ANNEXES A-6

GLOBAL SCAN OF ROADMAPS

CONTENTS

1 INTRODUCTION

The Global Scan chiefly achieves the dual aims of understanding the technological progress in other economies and learning from the architecture of their roadmaps. We looked at several key countries from the perspective of technology and our findings are presented in this report.

2 OBJECTIVE

The purpose of this document is to take a look at what key technology areas other countries are focusing on as part of their technology roadmap. This report is a summary of our findings based on publically available documents and is not intended as an exhaustive list of technology roadmaps in the world.

3 LIST OF ROADMAPS

Below are some of the roadmaps that were examined during the process of preparing this report:

1. Germany Industry 4.0
2. Germany Digital Strategy 2025
3. Estonia Digital Agenda 2020
4. E-Society Estonia
5. Smart Dubai 2021
6. UAE Artificial Intelligence Strategy 2031
7. Israel Innovation Report 2017
8. Israel 2028
9. US National IoT Dialogue
10. US Roadmap for Cybersecurity Research
11. US Government Cloud Computing Roadmap
12. Japan 5th Science & Technology Basic Plan: Society 5.0
13. Made in China 2025
14. Smart Cities in China – European Union (EU) SME Centre

We studied the different roadmaps listed above and have mapped what we think are the key technology focus areas for each roadmap.
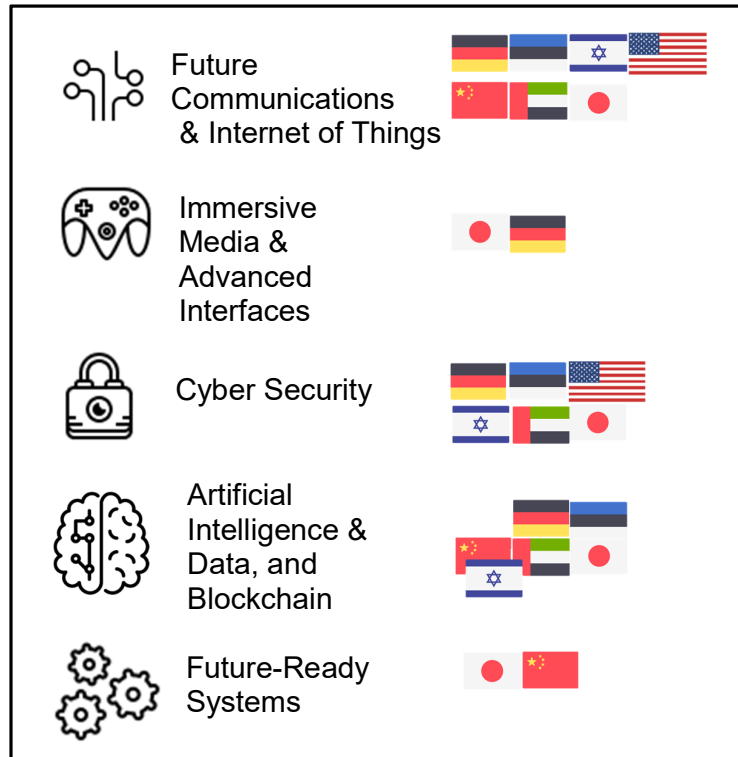

Exhibit 1: Key Technology Focus Areas for each Roadmap

We also categorised the different roadmaps based on their purposes, and our observations are summarised below:
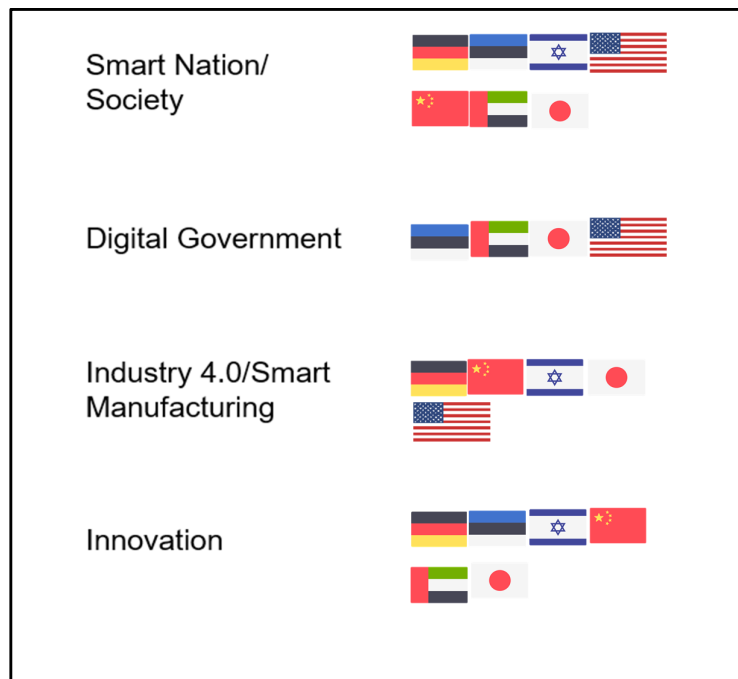

Exhibit 2: Roadmap Purposes

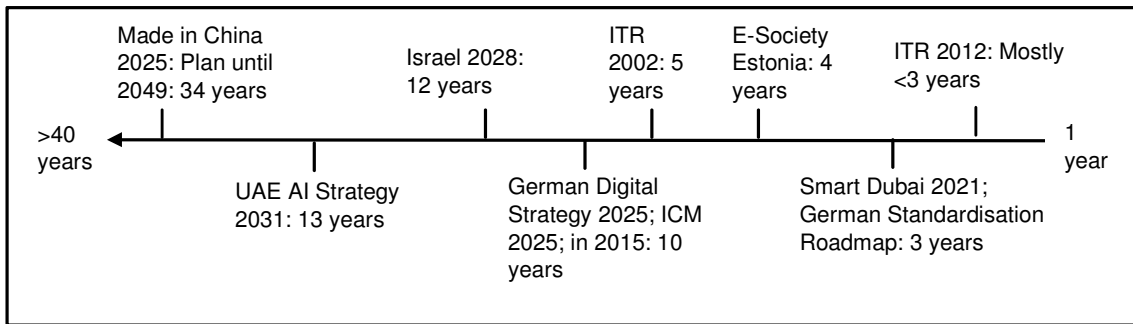We illustrate the different roadmaps according to their planning horizons below:

Exhibit 3: Roadmap Time Horizon

4   COUNTRIES STUDIED

4.1   Germany

a)   German Trade & Invest: Industry 4.0 [1] [2] [3] [4]

b)   Digital Strategy 2025 [5]

Germany [6] [7] [8] [9] is known to be the originator of the concept of Industry 4.0. The German economy is known for its high-tech exports and advanced manufacturing sector.

Germany has a strong focus in promoting high-tech manufacturing, and it aspires to be the world leader in Industry 4.0 solutions. It aims to use data, advanced information and communications technology (ICT), and a digitalisation strategy to achieve advanced manufacturing capabilities.

German Trade & Invest: Industry 4.0

Aim: Germany as lead provider of Industry 4.0 solutions

Vision: Globally competitive economy + high wages

Who: German Trade & Invest (GTAI)

Technological focus:

Cyber-Physical production systems

- Internet of Things (IoT) + Big Data in production
- Machine to machine (M2M) communication between Smart Machines
- Smart Factories + Automated Factories

Target audience

- Small and medium-sized enterprises (SMEs) in Germany

Exhibit 4: German Trade & Invest, Industry 4.0

Industry 1.0 to Industry 4.0

First Industrial Revolution:

Mechanical production with water and steam

Second Industrial Revolution:

Mass Production + Division of Labour

Third Industrial Revolution:

Embedded Systems + Automation

Fourth Industrial Revolution:

Cyber-Physical Systems
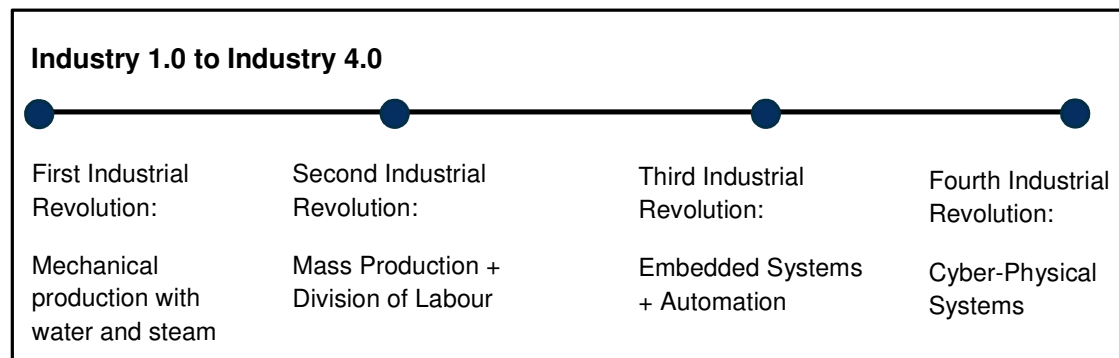
Exhibit 5: Industry 1.0 to Industry 4.0

Synopsis

Industry 4.0, or Smart Industry, is built around Cyber-Physical production systems that enable a shift from centralised production to decentralised, specialised production—meaning that the merchandise communicates its specifications to the production machinery. GTAI is optimistic that Industry 4.0 will help Germany become a global leader in Smart Manufacturing solutions, boost productivity, and sustain growth in a high wage economy.

GTAI highlights the importance of building IoT, Big Data, and M2M communications capabilities to support a Cyber-Physical infrastructure in Smart Factories. The report paints an overview of the government initiatives to promote the development and adoption of these technologies, as well as the involvement of various research institutions.

Furthermore, the report contains an Industry Voices section that includes detailed case studies of technology conglomerates such as Bosch, Festo, and SAP.

4.1.2 **Digital Strategy 2025**

Aim: Germany as lead provider of Industry 4.0 solutions

Vision: A digitalised German Society + Economy

Who: Federal Ministry for Economic Affairs & Energy (BMWi)

Technological focus:

Digital infrastructure

- Smart Networks
- Smart Homes (IoT)
- Big Data + Data Security
- Microelectronics
- Additive Manufacturing
- Service Robots

Target audience/stakeholders

- SMEs + Big firms in Germany
- Startups
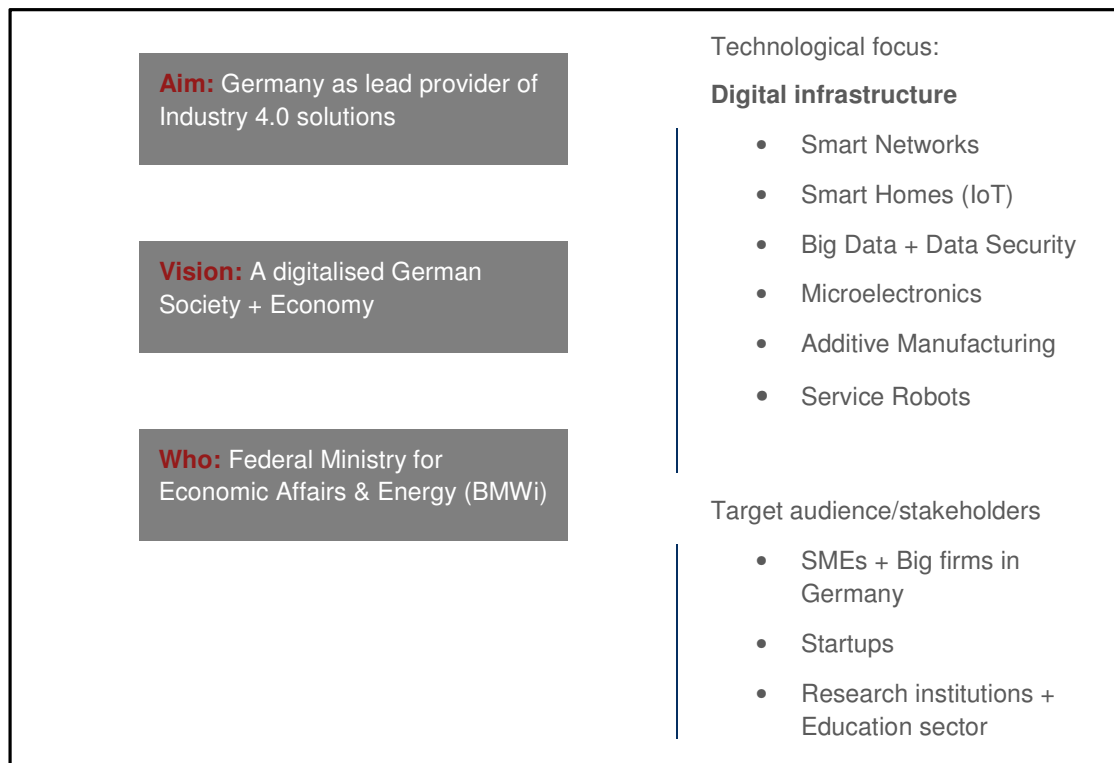- Research institutions + Education sector

Exhibit 6: Digital Strategy 2025

Synopsis

The 'Digital Strategy 2025' charts Germany's government strategy to achieve Germany's digitalisation vision by 2025. The Federal Ministry for Economic Affairs & Energy (BMWi) identified 10 projects for the next decade, which includes building a Gigabit Optic Fibre Network, helping technology startups innovate, building up digital education, and creating a digital agency. Stakeholders involved in this digitalisation project include economic regulatory bodies to promote technological innovation and the Federal Ministry of Education and Research (BMBF) to sustain technology education.

BMWi's focus is on building a Digital Infrastructure for Germany, and this is broken down into Smart Networks, Smart Homes, Big Data, and Data Security. BMWi specifically focuses on promoting private sector research into Microelectronics, Additive Manufacturing, and Service Robots to build up Industry 4.0 capabilities.

This report focuses on the supply side, as it details efforts to support technology startups and SMEs, promote research and development (R&D) in big firms, and bolster technology education to create a technologically-trained workforce.

4.2 Estonia

a) Digital Agenda 2020 [10]

b) E-Society Estonia [11] [12]

Estonia [13] [14] is often lauded as one of the most digitalised countries in Europe. Estonia has introduced novel projects such as the E-Residency project, as well as ambitious plans to digitalise most of government and social services for individuals, families, and businesses.

Estonia is concentrating on its efforts to digitalise most government services. Therefore, Estonia has a central focus on Big Data Analytics and Cyber Security to support its E-Residency and E-Services initiatives. In addition, Estonia focuses much of its efforts on blockchain technology to enhance the security and efficiency of public services transactions. Now, it wishes to extend blockchain technology for transactions between financial institutions.

4.2.1 **Digital Agenda 2020**

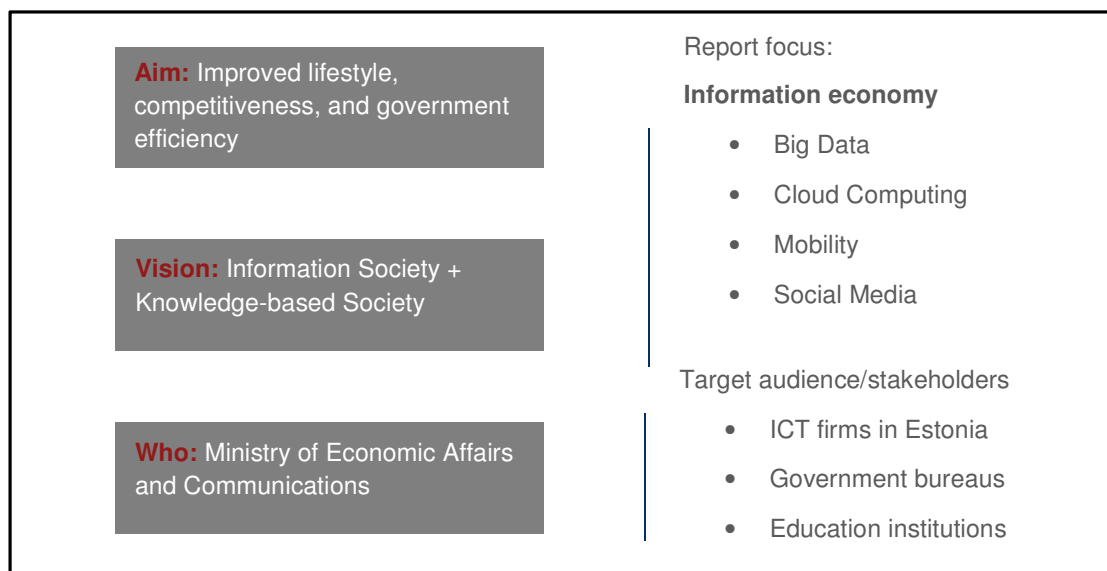|	Report focus:
Aim: Improved lifestyle, competitiveness, and government efficiency	**Information economy** • Big Data • Cloud Computing • Mobility • Social Media
Vision: Information Society + Knowledge-based Society	Target audience/stakeholders
Who: Ministry of Economic Affairs and Communications	• ICT firms in Estonia • Government bureaus • Education institutions

Exhibit 7: Digital Data 2020

Synopsis

The Digital Agenda 2020, published in 2010, paints a vision for a Digital Society in Estonia. The document lists the key performance index (KPIs) to achieve for Public Administration, Internet Usage and ICT Infrastructure, E-Government Services, Technology Manpower, and Digital Literacy. Back in 2010, the Ministry of Economic Affairs and Communications identified Big Data, Cloud Computing, and Social Media as emerging technological trends—all of which are widely adopted today, with Big Data and Cloud Computing continuing to show immense business potential. Specifically, Estonia identified Big Data and Cloud Computing as important horizontal enablers to support innovation in other sectors of the economy.

This Digital Agenda 2020 aggregates the works of various ministries to achieve the goal of an Information Society and a Smart Nation for Estonia.

4.2.2 **E-Society Estonia**

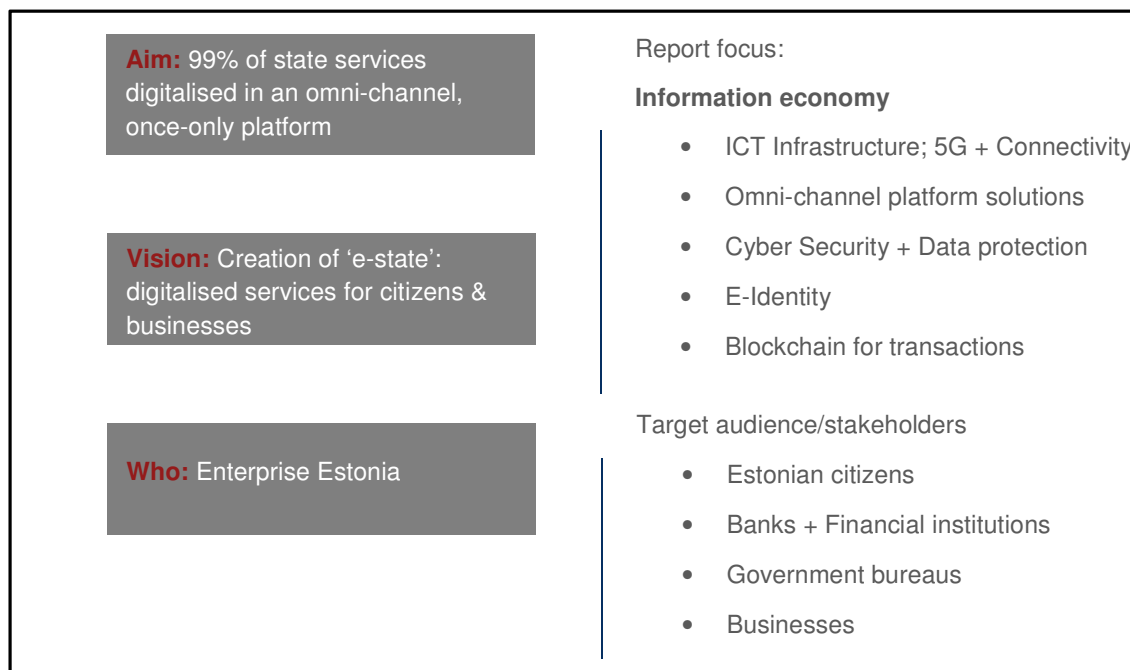|	
Aim: 99% of state services digitalised in an omni-channel, once-only platform	Report focus: **Information economy** • ICT Infrastructure; 5G + Connectivity • Omni-channel platform solutions • Cyber Security + Data protection • E-Identity • Blockchain for transactions
Vision: Creation of 'e-state': digitalised services for citizens & businesses	Target audience/stakeholders
Who: Enterprise Estonia	• Estonian citizens • Banks + Financial institutions • Government bureaus • Businesses

Exhibit 8: E-Society Estonia

Synopsis

E-Society is a project that aims to create an omni-channel platform for 99% of public services concerning individuals, families, businesses, and government bureaus. Citizens and businesses are issued with E-Identities that enable them to access an entire range of services based on the 'once-only' principle. Estonia is also exploring the use of blockchain technologies to facilitate electronic transactions involving businesses, individuals, banks, and government.

To support such an initiative, the Ministry of Economic Affairs and Communications is working to put in place an ambitious 5G network across the country by the end of 2018, and it is also investing heavily into cybersecurity and data protection frameworks.

4.3   United Arab Emirates (UAE)

a)   Smart Dubai 2021 [15] [16]

    i.   Smart Government [17] [18]

    ii.   Blockchain strategy [19]

    iii.   Autonomous Transport Strategy [20]

b)   UAE [21] Artificial Intelligence (AI) Strategy 2031

Dubai has also introduced measures to decouple from oil and diversify its economy, notably through promoting non-oil businesses and tourism in the region. Smart Dubai 2021 is an initiative undertaken by the government to sustain Dubai as one of the most forward-thinking cities in the world.

UAE devotes a large portion of its resources to digitalising government services. UAE has a significant focus on blockchain technology and it is another city that is seriously considering autonomous vehicles as a viable option for future commuters.

Dubai is trying to focus on using ICT to reinvigorate the services sector, as UAE is keen to transform itself into a world-class tourism and services centre to decouple from oil.
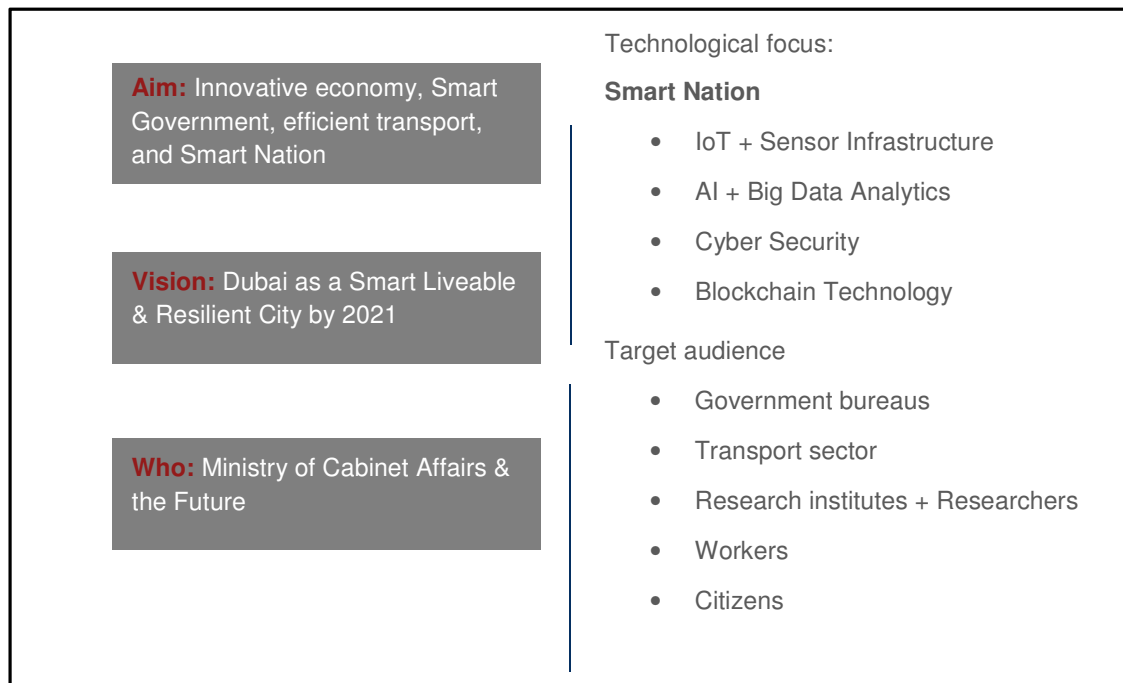
4.3.1   Smart Dubai 2021

Aim: Innovative economy, Smart Government, efficient transport, and Smart Nation

Vision: Dubai as a Smart Liveable & Resilient City by 2021

Who: Ministry of Cabinet Affairs & the Future

Technological focus:

Smart Nation

- IoT + Sensor Infrastructure
- AI + Big Data Analytics
- Cyber Security
- Blockchain Technology

Target audience

- Government bureaus
- Transport sector
- Research institutes + Researchers
- Workers
- Citizens

Exhibit 9: Smart Dubai 2021

Synopsis

Smart Dubai 2021 is a 5-year plan launched by the Ministry of Cabinet Affairs and the Future in 2017. Smart Dubai 2021 aims to achieve 6 objectives:

a) Smart and Resilient City

b) Competitive economy supported by innovation

c) Easy access to social services

d) Smart Transport powered by Autonomous & Shared Mobility vehicles

e) Clean environment and sustainable growth

f) Smart Government services

Smart Dubai 2021 emphasised the development of IoT and Big Data analytics capabilities to support the Smart Nation project. The project also had an explicit focus on Smart Transport, specifically into the areas of autonomous and shared mobility vehicles as well as smart traffic and transport infrastructure. The government envisions that by 2030, 25% of all trips made in Dubai will be driverless.

In addition, Smart Dubai 2021 pays close attention to blockchain. Dubai aspires to be the first city in the world to be fully powered by blockchain by 2020, and the strategy discussed case studies and use cases for both government and the private sector involving property transactions, food safety, education, commercial transactions, amongst others.

4.3.2 UAE Artificial Intelligence Strategy 2031

The UAE government unveiled a long-term plan for AI in 2031, and it aims to use AI to transform various sectors of the economy:

a) Transport: Reduce accidents and costs

b) Health: Improve preventive care and treatment

c) Space: Stretch space technology capabilities

d) Renewable energy: Managing facilities

e) Water: New water sources

f) Technology: Enhance productivity

g) Education: Improve education quality and delivery

h) Environment: Planting more trees and preserving environment

i) Traffic: Reduce traffic congestion

This project aims to boost government performance across a wide range of services, and eventually to drive R&D and innovation in the economy for growth. This project is still in the early stages, but various government bureaus, including the Dubai Police, have committed to being 100% reliant on AI by 2031.

4.4 Israel

    a)   Israel Innovation Authority Report 2017 [22] [23]

    b)   Israel 2028

Israel [24] is often lauded as the Silicon Valley of the Middle East, as it is one of the most innovative countries in the world. Each year, an average of 100 technological startups are acquired by the technology multi-national companies (MNCs) around the world. Furthermore, high-tech exports account for 40% of the total amount of Israel's exports.

Israel's innovation focus also encompasses the biotechnology and chemicals sectors, as these are its major exports. It also has a big focus on Robotics, IoT, and Big Data Analytics.

4.4.1 Israel Innovation Authority Report 2017

The Israel Innovation Authority emphasised the need to increase employment in the high-tech sector to ensure that the economy remains competitive and innovative. It pays special attention to the transformation of Israeli industries to Industry 4.0 through leveraging on Israel companies' expertise on Robotics, IoT, Machine Learning, Big Data, and AI.

In addition, the report also highlighted the need for more R&D in the life sciences, biotechnology, and chemicals sectors, as they are also major exports for the Israeli economy.

4.4.2 Israel 2028

Report focus:

Smart manufacturing

- Electronics, electro-optics
- ICT
- Chemistry
- Life Sciences
- Alternative Energy
- Agricultural Technologies
- Water Technologies

Target audience/stakeholders

- Key high-tech sectors in Israel
- Researchers

Aim: Sustain Israel's leading position in innovation and R&D

Vision: Israel as a leading economy with high quality of life

Who: Samuel Neaman Institute: National Policy Research Institute/think-tank

Exhibit 10: Israel 2028: Leveraging Scientific/Technological R&D

Synopsis

Israel 2028 is a whole-of-society transformation map drafted by the Samuel Neaman Institute. The chapter on Scientific/ Technological R&D aims to sustain Israel's position in innovation and R&D. The report focuses on bolstering Israel's technology manpower, encouraging innovation amongst startups, nurturing basic research at universities, and fostering Public-Private Partnerships. The report also discussed the funding allocation for Israel's key technology sectors.

4.5   United States of America (US)

a)   National IoT Strategy Dialogue [25] [26]

b)   Roadmap for Cybersecurity Research [27]

c)   US Government Cloud Computing Technology Roadmap [28] [29]

We examined two roadmaps: Roadmap for Cybersecurity Research by Homeland Security and the US Government Cloud Computing Technology Roadmap. On top of that, we perused the websites of the AI Roadmap institute and the IoT Institute—organisations established with help from the US government to inform, network, and create opportunities for research and innovation.

Lastly, we also examined the technologies mentioned in the 'Smart City Roadmap 1.0' [30] as well as the 'Technology and the Future of Cities' [31] report.

4.5.1   National IoT Strategy Dialogue

This report consolidated the discussions of 5 organisations: Intel, Samsung, Information Technology Industry Council, Semiconductor Industry Association, and the US. Chamber of Commerce Technology Engagement Centre. The discussion points aim to guide the US government's IoT policy vision and delved into areas including Public-Private Partnerships, Cybersecurity of IoT infrastructure, innovation, and 5G Broadband Networks.

Bringing together industry players and the government for a focused group discussion can elicit genuine industry responses and allow the government to understand some of their business challenges and concerns.

4.5.2   Roadmap for Cybersecurity Research

This report was drafted by the U.S. Department of Homeland Security in 2009, and it identified gaps in current cybersecurity research to construct a national R&D agenda. It defined 11 critical areas for further research:

a)   Scalable trustworthy systems

b)   Enterprise-level metrics

c)   System evaluation life cycle

d)   Combatting insider threats

e)   Combatting malware and botnets

f)   Global-scale identity management

g)   Survivability of time-critical systems

h)   Situational understanding and attack attribution

i)   Provenance (information, systems, hardware)

j)   Privacy-aware security

k)   Usable security

This report focuses solely on cyber security. The report identified beneficiaries, gaps in research and practice, the approaches required to plug these gaps, possible approaches as well as the potential benefits to various beneficiaries. The report also looked at the system evaluation life cycle and identified the beneficiaries, challenges and needs within this life cycle.

4.5.3   US Government Cloud Computing Technology Roadmap

This report was published by the National Institute of Standards and Technology in 2011. It identified the capabilities as well as the KPIs required for the US government to fully adopt Cloud Computing technologies.

This document was designed to foster adoption of cloud computing by US federal agencies and support the private sector, reduce uncertainty by improving the information available to decision-makers, and help facilitate further development of the cloud computing model.

Key audiences for this report would be US policymakers, US government agencies as well as cloud computing stakeholders which can include academia, government, industry, standards developing organisations, etc.

4.6   Japan

a)   5th Science and Technology Basic Plan – Society 5.0 [32]

Japan [33] focuses heavily on science and technology as well as being an innovation hub in the Asian Pacific region. Japan is the originator of the Society 5.0 concept, as Japan intends to use science and technology to transform society and address social issues.

Japan differs from the other countries examined because of the unique concept of Society 5.0, which is broader in scope than Germany's Industry 4.0. Society 5.0 involves the union of technology and policy to reinvigorate the services and manufacturing sectors, and it aims to improve the standard of living in its ageing population. This is project involves not only research and business investments but also policies to be implemented.

4.6.1 Japan 5th Science & Technology Basic Plan: Society 5.0

Aim: Use science and technology to address social problems + improve competitiveness

Vision: Society 5.0: Super-Smart Society + Sustainable Development

Who: Council for Science, Technology & Innovation (CSTI)

Technological focus:

Smart Nation

- IoT + Big Data
- Automation + Advanced Robotics
- Cyber Security
- Sensor + Actuator Technologies
- Biotechnology
- Nanotechnology + Materials
- Augmented Reality + Virtual Reality
- Photonics + Quantum Technologies

Target audience

- Workers (Human Capital)
- SMEs + Startups
- Research Institutes

Exhibit 11: Japan 5th Science & Technology Basic Plan, Society 5.0

4.6.1.1 Society 1.0 to Society 5.0

Society 1.0:

Hunting & Gathering

Society 2.0:

Agricultural

Society 3.0:

Industrial

Society 4.0:

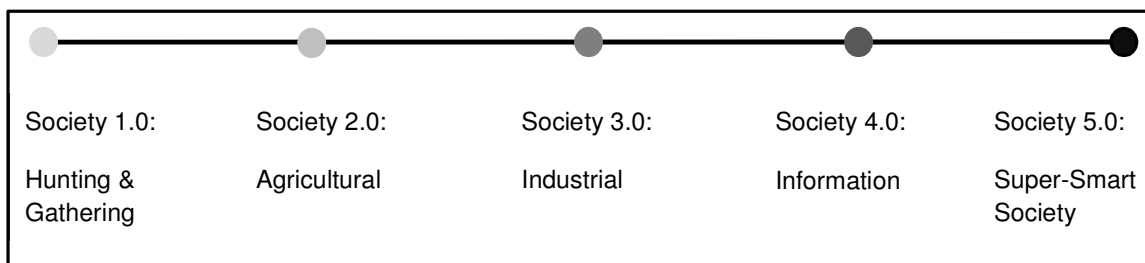Information

Society 5.0:

Super-Smart Society

Exhibit 12: Japan 5th Science & Technology Basic Plan, Society 1.0 to Society 5.0

Synopsis

Society 5.0, or Super-Smart Society and the 5th Science & Technology Basic Plan recommends broad areas of technology that research institutes and the private sector can consider for innovation and investment. It also stated the need for technology manpower in Japan to support the Smart Nation drive.

The aim of the Smart Society project is to tackle Japan's social and economic concerns, most notably an ageing population, growing urban-rural gap, and slowing competitiveness.

Japan identified certain technological areas to focus on namely IoT, Big Data, Cyber Security, Human-interface Technologies, and Quantum Technologies. It also identified the need for technology manpower and the need to foster innovation and entrepreneurship in SMEs and the private sector.

Other technologies identified by Japan were biotechnology (especially bio-sensors to support ageing population and Smart Healthcare), affective engineering (Kansei engineering for advanced human-interfaces), as well as advanced materials and nanotechnology to support smarter devices.

4.7 China

a) Made in China

    i.   Made in China 2025 – Official Government document [34]

    ii.   Made in China 2025 – US Chamber of Commerce [35]

b) Smart Cities in China – EU SME Centre [36]

China [37] [38] is often lauded as the 'Workshop of the World'. China's Made in China 2025 masterplan is a project that aims to transform the country's massive manufacturing sector into a high-tech sector that rivals the ones in other advanced economies.

China is also looking into Smart Cities, as the government has demonstrated considerable enthusiasm in transforming its leading cities such as Beijing and Shanghai.

China's focus is on Smart Cities and advanced manufacturing. China has always been seen as the low-cost manufacturing economy, but given competition from emerging low-cost economies such as Vietnam and Cambodia, China is keen to move up the manufacturing ladder and transform itself into a high-tech manufacturing powerhouse.

China's focus is on import-substitution: growing domestic industrial capacity to produce high-tech machineries that are traditionally exported from powerhouses such as Germany. It strives towards Germany's Industry 4.0 dream and aims to build up domestic production capacity for advanced manufacturing output.

4.7.1 **Made in China 2025**

Aim: Digitalise manufacturing, improve quality; innovation

Vision: Reinvigorate China into a competitive global manufacturing leader

Who: Ministry of Industry and Information Technology

Report focus:

Smart manufacturing

- Smart Manufacturing (Cyber-physical systems)
- IoT
- Robotics
- Cloud Computing
- Big Data
- Advanced Computing

Target audience/stakeholders
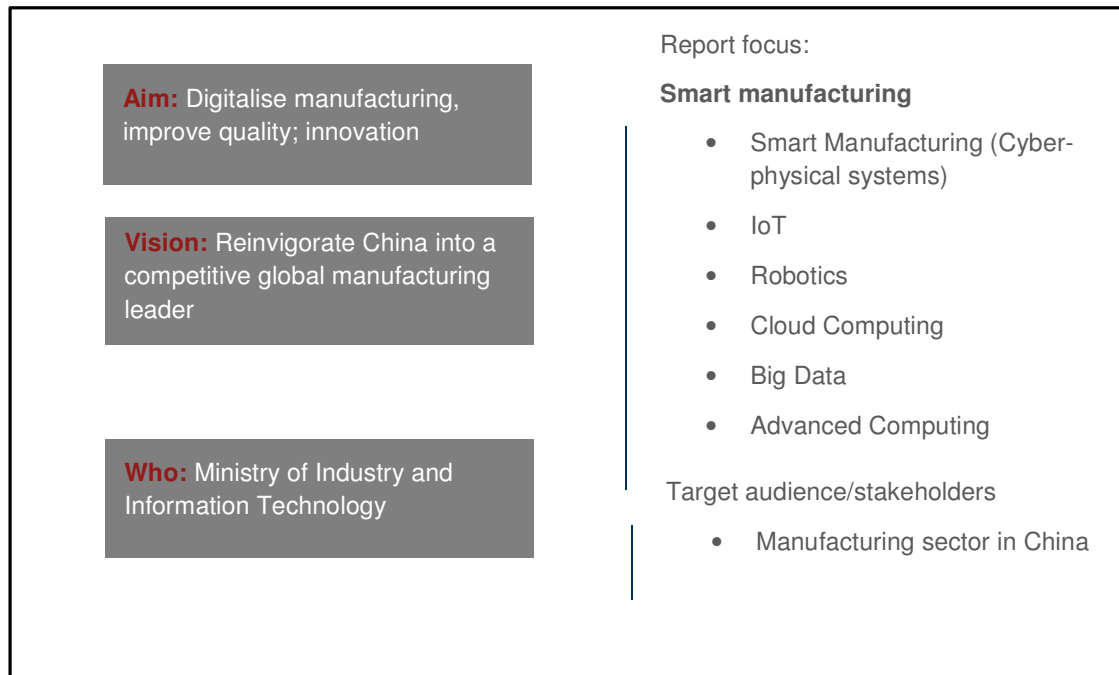
- Manufacturing sector in China

Exhibit 13: Made in China 2025

Synopsis

The 'Made in China 2025' report was drafted by the Ministry of Industry and Information Technology in 2015, and it is a 10-year master plan to reinvigorate China's manufacturing sector. The masterplan focuses on Import-Substitution: enhancing domestic capabilities to match the high-tech manufacturing exports of other advanced economies. The plan encompasses key areas such as next-generation information technology (IT), aviation, rail, new energy transport, and agricultural machinery. These key areas account for 40% of China's industrial manufacturing output. Key technologies that the report focused on include Smart Manufacturing, IoT, Robotics, Cloud Computing, Big Data, and Advanced Computing.

Overall, the plan spells out ambitions that stretch until 2049, the centennial of the People's Republic of China, with 2025 being the first phase of the plan.

4.7.2 **Smart Cities in China – EU SME Centre**

Aim: Identify sectors for EU ICT SMEs to create value in Chinese Smart Cities

Who: EU SME Centre

Report focus:

Smart Cities

- Smart Transport

- Smart Water

- Smart Energy

- Smart Healthcare

- Cyber Security

Target audience/stakeholders

- EU ICT SMEs wanting to enter the Chinese market

Exhibit 14: EU SME Centre, Smart Cities in China

Synopsis

The EU SME Centre identified opportunities for ICT SMEs in the EU to penetrate into the China market by riding on the wave of China's Smart Cities drive as well as the Made in China 2025 plan. The opportunities identified include Smart Transport, Smart Water, Smart Energy, Smart Healthcare, and Cybersecurity, and the report further identified specific use cases within these domains. The EU SME Centre also identified leading European and Chinese companies working on smart solutions as case studies and these companies include Schneider Electronics, ARUP, and IESLab. These case studies serve as valuable references for the SMEs which are considering entering into the Chinese market.

The report conducted further detailed market analysis of Beijing and Shanghai, specifically in terms of the technologies emphasised by the government to support its Smart Cities drive (Big Data, Cloud Computing, IoT, Network Security, and Next-generation Broadband).

5 SUMMARY

Germany:
- Industry 4.0
  - Smart Manufacturing + case studies
- Digital Strategy 2025

Estonia:
- Digital Agenda 2020
  - KPIs for digital economy
- E-Society Estonia
  - Smart Nation

China:
- Made in China 2025
  - Bolster Chinese manufacturing
  - High-tech manufacturing

Israel:
- Israel 2028
  - Whole-of-government vision for the future
- Innovation Report 2017
  - Policies to promote innovation

Singapore:
- ITRs 2012, 2005, 2002
- ICM 2025

US:
- Cloud Computing Roadmap
  - For government services
- Cybersecurity Research
  - Identify gaps in R&D
- National IoT Dialogue
  - Discussion with private sectors

UAE:
- Smart Dubai 2021
  - Smart Nation
- AI Strategy 2031
  - Long-term AI Roadmap

Japan:
- Society 5.0
  - Science, technology, and innovation for socio-economic challenges
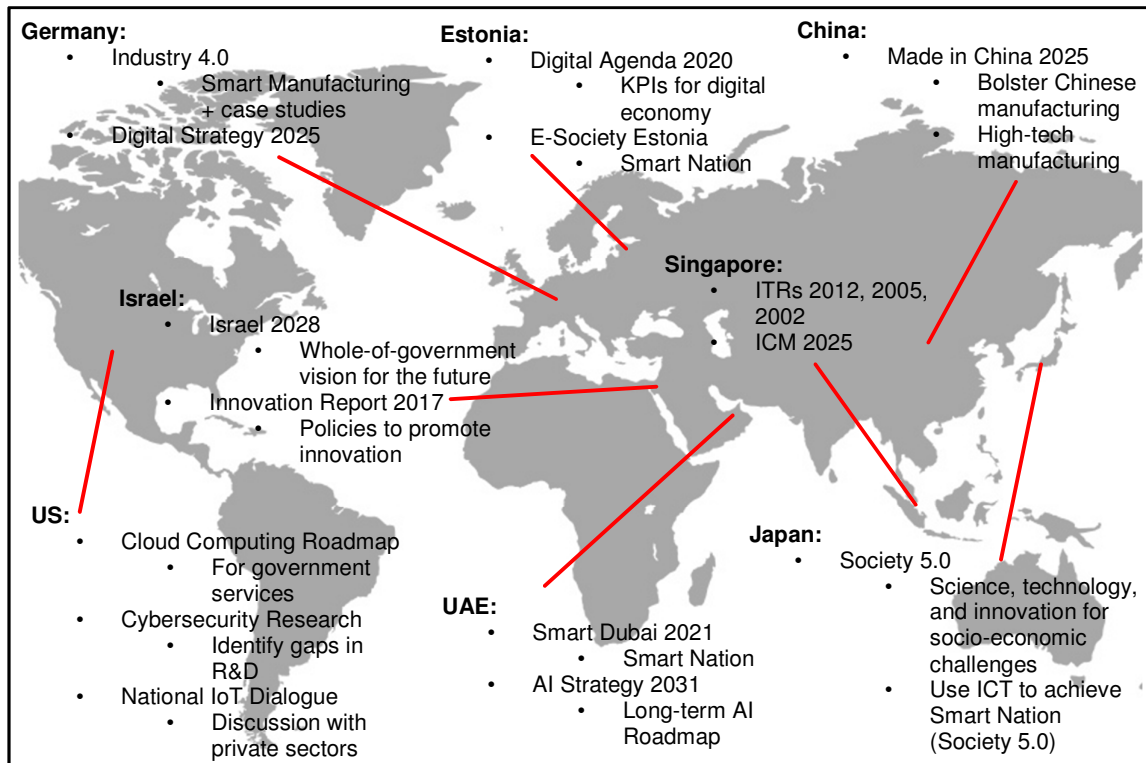 - Use ICT to achieve Smart Nation (Society 5.0)

Exhibit 15: Representation of countries and its respective roadmaps

In summary, the above is a representation of the countries and its respective roadmaps that were examined as part of the Global Scan report. As a general observation, we can conclude that most of the countries above have identified and are looking at similar areas that Singapore is also looking at. These areas are Future Communications & IoT, Immersive Media & Advanced Interfaces, Cyber Security, Artificial Intelligence and Data, and Blockchain as well as Future-Ready Systems.

Some learning points gathered from this exercise can be summarised as below:

1. Different countries have different objectives towards which technology roadmaps are developed for. For example, Japan wants to use technology to develop Society 5.0 with a lot of focus to cater to their ageing population. Germany is known for Industry 4.0 to boost their manufacturing competitiveness. Positioned the technology roadmaps differently to the public. Some connect it with a societal ambition (e.g. Society 5.0), some focus on industries (e.g. Germany Industry 4.0) and some keep it at a technology roadmap level

2. Technology portfolio is fairly similar across all countries. However, some countries have emphasised more on certain technologies depending on their economic priorities. E.g. Estonia focuses a lot on softer technologies to boost their knowledge economy objective and hence have roadmaps for Big Data, cloud computing, and blockchain. On the other hand, countries like Japan and Germany focuses on technologies that also help them to improve their manufacturing competitiveness.

3. Most countries in their technology roadmaps not only focus on the need for research and development activities but also drive initiatives towards the adoption of technology in their focus markets. E.g. Estonia have emphasised the use of technology to transform their government services. Israel focuses on sectors that are export oriented such as life sciences, biotechnology, and chemicals sectors.

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