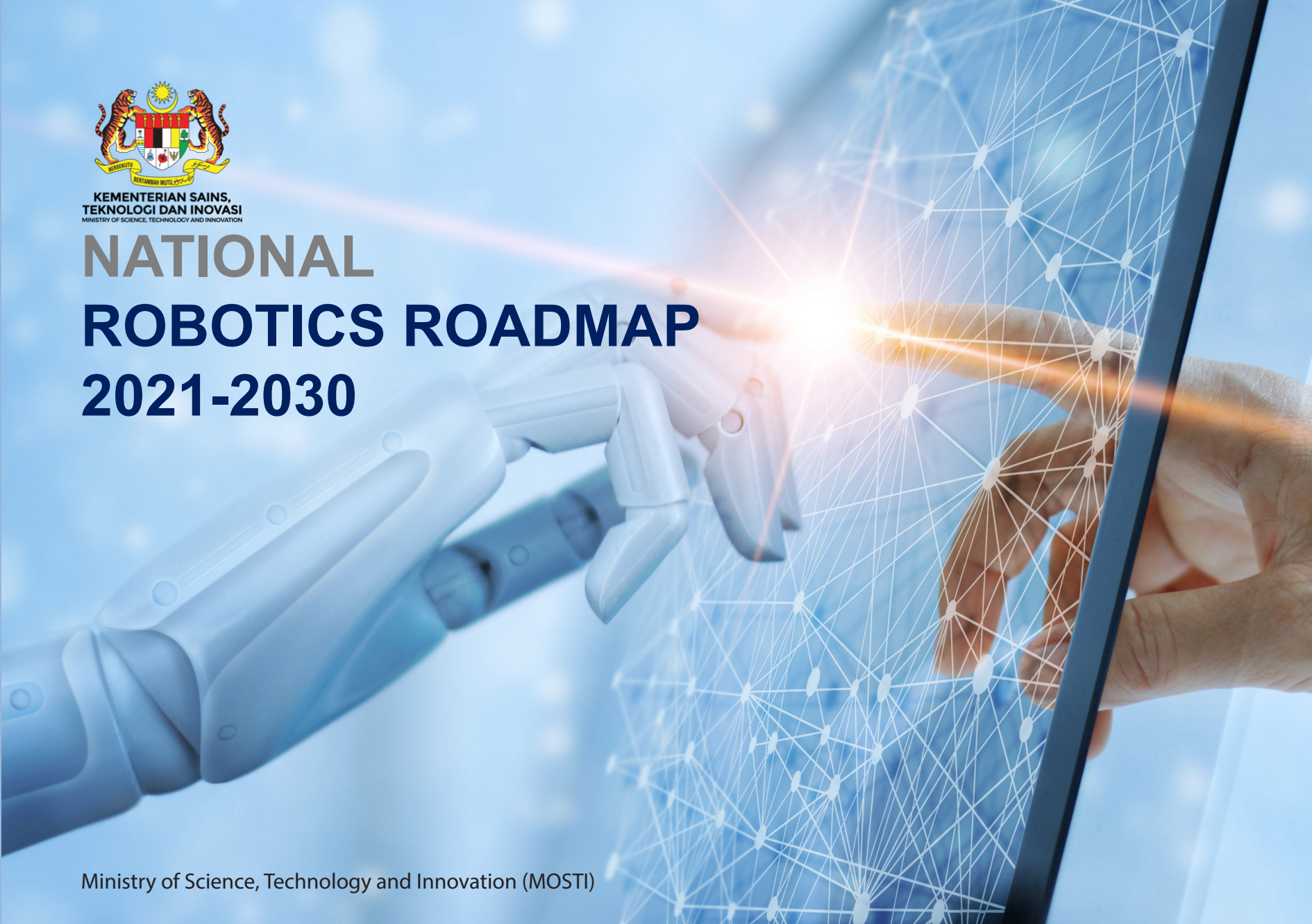
Ministry of Science, Technology and Innovation
(MOSTI)

KEMENTERIAN SAINS,
TEKNOLOGI DAN INOVASI
MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

NATIONAL ROBOTICS ROADMAP 2021-2030



Ministry of Science, Technology and Innovation (MOSTI)

CONTENTS

Executive Summary

Technology advancement in Fourth Industrial Revolution (4IR) has altered the way people live, work, and relate to one another. Emerging technologies breakthroughs such as robotics, artificial intelligence (AI), and the Internet of Things (IoT) are catalysing disruptive innovations across socio-economic sectors in the world. Robotics combined with AI and IoT are redefining the advancement and competitiveness of nations.

Due to the COVID-19 pandemic, adoption of robotics technology has been put into spotlight to accelerate automation. In most countries, robotics has become a national strategic priority. Based on the 2018 Automation Readiness Index, Singapore, South Korea, Japan, and Germany are the top 4 most prepared countries for robotics and automation. This is demonstrated by their consistent high rankings globally in the robot density measured by International Federation of Robotics (IFR). Their advancements in robotics are mainly driven by vibrant policy measures, assertive policy implementation and monitoring as well as a robust national innovation ecosystem. Strong government facilitation for innovation as well as comprehensive talent development have played a major role in enabling these countries to reach a high automation level.

Robotics is a key catalyst for Malaysia to achieve its aspiration of becoming a progressive, prosperous, and high-tech nation. Through robotics, several main challenges for Malaysia such as productivity, dependency on low-skilled foreign labour, outflow of local currency, quality of life, as well as pandemics and disasters could be addressed. Successful robotics adoption and development will help to accelerate the nation's gross domestic product (GDP) growth. Thus, aligned with 4IR, robotics is a key technology that is vital to address these challenges and finally contribute to the socio-economic development and advancement of the nation.

The robotics journey in Malaysia started way back in early 1990s for the 1 st phase (7 th – 8 th Malaysia Plan) with the commencement of robotics through education, research (first publication in Scopus 1992), technology adoption, and the start of a global robotics business enterprise in this country. Rapid improvement of robotics was seen during the 2 nd phase (9 th – 11 th Malaysia Plan) with the establishment of local robotics organisations, networks, business enterprises, and policies. Then, the 3 rd phase (12 th Malaysia Plan and onwards) marked the aggressive efforts of Malaysia to intensify the adoption and adaption of technology under the drive of Industry 4.0 and 4IR.

There are issues, gaps and challenges that hinder the sustainable development of the local robotics industry. For example, Malaysia's

adoption of technology in the manufacturing and services sectors remain low at 37% and 20% respectively (Source: Shared Prosperity Vision 2030). Although Malaysia is ranked 36 th out of 132 countries in the Global Innovation Index 2021 and 14 th for the 2018 Automation.

Readiness Index, much still need to be done to transform Malaysia into a producer of innovative products and services, and subsequently, enable Malaysia's participation in the higher end of the global value chain. These issues, gaps and challenges include the governance and ecosystem, talent, Research, Development, Commercialization, Innovation and Economy (RDCIE), legislation and socio-economic contributing to the slow progress of robotics development and adoption in Malaysia.

Realising the potential of global robotics technology, our pocket of excellence in robotics and the need to address various issues, gaps and challenges, Malaysia has taken a bold step in developing a specially formulated National Robotics Roadmap (NRR) 2021-2030 to provide strategic direction for robotics and the agendas in the country. The roadmap aims to position robotics as a key enabling technology to enhance the nation's productivity, competitiveness, and people's quality of life towards becoming a High-tech Nation by 2030. This roadmap envisions Malaysia as a regional robotics hub in services, agriculture, and manufacturing by 2030.

Malaysia recognises the importance of various key players in the development and progress of robotics in the country

The roadmap focuses on three high-impact sectors that have significantly contributed to the country's GDP. They are the Services (Retail & Healthcare), Agriculture, and Manufacturing sectors. In the fourth quarter of 2020, these sectors (services, agriculture, and manufacturing) had contributed 57.8%, 6.8% and 23.6% of Malaysia's GDP respectively (DOSM, 2021). For the Manufacturing sector, an increase in Malaysia's Robot Density will directly impact the nation's productivity level. Based on a Centre for Economic Performance London School of Economics (LSE) study in 2018, it was reported that a one-unit increase in robot density translates into an approximately 0.36% increase in labour productivity. This is in parallel with the targeted annual labour productivity growth of 3.6% in the Twelfth Malaysia Plan (12 th MP). While in the Agriculture sector, robotics plays a key role in precision agriculture. It supports the Malaysian government's efforts in increasing food production and supply which finally ensures food security for the nation. As for the Services sector, robotics plays a vital role during the current COVID-19 pandemic especially in ensuring the sector could resume. Furthermore, the adoption

of robotics in this sector will further drive the growth momentum in the wholesale and retail trade. Successful deployment of robotics in the high-impact sectors will then bring spill over impacts to other sectors which in turn improves the value chain from laggard sectors to pace-setter sectors.

To identify the areas that need to be prioritised in achieving the targeted 3.5% Gross domestic expenditure on R&D (GERD) by 2030 in the National Policy on Science, Technology & Innovation (NPSTI) 2021-2030 as well as to move Malaysia's robotics industry up the global innovation value chain, the roadmap has utilised the 10-10 MySTIE Framework as adopted in the Twelfth Malaysia Plan (EPU, 2021; ASM, 2021). Robotics converges with the Science & echnology (S&T) Drivers to serve as an enabler for all socio-economic drivers of the 10-10 MySTIE Framework. Therefore, robotics can be strategically positioned and harnessed for application in at least 26 out of 30 of the country's STIE niche areas.

Five strategic thrusts have been developed in the NRR to address the five focus areas that had been identified and will then serve as the main pillars to ensure a dynamic advancement and adoption of robotics in Malaysia. They are accompanied by 19 strategies, 24 initiatives and 40 targets.

The first strategic thrust focuses on the development of a conducive ecosystem and governance for robotics in Malaysia. With the formation of a dedicated national coordinating body for robotics, Malaysia will be able to set, coordinate and monitor its overall national robotics agenda. Long-standing issues such as lack of strategic direction, scattered and inaccessible data, and fragmented ecosystem will be addressed to support and elevate national robotics development towards the nation's advancement.

The second strategic thrust aims to nurture and develop industry-ready talent for robotics to ensure a robust and sustainable robotics ecosystem and development in Malaysia. This augurs well with the principle of cradle to grave education and instils the value of long-life learning effort in all fields of studies. Through this, the issues of lack of robotics talent, well-trained educators, and lack of awareness will be effectively tackled.

The third thrust focuses on bridging the gap between research and commercialisation as well as addressing the robotics adoption among users. Presently, there is still a gap in the alignment and strategic positioning of robotics R&D with the current National Research, Development, Commercialisation, Innovation & Economy (RDCIE) priority areas. This leads to low commercialisation as well as adoption and acceptance of local robotics technology. By connecting the research to businesses through the national collaborative platform for robotics, RDCIE efforts could fulfil the need of the markets and increase disruptive innovation. This finally

enables Malaysia to leverage new economic opportunities for Malaysian robotics industries to enter new and emerging global markets. This at the same time will contribute to achieving the target set in accelerating RDCIE in the Twelfth Malaysia Plan specifically 70% of R&D investment to be funded by the private sector and 30% by the government as well as 50% GERD comprises experimental development research.

The fourth strategic thrust touches on the legislation where it addresses the standard, safety, and regulations' strength to accelerate robotics innovation in a controlled, safe, and ethical manner. This will lead to a smoother integration with regional and global key players in robotics adoption. Development of proper guidelines will build up a greater confidence among the investors as the products are of high standard and quality. With recognised safety and standard guidelines, locally develop robotics products will be able to penetrate the international market. Thus, status of Malaysia as a globally recognised robotics hub supporting the vision and mission of the NRR will be elevated.

Finally, the fifth strategic thrust focuses on enhancing the socio-economic for societal well-being and quality of life. With proper implementation of the strategies, it will minimise the immediate negative social-economic impacts of the robotics adoption while building up the society's capacity to adapt. Without proper guidelines, the adoption of robotics will create fear and distrust among the community due to a mismatch of culture and traditional practices. One major area of concern will be job security where it was forecasted that around 14-18% of jobs were lost between 2016 to 2027 due to the adoption of Industry 4.0 in 5 industrial sectors (electrical & electronics, machinery & equipment, chemicals, medical device and aerospace). Hence, it will help in achieving a fairer and more equitable society which corresponds to the underline principals of Sustainable Development Goals (SDG) and SPV 2030.

In conclusion, effective implementation of the strategies and initiatives through a whole-of-nation approach will create a conducive ecosystem for the country to embrace robotics technology. The direction set forth by the National Robotics Roadmap (NRR) 2021-2030 will guide and assist stakeholders in building up avibrant and dynamic robotics ecosystem; bringing Malaysia closer towards its aspiration in becoming a progressive, prosperous, and high-tech nation. The success of the NRR will depend on the willingness of all stakeholders to embrace change and their close collaboration to systematically implement the strategic thrusts, strategies and initiatives. Steadfast commitment and support from all will ensure the realisation of the vision and mission of the roadmap.

The Global Robotics Benchmarking

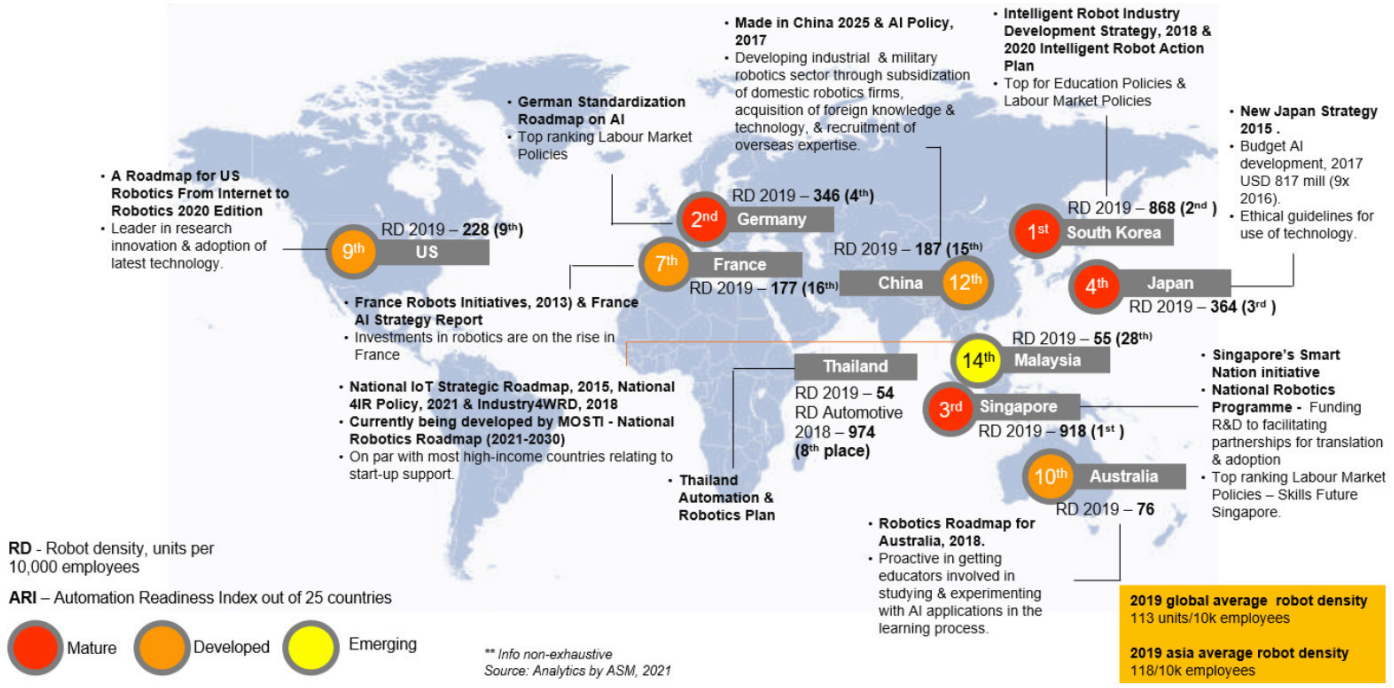
Developed countries such as the United States, France, European Union, China, Japan, Singapore, and South Korea have already engaged in this strategic technological race by rolling out their national robotics plans as the first step to better embrace the transformation. According to the International Federation of Robotics (IFR), robotics funding programmes are offered by their respective government with different strategic focuses. For example, the Chinese government has invested USD 577 million in the form of a research grant, industrial grant, and stimulus to support the development of intelligent robots in 2019. Then, China has boldly introduced the Made in China 2025 Policy under the Robot Industry Development Plan in 2020 to upgrade the manufacturing capabilities of the top 10 core industries with huge investment in advanced robots.

According to the statistical yearbook "World Robotics" by IFR, Japan is the world´s number one industrial robot manufacturer and delivered 52% of the global supply in 2018. To stay competitive, the Japanese government has increased the robot-related budget to USD 351 million in 2019. The spending aims to promote a Robot Revolution and makes Japan the robot innovation hub in the world. The action plan targets key sectors such as manufacturing, healthcare, agriculture, and infrastructure. Similarly, South Korea has allocated USD 126 million to boost their national robotic research and innovation. The statistical yearbook "World Robotics" showed a new record stock of about 300,000 operational industrial robots in the Republic of Korea (+10%).

Through the National Robotics Initiative (NRI), the United States (US) has set aside USD 35 million for fundamental robotics research, with a particular interest in fundamental science, technologies, and integrated systems. Additional robotics funding for application in defence and space is provided through the Department of Defence (DoD) and the Mars Exploration Program.

Based on 2018 Automation Readiness Index, Singapore, South Korea, Japan, and Germany have been ranked as the top 4 automated countries in the world. Vibrant policy support, assertive policy implementation, and a conducive environment were among the prerequisites to facilitate the robotics advancement of a country. In addition, strong government facilitation for innovation as well as talent development has successfully placed these countries in the top positions.

Figure 6 summarizes the strengths of the top 4 ranked automated countries. Comparatively, Malaysia is ranked at 14 th place. Despite government programs and funds have been in place to promote automation, there is still room for improvement from the



Source: ASM Analytics 2021 based on IFR, 2020 & The Automation Readiness Index, The Economist, 2018

Figure 1 : Global benchmarking on robotics adoption

perspective of legislation, research and talent development, investment, and commercialization. Ultimately, these factors are essential to nurture a conducive robotics ecosystem to support the long-term national robotics development in Malaysia.

Robotics as Catalyst to Achieve Malaysia's Aspiration

Malaysia's vision is to build a progressive country that is harmonious, prosperous, and sustainable. Success of the vision will be reflected on the well-being of the people, the success of the economy, and the sustainability of the development. To achieve the vision will highly dependent on the level of science, technology, innovation and economy (STIE) advancement. Nowadays, the Malaysian Government has always emphasized on the technology-driven efforts in driving Malaysia forward towards becoming a developed, prosperous and high-tech nation by 2030. Since 2019, majority of the national policies are prioritizing and diverted efforts towards IR4.0. 61% out of 49 active policies that developed from 2019 have placed emphasis on highlighting and providing strategic interventions that aligned with IR4.0.

It is undeniable that robotics is crucial as a key catalyst for Malaysia to achieve its aspirations. Nurturing a conducive research, development, commercialisation and innovation (RDCI) environment, increasing the capacity and capability of local talents, and nurturing local robotics brands are vital in realizing Malaysia's aspirations through its many initiatives. Among those prominent initiatives are the Shared Prosperity Vision (SPV) 2030, National Policy on STI (NPSTI) 2021-2030, National Policy on Industry 4.0 (Industry4WRD), National 4 th Industrial Revolution Policy, National Entrepreneurship Policy (NEP) 2030, National Automotive Policy (NAP) 2020 and National Science, Technology, Innovation and Economy (STIE) Niche Areas 2021-2030.

The primary aim of the National Robotics Roadmap (NRR) 2021-2030 is to position and extract the value of robotics as the key enabling technology and catalyst for the nation's productivity, competitiveness, and quality of life towards achieving a progressive, prosperous and High-tech Nation by 2030. It is envisioned through this roadmap for Malaysia to become a regional robotics hub in Services, Agriculture & Manufacturing by 2030.

This roadmap highlights on three top high-impact sectors that contribute to Malaysia's GDP i.e. the Services Sector (Retail & Healthcare), Agriculture Sector, and Manufacturing Sector. These sectors are positioned to intensify robotics as the main catalyst towards achieving the vision. By increasing the performance and productivity in these sectors, it will certainly elevate Malaysia's socio-economic development and competitiveness.

The National Robotics Roadmap - What do we want to achieve?

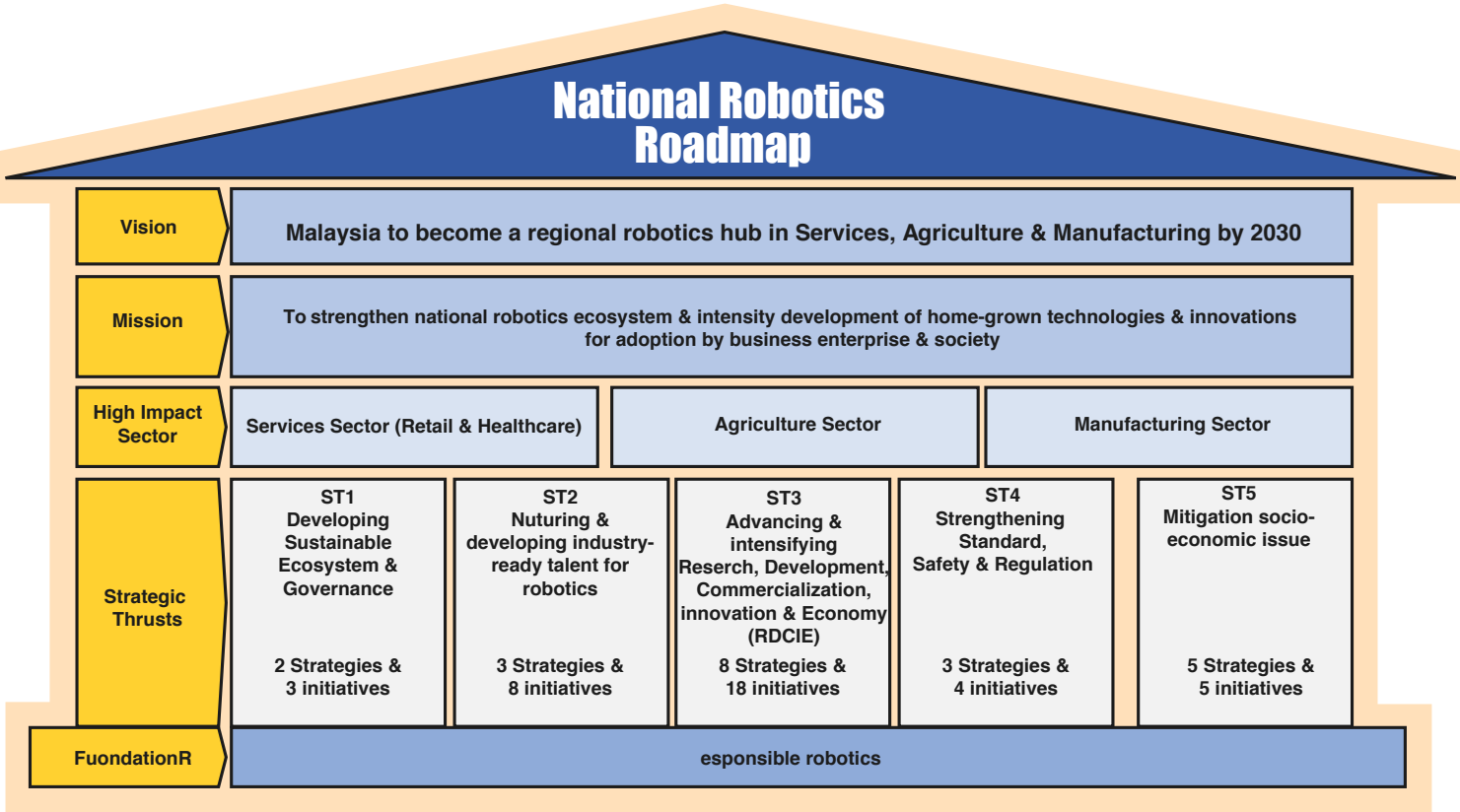


Figure 2 The National Robotics Roadmap

The Robot Density is based on the utilisation of robots in the manufacturing sector. The number of Robot Density in Malaysia for the year 2020 – 2030 is forecasted based on the historical data available from year 2005 – 2019 The number of Malaysia Robot Density is projected to reach 54 per 10,000 workers in 2021, 67 per 10,000 workers in 2025 and 82 per 10,000 workers in 2030. The projection shows that by the year 2030, Malaysia is still 137.5% away from reaching the Global Average Robot Density 2030 (195 per 10,000 workers) if no interventions are made to accelerate the adoption or robotics in Malaysia. Hence, a concerted and strategic effort among the robotics stakeholders and players through this roadmap would be vital towards increasing the Malaysia Robot Density and intensify the robotics adoption and utilisation in Malaysia to reach at least the global average in 2030.

Based on a Centre for Economic Performance, London School of Economics (LSE) study in 2018, one unit increase in Robot Density will contribute to 0.36% increase in Labour Productivity. It is forecasted that there is around 3 unit increase of Robot Density every year. Therefore, it is estimated around 1.08 increase in Labour Productivity per every year contributed by robotics. This adoption of robotics is certainly important and will contribute to the annual Labour Productivity growth of 3.6% that is targeted under the 12 th Malaysia Plan.

The Roadmap - Way Forward

Five strategic thrusts are drawn as the key pillars of this roadmap and accompanied by 21 strategies and 38 initiatives. The strategic thrusts are ecosystem & governance, talent, RDCIE, standard, safety & regulation, and socio-economy impacts. These thrusts will address the national robotics gap and challenges as well as provide the strategic direction towards strengthening national robotics agenda of the country. Finally, the vision of Malaysia to become a regional robotics hub in Services, Agriculture and Manufacturing by 2030 will be achieved.

Strategy 1.1 - Institutionalising national robotics governance

The National Robotics ecosystem would immensely benefit through the institutionalisation of a robotics governance structure that covers the aspects of legislation, inter-ministerial collaborations, coordination of the supporting bodies, R&D performance, and participation of the public in line with the whole-of-government and whole-of-nation approaches emphasised in the 12 th Malaysia Plan.

In addition to establishment of efficient governance and management, a robust robotics institutional framework will eliminate lapses, duplications, and obsolete elements in the overall landscape preserving precious resources for the most impactful initiatives. Following this,

the introduction and incorporation of legislative support will ensure a lasting commitment by the government in upholding the sustainability of the planned and implemented initiatives. As a whole, an efficient robotics governance will form a strong foundation in which a dynamic and empowering ecosystem could be built upon as Malaysia moves ever closer to its aspiration to become a high-tech nation by 2030.

Therefore, a centralised national committee named as the National Robotics Committee (NRC) is proposed to be established under the purview of MOSTI and provision with the necessary mandate to set the direction as well as coordinate and monitor the overall national robotics agenda for sustainable robotics development in the country. The Committee will be chaired by the Secretary General of MOSTI and report to the existing National Councils relevant to the robotics, namely the National Science Council and National Digital Economy and 4IR Council chaired by the Prime Minister. Matters pertaining to robotics technology application will be reported and channelled to the National Digital Economy & 4IR Council through the Emerging Technology Cluster chaired by YB Minister of Science, Technology and Innovation whilst matters on robotics technology development will be reported to the National Science Council via the High Tech Nation Council also chaired by YB Minister of Science, Technology and Innovation. Members of this Committee include representation of all robotics key players in Malaysia involving the entire quadruple helix (Government, Academia, Industry & Civil Society). 5 Sub-Committees will be established under the Committee according to the Strategic Thrusts led by the relevant key players that will be appointed among the NRC members and would be then responsible to strategies, execute, and monitor strategies and initiatives under the Strategic Thrusts. The structure of the Committee is as shown in Figure 5.

Scattered and inaccesible data and information on national robotics development has led to limited monitoring and strategizing. It is imperative to develop a centralised database and an impact tracking system. This system would not only be the centrepiece in monitoring and evaluating (M&E) all rolled-out initiatives but also provide various insights on various facets of the robotics ecosystem starting with baseline data (robot installations, robot density, etc.) to complex modelling and projections. As such, all future decisions would be based on hard evidence and guided by the principle of success-by-design rather than by-chance. The proposed system will be a part of a proposed national impact tracking system called that STI TrendWatch. This system enables interconnection with other technology and socio-economic areas and ensures the positioning of robotics technologies is aligned in achieving the targets of Malaysia's

national policies and plans as well as in immediate strategic interventions for socio-economic benefits. The overall impact tracking system will enable total monitoring of all technologies and socio-economic progress in the country. Figure 6 shows the structure of the overall of impact tracking system and how the multitude of components are linked. This will finally be able to provide an indigenous STI Composite Index for the country.

Strategy 1.2 - Nurturing an integrated robotics ecosystem

In line with the government's emphasis towards ecosystem creation and sustenance in the strategies outlined in the 12 th Malaysia Plan, a resilient robotics ecosystem will sustain innovation and value creation in robotics and thus, become the key indicator for Malaysia's competitiveness in this field. robotics possesses the potential to exponentially propel our socio-economic status as a cross-sectoral enabler for much of the technologies of the future.

To nurture an integrated robotics ecosystem, establishment of a collaborative platform in robotics-related areas for demand-driven R&D and market-driven delivery has been proposed (Figure 7). This collaborative platform would support and elevate national robotics development towards the nation's advancement comprising of 8 clusters of robotics key players that would give rise to a knowledge-based economy. Effective collaboration between stakeholders will help address all socio-economic matters and Strategic Thrusts under the roadmap through the implementation of robotics initiatives across localities in Malaysia. This platform is critical for translating research into transformative outcomes for the nation as it enables multichannel communication and feedback between the stakeholders ultimately facilitating effective decision-making and implementation of strategies.

The hub formed by the collaborative network will posses comprehensive well-oiled collaborative ecosystem, mutual reinforcements of activities that are created whereby, the technology drivers in the form of the R&D community provide value creation to the market through knowledge-based, high value products and services. At the same time, the market intelligence from the partners is relayed to the technology developers to ensure the R&D efforts remained demand driven.

Strategy 2.1 - Ensuring long-term sustainable commitment in developing robotics value chain

Realising current gaps in the robotics talent ecosystem from the perspective of students and instructors, it is crucial for Malaysia to commit towards a long-term, sustainable development of the robotics value chain. Modern

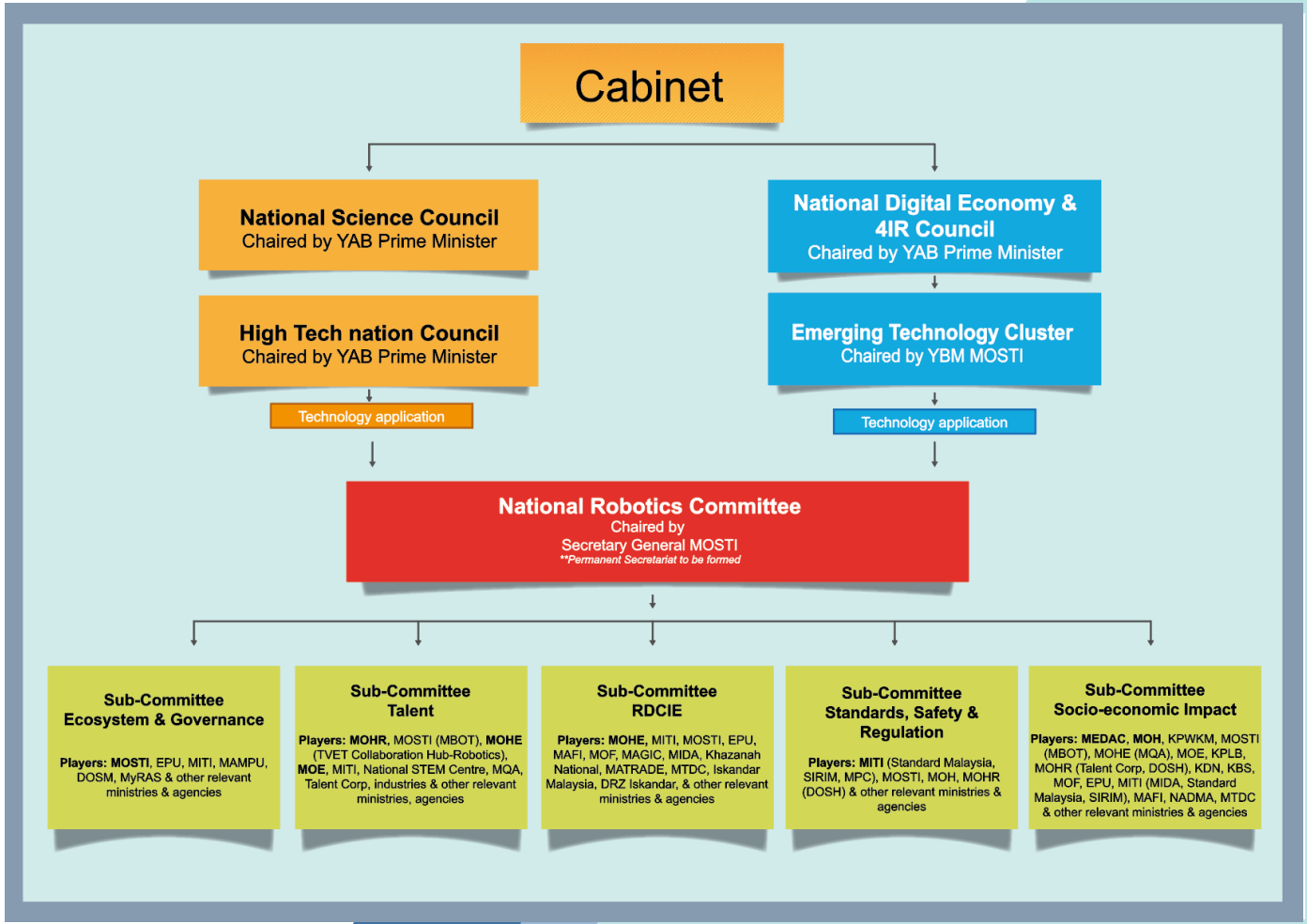


Figure 5 : Organisation structure of National Robotics Committee

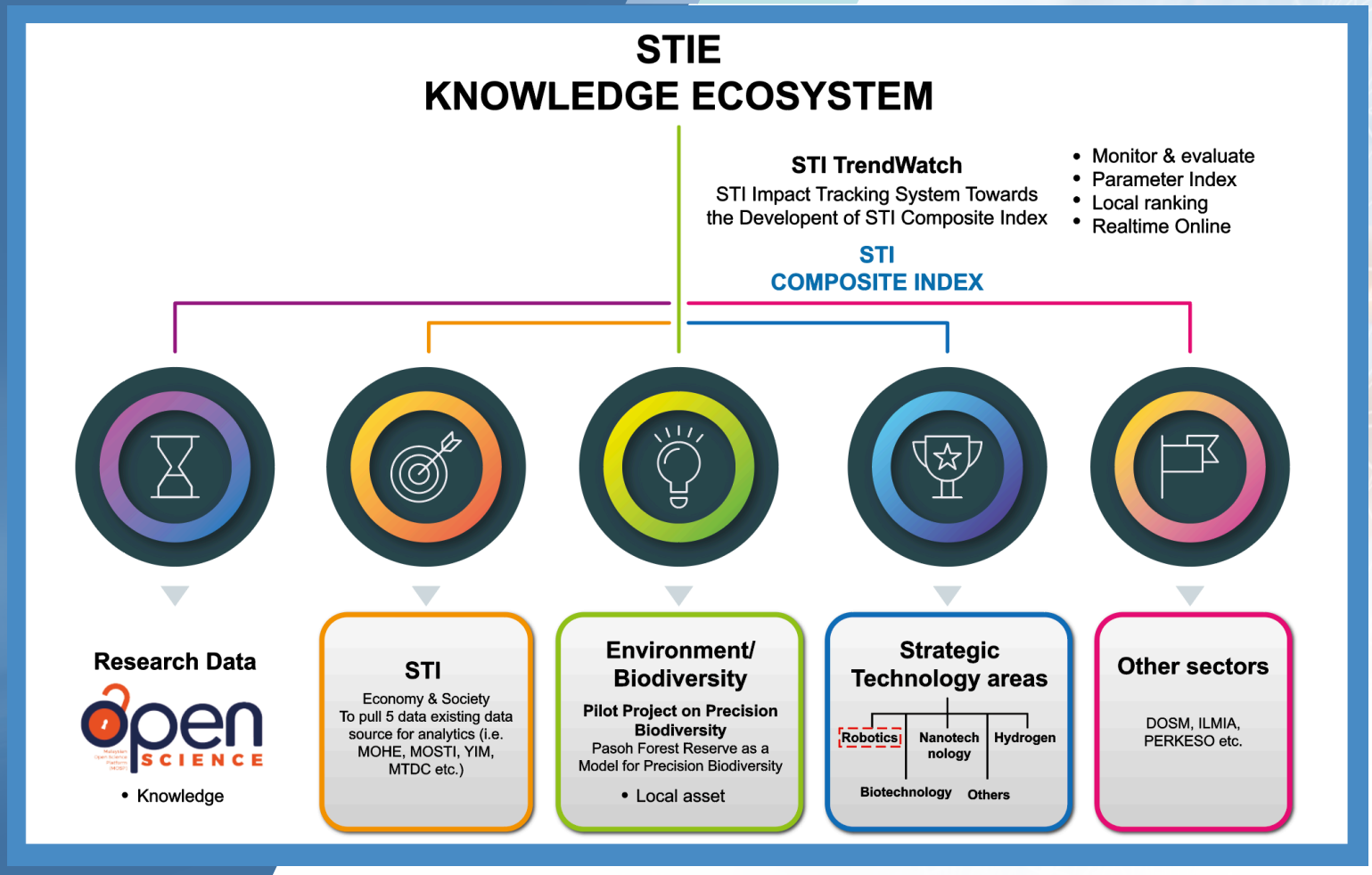


Figure 6 : Structure and connection of the robotics impact tracking system with the national impact Tacking System (STI TrendWatch)

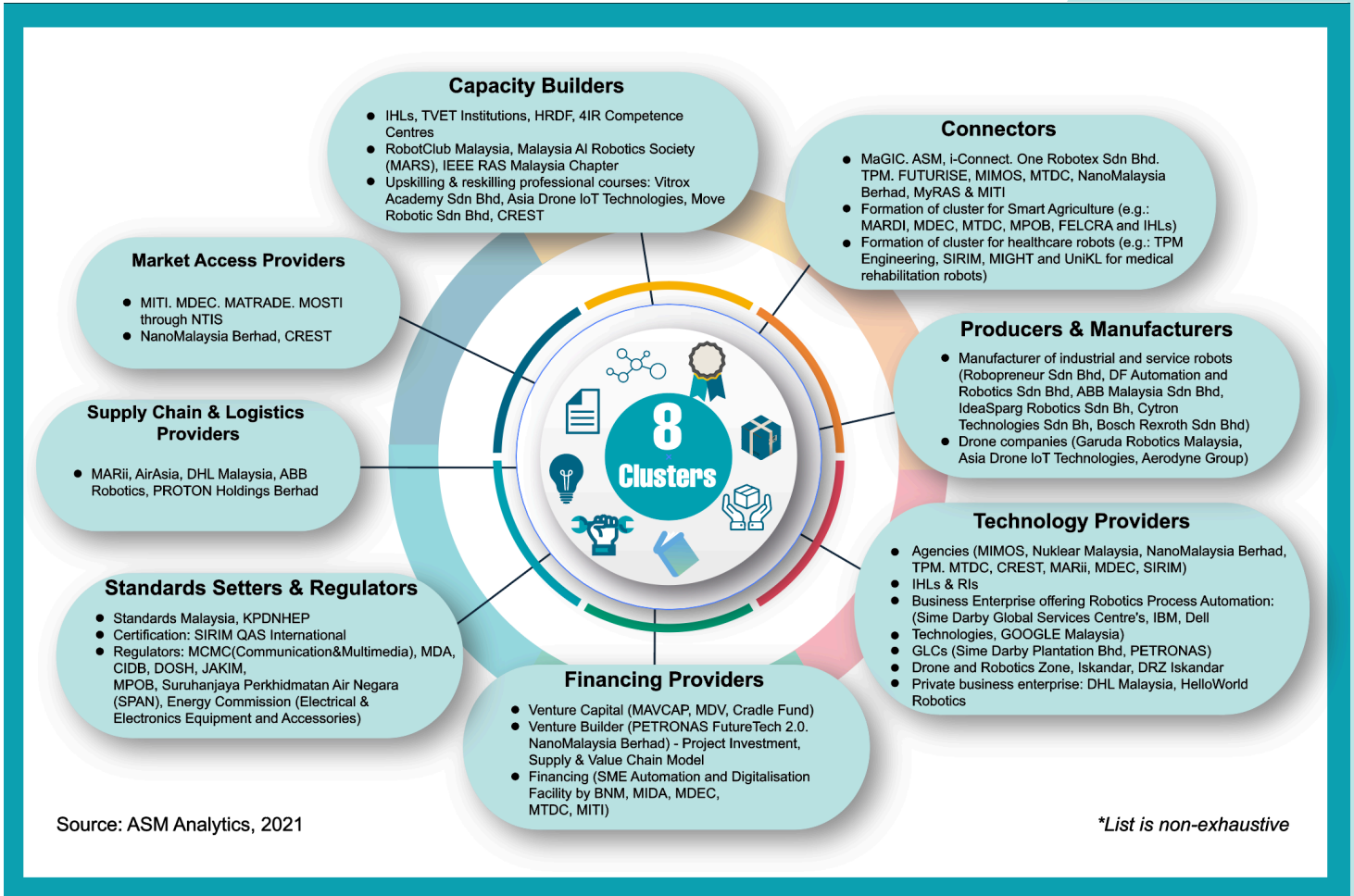


Figure 7 : Proposed national collaborative platform for robotics

technological breakthroughs are no longer confined to field specific as they were in the past. Therefore, the new generation of talents must be equipped with competency in various disciplines. Nonetheless, this multidisciplinary aspect should be defined acutely to ensure that their knowledge remains futureproof.

With a proper deep-dive of the underlying robotics technologies that would be most important in the coming years, a comprehensive plan for robotics talent could then be developed and aligned to the overarching next-generation national education plan.

Figure 9, NRR High Impact Sectors that are aligned with 12 TVET Collaboration Hubs that was approved in the Mesyuarat Majlis Pendidikan & Latihan Teknikal & Vokasional Negara (MTVET). Robotics applications in these sectors will cut across all TVET Collaboration Hubs. Therefore, talent development in Robotics is essential and hence, Robotics Talent Development Academy (RoTDA) is proposed.

Major components of RoTDA include:

a) A professional syllabus in robotics education that are suitable for beginners as young as primary school students to workers in automation industries. This includes a taxonomy of awareness, knowledge, and skills in both the software and hardware of the latest robotics technologies.

b) grading and certification system that can be used to assess and certify the students of the academy as they progress in their training and learning. The certificate will be recognised by employers nationally and possibly internationally so that the students can progress in their learning wherever they are stationed. Its certification can be in the form of digital badges.

c) A training of trainer (ToT) mechanism to ensure that the learning can take place in rural or urban settings, providing the opportunities for more Malaysians to learn robotics technology. License or certificate to the trainers will be given out by the academy. CPD can be imposed annually to ensure that the trainers upgrade their knowledge and skills with the latest robotics technology.

d) The training is arranged and conducted by licensed trainers based on the syllabus determined by the academy in their own comfortable settings. The trainers will arrange the examinations with the academy and are responsible in ensuring that their students achieve the level of knowledge and skills needed to pass the examinations.

e) Students can also choose to be trained at the academy by the full-time trainers stationed at the

academy.

f) The academy will provide the facilities for both the trainers and students at a minimal cost. There is also an exhibition area for visitors and a space similar to makerspace for the trainers and students to develop their robots.

g) The academy is also responsible in organizing robotics related competitions such as robots, programming, artificial intelligence, drones, etc.

h) The academy will be the custodian of the data of robotics talent in Malaysia. It will report and project the development of robotics talent in Malaysia and become the referral centre for robotics talent development.

i) Strengthening upskilling and reskilling scheme of essential robotics skills

For short term, the academy will operate like a network or consortium that brings together all key stakeholders among quadruple helix especially industry for the robotics talent development. The academy will leverage on existing government initiatives by teaming up with polytechnics, Malaysian Technical University Network (MTUN) and National STEM Centre to perform the activities for the academy. In the long run, a physical academy will be established to perform a comprehensive and sustainable function of the academy.

Under the proposed RoTDA, collaboration between players of the collaborative ecosystem particularly MOE, MOHE, MOHR and industries would lead to the development of a high impact robotics talent development programme. Through the adoption and refinement of ongoing concepts including Forward School, as well as programmes such as the 2u2i programme, more industry- based and future jobs-related courses can be offered. These talent development programmes will further expose the academics and students on the cutting-edge technology employed in the industries. As a result, the future robotics talents developed through the programme will not only enhance the already well-performing sectors but also bring in the necessary skills and know-how to boost the laggard economic sectors. Eventually, these programmes will help Malaysia to fulfil the tenets of the Shared Prosperity Vision 2030.

Strategy 2.2 - Strengthening life-long learning certification pathway for robotics professionals

One hot topic in robotics and automation is the displacement of existing workers especially those in the low-skilled and semi-skilled categories. To overcome this issue,

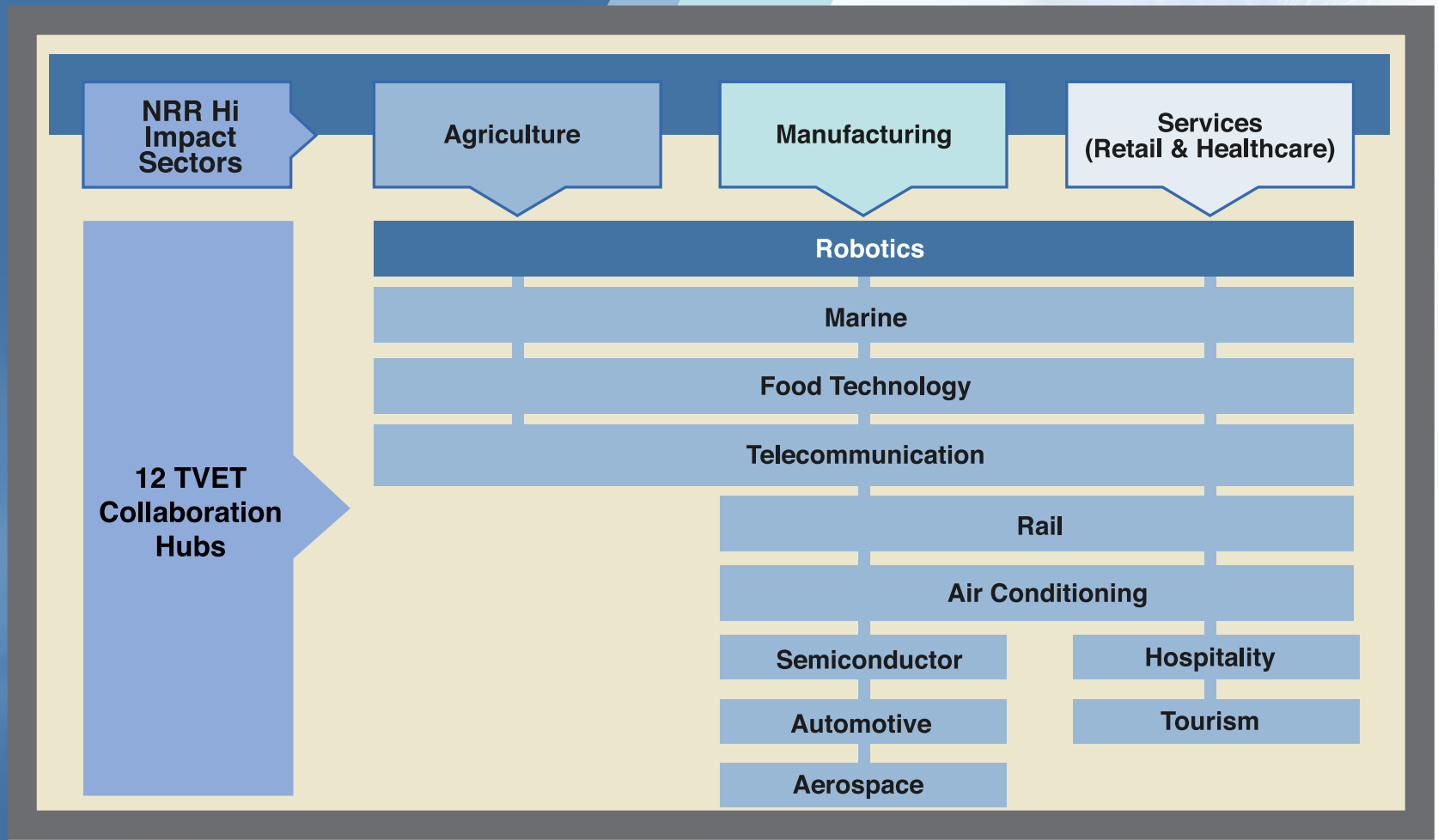


Figure 9 : NRR High Impact Sectors that are aligned with 12 TVET Collaboration Hubs that was approved in the Mesyuarat Majlis Pendidikan & Latihan Teknikal & Vokasional Negara (MTVET).

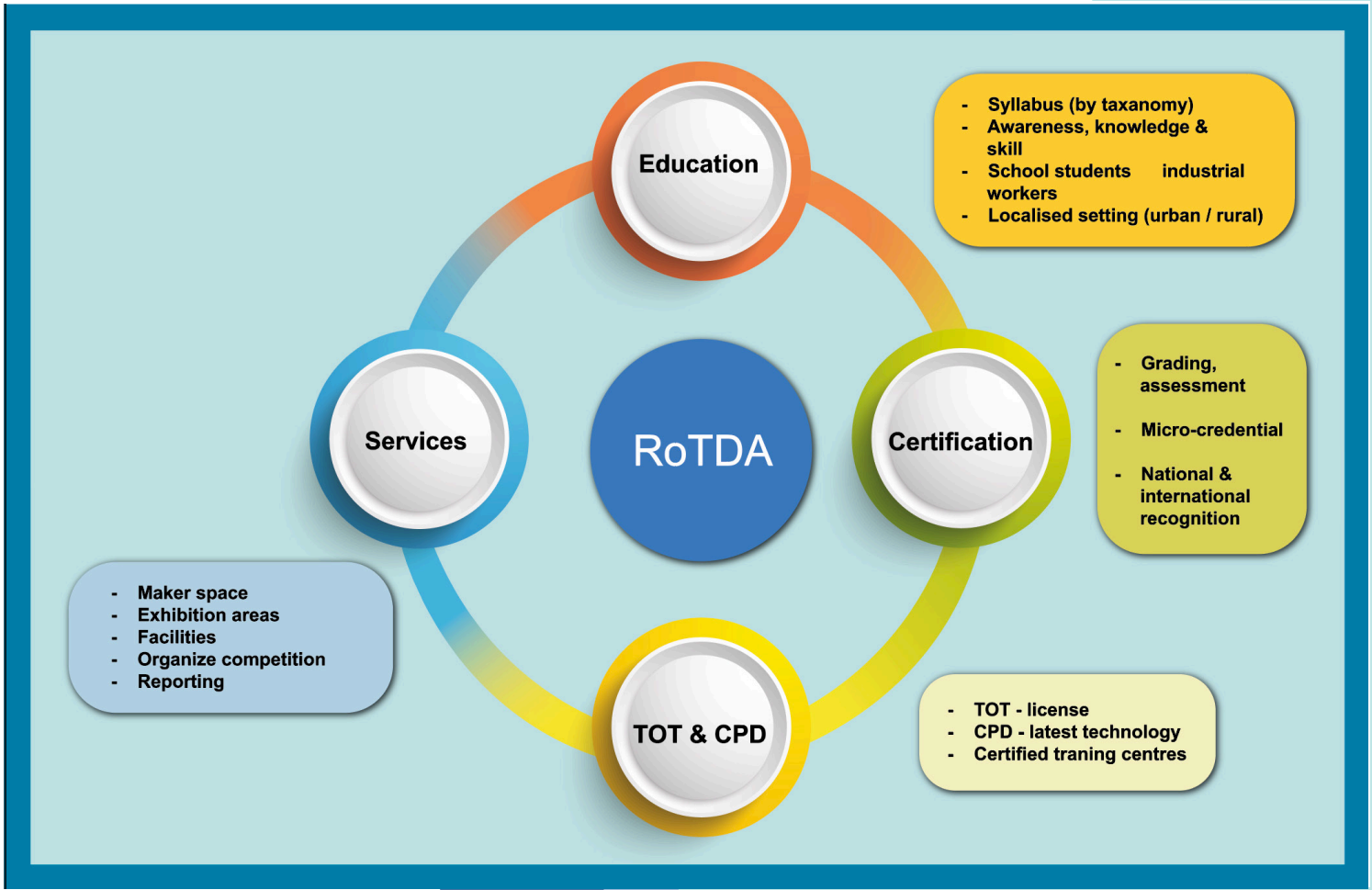


Figure 10 : The proposed Robotics Talent Development Academy

instilling a positive worldview towards lifelong learning amongst Malaysian employees should be the topmost priority supported by provision of opportunities for them to reskill and upskill themselves in line with the currenttechnological progress. The reskilled and upskilled workers will be able to continuously adopt to the high-tech, modern working environment. Offering of micro-credentials developed through the collaboration between industry and academia in identifying essential skills required by the relevant sectors will allow for the reskilling and upskilling process to be conducted dynamically with minimal impact towards the work-life balance of the workers. This ensures the maximum number of workers could be catered to for the purpose of reskilling and upskilling and at the same time, further reduces the time required for Malaysia to fully embrace robotics and automation.

Strategy 2.3 - Nurturing interest & increasing awareness in robotics-related education & career pathway

With the development of a robotics talent pipeline framework via RoTDA, a sustainable supply of individuals interested in robotics must be maintained to support this large scale robotisation effort.

An improved awareness in robotics-related education and career pathway provides a clearer view for the public on how they could best take advantage of all the benefits brought by robotics whilst mitigating and avoiding the potential pitfalls. Ultimately, the negative societal perceptions and misconceptions towards robotics and other technologies will be improved allowing for an accelerated technology adoption and innovation in Malaysia as outlined by the 12 th Malaysia Plan.

Strategy 3.1 - Aligning & strategic positioning of robotics in the National RDCIE priority areas

In recognition of the pool of excellences in robotics albeit an overall fragmented robotics and automation ecosystem, Malaysia needs to strategically place its science, research, and innovation investments within this field. Without clear national priorities for robotics-related R&D, Malaysia will not be able to optimally funnel research funds, negotiate with partners for the targeted short and long-term efforts, as well as stimulate the development of human resources crucial for research sustainability. The sector will be able to flourish in support of Malaysia's socio-economic development, ultimately increasing the nation's global competitiveness viathe outline of four critical elements of a holistic national research and innovation system for robotics: (1) focus, (2) priorities, (3) targets and (4) milestones.

As the healthy robotics adoption rate will be spurred by alignment with national RDCIE priorities, the potential for Malaysia's robotics scene to a reach the forecasted Compound Annual Growth Rate (CAGR) of 17.5% by 2027 would no longer remain a pipe dream but an achievable reality.

Strategy 3.2 - Enhancing Robotics RDCIE & promoting effecting partnering in research collaboration for high-value output, high-impact outcomes & innovation

Robotics and automation have long been considered as a very promising technology domain due to its high degree of applicability in various business activities as well as its potentially significant role in addressing both existing and emerging societal challenges related to labour productivity, food security, wellness, and healthcare as well as sustainability and climate change. Given that the number of players actively involved with robotics R&D and commercialisation in Malaysia is increasing, it is crucial for a comprehensive foresight process to be in place in ensuring that the RDCIE initiatives align not only with our current but more importantly, future needs.

Strategy 3.3 - Elevating & strengthening local robotics research excellence towards becoming the future robotics leader in the region

It is equally important that the local robotics research excellence is elevated and strengthened allowing Malaysia to become a renowned robotics leader in the future. Hence, the priority in this case would be explored and accumulate knowledge on strategic robotics research priority as well as frontier robotics research areas to establish and later on cement its foothold in the frontier of robotics technology. Similar to all research related efforts, a dedicated contestable fund on these robotics priority and frontier research areas is paramount in ensuring research continuity in which, the Malaysian Science Endowment and Research Cess Fund could be leveraged for this purpose.

Through efficient and effective data sharing, players within the proposed national collaborative platform for robotics will be provided a holistic overview on the Malaysian robotics R&D scene. Therefore, research institutions would be able to promptly identify any existing gaps within robotics research and tailor the direction of their research to complement one another. This collective improvement of each other's research efforts would then pave the way to the establishment of a

national robotics research consortium which would then be able to formally mobilise the robotics strategic research initiatives across the whole research communities. In addition to providing a shared vision in strategizing the robotics research initiatives, the consortium would also become the go-to platform to facilitate access to high-end research facilities between the research communities to enable significant improvement to the research standard of excellence. The practice of assets sharing would reduce the potential for unnecessary redundancy in procurement of equipment and building to ensure greater proportion of funds to be allocated for actual research works. As the national robotics research consortium is consistently guiding and monitoring the research priorities, it would gain insights on the talent requirements for frontier research in robotics. This knowledge would then be fed back into the previously discussed RoTDA which would then accommodate the necessary training in the aforementioned robotics talent development programme. Apart from that, being a research consortium at the national level, it would also be easier to conduct specialised knowledge transfer programmes especially in frontier robotics with other internationally renowned robotics centres of excellence. Thus, Malaysia would be able to map an overview of the international direction in robotics research in positioning the nation to become more agile in aligning local research efforts with global development ensuring high relevance of our robotics RDCIE efforts far into the future.

One of the major issues in adopting robotics technology could be attributed to the enormous capital requirement in sourcing robotic technologies from overseas. This problem is further exacerbated by the absence of locally-produced robotic components as well as professional service and certifications to support local development and commercialisation. In short, industries have to spend significantly not only to acquire the robots but to also maintain them. The prohibitive costs of acquiring both robotic components and technologies have resulted in minimal robotics development and commercialisation at the local level with locally developed robotic products rendered uncompetitive in terms of price and support available.

There is a need for Malaysia to facilitate locally produced robotics components and materials complemented with professional service and product certification in support of local robotics product development. The role of Drones & Robotics Zone (DRZ) Iskandar under the National Technology & Innovation Sandbox (NTIS) Initiative as the local robotics hub need to be empowered and enhanced in order to facilitate the production of locally produced components and materials as well as provide professional service and product certification. With the

nation striving towards becoming a technology innovator, the planned initiatives under DRZ Iskandar and other future facilities and hubs will allow for inventions and commercialisation of new robotics products as the developers will be fully supported both in terms of components, expertise as well as certification. The successful implementation of current initiative focused on DRZ Iskandar will serve as a model to develop other local robotic hubs throughout Malaysia; allowing for exponential growth in local robotics development and commercialisation. Through this, home-grown innovation of robotics would no longer be reliant on imported materials and components.

Strategy 3.5 - Provide facilitation & incentives to companies producing robotics-related products

In addition to providing local components, services, and certifications, it is vital to provide facilitation and incentives to the local business enterprises that produce and commercialize robotics-related products and services.

Currently, there are also several facilitation and incentives provided by the government for the development and commercialisation of locally produced or home-grown products. Among others is the industrial and commercialisation funds that were established to provide partial grants to qualified R&D projects to stimulate the need of harnessing technology for wealth creation. It aims at enhancing and improving the competitiveness and capacity of the Malaysian industrial sector by promoting the commercialisation of indigenous technology. The provided funds help to enable support commercialisation of home-grown R&D, developed by local universities/ research institutions or the private sector. Several fundings that are available are the Business Growth Fund and Business Start-up Fund under MTDC and Technology Acceleration and Commercialisation Scheme by Malaysia Debt Venture Berhad. For this, the R&D Services document published by MIDA is a suitable reference point for industries in finding the areas in which their robotic products would be most commercially viable.

To promote the production of robotic products, the current tax initiatives by the Inland Revenue Board of Malaysia (LHDN) for the R&D sector could also be leveraged to enable a more integrated and coordinated implementation of commercialisation throughout the country.

In relation to the 12 th Malaysia Plan, industries and products recognised through the Malaysian Commercialisation Year (MCY) initiative will also benefit from facilitation for the commercialisation of their products. Successful involvement of robotic product developers in

this initiative is crucial with Malaysia aiming to commercialise 500 products via NTIS and MCY which would then have a direct effect towards the push for local enterprises to then adopt home-grown robotic technologies.

Nevertheless, the government still needs to provide provisions in terms of funding and incentives to the business enterprises especially SMEs to help them in shaping up the conceptualisation of robotics into their products, solutions, and services.

Strategy 3.6 - Strategic government-corporate investment & obtaining Foreign Direct Investment (FDI) for merger acquisition of local high potential robotics business enterprise/ unicorn company to accelerate Malaysia to become the regional robotics hub

Malaysia is famous for acting as the regional manufacturing hub within Southeast Asia. Throughout the years, Malaysia has been able to attract investments through various Foreign Direct Investment (FDI) and Domestic Direct Investment (DDI) initiatives. Some notable examples include a project by Intel worth RM10 billion to bring the latest Advanced Assembly and Test technology to Malaysia, an investment by a British-based company, Smith+Nephew Healthcare Sdn Bhd which focuses on the manufacturing of knee and hip implants, to establish its orthopedics manufacturing facility in Pulau Pinang an investment from AAC Technologies, a global solutions provider for smart devices to set up production of front-end moulds and related components in Johor.

The FDI will be able to:

- Contribute to the creation of decent and value-adding jobs;
- Enhance the skill base of host economies;
- Facilitate the transfer of technology, knowledge and know-how;
- Boost competitiveness of domestic firms and enabling their access to markets; and
- Operate in a socially and environmentally zesponsible manner.

Major initiatives and strategies for attracting excellence FDI in robotics are to open markets and allow for FDI inflows by reducing restrictions on FDI as well as to provide open, transparent and dependable conditions for all kinds of firms, whether foreign or domestic, including: ease of doing business, access to imports, relatively flexible labour markets and protection of intellectual property rights.

Strategy 3.7 - Elevating and strengthening Malaysia's robotics export markets and innovation value chain towards becoming the regional robotics hub

In Malaysian robotics supply chain , majority of the local robotics industries are system integrators, provider of robotics solutions and distributors of robotics products. Only a small group of home-grown producers are producing robotics components and materials. Currently, Malaysia's robotics strength is in system integrator where most of the leading Malaysian robotics industries are contributed in the progress of industry such as Pentamaster and Vitrox. For Malaysia to become a regional robotics hub in Services, Agriculture and Manufacturing by 2030, Malaysia must focus on promoting homegrown essential components for robotics, materials for the development of the robots and eventually home-grown robots.

A strategic approach on merger and acquisition between the highly potential global robotics enterprises with local robotics enterprises/unicorn company can be implemented for the gradual development of local capacity and capabilities. In long term, these robotics components can be assembled together to produce fully home-grown robots. In order to strengthen Malaysia's robotics export markets, it is important for Malaysia to take part in the global robotics sandbox and establishing a regional robotics sandbox. These efforts would be able to provide a good test ground for our robotics products at the global markets which will finally open the door for our products to compete at the global market and subsequently enable them to continuously enhancing the products to remain competitive at the global markets. This initiative can leverage and connected together with NTIS. It is expected that at least one sandbox initiative annually to be executed between the year 2023 to 2030 depending on the availability of the funding.

Strategy 3.8 - Special facilitation & incentives for the adoption of robotics technologies among the local business enterprises as well as traditional or less developed sectors

With strong support towards automation and IR4.0, Malaysia's robotics market is projected to reach USD 273.61 Million by 2027 with CAGR of 17.5 % from 2020 to 2027. The market is projected to produce 4,742 units of robots by 2027, at a CAGR of 16.77 % from 2020 to 2027 (Verified Market Research, 2020). While robotics technology has substantial benefits to the country's market growth, the high cost of acquisition, as well as

maintenance of the technology, has restrained most of the industries in Malaysia to adopt and utilising robotics technologies in their industry. The deployment of robots in the manufacturing and other economic sectors would certainly offer tremendous benefits to the industry such as optimization of operation, time efficiency, accuracy and productivity.

Following this, a strategic approach and robust intervention should be taken towards enabling and increasing robotics adoption in local industries.

A feasible model of incentives for the SMEs that adopt local robotics products, technologies, and services needs to include the following benefits:

(a) Research Incentive Scheme: To enhance technology absorption and allow local companies to hire experienced researchers as a measure to stay competitive. This is part of the tax incentives for SMEs that invest into adopting robotic R,D,C&I) into their product, solutions, and services.

(b) Reduce the interest rate for a scale-up production.

(c) Provide in-kind support (match funding, facilities, or infrastructure) to support the marketing and distribute their products domestically till it penetrates the local market.

(d) Government needs to explore procuring services and essential necessities from SMEs that adopt robotics technology.

(e) Incentives for products and services that has obtained certification from the relevant certified bodies.

Towards increasing robotics technology adoption in the industries, there are several efforts that need to be implemented. First, facilitating access to the existing incentives could support robotics adoption such as the automation incentive provided by MIDA as well as the domestic investment strategic fund, the Industry4WD intervention fund and the Smart Automation Grant (SAG) among others. Project implementation could then be expedited by leveraging the recently introduced federal government initiative, Project Acceleration and Coordination Unit (PACU) under PENJANA.

At the same time, it is important to provide incentives, tax benefits, grants or leasing that could facilitate industries to acquire robotics technologies. Through leasing, this would be able to increase industry's interest to acquire robotics technologies as this will address their concern on the costs and expertise for the maintenance of the technologies as well as being more affordable. The leasing facilitation can be established through the strategic partnership initiative with the Malaysian/ sole distributors of robotics products such as UMW that will enable special leasing services to the Malaysian industries. In this case,

tax benefits can be provided to the participating sole distributors in order to attract this partnership.

Finally, the efforts in providing special facilitation and incentives for the adoption of robotics technologies must be complemented with improved awareness amongst the potential users in order for them to partake and thus benefit from the initiatives. For this purpose, existing promotional initiatives under Industry4WD for the adoption of Industry 4.0 in which robotics is one of the subsets could be leveraged and strengthened. This will ultimately ensure that all relevant industry players particularly those from the traditional and less developed sectors can leverage the benefits brought about by informed adoption of robotics and automation in their operations.

Strategy 4.1 - Review & coordinate the current standards & regulations that can be adopted for the robotics-related products

Successful exploitation of new ideas is important for businesses to improve its processes, introduce new and improved products and services to the market, improve process efficiency as well generate higher profits.

Product innovation represents a measure of a country's ability to develop new products through the application and integration of new technology.

In addition to developing a comprehensive inventory, one of the ways to promote adoption of robotics products is to have clear standards and regulations that could be effectively adopted. Therefore, all current standards and regulations related to robotic products must be systematically reviewed and collated in a coordinated manner to ensure adoption by the end-users.
The review will also look at the regulatory issues raised by new robot technology and determine If the existing legislation isadequate to meet the any legal issues raised by robotics technology, as well as to ensure that they provide adequate circumstances to encourage robotics innovation. Other components include the legislation ecosystem support, barriers and liability issues linked to regulatory barriers. This will ensure the needs of different key stakeholders in the ecosystem are taken into consideration and balanced.

Strategy 4.2 - Promoting & establishing a comprehensive indigenous standard and also regulations with regards to safety & ethics that specially developed to align with the local robotics needs & culture as well as for the future preparedness & competitiveness

With a proper strategic review and coordination plan accounting for all existing standards and regulations being in place through Strategy 4.1, we can now move on towards the next stage in strengthening standard, safety, and regulation i.e. to establish and subsequently promote a comprehensive indigenous standard and regulations that are aligned with local robotics needs and culture. This new set of standards and regulations will account for future robotic preparedness and competitiveness.

In first phase of standards development, a comprehensive analysis is carried out on the socioeconomic conditions and national development plans.

The second phase begins with the mapping of national priorities to existing standards and ongoing standardisation projects collated in the strategic review as well as to the development of new set of standards.

In summary, achieving the target set for establishing standard, safety and ethics regulations will ensure that safe and ethical adoption of robotics technologies in order to benefit all players globally.

Strategy 4.3 - Nurturing awareness among the business enterprises on the importance of adopting robotics standards and also safety & ethics regulations

As the adoption of standards is voluntary in nature, industry players must collectively collaborate to ensure that the adopted standards are well-preserved with the benefit of adding value to the products. With the line separating the technological and biological domain becoming less pronounced through the adoption of 4IR principles, a greater degree of robotics integration in our daily life is inevitable. Hence, nurturing awareness among the enterprises and general public on the importance of roboticsstandards, safety and ethics regulation is very important to ensure they are well aware on the conveniences and risks associated with robotisation.

Since robotics development occur at a rapid pace, there will surely be adjustments required on its standards, safety, and ethics regulations to accommodate for new breakthroughs. This must then be taken into account in planning and implementing the awareness programmes on the importance of adopting robotics standards as well safety and ethics regulations. With this in mind, it is targeted for one awareness programme on this topic to be conducted annually providing the justifications on why robotics standards, safety, and ethics regulations are important both from the perspective of the developers as well as the end-users.

Strategy 5.2 - Empowering women

towards adoption of robotics technology for the improvement of quality of life & career development

As Malaysia strives to become a country that treats both genders equally, adoption of robotics would greatly assist in empowering women towards improving overall quality of life and providing more choice in career development.

Hence, by incentivising adoption of robotics-related products at home, tedious house chores could be taken over by service robots providing parents more opportunities for family activities. This also provides the benefit for women to increase their focus in career advancement as they are less burdened at home. As a result, the income gap between genders could be reduced allowing for the realisation of a fair and equitable society.

In addition to incentivising robotics adoption at home, robotisation will also further empower women as well as high need individuals through their participation in robotics-related capacity building programmes. Through this scheme, participants will be provided the necessary knowledge to reskill and upskill themselves in preparation for the adoption of robotics in the workforce.Regardless of their job tier, be it low-skilled, semi-skilled or skilled, participants of the initiatives will be able to fit in to the new 4IR working environments which involves high integration of robotics and other advanced technologies.

Strategy 5.3 - Strategic robotics solution development for improving quality of life and unfortunate/ unexpected/destructive events preparedness

Our recent experience with the Covid-19 pandemic and the sudden flash flood across several states in Malaysia has implied the importance of having strategic robotic solutions to improve quality of life as well as in preparation for unfortunate and unexpected destructive events.

Henceforth, the establishment of strategic robotic solution development programmes will provide a platform for technology providers to innovate on robotic solutions which in turn will improve the quality of life especially for the elderlies apart from preparing for future unfortunate events.

Malaysia will be better prepared as its citizen move into the forecasted ageing society within the near future as well as in pre-empting for natural disasters worsened by human contributions towards climate change. The disaster relief robots would also ensure that the government will be able to provide effective response to disaster relief efforts minimising risks to personnel whilst simultaneously maximising the number of lives that will be saved.

Strategy 5.4 - Facilitating access to robotics technology among the underprivileged society or traditional sectors

Caution must be taken that proper development and adoption of robotic technologies are not done at the expense of the underprivileged. To address potential social disparity due to limited access to robotics technology, access must also be facilitated to both the underprivileged sectors as well as the traditional sectors. In achieving this, a high impact robotics programme will be developed for the whole B40 group to create technopreneurs through collaboration between government and relevant agencies along with all \key players in the aforementioned robotics collaborative platform.

With reference to the limited adoption of robotics in traditional sectors attributed to the traditional belief that there is no need to change the process, facilitating their access to robotics technology is still a must to protect the survivability of these sectors in the future.

Traditional sectors which are typically viewed as low-tech would be able to explore and discover how adoption of robotics technology that best enhance their operations ultimately demonstrating the positive 'Whole-of-Society' benefits brought about by robotisation.

Strategy 5.5 - Promoting awareness on socio-economic impacts of robotics to the public

To overcome the fear and distrust among the community towards robotics due to safety, culture, and traditional practices, promote and build up awareness on the positive socio-economic impacts of robotics to the general public would be the best way forward in gaining public acceptance on robotics adoption.

Thus, it is targeted for at least five strategic awareness and engagement programmes be conducted annually to communicate, build up awareness, and eventually enculturate the various societal groups on how robotics and automation help address the specific needs of these groups as well as in improving their economic status. With the buy-in from the public towards robotisation secured, it would ease the execution of other strategies outlined in the roadmap. Subsequently, this will drive Malaysia one step closer in its aspiration to become a High-Tech Nation with fair and equitable distribution of prosperity by 2030.

Conclusion

High valued, high skilled driven products will define the future global market with the advance of hardware and software technology. Clear vision over the 10 years technological development pathway need to be defined today. Modernization of national strategic areas requires urgent attention from the Government. Specifically, actions need to be carried out in the form of R&D research funds, tax relief, incentive, upskill and reskill initiative, reshuffle of current legislation on robotics and formation of a national robotic governance body. Figure 11 shows that this roadmap is poised to prepare Malaysia toward becoming a progressive, prosperousand high-tech nation.

By 2030, this roadmap envision Malaysia to become the regional robotics hub in services, agriculture and manucaturing sectors as well as a high-tech nation. Malaysia Robotics Market is projected to reach a compound annual growth rate (CAGR) of 17.5% by 2027 from the current USD 88.46 Million in 2020 to USD 273.61 Million in 2027. Besides that, a 15% limit cap of total workforce for foreign workers will be enforced to reduce the dependency on low-skilled, foreign labour in the production and service market. The labour productivity growth is targeted to be increased 3.6% per annum. This will place Malaysia on par with other developed countries. Furthermore, the Malaysian Wellbeing Index (MyWI) is targeted to increase from 121.0 in 2019 to 136.5 by 2030. Lastly, it is projected that the robot density will reach 195 units per 10,000 employess (global average) with the implementation and adoption of the National Robotics Roadmap (NRR) 2021-2030.

Effective implementation of the strategies and initiatives through a whole-of-nation approach will create a conducive ecosystem for the country to embrace robotics technology. The direction set forth by the NRR will guide and assist stakeholders in building up a vibrant and dynamic robotics ecosystem; bringing Malaysia closer towards its aspiration in becoming a progressive, prosperous, and high-tech nation. The success of the NRR will depend on the willingness of all stakeholders to embrace change and their close collaboration to systematically implement the strategic thrusts, strategies and initiatives. Steadfast commitment and support from all will ensure the realisation of the vision and mission of the roadmap.

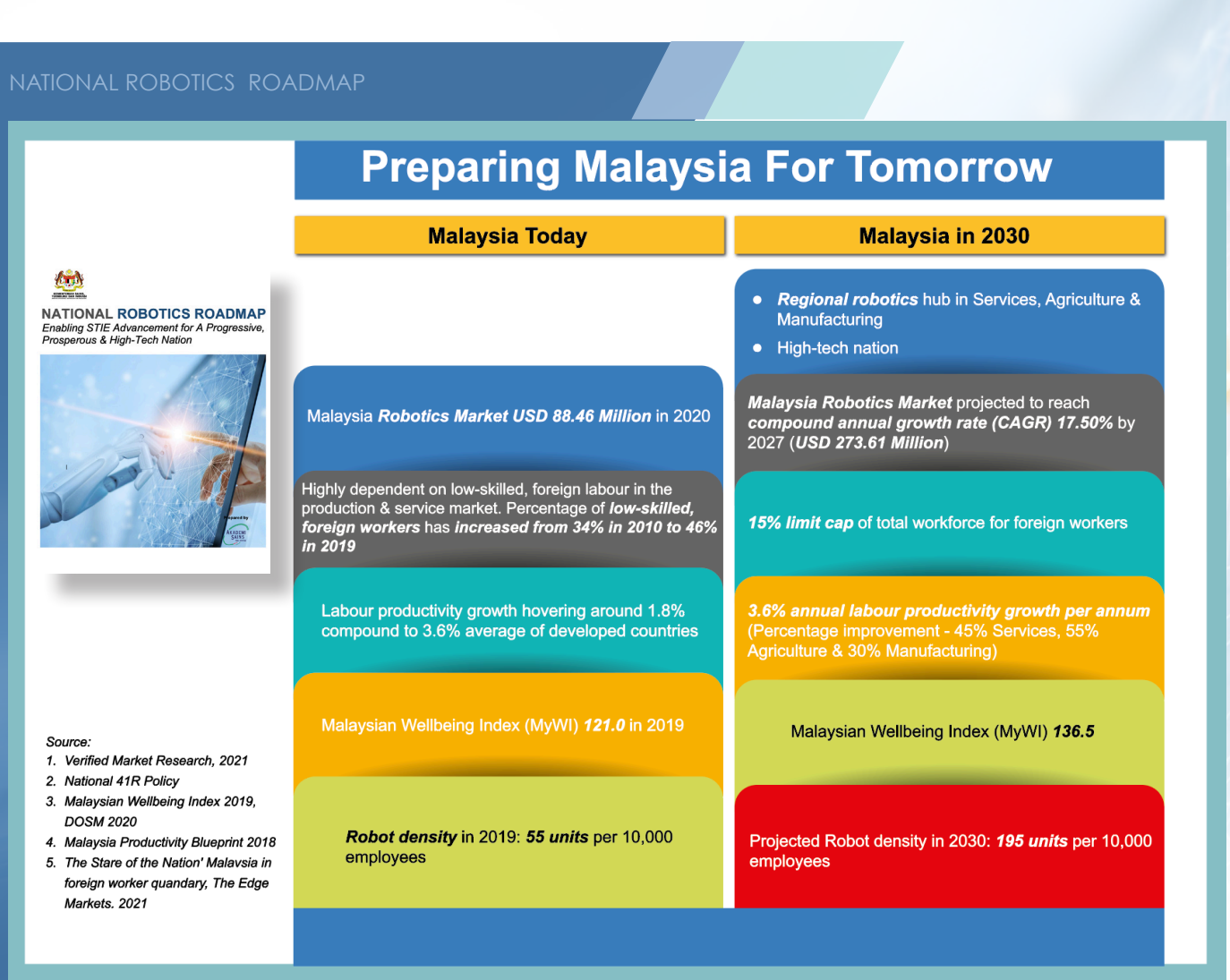


Figure 11 : National Robotics Roadmap preparing Malaysia for tomorrow

Ministry of Science, Technology and Innovation
(MOSTI)