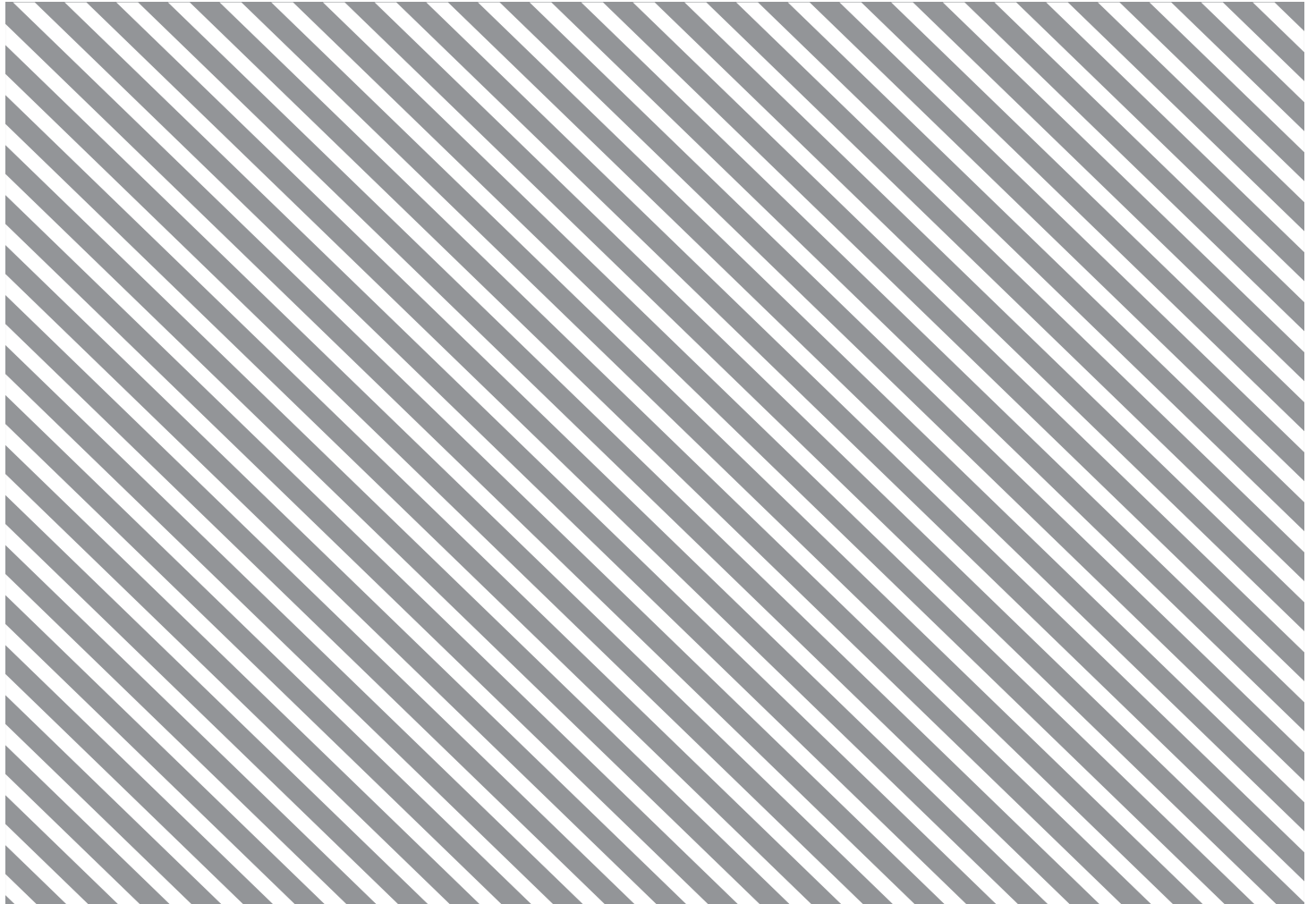


White Paper

A Framework for Developing a National Artificial Intelligence Strategy

Centre for Fourth Industrial Revolution

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Introduction

Over the past decade, artificial intelligence (AI) has emerged as the software engine that drives the Fourth Industrial Revolution, a technological force affecting all disciplines, economies and industries. The exponential growth in computing infrastructure combined with the dramatic reduction in the cost of obtaining, processing, storing and transmitting data has revolutionized the way software is developed, and automation is carried out. Put simply, we have moved from machine programming to machine learning. This transformation has created great opportunities but poses serious risks. Various stakeholders, including governments, corporations, academics and civil society organizations have been making efforts to exploit the benefits it provides and to prepare for the risks it poses. Because government is responsible for protecting citizens from various harms and providing for collective goods and services, it has a unique duty to ensure that the ongoing Fourth Industrial Revolution creates benefits for the many, rather than the few.

To this end, various governments have embarked on the path to formulate and/or implement a national strategy for AI, starting with Canada in 2017. Such efforts are usually supported by multimillion-dollar – and, in a few cases, billion-dollar-plus – investments by national governments. Many more should follow given the appropriate guidance. This white paper is a modest effort to guide governments in their development of a national strategy for AI. As a rapidly developing technology, AI will have an impact on how enterprises produce, how consumers consume and how governments deliver services to citizens. AI also raises unprecedented challenges for governments in relation to algorithmic accountability, data protection, explainability of decision-making by machine-learning models and potential job displacements. These challenges require a new approach to understanding how AI and related technology developments can be used to achieve national goals and how their associated risks can be minimized. As AI will be used in all sectors of society and as it directly affects all citizens and all of the services provided by governments, it behoves governments to think carefully about how they create AI economies within their countries and how they can employ AI to solve problems as diverse as sustainability of ecosystems to healthcare. Each country will need AI for different things; for example, countries with ageing populations may not be so worried about jobs lost due to AI automation, whereas countries with youthful populations need to think of ways in which those young people can participate in the AI economy. Either way, this white paper provides a framework for national governments to follow while formulating a strategy of national preparedness and planning to draw benefits from AI developments.

The framework is the result of a holistic study of the various strategies and national plans prepared by various countries, including Canada, the United Kingdom, the United

States, India, France, Singapore, Germany and the UAE. Additionally, the World Economic Forum team interviewed government employees responsible for developing their national AI strategies in order to gain a detailed understanding of the design process they followed. The authors analysed these strategies and designed processes to distil their best elements.

The framework aims to guide governments that are yet to develop a national strategy for AI or which are in the process of developing such a strategy. The framework will help the teams responsible for developing the national strategy to ask the right questions, follow the best practices, identify and involve the right stakeholders in the process and create the right set of outcome indicators. Essentially, the framework provides a way to create a “minimum viable” AI strategy for a nation.

Why do you need a national strategy for AI?

At its core, the Fourth Industrial Revolution can be characterized by the development of emerging technologies such as AI, robotics, nanotechnology, quantum computing, biotechnology, the internet of things (IoT) and blockchain, all of which will change the way we live and work. This revolution fundamentally challenges the classic policy-making process, whereby governments tend to react to technological change rather than guiding it. Within this new paradigm, governments should adopt a proactive stance and actively co-design, through a multistakeholder approach, the appropriate environment to support the responsible conception, development and use of emerging technologies, starting with AI.

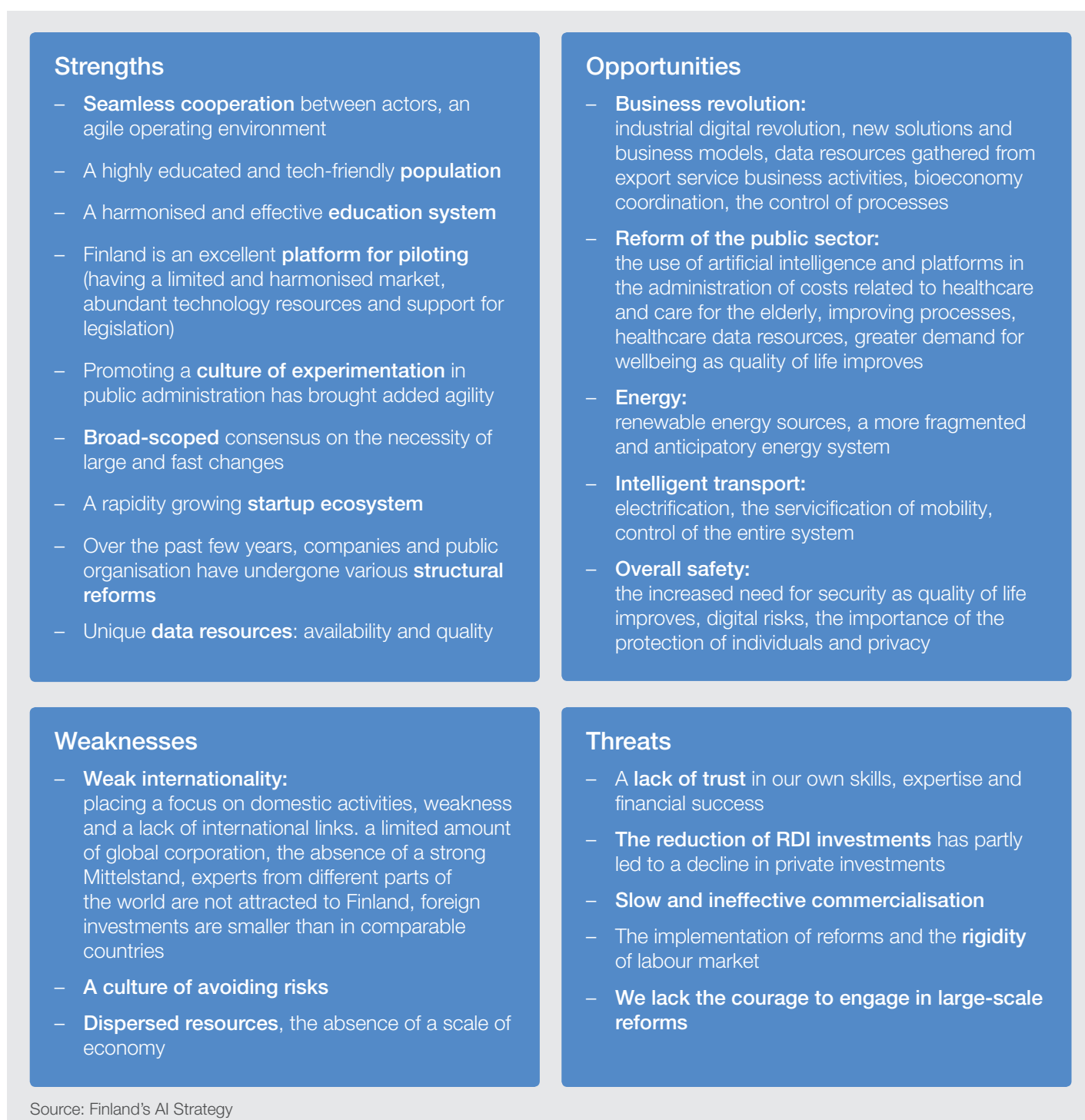
Indeed, carrying on with the same approach may bear a significant cost in terms of preventable harms, technologically ill-informed policies, missed opportunities, growing public concern and ultimately lower collective resilience. In this regard, multistakeholder theory, as propounded by World Economic Forum Founder and Executive Chairman Klaus Schwab, has never been so appropriate as it is in developing policy responses to use AI to its fullest potential for humanity. In practice, it implies that national governments must prepare themselves to skill their workforce, develop their research potential, maintain the competitiveness of their economy and ensure the ethical use of technology. A national strategy with long-term planning and a global outlook will steer the country in the right direction, not just to manage any concerns but also to make the fullest use of AI's potential.

How to design your AI national strategy

Any national AI strategy should start with an assessment of a country's strategic priorities, strengths and weaknesses. The deployment of a nation's limited resources to any strategic goal should be in line with what the country requires in terms of its demographic needs, strategic priorities, urgent concerns, the aspirations of its citizens, its resource constraints and geopolitical considerations.

From this perspective, Finland's AI strategy (see the report: "[Finland's Age of Artificial Intelligence](#)") is a distinguished example of such thoughtful self-assessment. It incorporates the SWOT (strengths, weaknesses, opportunities and threats) model analysis.

Figure 1: Country SWOT analysis



Assessing a nation's SWOTs regarding AI should make it possible to identify the central focus areas of its strategy:

Box 1: Parameters for analysis of national strengths/weaknesses for AI

	Strengths	Weaknesses
Workforce		
Digitization/ infrastructure		
Industry- academy collaboration		
Training capacity		
Regulation		

These parameters are not ranked in order of importance because it is up to each country to identify its priorities. However, it is essential to bear in mind that any digital environment requires a solid digital infrastructure – the large spectrum of networks, computers and storage capabilities required for the successful delivery of applications and services as well as the processing of data. Therefore, in any country where digital infrastructure is under-capacity, national efforts should focus on the creation of easily accessible and affordable digital infrastructure.

Box 2: Parameters for analysis of national opportunities/threats for AI

	Opportunities	Threats
Innovation ecosystem		
Industry adoption		
Public-sector adoption		
International collaboration		

Establish a set of objectives

A national AI strategy should be designed to serve a set of defined objectives. In line with national SWOT analysis, objectives of the national AI strategy should focus on specific targets in the following areas:

- **Target for capacity** – human resources and digital infrastructure
- **Target for investments** – research and development, grants
- **Target for adoption** – socioeconomic sectors, industrial sectors
- **Target for regulation** – enabling regulation such as privacy and ethical standards for the use of data

Key dimensions of a national AI strategy

Although no two national strategies are alike in most respects, a comprehensive study of various AI strategies helped in ascertaining the key dimensions of sound national AI strategy. The specific recommendations for achieving the national objectives (as formulated in the section above) will be different for each country based on its national priorities, but a national AI strategy without focus on the following areas would be an incomplete policy plan. The following elements form the backbone of a “minimum viable” strategy.

- **Key dimension 1: Providing a set of standardized data-protection laws and addressing ethical concerns**

Data is the fuel powering AI. Therefore, it is essential to establish a unified and sustainable regulatory environment of mutual trust between data subjects and organizations that clearly explains how data can be collected, stored, processed, shared and potentially deleted. In this domain, the EU’s General Data Protection Regulation (GDPR) has emerged in the wake of AI technology development and the need for individual data protection, along with its growing reliance on personal data.

Further, considering the growing influence of AI solutions on all aspects of our lives, we must ensure that their development supports human flourishing. Doing so requires tackling the ethical challenges (e.g. bias and discrimination; denial of individual autonomy, recourse and rights; unexplainable outcomes) associated with this emerging technology and actively promoting the responsible design and implementation of AI solutions through a robust regulatory framework. See the figure below on how China’s AI plan has delineated its regulatory vision.

Figure 2: China's regulatory roadmap for AI

(A) Develop laws and regulations and ethical norms that promote the development of AI.

Strengthen the research on legal, ethical and social issues related to AI, and establish laws, regulations and ethical frameworks to ensure the healthy development of AI. Carry out research on legal issues such as civil and criminal responsibility confirmation, privacy and property protection, information security utilization related to the application of AI. Establish a traceability and accountability system. Clarify the legalities of AI and related rights, obligations and responsibilities. Focus on automatic driving, service robots and other applications based on the better subdivision areas. Speed up the study and development of relevant safety management laws and regulations, lay the legal framework for the rapid application of new technology. Carry out AI in behavioural science, the study of ethics and other issues. Establish ethical and moral multi-level judgement structures and the ethical framework in human-computer collaboration. Develop a code of ethics for R&D designers of AI products. Strengthen assessments of potential hazards and benefits of AI, and build solutions for emergencies in complex situations. Actively participate in global governance of AI. Strengthen the study of major common international problems such as robot alienation and safety supervision. Deepen international cooperation in AI laws and regulations, international rules and so on, and jointly cope with global challenges.

France's "AI for Humanity" report also underlines the requirement of ethical AI development as a crucial part of its national efforts. Known as the Villani Report, it suggests establishing AI ethics committees to work along with sector committees.

Figure 3: AI ethics committee recommended by French AI strategy

Setting up an AI ethics committee

Our mission recommends the creation of a digital technology and AI ethics committee that is open to society. This body would be in charge of leading public discussion in a transparent way, and organized and governed by law. It should work alongside sector committees and combine short-term considerations, such as economic and industrial impacts, with the ability to take a step back and take the long view.

Recommendations from the committee, which would operate entirely independently, could help inform researchers', economic players', industry's and the State's technological decisions. Its recommendations could act as a benchmark for resolving ethical matters (e.g. on self-driving vehicles) and hence provide a standard for AI developments.

– Key dimension 2: Establishing a strong research environment and forging industry-academia integration

The AI technology research landscape is unique compared with other scientific research sectors, with enterprises and academic research potential being equally valued. The creation of and access to open data becomes a crucial infrastructure on which AI solutions development rides. Almost all of the countries we studied have focused on investing in research – basic research and applied research – through various modalities. Given the strategic focus and goals of the country, nations pursuing AI strategy should propose a way forward to create a domestic research environment that makes use of industry-academia collaboration. The focus should be on attracting the best talent for basic and applied research and examining how the existing incentive systems in research could be reformed for greater cross-sectoral integration in industry and governance.

Canada's AI strategy undertakes this effort through clearly spelled-out goals and a commitment to public investment aimed at developing Canada as a research hub for AI.

Figure 4: Canada's goals to strengthen AI research

CIFAR is leading the Government of Canada's \$125 million CIFAR Pan-Canadian Artificial Intelligence Strategy, working in partnership with three newly established AI institute – the Alberta Machine Intelligence Institutes (Amii) in Edmonton, Mila in Montreal and the Vector Institute in Toronto.

Announced in the 2017 federal budget, the Strategy has four major goals:

- To increase the number of outstanding artificial intelligence researchers and skilled graduates in Canada.
- To establish interconnected nodes of scientific excellence in Canada's three major centres for artificial intelligence in Edmonton, Montreal and Toronto.
- To develop global thought leadership on the economic, ethical, policy and legal implications of advances in artificial intelligence.
- To support a national research community on artificial intelligence.

– **Key dimension 3: Preparing the workforce for the AI economy**

Any national response to AI technology development must anticipate its potential impact on the current workforce, future-proofing the skills of the potential workforce and creating capacity and infrastructure for this shift. Apart from ascertaining the impact of AI and automation on job displacement, which is a huge exercise, the strategy should

understand the implications of potential job displacement and create provisions for and investments in skilling and reskilling the workforce accordingly.

Japan's national AI strategy undertakes this effort in a very detailed manner, and has projected estimates for "leading IT human resources" and training scales for national universities as a result.

Figure 5: Japan's projections for required AI talent

Future estimates for "leading IT human resources" (People)	2016	2018	2020
Scale of potential human resources (a + b)	112,090	143,450	177,200
Number of human resources lacking as of the current point in time (b)	15,190	31,500	47,810
Current number of human resources (a)	96,900	111,950	129,390

Source: Created by the secretariat based on Ministry of Economy, Trade and Industry "Results of Study of Recent Trends and Future Estimates Concerning IT Human Resources" (March 2016, commissioned to Mizuho Research & Information Institute) p.218, Figure 4-183; "Leading IT human resources" refers to human resources engaged in big data, IoT, and AI (ibid., pp. 84 and 218)

Figure 6: Japan's projection for training capacity required for AI

Example of provisional calculation of the annual training scale at universities (People)	Master's program (estimated) *2	Doctoral program (estimated) *3
Hokkaido University	54.5	9.0
Tohoku University	50.9	13.6
University of Tokyo	118.0	19.3
Tokyo Institute of Technology	116.0	23.0
Nagoya University	51.0	6.0
Kyoto University	81.7	20.5
Osaka University	90.6	19.1
Kyushu University	56.4	12.6
University of Tsukuba	98.4	16.9
Waseda University	83.0	9.0
Keio University	63.3	6.4
Total	863.8	155.4

* 1 Strategic Training Council for Technology study at human resources fostering TF. For Tsukuba and Waseda, the numbers represent the number of new students at FY2015, and for all other universities, the numbers represent the number of people completing the programs in FY2015.

*2 The number of human resources engaged in AI technology were calculated for the graduate schools/specializations related to AI technology at each university based on "Number of new students or graduates for the corresponding graduate schools/specializations" x "percentage of research laboratories conducting research related to AI technology within the corresponding graduate schools/specializations" (if the actual number of students affiliated with a research laboratory engaged in AI technology is known, calculations are made based on this actual number).

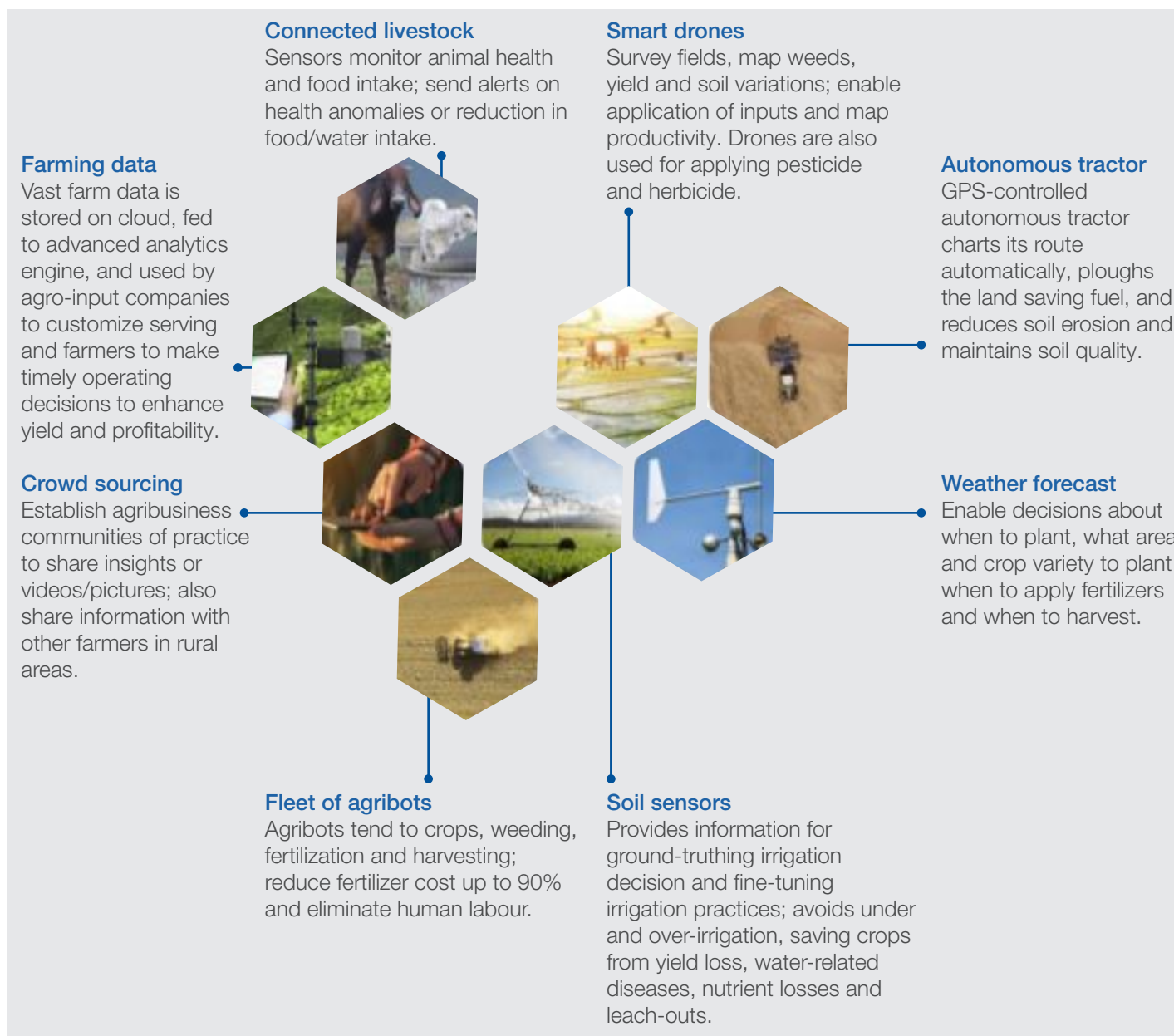
*3 The number of human resources in doctoral program s was also calculated using the same method as for those in master's programs.

– **Key dimension 4: Investing primarily in strategic sectors**

To succeed in the Fourth Industrial Revolution, nations must make the most of their economy’s comparative advantages and sectors of excellence. In practice, they should primarily design their AI ecosystems around their economy’s vital industries. In contrast, spreading small amounts of resources across every sector should be avoided as it will

certainly not provide the greatest return. This is especially true in emerging countries where public funding is more limited. Here, India’s national AI strategy is a good example of such a sectoral approach. It includes a detailed chapter on application areas and enablers. It has identified five sectors of social application and national priorities where AI can play a role in addressing national challenges. The following schematic shows how it is envisaged AI will be used to achieve goals in precision agriculture in India.

Figure 7: India’s AI strategy recommending use cases in agriculture



Denmark's national strategy for AI is another good example. It identifies four focus areas and four priority areas:

Figure 8: Denmark's AI strategy's focus and priority areas

Four focus areas

1. A responsible foundation for artificial intelligence
2. More and better data
3. Strong competences and new knowledge
4. Increasing investment

Priority areas

- Healthcare
- Energy and utilities
- Agriculture
- Transport

The Government of Denmark identifies four priority areas of the economy where public investment would be made to accelerate AI research and solution development and advance their adoption in the country.

- **Key dimension 5: Engaging in international collaboration**

Considering the pace, scope and global reach of AI technologies, it is an illusion to believe that any country could reap its full benefits by working in isolation. Open ecosystems are better suited for emerging technologies because they involve a set of expertise and capabilities, within academia and the industry, distributed across the world. Thus, it becomes imperative that nations develop a plan to draw on international collaboration. Nations should make efforts to collaborate and contribute, not just in technology development but also in global efforts towards regulation and governance. The German AI strategy has specific plans to use international cooperation in the development and regulation of AI.

“

Working with France, we will drive forward the development of a Franco-German research and development network (“virtual centre”) that is based on existing structures and the particular skills offered by each of the two countries.

”

Germany's AI strategy recommendation on collaborating with France

India's national strategy plans to develop an international alliance called “AlforAll Alliance”, which draws inspiration from the International Solar Alliance and CERN to syncretize global efforts towards building international collaboration on AI research and governance for social good.

“

To achieve #AlforAll, which gives the mandate for inclusive AI for the world, the Government of India should take the lead in bringing together the relevant parties to create People's AI, the CERN for AI. India has a proven track record for leading projects with ambitions of greater good. India is already playing a leading role in climate leadership, with Hon'ble Prime Minister Narendra Modi vowing to go “above and beyond” India's commitment on Paris Agreement on climate change. Similarly, India has been a pioneer in a sustained push for clean energy revolution by leading the International Solar Alliance, and setting an ambitious target of 100GW of installed solar energy capacity by 2022. With 20GW of installed solar capacity, India is well and truly on its way to achieving this target. With the Government of India's focus on inclusive growth which saw several transformational reforms in the last few years, India is poised and most suited to wear the mantle of leading the #AlforAll movement. Furthermore, India offers the best possible test bed and a plethora of use cases for building AI solutions fulfilling the inclusive AI criteria, be it in healthcare, education or agriculture.

”

India's recommendation to create an international alliance on AI

Determine the implementation plan

Any national strategy will be ineffective if it does not include an implementation plan and a responsibility allocation for all of the stakeholders involved. The technological force that will have a multisector impact will need to be steered and guided in the country's desired strategic direction; this should be done through assigning specific responsibilities to all of the stakeholders – ministries, legislature, enterprises, academia and ecosystem players.

Countries should develop a responsibility matrix for all stakeholders and map how it relates to the goals and objectives set up for the national strategy. The implementation plan should include the following components:

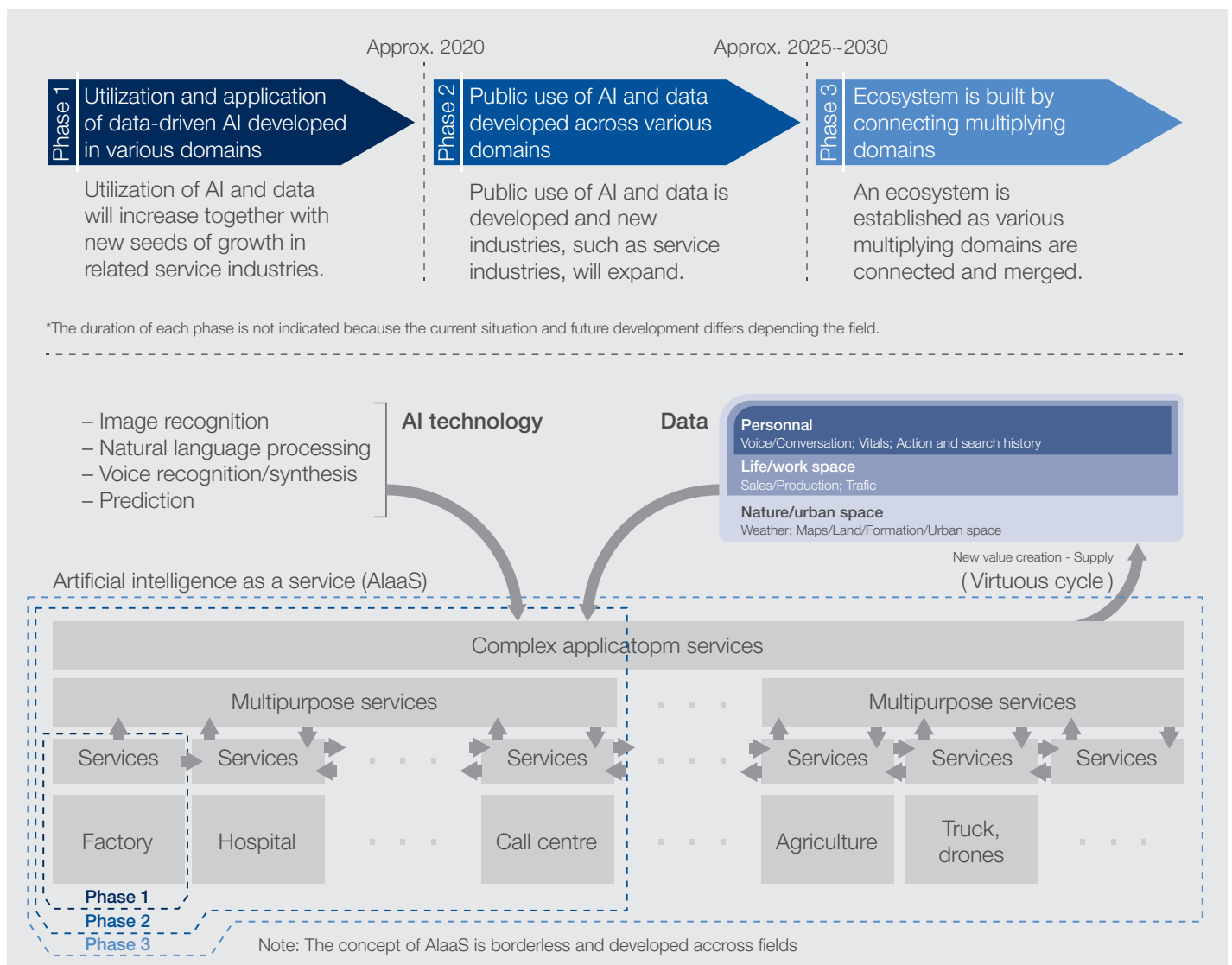
- Phases and milestones
- Timelines
- Role of all stakeholders

- Government: ministries, legislature
- Independent organizations: standard-setting organizations, industry organizations
- Private-sector enterprises: industry leaders, start-ups
- Academia: universities, schools and colleges, research institutions

- **Budget allocation: by the government on public-sector initiatives and fiscal incentives to the private sector**
- **Administrative structure for implementation of the strategy**

For instance, Japan's national strategy endeavours to project how the technology strategy roadmap will develop across three phases:

Figure 9: Japan's three-phase development of AI strategy



An appropriate administrative structure is required for the implementation of the national strategy. It must be stressed that the administrative structure should be designed for better implementation and not strategy formulation. Given the multidisciplinary nature of the strategy, an agency that has coordinating capabilities with multiple arms of the government, private-sector enterprises and academia will be an effective agency type for implementation of the strategy.

For instance, AI Singapore has been constituted in Singapore for AI strategy implementation. Hosted by a national university, it coordinates with all of the crucial agencies and stakeholders to develop national capacity in AI.

Figure 10: AI Singapore administrative structure

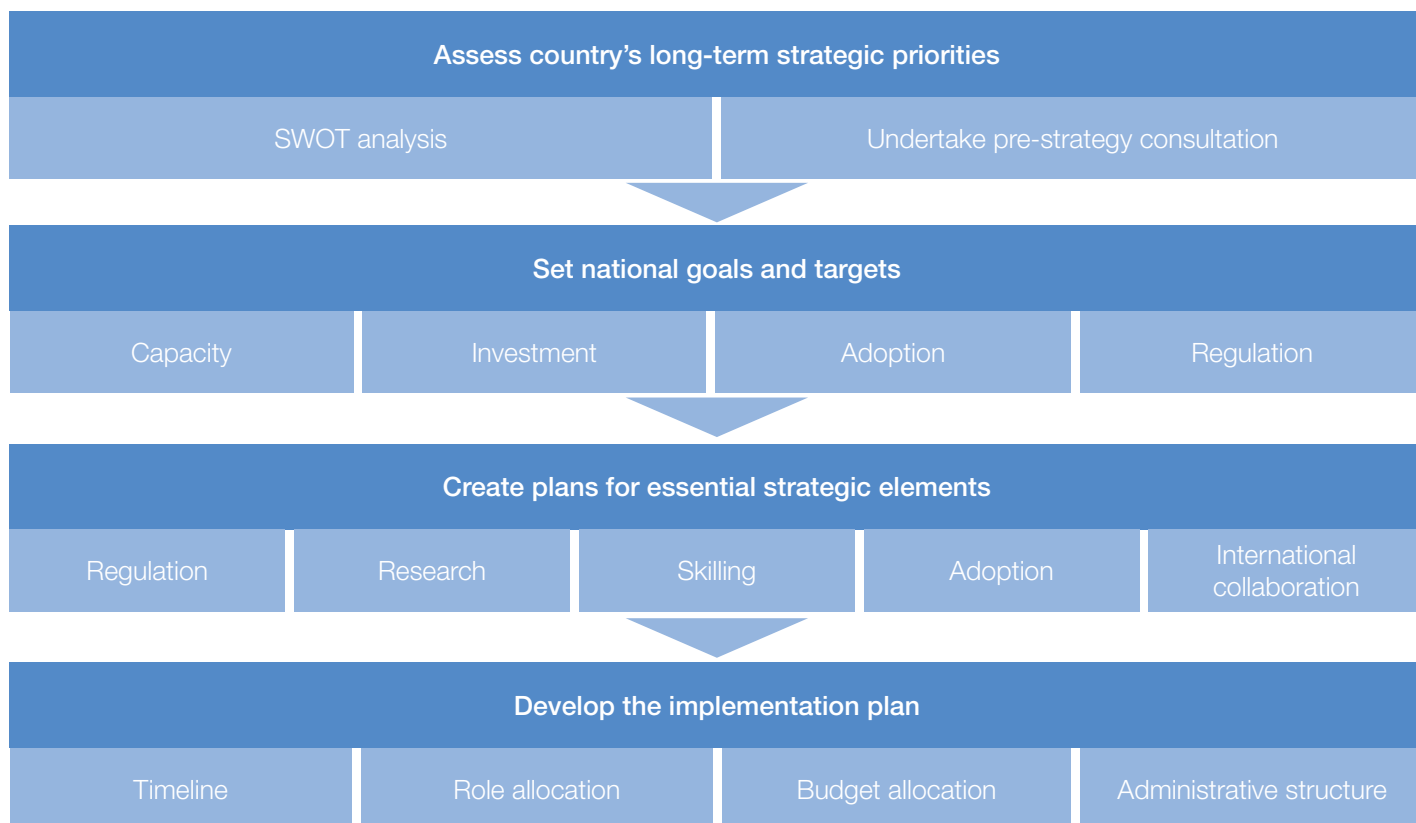
AI Singapore (AISG) is a national AI programme launched by the National Research Foundation (NRF) to anchor deep national capabilities in artificial intelligence (AI) thereby creating social and economic impacts, grow the local talent, build an AI ecosystem, and put Singapore on the world map.

The programme office is hosted by the National University of Singapore (NUS) and brings together all Singapore-based research institutions and the vibrant ecosystem of AI start-ups and companies developing AI products to perform use-inspired research, grow the knowledge, create the tools, and develop the talent to power Singapore's AI efforts.

AISG is driven by a government-wide partnership comprising NRF, the Smart Nation and Digital Government Office (SNDGO), the Economic Development Board (EDB), the Infocomm Media Development Authority (IMDA), SGInnovate, and the Integrated Health Information Systems (IHIS).

The National AI Strategy Framework in action

Summarizing the above essential elements for a national AI strategy and the process to be followed, we have developed the following step-by-step framework. Country teams engaged in developing a national strategy for AI can use the following framework to ensure the fundamental building blocks of an AI strategy are designed for the country.



Conclusion

The Fourth Industrial Revolution and the artificial intelligence at its core are fundamentally changing the way we live, work and interact as citizens. The complexity of this transformation may look overwhelming and to many threatening. We should remember that all technologies are social constructs shaped by our individual and collective choices. Indeed, AI technologies have no other objectives than the ones that we assigned them. Yet our failure to proactively shape their development may lead to unfortunate outcomes. Therefore, this is the time not for regrets but for decisive action to forge a positive way forward. We must engage in a multistakeholder collaboration to actively guide the ongoing revolution and ensure benefits for the many rather than the few. Careful planning is the most effective way to ensure positive outcomes. From this perspective, we strongly encourage nations around the world to design their own national AI strategies, not to win the global AI race but as an expression of their duty to protect and provide for their citizens in this time of technological change. To this end, we have prepared a short framework for designing a national AI strategy, building on the insights of those already released to help those who have not yet done it. Through the World Economic Forum's Centre for the Fourth Industrial Revolution, we will support volunteer governments in the design of their strategy. Thus, this framework will be tested on the ground and key learnings will be disseminated publicly.

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