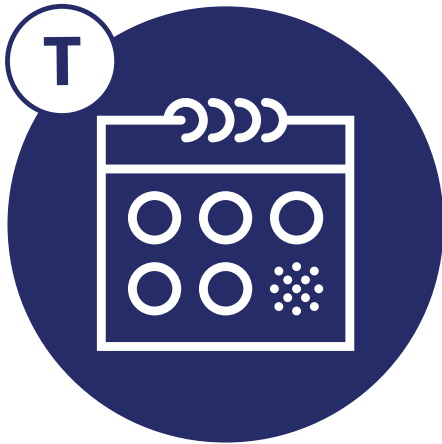


Figure 6: The TIER Framework



TODAY'S STATE

Develop an in-depth understanding of the company's current Industry 4.0 maturity level.

Before starting on any prioritisation exercise, it is important for companies to be aware of the present state of their factories. This can be achieved by conducting a detailed and ideally independent assessment of their manufacturing facilities. With that knowledge, manufacturers can identify areas of strengths to build on and areas of weaknesses for improvements. The assessment results can also empower companies to identify the most pressing opportunities for change.

A comprehensive and neutral evaluation of their manufacturing facilities will also allow companies to review any notions that may be outdated or inaccurate. Awareness and willingness to address potential misperceptions is a critical early step in developing a well-defined transformation plan.



IMPACT TO BOTTOM LINE

Analyse how distinct Industry 4.0 areas affect profits and identify those that can generate the greatest financial return.

Companies exist to sell goods and/or services to make a profit, and their fundamental aim is to maximise profits. While there may be numerous initiatives that a company may find exciting and appealing, some may not be financially feasible. Even initiatives that are economically viable will vary in their return on investments and profitability. Hence, a company must constantly decide how to allocate its resources while bearing in mind its profit maximisation objective.

Any manufacturer that intends to adopt Industry 4.0 concepts and technologies must consider the potential impact on profits. For instance, if a company's utilities costs make up a significant percentage of revenue, investing in digital technologies that reduce energy and water consumption will likely result in bigger savings compared to investments in another area like IT integration.

By being mindful of the impact of an Industry 4.0 area on the bottom line, companies will be better equipped at identifying action areas that will yield the greatest financial benefits and consequently, ensure a more sustainable Industry 4.0 transformation.



ESSENTIAL BUSINESS OBJECTIVES

Determine the most critical business objectives to guide the selection of relevant Industry 4.0 areas.

Understanding the current state of a manufacturing facility is not enough for prioritisation. It is also vital to determine a company's aspirational state, which is guided by its essential business objectives.

As such, the third principle of prioritisation involves determining the business objectives that matter to a company, and the extent to which they matter. Business objectives are measurable indicators of what constitute success to a company and may not necessarily have a direct or immediate impact on the company's bottom line. They can be described by specific outcomes like achieving net zero emissions in production or significant reductions in time to market.

When companies are clear about which business objectives matter and how much they matter, they will be more successful in narrowing down the list of Industry 4.0 areas to those that best propel them towards their desired state. This ensures that time and effort is spent on areas that will address problems unique to a company and yield outcomes that matter most.



REFERENCES TO THE BROADER COMMUNITY

Emulate the successes of the broader manufacturing community and learn from their mistakes as well.

As companies seek to transform their manufacturing facilities, it is not enough to rely solely on introspective and retrospective data points to guide the architecture of their future states. No company is alone on its journey towards Industry 4.0 transformation. However, as there are no universal Industry 4.0 maturity benchmarks today, conducting a comparative analysis helps companies establish objective reference points regarding Industry 4.0 leaders and laggards.

Therefore, the final principle of prioritisation encourages companies to look outwardly towards their peers and the rest of the manufacturing sector. By discerning the factors of success and avoiding common mistakes of others, companies can develop a reference model for the potential Industry 4.0 areas that have the highest probability of delivering value.

The Smart Industry Readiness Index Prioritisation Matrix

Objectives and Intent

The TIER Framework is a high-level conceptual guide for companies that wish to embark on a comprehensive and rigorous prioritisation exercise. To translate the four TIER principles into practice, the Prioritisation Matrix was developed to help provide recommendations that are company-specific and directionally correct.

The Prioritisation Matrix is a management planning tool for manufacturers to identify high-impact Industry 4.0 focus areas, after they have used the Assessment Matrix to determine the Industry 4.0 maturity of their manufacturing facilities. Specifically, the Prioritisation Matrix aims to equip companies with knowledge of which SIRI Dimensions to prioritise.

Development Process

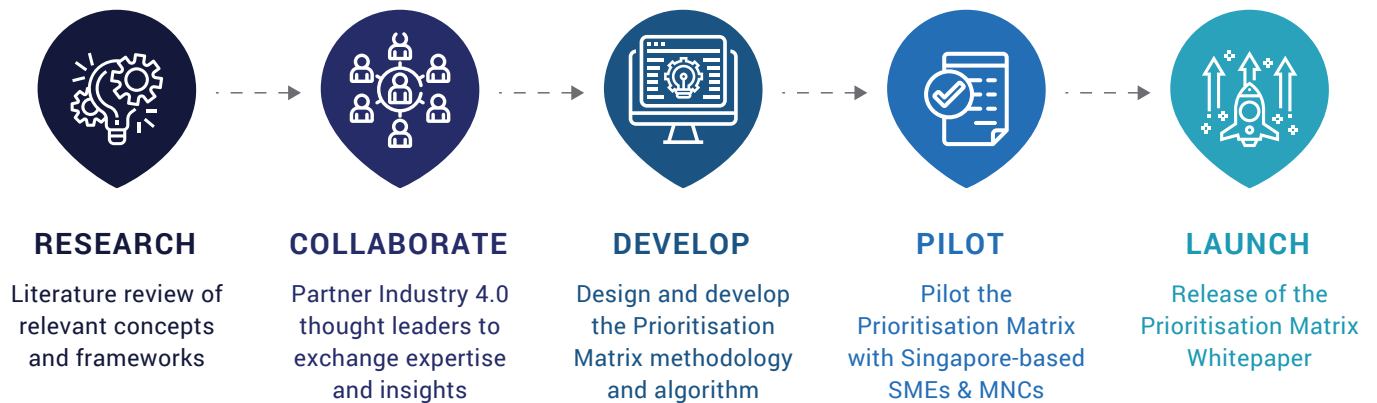


Figure 7: Development Methodology

“There is no shortage of technologies, products and solutions for the average manufacturing facility that wants to start its digitalisation journey. The challenge is in knowing which areas to work on to realise the greatest amount of benefit given a certain amount of resources available. The Prioritisation Matrix serves as a useful and neutral tool to guide companies to identify those areas.”

– Dr Andreas Hauser, Director, Digital Services, TÜV SÜD

Development of the Prioritisation Matrix began with a wide-ranging literature review of Industry 4.0-related concepts and frameworks. These included industry reports, landscape studies, business surveys, and models produced by leading associations and industry players.

To ensure the technical robustness of the Prioritisation Matrix, Fraunhofer Institute, McKinsey & Company, SAP, Siemens, and TÜV SÜD were consulted in the development process. As established leaders in their respective fields, the knowledge partners provided their expertise and counsel to enhance the integrity of the tool.

The Prioritisation Matrix was then piloted with a diverse group of manufacturers, ranging from small and medium-sized enterprises (SMEs) to multinational corporations (MNCs) across both discrete and process industries. Each pilot was conducted through a workshop involving the company’s senior management, operations, and finance teams. The insights, suggestions, and feedback gained from each pilot were used to further refine the Prioritisation Matrix.

“Many companies that have begun their Industry 4.0 transformations find themselves stuck at the pilot stage. Our research shows the successful ones are those that holistically tackle business processes, technology architecture, and organisation challenges. With this logic, the Prioritisation Matrix helps companies understand where to further diagnose, design, and ultimately implement Industry 4.0 at scale. ”

– Dr Alpesh Patel, Director of Digital Capability Centre, Singapore, McKinsey & Company

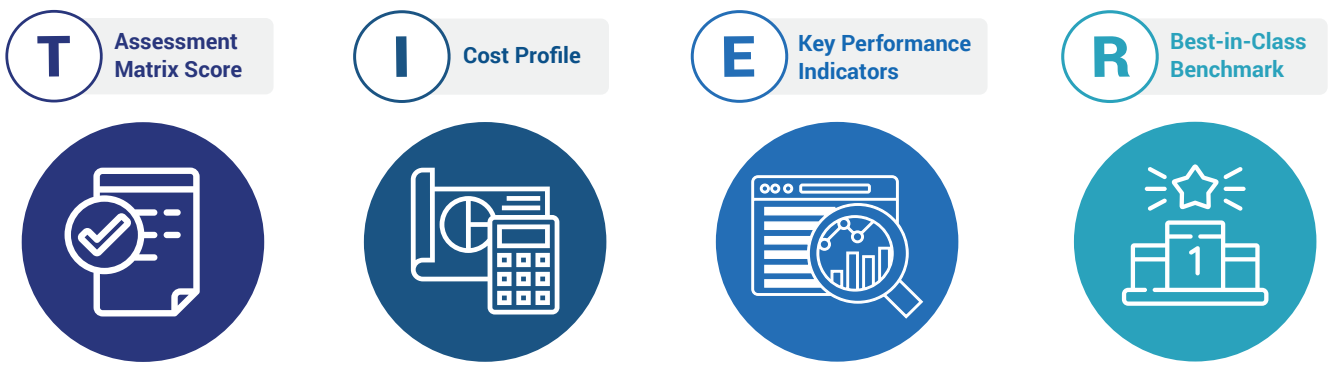
The Prioritisation Matrix Formula

The Prioritisation Matrix formula comprises three key factors: cost, top key performance indicator categories, and a company’s proximity to the industry best-in-class. Each is weighted based on how much it influences the company at the point of the prioritisation exercise. The three factors are derived from four inputs which in turn reflect principles of prioritisation in the TIER Framework.

To identify the high-priority SIRI Dimensions, the Prioritisation Matrix formula processes the three weighted factors to calculate an Impact Value for each of the 16 SIRI Dimensions. Manufacturers

can then quantitatively identify the dimensions to prioritise, by comparing the Impact Values across the 16 SIRI Dimensions.

To develop a holistic Industry 4.0 transformation strategy and roadmap, it is important that firms consider all three building blocks of the SIRI Framework (Process, Technology, and Organisation). **Therefore, the Prioritisation Matrix will recommend at least one SIRI Dimension – the one with the highest Impact Value – from each building block.**



THE PRIORITISATION MATRIX FORMULA

$$\begin{aligned}
 \text{Impact Value of SIRI Dimension } i &= \text{Weighted Cost Factor } i + \text{Weighted KPI Factor } i + \text{Weighted Proximity Factor } i \\
 &= W_c \cdot \text{Cost Factor } i + W_k \cdot \text{KPI Factor } i + W_p \cdot \text{Proximity Factor } i \\
 &= W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC} - \text{AMS}]_i
 \end{aligned}$$

AMS: Assessment Matrix Score

BIC: Industry Best-in-Class Benchmark

DOR_c: Degree of Relevance (Cost)

DOR_k: Degree of Relevance (KPI)

W: Weightage assigned to the factor

Figure 8: The Prioritisation Matrix Formula

The 3 Factors of the Prioritisation Matrix Formula

Cost Factor

THE PRIORITISATION MATRIX FORMULA

$$\text{Impact Value of SIRI Dimension } i = W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC - AMS}]_i$$

The Cost Factor of a SIRI Dimension reflects the level of impact that the SIRI Dimension can have on a company's bottom line. The Cost Factor is essential as it guides companies to prioritise SIRI Dimensions that have greater influence over key cost drivers. This ensures that the recommended SIRI Dimensions will include those that deliver the greatest financial benefits to companies.

Calculating the Cost Factor of a SIRI Dimension requires information on the Cost Profile of a company and the Degree of Relevance (Cost) ("DOR_c") Table (page 38).

The Cost Profile of a company refers to the breakdown of a company's costs as percentages of its overall revenue. For instance, if a company has an annual revenue of \$100 million and spends \$15 million on maintenance and repairs, then maintenance and repair costs can be represented as 15 per cent of the company's overall revenue.

The company's overall revenue is used as the divisor so that the influence of each cost category can be diminished or amplified, depending on whether the company is profitable or loss-making. For example, a company has a total cost of \$40 million, of which \$20 million is attributed to labour costs. When the company's revenue is at a profitable level of \$50 million, labour as a cost category is represented at 40 per cent of revenue. However, if the same company's revenue falls to an unprofitable level of \$30 million, labour increases to 66 per cent of revenue. Consequently, labour as a cost category will have greater influence in the Prioritisation Matrix formula.

A company's Cost Profile can be distilled into 10 cost categories that are commonly reflected in companies' financial statements.

How a company's Cost Profile influences the prioritisation of SIRI Dimensions

If a company's direct labour cost is 50 per cent of its overall revenue while its utilities cost is only five per cent, then directing resources to achieve improvements in a dimension like Shop Floor Automation (strongly correlated to reducing labour costs) is likely to be more valuable than investing in another dimension like Facility Connectivity (strongly correlated to reducing energy costs).

The 10 Cost Categories

 <p>Aftermarket/ Services</p>	<p>Expenses that the company expects to or has already incurred for the repair or replacement of goods that it has sold. The total expense is limited by the warranty period that the company provides.</p>
 <p>Depreciation</p>	<p>A non-cash expense representing the portion of all fixed assets owned by the company that has been considered consumed over an accounting or financial period.</p>
 <p>Labour</p>	<p>The sum of all wages paid to employees, as well as the cost of employee benefits and payroll taxes paid by an employer. This includes employees who are directly involved in the maintenance and production processes, and support teams that ensure the smooth running of the entire facility.</p>
 <p>Maintenance & Repair</p>	<p>All expenses required to bring capital assets – such as building, infrastructure, equipment, and machinery – back to good working order, or to keep them operating at optimal condition. This includes fixing broken assets and routine servicing.</p>
 <p>Raw Materials & Consumables</p>	<p>Raw materials and consumables costs include both direct materials, which are incorporated into the final product, and indirect materials that are consumed during the production process but not incorporated into the final product.</p>
 <p>Rental & Operating Lease</p>	<p>Costs associated with the use of assets which the company does not own. These include but are not limited to property, plant, and equipment.</p>
 <p>Research & Development</p>	<p>All expenses relating to activities for the development or improvement of products or processes. Such activities can include product design improvement and production process enhancement.</p>
 <p>Selling, General & Administrative Expense (“SG&A”)</p>	<p>All operating expenses which are not directly tied to the cost of making a product or providing a service. It includes corporate, accounting, legal, sales, and marketing expenses.</p>
 <p>Transportation & Distribution</p>	<p>All expenses relating to the transportation of goods from one location to another. It includes the cost of transporting goods from suppliers and to customers via methods such as trucking, shipping, and freight (land, air, and sea).</p>
 <p>Utilities</p>	<p>Cost of electricity, heat (gas/fuel), sewer, and water used by a factory or plant to ensure the smooth running of both the direct manufacturing process and its surrounding environmental conditions.</p>

Figure 9: The 10 Cost Categories

Key Performance Indicator (KPI) Factor

THE PRIORITISATION MATRIX FORMULA

$$\text{Impact Value of SIRI Dimension } i = W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC - AMS}]_i$$

Key Performance Indicators (KPIs) are measures used to evaluate a company's success or effectiveness in achieving its key business objectives and strategic directives. Therefore, the KPI Factor of a SIRI Dimension reflects the level of impact that the SIRI Dimension can have on a company's essential business objectives.

Calculating the KPI Factor of a SIRI Dimension requires companies to identify their **Top KPI Categories**¹ that best reflect their desired future positioning and business outcomes, as well as the **Degree of Relevance (KPI)** ("DOR_k") Table (page 39).

The Prioritisation Matrix considers the following 14 categories of KPIs that are organised into four groups: Productivity, Quality, Flexibility, and Speed.

The 14 Key Performance Indicator (KPI) Categories

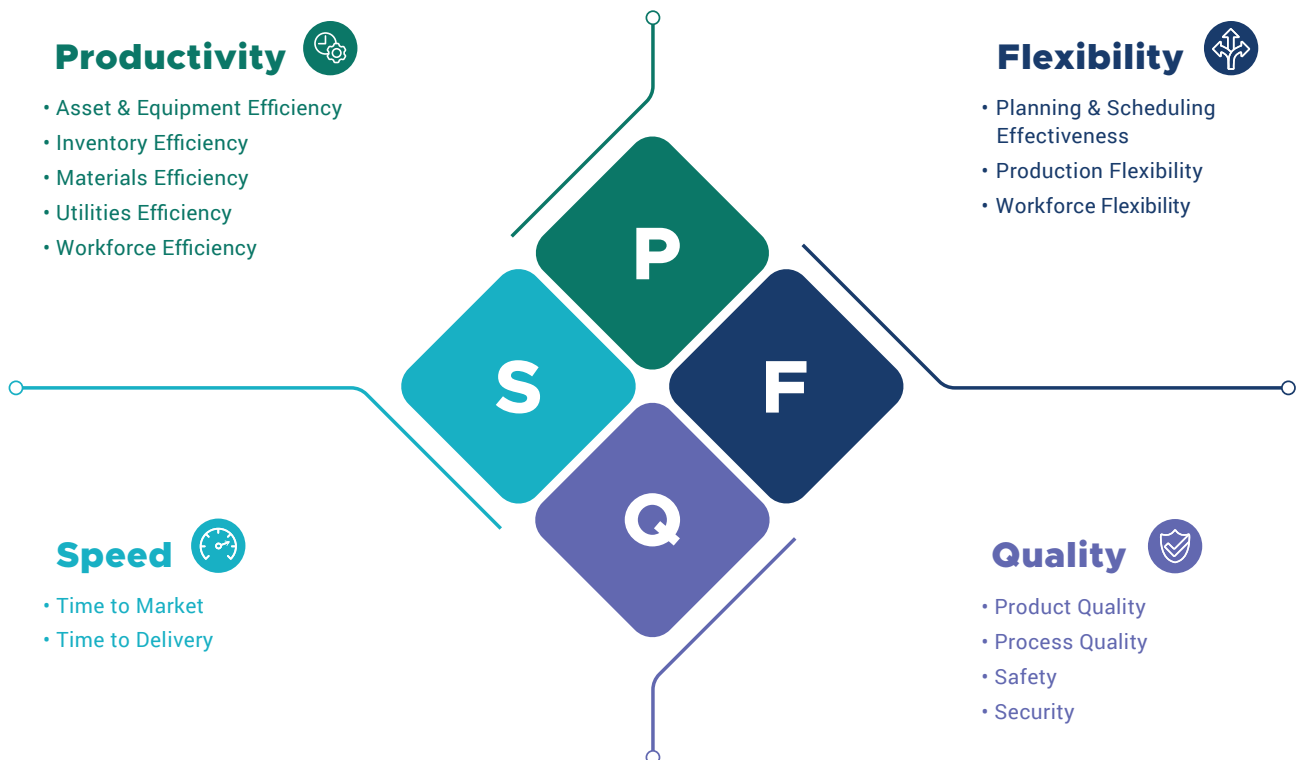


Figure 10: The 14 Key Performance Indicator (KPI) Categories

¹ For the purposes of the Prioritisation Matrix formula calculation, the top five KPI categories are selected.

Productivity

Productivity is a measurable concept that is quantitatively determined by the ratio of useful output to total input. It signifies a level of performance or a desired state that comes from using the least amount of input – such as time, energy, materials, manpower, and money – to achieve the highest amount of output. Apart from pursuing bottom-line benefits, companies striving for efficient operations could also be motivated by strategic business considerations. Under Productivity, there are five categories of KPIs.

KPI 1: Asset & Equipment Efficiency

KPIs under this category measure the company's ability to maximise the utility of assets and equipment that are used for production within its factory or plant. Parameters used by manufacturers within this category include overall equipment effectiveness (OEE), frequency of unplanned downtime, duration of assets' lifespan, and unit throughput. Improvements to asset and equipment efficiency will increase a manufacturing facility's production volume, leading to revenue gains and reduced excess capital spent on repairs and replacements.

KPI 2: Workforce Efficiency

KPIs under this category assess both the direct and indirect labour productivity in factories or plants. Companies with strong workforce efficiency will generally require fewer man-hours per task. Depending on the companies' human resources policies, employee turnover and training effectiveness could also be additional parameters in both influencing and determining workforce efficiency. Improvements in workforce efficiency can result in greater revenue contributions per employee and enhance intangible elements like workforce morale.

KPI 3: Utilities Efficiency

KPIs under this category take into consideration the amount of energy and water consumed, as well as emissions and wastewater produced by a company's manufacturing operations. If utilities costs make up a significant portion of a company's production expenses, improvements in utilities efficiency will enable it to produce at a lower cost or operate with a higher profit margin. In addition, given the growing focus on climate change and sustainability, companies operating at a higher utilities efficiency level may also be perceived as being more environmentally responsible. This could be a significant consideration for companies in brand-conscious, consumer-facing industries.

KPI 4: Inventory Efficiency

KPIs under this category aim to guide manufacturers towards optimising and/or minimising the average volume of inventory required. Storing excess inventory creates unnecessary burdens and costs, particularly for factories or plants that have limited land or storage space. In addition to locking up working capital, manufacturing facilities with large volumes of unutilised inventory can experience increased costs resulting from higher land and/or building rentals, extra manpower to manage inventory, and greater wastage due to expiring inventory. In extreme cases, excess inventory can even cannibalise space that could have been designated for new manufacturing lines or functions such as product design or testing.

KPI 5: Materials Efficiency

KPIs under this category aim to measure the company's efforts in optimising the usage of raw materials in its production process. Success in this category can come from using less inputs for the same amount of output or recycling a larger amount of unused/unprocessed inputs for subsequent production. Achieving higher levels of material efficiency can not only yield economic benefits such as savings in raw materials, but also contribute towards environmental stewardship by reinforcing the sustainability imperative of the company.

“At Rockwell Automation, we recognise the urgency to bring the Connected Enterprise to life to maintain our competitiveness. The TIER framework provides us with a comprehensive, yet easy-to-use approach to guide our digital transformation efforts towards areas that are of high-impact to our company.”

**– Mr Yeoh Pit Wee, Director of Operations for Asia-Pacific, Europe, Middle East and Africa,
Rockwell Automation**

Quality

KPI categories under the Quality group reflect a company's desire to prevent defects in its work-in-progress and finished goods during the manufacturing process, as well as faults in its products after they have been delivered to the customers. While Quality KPIs have always been important to ensure that a manufacturer can meet the ever-rising demands and expectations of customers, a growing number of manufacturers today are voluntarily holding themselves to higher standards in this area. This is because excellent performance in these KPIs not only strengthens customer trust and loyalty, but also reduces costs associated with remanufacturing or replacing faulty products. Over time, this establishes a stronger reputation and brand premium for the manufacturer. There are four KPI categories under the Quality group.

KPI 6: Process Quality

KPIs under this category evaluate the performance and resilience of a company's core and support processes, which include the company's ability to achieve and maintain the required product specifications during production, while minimising the number of deviations and irregularities from the intended system parameters and conditions. Success in this KPI category is characterised by dependable production lines, increased production output, lower defect rates, or reduced material wastage.

KPI 7: Product Quality

KPIs under this category emphasise the company's ability to produce a low percentage of defective products – both work-in-progress and finished goods – and that all products are manufactured as closely to the target specifications as possible. Achieving this will reduce the defect rate of finished goods and the likelihood of after-sale failures and product rejections. This will enable the company to sell more products per batch and reduce the costs associated with product repairs, replacements, and warranties.

KPI 8: Safety

KPIs under this category measure and track the number of workplace health and safety incidents in the company's facilities. Having few or no health and safety issues within the working environment will help minimise disruptions and ensure the company's operations continue running smoothly. Additionally, keeping employees healthy and safe reduces regulatory and compensation costs, and more importantly, helps to raise the morale and confidence of employees. In the long run, this can also create positive spin-offs in employer branding and customer confidence.

KPI 9: Security

KPIs under this category measure and track the number of security (physical and digital) breaches in the company's facilities. In recent times, the increasing digitalisation of manufacturing facilities and growing interconnectivity of assets have led to a heightened level of vulnerability in production systems and networks. This results in a greater need for more robust and resilient cyber-physical security plans to lower the risk of cyber-physical threats that may disrupt the smooth running of manufacturing facilities. The threats include the introduction of viruses and malware that may shut down or reconfigure ongoing production processes and the exposure of sensitive information to non-authorised personnel.

Flexibility

KPI categories under the Flexibility group evaluate a company's overall ability to adapt and manage ever-changing business conditions and demands. Today, a company might look to enhance its flexibility in areas such as the production floor, workforce, and/or supply chain. Companies that stress excellence in flexibility are often within the first wave of enterprises that successfully exploit new opportunities arising from dynamic market forces. They are often the same companies that other businesses will turn to for time-sensitive and/or critical contracts due to their ability to react responsively and flex accordingly. There are three KPI categories under the Flexibility group.

KPI 10: Planning & Scheduling Effectiveness

KPIs under this category focus on the manufacturer's proficiency and adaptability in its planning and scheduling functions. Companies that excel in this area generally have strong predictive analytic capabilities and clear visibility of their supply chains. This is on top of a wide network of reliable partners (suppliers and customers) which allows them to effectively handle volatile market demand and supply, and take on/fulfil orders at short notice, without significant disruptions to manufacturing and supply chain operations. Success in this area will drive top-line growth through an enhanced ability to take on more business. It also limits the adverse impacts of any market demand and supply shortfall, which subsequently fosters a strong corporate reputation for reliability and adaptability.

KPI 11: Production Flexibility

KPIs under this category measure a manufacturer's ability to augment and decentralise its production processes through a plug-and-play approach. Flexible production is where equipment, machinery, and computer-based systems can be modified, reconfigured, and retasked quickly and easily when needed, thus enabling a manufacturer to manage various permutations of product mix and volume. This allows the manufacturer to promptly achieve a high number of SKUs in accordance with changing customer needs and market demands, while incurring relatively low cost.

KPI 12: Workforce Flexibility

KPIs under this category assess the ability of a company's workforce to perform a variety of different job functions. Building a strong team of multi-skilled workers across the different levels of the organisation allows a manufacturer more options in potentially redeploying employees during periods of volatility, such as when market demand fluctuates. This enables the company to achieve stability more quickly and effectively. Having a flexible workforce also enables a company to better cope with sudden attrition, thus strengthening the company's business continuity.

Speed

The growing interconnectivity of systems and rise of new digital technologies such as big data and advanced analytics are providing companies with richer insights into their products, customer preferences, and market expectations. This has led to shorter product life cycles. With this overall trend, Speed is evolving to be less of a differentiator, and more of a necessity for manufacturers to remain competitive. Increased speed to market enables a manufacturer to reach a wider pool of consumers and maximise sales. There are two KPI categories under the Speed group.

KPI 13: Time to Market

KPIs under the Time to Market (TTM) category measure the length of time it takes for a company to conceive a new product, or augment an existing one, and launch it in the market. The digitalisation of industrial sectors has led to an increase in information flow and data exchange across the entire product value chain and allowed companies today to have greater access to customer feedback. This reduces the amount of time needed to augment or develop products that can better support changing market needs. Having a short TTM will allow companies to capitalise on emerging business trends, especially when there is a narrow window of opportunity. By ensuring its products hit the markets ahead of its competitors, a company with a shorter TTM can capture a larger market share through its first-mover advantage.

KPI 14: Time to Delivery

KPIs under this category measure the length of time a company needs to go from initiation of a project or contract to producing and delivering the finished products to end-customers. For many industries, most product orders are subjected to some level of time-sensitivity, and a delayed delivery could translate to substantial losses in future business opportunities. Companies that can deliver outcomes more quickly and reliably will be able to establish themselves as the premier providers in the industry, and possibly command a service premium for urgent orders.

How a company's strategic direction is reflected in their selection of top KPI categories

Consumer Goods Industry

A shoe manufacturer that aims to position itself as the go-to company for high-end customised sneakers will place greater importance on KPI categories such as Product Quality and Production Flexibility. Performing well in those KPI categories allows the company to manufacture a diverse range of long-lasting, hyper-personalised shoes while maintaining a healthy profit margin.

Chemicals Industry

Polyethylene is the most used plastic in the world, with global production topping more than 80 million tonnes in 2017. However, it is also highly commoditised. As polyethylene manufacturers are unable to set the price of the product, they typically strive to be the most cost-competitive to extract the highest possible profit margin. These manufacturers would place a larger emphasis on Productivity-linked KPI categories such as Asset & Equipment Efficiency, Materials Efficiency, Workforce Efficiency, and Utilities Efficiency.

“As a medium-sized enterprise with limited resources, it is especially important that we invest our time and effort in the right areas. The Prioritisation Matrix is a valuable tool because it highlights the high-impact areas that we should focus on for our Industry 4.0 plans.”

– Mr Aaron Teo, CEO, Shine Precision

Understanding the Degree of Relevance Tables

THE PRIORITISATION MATRIX FORMULA

$$\text{Impact Value of SIRI Dimension } i = W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC - AMS}]_i$$

The Degree of Relevance (“DOR”) Tables reflect the relative impact that each SIRI Dimension can have on a cost or KPI category. The DOR_c and DOR_k Tables can be found on pages 38 and 39.

The levels of impact in the DOR Tables are ranked into three degrees of relevance, indicated in Figure 11 below.

The 3 Degrees of Relevance

- 0 – Negligible
- 1 – Small and/or Indirect
- 3 – High and Direct

Figure 11: The 3 Degrees of Relevance²

For instance, in the DOR_c Table, the Shop Floor Automation SIRI Dimension has a DOR of “3” for the Labour cost category. This is because improvements in automating shop floor production processes will significantly help to reduce labour costs. On the other hand, the Integrated Product Lifecycle SIRI Dimension has a DOR of “0” for the Utilities cost category, as the association between the SIRI Dimension and the cost category is negligible.

Similarly, in the DOR_k Table, the Horizontal Integration SIRI Dimension has a DOR of “3” for the Time to Delivery KPI category. This is because when the company’s supply chain processes are more integrated with those of suppliers, delivery operations are better optimised and the time to transport goods to customers may be shortened. On the other hand, the Enterprise Automation SIRI Dimension has a DOR of “0” for the Utilities Efficiency KPI category, as the association between the SIRI Dimension and the KPI category is negligible.

² There is a step increase in the degrees of relevance between “1” and “3” to create greater differentiation in the mathematical calculations between SIRI Dimensions that have a high level of impact and those that have a moderate level of impact.

Proximity Factor

THE PRIORITISATION MATRIX FORMULA

$$\text{Impact Value of SIRI Dimension } i = W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC} - \text{AMS}]_i$$

The final factor in the Prioritisation Matrix formula is the Proximity Factor. A company's **Assessment Matrix Score** serves as the baseline from which it will measure the impact of changes and track the progress of its transformation. The Proximity Factor of a SIRI Dimension reflects the gap between a company's current state and that of the best-in-class. It is therefore calculated by taking the difference between the company's **Assessment Matrix Score** and the **Industry Best-in-Class Benchmark** (indicated in the formula as "AMS" and "BIC" respectively).

The **Industry Best-in-Class Benchmark** is defined as the average performance of the top 10 per cent of manufacturers in a particular industry, across all 16 SIRI Dimensions. The **Industry Best-in-Class Benchmarks** for 14 manufacturing industries³, derived from the Official SIRI Assessment database and further refined by a panel of industry experts, can be found on page 40.

Knowing and comparing with the **Industry Best-in-Class Benchmark** is important for two reasons.

Firstly, a company that knows what its industry's best-in-class looks like has a better sense of what is achievable. Not every Industry 4.0 technology or solution in the market is financially practical to procure today. Even among the technologies and solutions that are commercially viable, many are often beyond what a typical manufacturer needs to become industry-leading. By recognising what the top manufacturers in their industries have attained, companies have a more realistic point of reference and are better able to set pragmatic goals and aspirations.

Secondly, by comparing one's facility against its **Industry Best-in-Class Benchmark**, manufacturers are better able to identify aspects where they lag the most, which are often the areas with the greatest scope for improvements.

For companies that are best-in-class in certain aspects, the information can be a basis for deliberate efforts to widen the gap between them and the rest of the manufacturing community, which further extends their leadership position. Either way, when companies know where they stand relative to their **Industry Best-in-Class Benchmark**, they can better articulate the rationales for embarking on transformation in specific Industry 4.0 areas.

³ The list of 14 industries and their descriptions can be found on pages 42, 43 and 44

Assigning Weightages: Using a Company's Planning Horizon as a Guide

THE PRIORITISATION MATRIX FORMULA

$$\text{Impact Value of SIRI Dimension } i = W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC - AMS}]_i$$

The Prioritisation Matrix formula incorporates three key factors described in the earlier sections. While the three key factors ensure a comprehensive prioritisation exercise, each factor will have a varying level of influence depending on a company's considerations.

To incorporate each factor's varying level of influence, we introduced the concept of applying weights to each factor in the Prioritisation Matrix formula. In addition, this whitepaper recommends the use of a company's business planning horizon to guide the assignment of weightages across the three key factors. A company's business planning

horizon is the length of time into the future that is accounted for in the development of a business plan or strategy. It often reflects the various considerations that the company may have for its prioritisation exercise and hence provides a good indication as to how the weightages should be distributed across the three key factors.

The weights indicated in the Figure 12 below are organised according to a company's business planning horizon and they provide a reference for companies. However, companies may choose to adjust the weights for each factor according to their unique circumstances.

Weightage Distribution according to Planning Horizon			
Planning Horizon	Cost Factor (W_c)	KPI Factor (W_k)	Proximity Factor (W_p)
Strategic (3 – 5 years)	30%	40%	30%
Tactical (1 – 2 years)	45%	30%	25%
Operational (3 – 6 months)	60%	20%	20%

Figure 12: Weightage Distribution according to Planning Horizon

Strategic

The Strategic planning horizon accords the highest weightage to the KPI Factor. Compared to the other planning horizons, it also accords the greatest weightage to the Proximity Factor. Companies that reference the Strategic planning horizon are often large MNCs that aspire to keep pushing the boundaries and maintain a lead over their peers, or those that intend to make a deliberate push to overtake their closest competitors. It is generally recommended that a company should seek to adopt a Strategic planning horizon only if there is no near-term pressure to improve its financial and market positions.

Tactical

Globally, the Tactical planning horizon is the one most commonly adopted by businesses, particularly SMEs. These businesses either lack the resources and risk appetites to commit to transformation plans beyond two years or have no need and/or ability to transform into a global best-in-class manufacturing firm. Even a number of organisations with regional presence, both publicly listed and family-owned, may choose to adopt the Tactical planning horizon from time to time. This helps them remain nimble in responding to changing market conditions, especially during periods when the business outlook offers limited security or certainty.

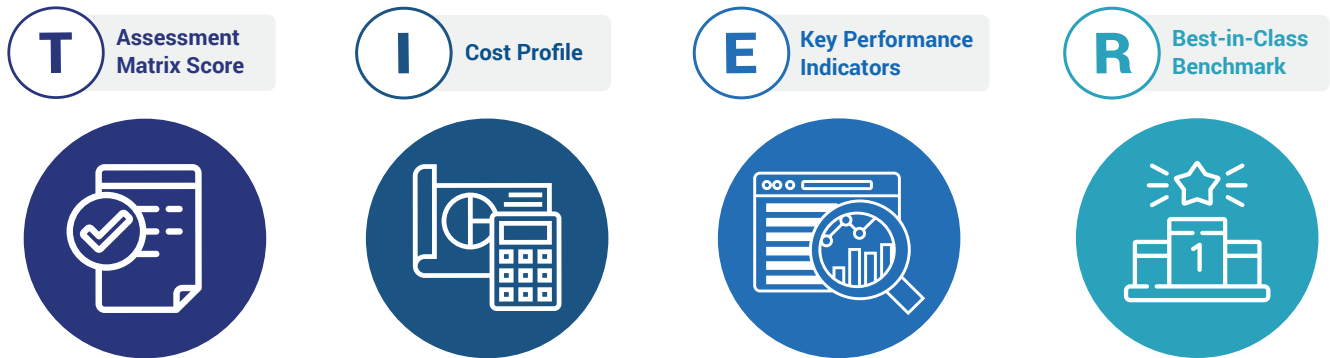
Operational

The Operational planning horizon accords the greatest weightage to the Cost Factor. This planning horizon should be adopted by companies that are under pressure to deliver quick, short-term financial returns. A small weightage remains attributed to both the KPI and Proximity Factors as cost reduction, while important, is not the only effective intervention to address short-term business issues. Micro-sized local enterprises with a very limited product range and/or volume may choose to reference this planning horizon.

“The logic behind the practical Prioritisation Matrix approach to maturity measurement in the context of Industry 4.0 is sound. I am confident that this approach will greatly assist companies in managing their activities as they move towards Industry 4.0.”

**– Prof. Dr. Michael Henke, Director, Enterprise Logistics,
Fraunhofer Institute for Material Flow and Logistics IML**

Bringing It All Together: An Illustrative Case Study



THE PRIORITISATION MATRIX FORMULA

$$\begin{aligned}
 \text{Impact Value of SIRI Dimension } i &= \text{Weighted Cost Factor } i + \text{Weighted KPI Factor } i + \text{Weighted Proximity Factor } i \\
 &= W_c \cdot \text{Cost Factor } i + W_k \cdot \text{KPI Factor } i + W_p \cdot \text{Proximity Factor } i \\
 &= W_c \cdot [\text{DOR}_c \cdot \text{Cost Profile}]_i + W_k \cdot [\text{DOR}_k \cdot \text{Top KPIs}]_i + W_p \cdot [\text{BIC} - \text{AMS}]_i
 \end{aligned}$$

AMS: Assessment Matrix Score

BIC: Industry Best-in-Class Benchmark

DOR_c: Degree of Relevance (Cost)

DOR_k: Degree of Relevance (KPI)

W: Weightage assigned to the factor

Figure 13: The Prioritisation Matrix Formula

Company A is a leading regional electronics manufacturer with a diverse portfolio of consumer products generating an annual revenue of over US\$30 billion (about S\$41.7 billion). It has a factory in Southeast Asia that is 20 years old. To ensure that the manufacturing facility continues to be cost competitive, the general manager has decided to tap on SIRI to help kick-start the facility's digital transformation journey.

Having completed the Assessment Matrix to understand the facility's current Industry 4.0 maturity level, the company intends to use the Prioritisation Matrix to identify the priority SIRI Dimensions to focus on.

The company engaged a Certified SIRI Assessor and provided the following information as seen in Figure 14:

- Assessment Matrix Score**
- Cost Profile** ("Cost Categories as a Percentage of Annual Revenue")
- Top KPI Categories**
- Planning Horizon**
- Industry Group for the Industry Best-in-Class Benchmark** ("Industry Best-in-Class Benchmark")

Company A's Inputs						
Assessment Matrix Score		Cost Categories as a Percentage of Annual Revenue		Top KPI Categories (Select 5)		
Vertical Integration	1	Aftermarket Services / Warranty	0%	Asset & Equipment Efficiency		
Horizontal Integration	1	Depreciation	3%	Workforce Efficiency		X
Integrated Product Lifecycle	2	Labour	24%	Utilities Efficiency		
Shop Floor Automation	1	Maintenance & Repair	1%	Inventory Efficiency		X
Enterprise Automation	1	Raw Materials & Consumables	38%	Materials Efficiency		
Facility Automation	0	Rental & Operating Lease	0%	Process Quality		X
Shop Floor Connectivity	0	Research & Development (R&D)	5%	Product Quality		
Enterprise Connectivity	2	Selling, General & Administrative Expense ("SG&A")	17%	Safety		
Facility Connectivity	0	Transportation & Distribution	3%	Security		
Shop Floor Intelligence	1	Utilities	5%	Planning & Scheduling Effectiveness		X
Enterprise Intelligence	2	Planning Horizon (Select 1)		Production Flexibility		
Facility Intelligence	0	Strategic	X	Workforce Flexibility		X
Workforce Learning & Development	2	Tactical		Time to Market		
Leadership Competency	1	Operational		Time to Delivery		
Inter- & Intra-Company Collaboration	2					
Strategy & Governance	1					
Industry Best-in-Class Benchmark (Select 1)						
Aerospace	Automotive	Electronics	Energy & Chemicals (Downstream)	Food & Beverage	General Manufacturing	Logistics
Oil & Gas (Upstream)	Machinery & Equipment	Medical Technology	Pharmaceuticals	Precision Parts	Semiconductors	Textile, Clothing, Leather & Footwear

Figure 14: Company A's Inputs

Results

Using the information provided by Company A, the Prioritisation Matrix⁴ identified the following four SIRI Dimensions as the high-impact areas for Company A to focus its resources and attention on:

Process	Technology	Organisation
<ul style="list-style-type: none">• Vertical Integration• Horizontal Integration	<ul style="list-style-type: none">• Shop Floor Intelligence	<ul style="list-style-type: none">• Leadership Competency

Figure 15: High-impact areas of focus for Company A

Enhancing Vertical Integration and Shop Floor Intelligence will improve Company A's ability to uphold the quality of its manufacturing processes through processing and analysing data. Working on these two dimensions will consequently strengthen Company A's Workforce Efficiency and Workforce Flexibility, both of which were highlighted as the company's top KPI categories.

Furthermore, Company A's improvement in the Horizontal Integration dimension will increase its Planning & Scheduling Effectiveness. This will help the company optimise the management of its

Raw Materials & Consumables, which currently make up more than a third (38 per cent) of the company's annual revenue.

Finally, improvements to Leadership Competency will position Company A's management team to better leverage the latest trends and technologies to develop relevant transformation initiatives. This will enhance the company's capability to develop a more robust, long-term transformation plan, which is aligned with its intentions to adopt a Strategic planning horizon.

"There is no favourable wind for the sailor who does not know where to go (Seneca). The Prioritisation Matrix helps a company to identify the key areas that it should focus on as it starts its Industry 4.0 journey. Knowing which is the first step in the right direction and the expected outcomes, is crucial before you decide to make the required investment in the people, the technology and the processes that will ultimately make your manufacturing business more agile and resilient."

– Mr David Marchesseau, Regional Vice President, Head of Industries, SAP

⁴ The step-by-step calculation methodology of the Prioritisation Matrix tool can be found on pages 35-41

The Way Forward

Planning and executing an Industry 4.0 transformation plan is no small undertaking. It requires companies to invest significant resources into areas such as conducting research, engaging potential solution providers, performing cost-benefit analyses, and monitoring the progress of projects. As a result, few companies are willing to take the plunge, unless they are highly confident that implemented projects will achieve their desired outcomes.

The TIER Framework and the Prioritisation Matrix can help bolster clarity and reduce uncertainty, by offering manufacturers a systematic approach to prioritise their focus areas.

EDB and its knowledge partners look forward to companies making full use of the TIER Framework and the Prioritisation Matrix, to move in the right direction and forge ahead with their Industry 4.0 transformation.

“For a company like Infineon that has embarked on our Industry 4.0 plans, the Prioritisation Matrix serves as a useful tool to help us review whether our on-going efforts are in the right direction.”

– Dr Laurent Filipozzi, VP and Site Head Plant Singapore, Infineon

Calculation Methodology of the Prioritisation Matrix

This step-by-step guide outlines the calculation methodology of the Prioritisation Matrix tool. This is referenced in the Company A case study on page 31.

Step	Instructions
1	<p>Obtain the company's inputs for the Prioritisation Matrix</p> <p>The inputs required for the Prioritisation Matrix are:</p> <ul style="list-style-type: none"> • Assessment Matrix Score: Conduct an evaluation of the facility's current state by using the Assessment Matrix to obtain the banding across the 16 SIRI Dimensions • Cost Profile: Input the breakdown of each cost category as a percentage of the company's annual revenue* • Top KPI Categories: Choose five out of the 14 KPI categories • Planning Horizon: Indicate the company's planning horizon • Industry Best-in-Class Benchmark: Select the appropriate industry group <p>* The percentages need not add up to 100% if the company is profitable. The percentages may add up to more than 100% if the company is loss-making.</p>
2	<p>Calculate the Cost Factor</p> <ol style="list-style-type: none"> In the DOR_c Table (page 38), insert the company's Cost Profile in the "Input" column as a decimal representation of the percentage (for example, input 0.15 if the cost category is 15 per cent of annual revenue) For each SIRI Dimension: <ul style="list-style-type: none"> • Multiply the DOR_c value by the corresponding value in the "Input" column for all 10 cost categories and sum the values to obtain a cumulative value • In the "Cost Factor" row, indicate the cumulative value <p>Example calculation:</p> $[\text{Cost Factor}]_{\text{Vertical Integration}} = (0.00*0) + (0.03*1) + (0.24*3) + (0.01*3) + (0.38*3) + (0.00*1) + (0.05*1) + (0.17*1) + (0.03*0) + (0.05*1) = 2.19$

Step	Instructions
3	<p>Calculate the KPI Factor</p> <ol style="list-style-type: none"> In the DOR_k Table (page 39), indicate the following in the “Input” column: <ul style="list-style-type: none"> For the 5 chosen KPI categories, indicate “1” For the remaining 9 KPI categories, indicate “0” For each SIRI Dimension: <ul style="list-style-type: none"> Multiply the DOR_k value by the corresponding value in the “Input” column for all 14 KPI categories and sum the values to obtain a cumulative value In the “KPI Factor” row, indicate the cumulative value <p>Example calculation: [KPI Factor]_{Vertical Integration} = (0*3) + (1*3) + (0*1) + (1*3) + (0*3) + (1*3) + (0*3) + (0*1) + (0*1) + (1*1) + (0*3) + (1*3) + (0*0) + (0*3) = 13</p>
4	<p>Calculate the Proximity Factor</p> <ol style="list-style-type: none"> In the Industry Best-in-Class Benchmarks Table (page 40) <ul style="list-style-type: none"> Indicate “X” in the “Input” column against the selected industry for comparison Input Company A’s Assessment Matrix Score in the “Assessment Matrix Score” row For each SIRI Dimension: <ul style="list-style-type: none"> Subtract the value in the “Assessment Matrix Score” row from the value in the selected “Industry” row and indicate the difference* in the “Proximity Factor” Row <p>*If the difference has a negative value, indicate “0” into the “Proximity Factor” row.</p> <p>Example calculation: [Proximity Factor]_{Vertical Integration} = [Selected Industry] value – [Assessment Matrix Score] value = 4 – 1 = 3</p>
5	<p>Compile the Cost, KPI, and Proximity Factor values into the Summary Table</p> <ol style="list-style-type: none"> In the Summary Table, input the respective rows: <ul style="list-style-type: none"> Cost Factors for all 16 SIRI Dimensions KPI Factors for all 16 SIRI Dimensions Proximity Factors for all 16 SIRI Dimensions Selected planning horizon and the corresponding weights for each factor Company A’s Assessment Matrix Score For each of the 3 factors, sum the values across all 16 SIRI Dimensions and input the cumulative value in the “Total” column.

Step	Instructions
6	<p>Normalise the values for all 3 factors</p> <p>At present, the Cost, KPI, and Proximity Factors differ in the magnitude of their ranges. To allow for a more equitable comparison, the factors are normalised.</p> <p>a. In the Summary Table, for each of the 16 SIRI Dimensions:</p> <ul style="list-style-type: none"> • Divide the “Cost Factor” value by the corresponding value in the “Total” column of the same row. Input the resulting value (to 3 significant figures) in the “Cost Factor_N” row • Divide the “KPI Factor” value by the corresponding value in the “Total” column of the same row. Input the resulting value (to 3 significant figures) in the “KPI Factor_N” row • Divide the “Proximity Factor” value by the corresponding value in the “Total” column of the same row. Input the resulting value (to 3 significant figures) in the “Proximity Factor_N” row <p>Example calculation: $[\text{Cost Factor}_N]_{\text{Vertical Integration}} = (2.19 / 22.6) = 0.0969$</p>
7	<p>Apply the weights to the normalised factors</p> <p>a. In the Summary Table, for each of the 16 SIRI dimensions:</p> <ul style="list-style-type: none"> • Multiply the values in the “Cost Factor_N”, “KPI Factor_N”, and “Proximity Factor_N” rows with the corresponding weight for each factor • Sum up the 3 weighted values and input the result into the “Impact Value” row <p>Example calculation: $[\text{Impact Value}]_{\text{Vertical Integration}} = W_{\text{cost}} \cdot \text{Cost Factor}_N + W_{\text{KPI}} \cdot \text{KPI Factor}_N + W_{\text{Proximity}} \cdot \text{Proximity Factor}_N$ $= (0.30 * 0.0969) + (0.40 * 0.0839) + (0.30 * 0.0714) = 0.0840$</p>
8	<p>Select the Prioritised SIRI Dimensions</p> <p>a. In each of the 3 building blocks of the SIRI Framework (“Process”, “Technology”, and “Organisation”), select the SIRI Dimension that corresponds to the highest Impact Value</p> <p>b. Among the remaining 13 SIRI Dimensions, select the SIRI Dimension with the highest Impact Value</p>

Degree of Relevance (Cost)

Cost Categories	Input	Process			Technology										Organisation				
		Vertical Integration	Horizontal Integration	Integrated Product Lifecycle	Shop Floor Automation	Enterprise Automation	Facility Automation	Shop Floor Connectivity	Enterprise Connectivity	Facility Connectivity	Shop Floor Intelligence	Enterprise Intelligence	Facility Intelligence	Workforce Learning & Development	Leadership Competency	Inter- & Intra-Company Collaboration	Strategy & Governance		
Aftermarket Services / Warranty	0.00	0	1	3	0	3	0	0	1	0	0	0	0	1	3	0	1	1	1
Depreciation	0.03	1	0	0	0	0	0	1	0	1	1	1	0	0	1	1	0	1	1
Labour	0.24	3	0	0	3	0	3	1	0	1	1	3	0	3	3	3	3	3	3
Maintenance & Repair	0.01	3	1	1	1	1	1	1	1	1	1	3	1	3	3	3	1	1	1
Raw Material & Consumables	0.38	3	3	1	1	1	1	1	1	1	1	3	1	3	0	1	1	1	1
Rental & Operating Lease	0.00	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
Research & Development	0.05	1	1	3	0	3	0	0	1	0	0	0	3	3	0	3	1	3	3
SG&A	0.17	1	3	1	0	3	0	0	1	0	0	0	3	3	0	3	3	3	3
Transportation & Distribution	0.03	0	3	0	0	1	0	0	1	0	0	0	3	3	0	1	1	3	1
Utilities	0.05	1	1	0	1	1	3	1	1	1	1	3	1	1	0	1	1	0	1
Cost Factor		2.19	1.85	0.71	1.16	1.13	1.26	0.71	0.69	0.71	1.97	1.95	1.31	1.44	1.78	1.86	1.88		

Degree of Relevance (KPI)

KPI Categories	Process			Technology								Organisation					
	Input	Vertical Integration	Horizontal Integration	Integrated Product Lifecycle	Shop Floor Automation	Enterprise Automation	Facility Automation	Shop Floor Connectivity	Enterprise Connectivity	Facility Connectivity	Shop Floor Intelligence	Enterprise Intelligence	Facility Intelligence	Workforce Learning & Development	Leadership Competency	Inter- & Intra-Company Collaboration	Strategy & Governance
Asset & Equipment Efficiency	0	3	1	0	3	1	3	3	1	3	3	1	3	1	1	1	1
Workforce Efficiency	1	3	3	3	3	3	3	1	1	1	3	3	3	3	3	3	3
Utilities Efficiency	0	1	0	0	1	0	3	1	0	3	1	0	3	1	1	1	1
Inventory Efficiency	1	3	3	0	3	3	0	1	1	0	3	3	0	1	1	1	1
Materials Efficiency	0	3	0	3	1	1	0	1	1	0	3	3	0	1	1	1	1
Process Quality	1	3	1	1	3	3	3	1	1	1	3	3	3	3	3	3	1
Product Quality	0	3	1	3	3	1	1	1	1	1	3	1	1	3	1	3	1
Safety	0	1	0	0	3	0	3	1	0	1	3	0	3	1	3	1	1
Security	0	1	1	1	0	0	0	3	3	3	1	1	1	3	3	1	3
Planning & Scheduling Effectiveness	1	1	3	0	0	3	0	1	3	0	1	3	0	1	1	1	1
Production Flexibility	0	3	1	0	3	0	1	3	0	1	3	0	1	1	3	1	3
Workforce Flexibility	1	3	1	1	1	1	1	3	1	3	3	1	3	3	3	3	3
Time to Market	0	0	0	3	0	3	0	0	3	0	0	3	0	1	3	1	3
Time to Delivery	0	3	3	0	3	3	1	3	3	1	3	1	1	3	3	3	1
KPI Factor		13	11	5	10	13	7	7	7	5	13	9	11	11	11	11	9

Industry Best-In-Class (BIC) Benchmarks






SIRI Industry Classification	Input			Process				Technology								Organisation			
	Vertical Integration	Horizontal Integration	Integrated Product Lifecycle	Shop Floor Automation	Enterprise Automation	Facility Automation	Shop Floor Connectivity	Enterprise Connectivity	Facility Connectivity	Shop Floor Intelligence	Enterprise Intelligence	Facility Intelligence	Workforce Learning & Development	Leadership Competency	Inter- & Intra-Company Collaboration	Strategy & Governance			
Aerospace	3	3	3	2	3	2	4	4	2	3	3	2	3	3	3	3			
Automotive	3	4	4	2	3	2	4	4	2	3	3	2	4	4	4	4			
Electronics	4	4	3	3	3	2	4	4	3	5	4	4	4	4	4	4			
Energy & Chemicals (Downstream)	4	3	3	3	3	3	4	4	4	4	3	4	4	4	4	4			
Food & Beverages	4	3	3	3	3	3	4	4	4	3	2	2	4	4	4	4			
General Manufacturing	4	4	4	3	3	2	4	4	2	3	3	2	4	4	4	4			
Logistics	2	4	3	3	4	3	4	4	4	2	3	2	3	3	3	3			
Machinery & Equipment	3	4	4	2	2	2	4	4	2	2	3	2	3	3	4	3			
Medical Technology	4	4	3	4	3	2	4	4	2	3	2	2	4	4	4	4			
Oil & Gas (Upstream)	2	3	3	2	2	2	2	3	2	2	3	2	2	2	2	2			
Pharmaceuticals	4	3	3	3	2	3	4	4	4	4	3	4	4	4	4	4			
Precision Parts	3	3	3	3	3	2	4	4	2	2	2	2	3	3	3	3			
Semiconductors	4	4	3	3	3	3	4	4	4	3	3	2	4	4	4	4			
Textiles, Clothing, Leather & Footwear	3	4	4	2	3	2	4	4	2	3	3	2	3	4	4	4			
Assessment Matrix Score	1	1	2	1	1	0	0	2	0	1	2	0	2	1	2	1			
Proximity Factor	3	3	1	2	2	2	4	2	3	4	2	4	2	3	2	3			






Summary Table


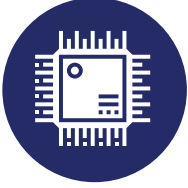

$$\text{Impact Value} = [W_{\text{cost}} \cdot \text{Cost Factor}_N] + [W_{\text{KPI}} \cdot \text{KPI Factor}_N] + [W_{\text{Proximity}} \cdot \text{Proximity Factor}_N]$$

Dimension	Technology										Organisation					Total				
	Process			Shop Floor Automation	Enterprise Automation	Facility Automation	Shop Floor Connectivity	Enterprise Connectivity	Facility Connectivity	Shop Floor Intelligence	Enterprise Intelligence	Facility Intelligence	Workforce Learning & Development	Leadership Competency	Inter-/Intra-Collaboration		Strategy & Governance			
Cost Factor	2.19	1.85	0.71	1.16	1.13	1.26	0.71	0.69	0.71	1.97	1.95	1.31	1.44	1.78	1.86	1.88	22.6			
KPI Factor	13	11	5	10	13	7	7	7	5	13	13	9	11	11	11	9	155			
Proximity Factor	3	3	1	2	2	2	4	2	3	4	2	4	2	3	2	3	42			
Normalised Factors																				
Cost Factor _N	0.0969	0.0819	0.0314	0.0513	0.0500	0.0558	0.0314	0.0305	0.0314	0.0872	0.0863	0.0580	0.0637	0.0788	0.0823	0.0832				
KPI Factor _N	0.0839	0.0710	0.0323	0.0645	0.0839	0.0452	0.0452	0.0452	0.0323	0.0839	0.0839	0.0581	0.0710	0.0710	0.0710	0.0581				
Proximity Factor _N	0.0714	0.0714	0.0238	0.0476	0.0476	0.0476	0.0952	0.0476	0.0714	0.0952	0.0476	0.0952	0.0476	0.0714	0.0476	0.0714				
Weightages																				
Strategic			W _{Cost}			0.3			W _{KPI}			0.4			W _{Proximity}			0.3		
Prioritisation Matrix Results																				
Assessment Matrix Score	1	1	2	1	1	0	0	2	0	1	2	0	2	1	2	1	1			
Impact Value	0.0840	0.0744	0.0295	0.0555	0.0628	0.0491	0.0561	0.0415	0.0438	0.0883	0.0737	0.0692	0.0618	0.0734	0.0674	0.0696	0.0696			

The 14 Industries

Industry	Description
 <p data-bbox="225 808 354 837">Aerospace</p>	<p data-bbox="491 640 1418 781">The Aerospace Industry comprises companies that manufacture, assemble, repair, and/or service equipment, parts, and products for civil aircraft, military aircraft, and spacecraft. Products include but are not limited to engines, fan blades, avionics, and remanufactured parts.</p>
 <p data-bbox="220 1120 360 1149">Automotive</p>	<p data-bbox="491 960 1361 1102">The Automotive Industry comprises companies that manufacture and assemble motor vehicles and/or the parts and accessories for motor vehicles. Motor vehicles include but are not limited to cars, motorcycles, trucks, and buses.</p>
 <p data-bbox="225 1424 354 1453">Electronics</p>	<p data-bbox="491 1247 1401 1429">The Electronics Industry comprises companies that manufacture electronic components, equipment, computer peripherals, data storage products, and consumer electronics products. Products include but are not limited to connection devices, electron tubes, electronic capacitors, resistors, communications equipment, and printed circuit boards.</p>
 <p data-bbox="170 1727 411 1787">Energy & Chemicals (Downstream)</p>	<p data-bbox="491 1545 1431 1760">The Energy & Chemical (Downstream) Industry comprises companies that engage in the refining and cracking of crude oil as well as the production of petrochemicals, specialty chemicals, and other chemical products. Products include but are not limited to petroleum naphtha, gasoline, diesel, liquefied petroleum gas, olefins, fuel oils, plastics, synthetic fibres, additives, adhesives, sealants, specialty paints, pigments, coatings, and fragrances.</p>
 <p data-bbox="188 2047 392 2076">Food & Beverage</p>	<p data-bbox="491 1890 1410 2031">The Food & Beverage (F&B) Industry comprises companies that process, produce, and package food and beverage products. Products include but are not limited to baked goods, canned products, dairy, alcoholic/non-alcoholic beverages, grains, and tobacco products.</p>

Industry	Description
 <p data-bbox="153 443 429 472">General Manufacturing</p>	<p data-bbox="491 282 1430 427">The General Manufacturing Industry comprises companies that manufacture broad-based consumer and commercial products that are not classified under other industries. Products include but are not limited to bicycles, packaging boxes, and printed media.</p>
 <p data-bbox="236 763 347 792">Logistics</p>	<p data-bbox="491 602 1394 748">The Logistics Industry comprises companies that provide freight transportation, courier, warehousing, and other logistical services. Services include but are not limited to storage, distribution, freight forwarding, and end-to-end goods delivery.</p>
 <p data-bbox="165 1084 416 1113">Oil & Gas (Upstream)</p>	<p data-bbox="491 922 1423 1095">The Oil & Gas (Upstream) Industry comprises companies that manufacture, assemble, repair, and/or service machinery and equipment for the exploration and extraction of crude oil and natural gas. Products include land drilling rigs, completion tools, offshore platforms, and Floating Production Storage & Offloading (FPSO) conversion units.</p>
 <p data-bbox="148 1404 434 1433">Machinery & Equipment</p>	<p data-bbox="491 1225 1445 1438">The Machinery & Equipment Industry comprises companies that manufacture, assemble, and repair complex machinery and equipment serving a wide variety of industries such as electronics, aerospace, and medical technology. Products include but are not limited to laser systems, welding equipment, semiconductor foundry equipment, industrial process control equipment, robots, transformers, and machine tools.</p>
 <p data-bbox="170 1724 413 1753">Medical Technology</p>	<p data-bbox="491 1563 1414 1742">The Medical Technology Industry comprises companies that engage in the production of life science tools, implantables, eyecare, healthcare equipment, and supplies. Products include but are not limited to sequencers, hearing aids, heart valves, contact lenses, mass spectrometers, and cardiovascular and orthopaedic devices.</p>
 <p data-bbox="188 2045 392 2074">Pharmaceuticals</p>	<p data-bbox="491 1910 1422 2011">The Pharmaceuticals Industry comprises companies that engage in the production of pharmaceuticals products. Products include but are not limited to active pharmaceutical ingredients, medicines, and veterinary drugs.</p>

Industry	Description
 <p data-bbox="197 443 384 472">Precision Parts</p>	<p data-bbox="491 286 1460 432">The Precision Parts Industry comprises companies that manufacture precision parts, modules, and components serving a wide variety of industries such as electronics, aerospace, and medical technology. Products include but are not limited to bearings, tubes, rings, springs, wires, gears, casings, and seals.</p>
 <p data-bbox="197 763 384 792">Semiconductors</p>	<p data-bbox="491 613 1394 759">The Semiconductors Industry comprises companies engaged in the production, assembly, and testing of semiconductors and related products. Products include but are not limited to integrated circuits, solar wafers and cells, and electronic discrete components such as diodes and transistors.</p>
 <p data-bbox="140 1099 442 1160">Textile, Clothing, Leather and Footwear</p>	<p data-bbox="491 922 1437 1140">The Textile, Clothing, Leather and Footwear Industry comprises companies that convert natural and/or synthetic fibres such as cotton, wool, and polyesters into textiles, textile products and clothes; and companies that manufacture leather products and footwear. Products include but are not limited to textiles (fabrics, carpets, knitted garments), wearable apparel (shirts, pants, dresses), leather goods (handbags) and footwear (boots, shoes).</p>

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3. Pacific Refreshments Pte. Ltd.
4. Procter & Gamble International Operations SA Singapore Branch
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6. SATS Ltd.
7. Shine Precision Engineering Pte. Ltd.
8. Sunningdale Tech Ltd
9. Univac Precision Engineering Pte. Ltd.

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“We began our transformation journey back in 2014, when Industry 4.0 was a relatively new concept. The Prioritisation Matrix is therefore timely as it not only validates our ongoing initiatives, but also helps provide greater clarity on their desired outcomes. We will be using the recommendation from the Prioritisation Matrix to review our implementation plans and ensure that we are able to harness the full potential of Industry 4.0 over time.”

– Ms Maeve Lynch, Plant Manager of Pacific Refreshments Pte. Ltd. (Coca-Cola)



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