THE NATIONAL INITIATIVE FOR SECURED INTELLIGENT SYSTEMS

TO EMPOWER THE NATIONAL SECURITY AND THE TECHNO-SCIENTIFIC RESILIENCE:

A NATIONAL STRATEGY FOR ISRAEL

Special Report to the Prime Minister

PART I: Executive Summary & Recommendations

Initiative Co-Chairs: Prof. Isaac Ben-Israel | Prof. Eviatar Matania
Initiative Coordinator: Leehe Friedman

September 2020

The National Initiative for Secured Intelligent Systems to Empower the National Security and Techno-Scientific Resilience: A National Strategy for Israel

Special Report to the Prime Minister

Part I: Executive Summary and Recommendations

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12 Elul 5780

To: The Prime Minister (through the National Security Adviser and the Head of the National Security Council)

Re: The National Initiative for Secured Intelligent Systems
A National Strategy for Israel in the Field of Artificial Intelligence

Following a brainstorming session led by you, on February 20, 2018, coordinated by the National Security Council (NSC) and the signatories to this letter, and with the participation of several opinion leaders from universities in the country, as well as other relevant parties, we were approached by you to lead a national initiative in the field of secured intelligent systems. This is in order to formulate and recommend a strategic national plan to strengthen national security and the scientific and technological resilience of Israel. The goal is to place Israel in the top five countries in the world in the core areas of artificial intelligence, which are critical to Israel's security, are appropriate to its size and capabilities, and where it is possible for Israel to become a world leader. This was stated, as follows, in the summary of the work meeting between the PM and the head of the NSC, on May 3, 2018:

The vision:

To strengthen Israel's resilience as a techno-scientific power in relation to national security (defense, economic, and social) whilst also securing the future and the national resilience of the State of Israel as a safe, open, democratic, and knowledge-based society.

The objective:

To place Israel in the top five countries in the world in the core technological areas, which serve this vision, within five years.

The initiative was launched in July 2018, after we recruited a leading team that included the best people from government (including the defense forces), academia and industry. Hundreds of experts from all over Israeli ecosystem quickly volunteered to join the initiative, representing many different points of view and interests, in order to structure a comprehensive national plan, as requested. The volunteers were divided into 14 sub-teams, as well as an integration forum, and worked tirelessly to get to know the current situation, understand its shortcomings, analyze the strengths and weaknesses, and recommend an overall strategy. In this sense, the report presented below is a product of the wisdom of many experts, all of whom we whole-heartedly thank for their insights and the effort they invested in this work.

With the help of a small team, we have gathered, from the myriad of insights, the main conclusions and strategy which, to our understanding, will lead the State of Israel to realize the defined vision and the objectives set before us. The strategy proposed in this paper[1] builds on all the insights generated from all the teams during this piece of work, but naturally summarizes and emphasizes one coherent picture, which is our sole responsibility.

The main insight that emerges from this is that the field of artificial intelligence and the technologies involved therein are an **infrastructure of infrastructures**. This is an infrastructure that is critical to the future of the State of Israel – to its security, technological resilience, economy, and the well-being of its population.

The ability to position the State of Israel as a world leader in the field and to take full advantage of it can only be achieved, and we emphasize – only, if the Israeli government defines it as a major and critical area for the future of the country, budgets it as such, with an understanding that its future is based on it, and establishes a dedicated administration that will lead and integrate the national strategic plan.

To this end, 5 national goals must be achieved (see details below on pp. 22-26):

1. **National priority**

   Declaring that the issue of intelligent systems and artificial intelligence constitute a critical infrastructure for the future of the country and a field of national priority.

2. **National plan**

   Establishment of a national plan to create a complete and sustainable ecosystem for intelligent systems (full details below, pp. 27-46), based on 3 axes:

   - **Critical infrastructure axis** as a necessary basis for strength building (physical, human, research and data accessibility infrastructure);
   - **Enabling conditions axis** (Cyber security and balanced regulation that will enable economic growth whilst maintaining privacy and civil rights);
   - **National capacity building axis** (National projects in the fields of health, transportation, agriculture, digitization, the introduction of artificial intelligence tools in government services, and the encouragement of industry alongside national security projects, especially in relation to the handling of emergencies).

3. **Budgeting the plan**

   In order to implement the proposed plan, the Israeli government has to allocate a budget of NIS 10 billion between the years 2021-2025 (5 years).

4. **Directing the plan**

   Establishment of a national administration dedicated to managing the national initiative for secured intelligent systems in the Prime Minister's Office.

5. **Advisory committee**

   Establishment of a 5-member non-governmental advisory committee to the Prime Minister.

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1 Part I below, which includes the summary and recommendations, was prepared and written by the signatories below and by Ms. Leehe Friedman, the initiative coordinator. The sub-team reports, which are presented in Part II, were written by the heads and members of the sub-teams and were integrated into this document by the initiative coordinator.

The publication of this report was delayed due to the lengthy election campaign (during which the government could not allocate budgets for new issues), and because of Coronavirus crisis. We believe that the global economic slowdown, in the wake of the Coronavirus crisis, could actually become, through artificial intelligence, a springboard and an opportunity.

We believe that a strategic investment in artificial intelligence, digitization, and cyber infrastructure, as proposed below, could not only help Israel in overcoming this crisis, but also turn it into a springboard for building a world-leading power for the benefit of security, the economy, and improving life in the country.

Note: Shortly after we were asked by the Prime Minister to head the project, the National Infrastructure Forum for Research and Development (TELEM) also decided to establish a committee to promote quantum technologies in Israel. In order to avoid doing the same work twice, we decided that the leader of the sub-team who examines the issue of computing infrastructure (including quantum computing) in our initiative will also serve as the chairperson of the TELEM committee. The sub-team for computer infrastructure completed its work and submitted its recommendations, which were approved by the TELEM forum even before the publication of our report. Later, TELEM expanded the scope of their work and included additional infrastructure. It should be emphasized here that we accept most of these recommendations. However, it must be remembered that TELEM deals with national research infrastructures, which form only one facet of the complex required to build the capacity and achieve the objectives set before us, and that we must not fall into the trap and regard the TELEM report as encompassing the entire scope.

We are convinced that if you and the government adopt the recommendations of this initiative, over the next five years and into the next decade, the State of Israel will leap to the forefront among the world countries in every security, economic and technological parameter.

Sincerely,

With many thanks to all the people who contributed to this initiative (their names are mentioned in detail in Part II),

And with profound gratitude for the privilege we have been given to head this initiative,

Prof. Isaac Ben-Israel **Prof. Eviatar Matania**

Copies:

Ministers:

Minister of Defense, Minister of Finance, Minister of the Economy, Minister of Health, Minister of Transportation, Minister of Agriculture, Minister of Science, Minister of Education, Minister of Higher Education, Minister of Cyber and National Digital Matters, Minister of Public Security, Minister of Justice;

Director Generals of a Government Ministries:

Acting Director General of the Prime Minister's Office, Director General of the Ministry of Defense, Acting Director General of the Ministry of Finance, Director General of the Ministry of the Economy, Director General of the Ministry of Health, Director General of the Ministry of Transportation, Director General of the Ministry of Agriculture, Director General of the Ministry of Science, Director General of the Ministry of Education, Director General of the Ministry of Higher Education, Director General of the Ministry of Cyber and National Digital Matters, Director General of the Ministry of Public Security, Director General of the Ministry of Justice;

Cabinet Secretary;

The Defense Forces:

Head of the National Security Council;

Director of the Mossad, Director of the Israel Security Agency, Director of the Israel National Cyber Directorate;

IDF: Chief of the General Staff, Deputy Chief of the General Staff, Head of the C4I and Cyber Defense Directorate, Head of the Military Intelligence Directorate, Head of the Planning Directorate;

The Military Secretary to the Prime Minister, the Military Secretary to the Defense Minister;

The Ministry of Defense: Head of the Administration for the Development of Weapons and Technological Infrastructure;

Israel Police: Acting General Commissioner;

Government units and offices:

Head of the National Council for Civilian Research and Development, Head of the Planning and Budgeting Committee, Chairman of the Israel Innovation Authority, CEO of the Israel Innovation Authority, Acting Head of the Budget Department, Deputy Attorney General for International Law, Deputy Attorney General for Civil Law Matters, Legal Advisor to the Prime Minister, Acting Head of the Privacy Protection Authority, Acting Chief of Staff of the National Digital Israel Initiative, Acting Head of the Government ICT Authority;

Academia:

President of the Israel Academy of Sciences and Humanities;

Tel Aviv University: President, Rector, Chairman of the Board of Directors;

Technion: President, Rector, Chairman of the Board of Directors;

The Hebrew University of Jerusalem: President, Rector, Chairman of the Board of Directors;

Ben Gurion University of the Negev: President, Rector, Chairman of the Board of Directors;

University of Haifa: President, Rector, Chairman of the Board of Directors;

Bar Ilan University: President, Rector, Chairman of the Board of Directors;

Weizmann Institute of Science: President, Rector, Chairman of the Board of Directors;

Ariel University: President, Rector, Chairman of the Board of Directors.

Table of Contents

I. Introduction

One of the pillars of the national security of the State of Israel is its **techno-scientific** leadership to be at the forefront of global knowledge in critical areas. Already at the time of the establishment of the state, its founders realized that we have no way of overcoming the **quantitative** gap between Israel and its enemies in relation to resources and manpower but through **quality**, whose practical expression is the **quality of the human factor and the quality of our scientific and technological capabilities**.

Cultivating the quality factor is essential both for our security capabilities to deal with a hostile environment, and for the creation of economic prosperity, which relies on technological innovation and ingenuity to be at the forefront of global knowledge, which in turn leads to a higher value-added national product. Such prosperity directly contributes to the quality of life, and to the increase in resources that the state can devote to social advancement, economic growth and security needs.

Some technological fields are crucial for security and also constitute a growth engine for knowledge-intensive industries at the same time. Therefore, a double rationale is created for promotion of these fields, and even more – a positive feedback loop: academia creates new knowledge, industry relies on this knowledge and develops advanced capabilities with high added-value in accordance with market needs and global demand, the defense system benefits from the knowledge and the new capabilities, and in turn contributes excellent personnel, as well as unique needs and understanding that nourish academia and industry, and so on. Through the transition of talented people from the defense system to industry and academia, an interrelated system is created, an **eco-system** in which knowledge passes between these three systems (security and government, industry, and academia).

The idea described above is not new. The State of Israel has undergone a similar revolution in the late 1980s and the early 1990s in the field of information and communication technologies (ICT). To this day, the main engine for economic growth in Israel has been high tech. A second revolution took place only a few years ago, when the Israeli government decided to build a leading national strength in the field of cyber security. This field was chosen for the following reasons: firstly, it enables the best response to emerging threats in this domain; and secondly, it has transformed Israel into one of the global knowledge centers in the field, enabling us to be one of the major players in the global market, which is reflected in greater economic prosperity.

The cyber revolution was carried out through addressing the **overall ecosystem – academia and education systems, industry, government, and security.** The main rationale of the plan was precisely that dual combination of security needs and economic opportunity in the broadest sense, which together creates a positive feedback loop. The combination of the creation of an academic-industrial-government center of excellence in cyber, whilst leveraging the economic opportunity, has led to Israel becoming a global cyber powerhouse. For example, in 2019, Israel's exports of cyber products and services accounted for about 5%-10% of the global market, and perhaps more importantly – close to 20% of all global investment in cyber business R&D was invested in Israel.

II. The Next Step: Intelligent Systems

It is well known that the pace of technological invention and innovation is increasing and unprecedented. This means that we are not allowed to rest on our laurels and enjoy the fruits of the effort of the high-tech and cyber revolutions without preparing ourselves for the technological revolutions that are at the gate and figure out our next steps. We are therefore faced with a difficult question: **what is** the **techno-scientific issue that needs to be focused on today, at the national level, in order to achieve the dual goals of security and economic growth (including feedback between the two) and to put Israel once again at the forefront of global knowledge in the chosen field?**

We face this question not only in terms of viability, but also as a vital necessity for our security, techno-scientific and economic futures alike. The right choice of field requires understanding the directions of global technological-scientific development on the one hand, and the needs, benefits and limitations of the State of Israel on the other hand.

The development of computers in the last fifty years and their penetration into all areas of our lives has led to **computer technology becoming the dominant technology in our lives**. In the first stage – a stage that can be called "**the computer as a platform**" – these technologies introduced computational and management capabilities that we did not possess before, and entered all organizations, first as systems and then as networks. The second stage, in which we currently live, is the "**cyber**" stage: the almost-total connectivity of computer and communication networks, the Internet connection that connects almost every corner and every person in the world (thanks to end-devices such as the smartphone), processing speeds that allows a huge flow of information volumes, lowered costs of computing and memory components, and the ability to store and process unimaginable quantities of information; all of these have led to a change in the world of industry, the economy, the fabric of life, and this includes new threats (cyber threats). These factors affect our entire lives as individuals, as a society, and as a country.

The third stage of the computing revolution, towards which we are rapidly advancing, is a combination of many scientific and engineering achievements over the last four to five years, which has brought computer technology to a stage where computer systems can generate new knowledge and function independently and "intelligently". For convenience, we will refer to this stage as "**intelligent systems**".

The techno-scientific basis on which this stage is based is twofold: the extraordinary advances in **Artificial Intelligence (AI)**, especially in the field of **Deep Learning**, together with **unprecedentedly advances in computing, communication and processing capabilities, including quantum technologies**.

Under the title of "Intelligent Systems", the current initiative refers to a number of advanced technologies, which define and shape the economic and security rules of the game in this information age, most of which are related to the field of artificial intelligence. The core technologies will be described and analyzed below. However, this requires a **clarification of terminology.** The concept of **artificial intelligence** has become a commonplace expression for many who attribute it with a variety of meanings, most of which can be roughly classified into one of two approaches. According to one approach, artificial intelligence describes all technological operations for extracting information and generating insights from databases. According to this approach, which is associated with the field of data science, those who hold the more of the highest quality information shall have the greatest advantage. The second approach is identified with the field of machine learning, and it argues that artificial intelligence is the capability of a machine to learn how to perform an action and to improve its performance based on data, examples, and accumulated experience. Algorithms programmed for self-learning and self-improvement allow the machine, which is fed with examples and data on how to perform an action, to discover consistency and to formulate a manner in which it will act if it is required to do so. This approach also argues that the data is essential, but the advantage will be in the hands of those who manage to produce better algorithms for faster and more accurate learning. The national initiative

and this report see these approaches as complementary to one another, and therefore, wherever the concept of artificial intelligence appears in this report and its appendices, it refers both to the issue of extracting information and to machine learning, unless stated otherwise.

The global race for technological superiority in the information age is conducted both in the field of machine learning and in tangential fields, such as data infrastructures and computing power required for the development and use of artificial intelligence systems. The current initiative examined several technologies that have been identified as the most relevant to the global race and to Israel in particular: machine learning (ML) and data science (DS), IoT and sensors[2], robotics and autonomous systems, distributed intelligence[3], computing power and quantum computing[4]. Applications of these basic fields of science, along with a number of other selected technologies, have far-reaching and broad implications in most areas of our lives, including security, medicine, transportation, automation, retail, sales, customer service, and virtually every field relevant to modern life. The various learning algorithms, along with the huge increase in computing power, are already beginning to penetrate all areas of our lives, and their understanding requires mastery, not only of the "natural" technological disciplines – such as computer science, mathematics and engineering – but also of social, legal, business, and even philosophical aspects.

Warning note: Increasing the applications of artificial intelligence in all sectors of the economy has not only advantages, but it may also entail an increase in risks. As we increase the use of computers, we create a weak point by increasing our dependence on the proper operation of these computers. For this reason, cyber security is taking up more and more space in recent years. Massive entry into the field of intelligent systems will further intensify this phenomenon, not only due to our increasing reliance on computers, but also because some artificial intelligence technologies are consciously built on self-altering algorithms, thus we lose (consciously) some of our control over machines. Malevolent factors can exploit this fact to aid, not the original purpose (optimizing and improving our lives), but their own interests – ranging from criminal activity, through ideological groups to terrorists, and hostile countries. Therefore, the **security of the intelligent systems** must be considered in advance, which is why we set up a special sub-team to deal with the issue and named this initiative '**Secured Intelligent Systems'**.

To examine the issue, on February 20, 2018, the Prime Minister convened a brainstorming session, coordinated by the National Security Council (NSC) and the signatories to this document, with the participation of several opinion leaders from universities in Israel, involved in advanced technological fields, and relevant government officials. The discussion revolved around the most critical core technological fields for the coming decades, which are the core infrastructure for technological progress in many sectors. These fields constitute an essential infrastructure for security, the economy and society in Israel. Furthermore, Israel already has a foundation in these fields, which allows it to reach the forefront of knowledge. At the conclusion stage, the Prime Minister asked the undersigned – Prof. Isaac Ben-Israel and Prof. Eviatar Matania – to submit a proposal for a national initiative in the field of intelligent systems.

We then delivered to the Prime Minister a concluding document focusing on the topic of intelligent systems and artificial intelligence technologies. Based on this paper, the Prime Minister decided to establish the National Initiative for Intelligent Systems, and appealed to the undersigned to head it (summary of the work meeting between the PM and the Head of the NSC, on May 3, 2018). This was done to formulate and recommend to the Prime Minister and to the government a national strategic plan that will place the State of Israel at the forefront of the global stage in the field of intelligent systems, with an aim to strengthen Israel's national security and techno-scientific resilience, and realize the following vision and objective:

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2 IoT is the Internet of Things, meaning a communication system between different sensors ("things"). Connecting a learning machine to other sensors using IoT could greatly improve the applications of artificial intelligence.

3 This refers to the typical intelligence of bee swarms or flocks of birds or schools of fish in which, although each individual behaves according to the local data, the entire group behaves "intelligently" without a central brain.

4 The main ideas of artificial intelligence were created at the early 1950s. The tremendous developments in recent years is mainly due to a vast increase in computing power, which is reflected in supercomputers, graphics accelerators, and more recently in computers based on the principles of quantum theory.

<u>The vision</u>:

To strengthen Israel's resilience as a techno-scientific power in relation to national security (defense, economic, and social) whilst also securing the future and the national resilience of the State of Israel as a safe, open, democratic, and knowledge-based society.

<u>The objective</u>:

To place Israel in the top five countries in the world in the core technological areas, which serve this vision, within five years.

III. The Initiative

The initiative was launched in July 2018, and soon thereafter it was joined by hundreds of experts from all over the Israeli economy who represented different points of view and interests – from academia, industry, the defense forces and government, all willingly volunteering in order to structure a comprehensive national plan as requested. The volunteers worked tirelessly to learn the current situation, understand the shortcomings therein, analyze the strengths and weaknesses, and recommend an overall strategy.

Since Israel cannot build capabilities in all areas and compete in all markets due to its size and limited resources, it must plan its steps in advance and formulate a national plan that will be applicable and appropriate to its unique characteristics. Accordingly, the plan of the initiative presented here was formulated in view of three key questions:

1. Which capabilities and technologies are critical to ensuring Israel's national security and its continued existence as a high-tech power?

2. In which fields and technologies does Israel have a relative advantage that will allow it to be a global leader and to reap the economic and social fruits of such leadership?

3. Which leading national plan will make it possible to bring about the revolution required in Israel for the realization of the above vision and objective?

In order to answer these questions and formulate recommendations that will enable the realization of this vision, 14 professional sub-teams were established, divided into three axes, and coordinated by an integration forum that also included all the sub-team leaders:

1. The Technology Axis

In a preliminary study for the initiative, a number of technologies[5] from the worlds of artificial intelligence and tangential fields were identified as relevant: AI, machine learning (ML) and data science (DS), IoT and sensors, robotics and autonomous systems, distributed intelligence, computing power (including quantum computing[6]).

The initiative addresses all of these technologies under the title of "Intelligent Systems". A dedicated examination sub-team was established for each of them.

2. The Applications Axis

In this axis, five main sectors were selected in which great improvement can be brought about through the use of artificial intelligence technologies: (1) healthcare and medicine; (2) transportation; (3) security; (4) the financial sector; and (5) the agriculture[7] sector.

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5 For a detailed explanation of each technology see Appendix A – The Definition of Intelligent Systems.

6 Shortly after we were asked by the Prime Minister to head the initiative, the National Infrastructure Forum for Research and Development (TELEM) also decided to establish a committee to promote quantum technologies in Israel. In order to avoid doing the same work twice, we decided that the leader of the sub-team who examines the issue of computing infrastructure (including quantum computing) in our initiative will also serve as the chairperson of the TELEM committee. The sub-team completed its work and submitted its recommendations, which were approved by the TELEM forum even before the publication of our report. It should be emphasized here that we find all of these recommendations acceptable in their original formulation. Therefore, in this report we have addressed only the additions required beyond the recommendations approved by TELEM.

7 This sector was not included in the original plan and was added to the initiative as the work progressed.

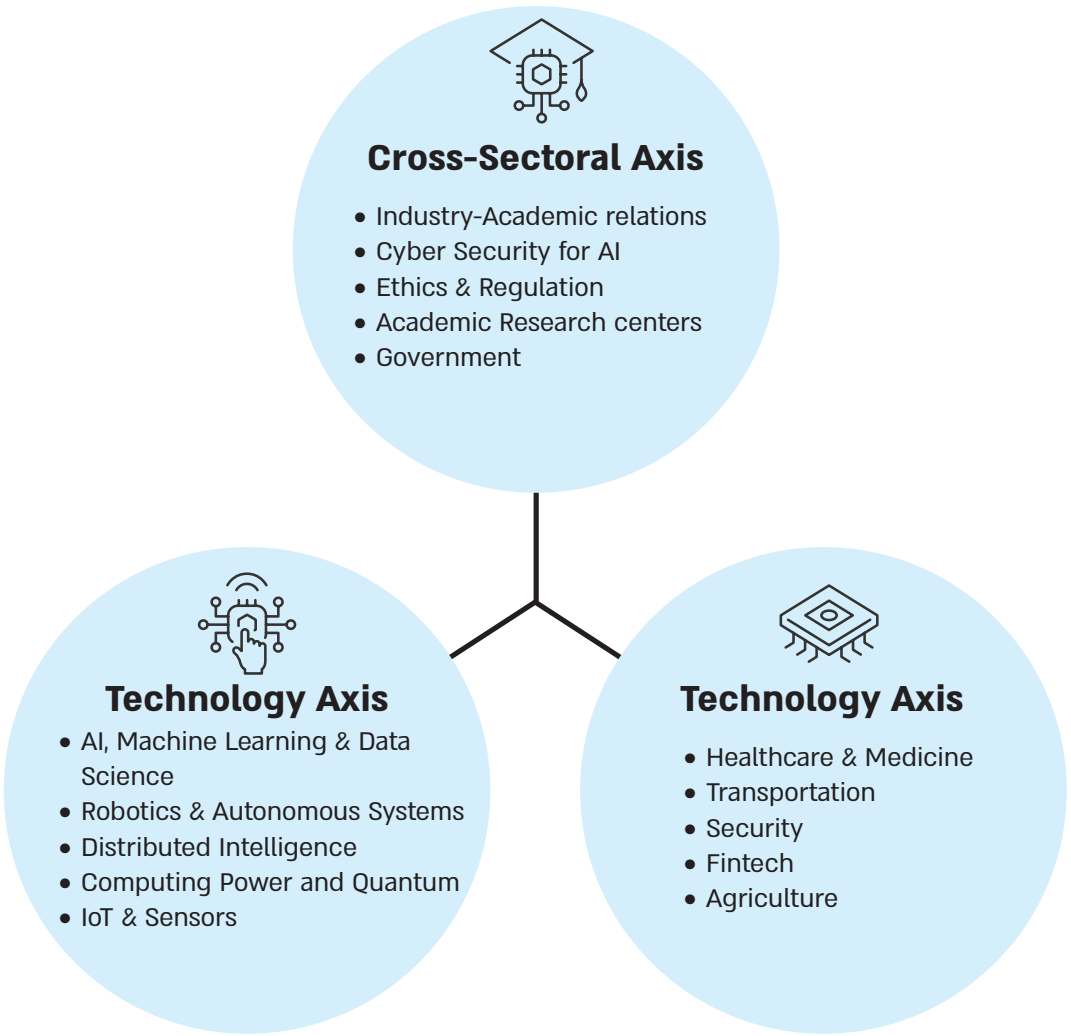
For each sector, a sub-team headed by an expert in the field was established and examined the feasibility of a flagship project that will meet the following criteria: (1) Creating a rapid and significant improvement in the sector in question; (2) Demonstrating to both the public and decision-makers that the field of intelligent systems is not "futuristic" technology but rather technology that can already be applied in the present; (3) Demonstrating the inherent capability of artificial intelligence applications through a "technological locomotive" that will drive the formation of the required national ecosystem; (4) Creation of unique intellectual property (IP) for the benefit of the economy.

3. **The Cross-Sectoral Axis**

   In this context, cross-sectoral issues necessary for the success of the previous two axes were discussed, such as education and training of personnel, university research, budgets, organization of government ministries, ethics, regulation, and mechanisms to increase cooperation between academia and industry.

The sub-teams mapped the current situation in Israel and in the world today and identified gaps, as well as potentials and advantages over the world's leading players in the field of intelligent systems. Each sub-team submitted a detailed report with its findings and recommendations, and all of the reports are presented in Part II as appendices to this report.

Over time, the sub-teams described in the following illustration were established:



The report and its recommendations are the product of the wisdom of many experts from the joint work for over a year of hundreds of leaders from all sectors and areas of the economy. We are grateful to all those involved in this task, who agreed to participate in the initiative on a voluntary basis, and especially to the sub-team leaders and members of the integration forum (see Part II for the full list of participants). It should be emphasized that the product does not express the official positions of the organizations or companies that employ the participants in the initiative. Furthermore, many different opinions were voiced on various issues as part of the initiative, and naturally not all of them could be included here. The report aims to reflect the positions on which there was a broad consensus, and where disagreement arose, to provide as comprehensive and complete a view as possible, and to conclude with the recommendations that were found to be the most convincing. Accordingly, we consider it appropriate to emphasize that the responsibility for the final conclusions rests solely with the undersigned.

Before we move on to the analysis of the findings, insights and recommendations, it is important to note that the very initiation of this initiative and its work has already contributed to advance this issue in Israel, even before the plan was officially approved by the government. Thus, for example, more and more start-up companies have been created in the last two years in the fields of artificial intelligence, and even government entities, which 'dragged' their feet prior to this initiative, have initiated activities in the field during this period. Experts who participated in the various teams have sharpened their knowledge and focused their efforts in relevant directions that emerged.

Various foreign entities, governments and global companies alike, also knocked on our doors from time to time in order to understand what the State of Israel is planning on the subject, out of the assumption that the plan formulated and adopted by the government will propel Israel to a respectable place in the forefront of the world in the field of intelligent systems[8]. The interest shown by the various organizations stemmed from a combination of several factors. Firstly, a desire to get to know and learn from the overall Israeli approach to the subject, since Israel has already proven several times, especially in the cyber field, that it has succeeded in formulating a comprehensive national method for advancing significant technological areas. In addition, we have witnessed an interest in creating collaborations with Israel in the field, from the search for joint projects between government and industry, to investments and research collaborations.

In this context, we identify the issue of intelligent systems as one of the main and important areas for Israel in building international collaborations – governmental, academic and industry alike, as well as an area that will significantly contribute to its soft power in the international system.

8 For example, in January 2019, the Danish Innovation Center in Israel published a comprehensive report on the state of artificial intelligence in Israel and the expected directions of development, with reference to the national initiative, in order to identify lessons for Denmark. See THE STATE OF ARTIFICIAL INTELLIGENCE IN ISRAEL, Innovation Centre Denmark in-depth report by Samuel Scheer, 2019.

IV. Analysis of the Situation in Israel and the Rest of the World

The Situation in the Rest of the World

Since 2017, over 30 countries have published national strategies or national plans in the field of artificial intelligence, as well as national investments that reach as high as billions of dollars. Some countries have even published additions or updated editions (see Appendix C – State Strategies and Investments in AI around the World). While different countries emphasize different aspects and uses of the technology, consensus stands out globally the importance of artificial intelligence as an infrastructural technology which will affect all areas of life, and form the basis for most future technologies. To emphasize the revolutionary potential of artificial intelligence, as well as its basis for future progress, Finland and other countries compare it to electricity technology[9].

Therefore, it is already possible to clearly identify an **economic and security arms race to achieve superiority in artificial intelligence**[10]. Russian President Vladimir Putin's statement that "whoever rules this sphere [artificial intelligence] will be the ruler of the world"[11] reflects this well, as does the investment in the field by the Russian government, estimated at about 3.4 billion USD[12]. China's national strategic plan is also based on the recognition that the rapid development of artificial intelligence will significantly change society and the world. China plans government investment estimated at tens of billions of dollars in the development and assimilation of technologies aimed to meet its national objective – to make China a global leader in the field of artificial intelligence by 2030 with an AI-based industry of 150 billion USD [13]. Thus, China leads the government investment race by a significant margin. In the US, President Trump worked to promote artificial intelligence as an area of national priority. In early 2019 he launched the US Initiative for Artificial Intelligence by an executive order, and in the 2021 budget he pledged to double by 2022 the resources allocated to research and development in the field. "In a time of great power competition, President Trump's FY 2021 Budget puts America in position to maintain its global leadership in science and technology for generations to come"[14]. European countries have also been preparing for the race at the national level, such as France – who plan to invest EUR 1.5 billion over 5 years, or Germany – who have allocated EUR 3 billion by 2025[15]. They are also preparing at a higher regional level, like the EU which has already allocated EUR 1.5 billion to the field of artificial intelligence as part of the research and innovation program, Horizon 2020 (in addition to the investment of the member

9 AI Finland: "Artificial intelligence is the new electricity", https://www.tekoalyaika.fi/en

10 Pecotic, A. (March 5, 2019) Whoever predicts the future correctly will win the ai arms race. *Foreign Policy*. https://foreignpolicy.com/2019/03/05/whoever-predicts-the-future-correctly-will-win-the-ai-arms-race-russia-china-united-states-artificial-intelligence-defense

11 Kahan, R. (March 3, 2017) "Putin: The nation that leads in AI will rule the world". *Calcalist*. https://www.calcalist.co.il/internet/articles/0,7340,L-3720438,00.html (Hebrew)

12 In May 2019, it was announced that the Russian national plan is based on a budget of 1.4 billion USD over a period of 6 years, and it was reported that the Russian government investment fund will allocate an additional 2 billion USD to promote Russian companies in the field of artificial intelligence. See in detail in Appendix C.

13 FLIA. (2017, July 30). China's New Generation of Artificial Intelligence Development Plan, https://flia.org/wp-content/uploads/2017/07/A-New-Generation-of-Artificial-Intelligence-Development-Plan-1.pdf

14 The White House. (February 11, 2020). President Trump's FY 2021 Budget Commits to Double Investments in Key Industries of the Future. https://www.whitehouse.gov/briefings-statements/president-trumps-fy-2021-budget-commits-double-investments-key-industries-future/

15 Loucks, J., Hupfer, S., Jarvis, D. and Murphy, T. (19 May, 2019) Future in the balance? How countries are pursuing an AI advantage. Deloitte Insights https://www2.deloitte.com/us/en/insights/focus/cognitive-technologies/ai-investment-by-country.html

states of the European Union). The EU has also launched a program to promote collaborations of member states in the field of artificial intelligence under the name 'Made in Europe'[16].

It is important to clarify that beyond government investment, artificial intelligence technologies have tremendous economic potential in the private sector. The value of the global artificial intelligence market in 2019 is estimated at 1.9 trillion USD. Forecasts for 2022 estimate it to be at around 3.9 trillion USD [17]. According to estimates by sources such as Gartner and McKinsey, the market value in the next five years will increase by 600-800 billion USD annually (see Appendix B – Future Global AI Market Value Estimates).

16 Policy on artificial intelligence on the European Commission website, https://ec.europa.eu/digital-single-market/en/artificial-intelligence#Coordinated-EU-Plan-on-Artificial-Intelligence

17 See Gartner Says *Global Artificial Intelligence Business Value to Reach $1.2 Trillion in 2018 (April 25, 2018) and McKinsey Global Institute: Notes from the AI Frontier: Insights from Hundreds of Use Cases (April 2018),* in Appendix B – Future Global AI Market Value Estimates.

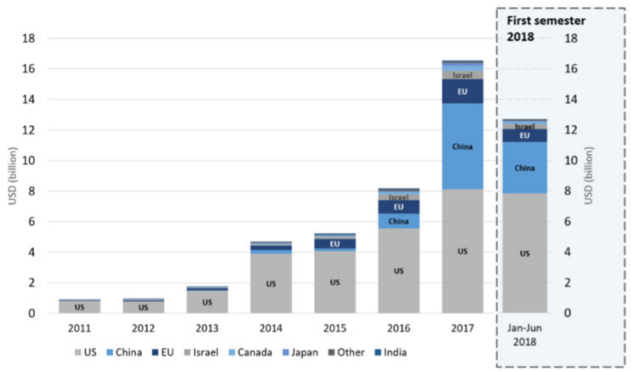
The Situation in Israel

1. Strengths

The mapping of the current situation has made it clear that **Israel possesses a number of base strengths in the field of artificial intelligence, reflected in the volume of startup companies in the country, the presence of international research and development centers and centers of excellence in academia on a variety of subjects**. In terms of investments in artificial intelligence startups, Israel is measured on the same (absolute) scale as leading nations such as the US, China, Japan, Canada, and the EU[18], despite its significant smaller size and resource capacity in all parameters. In the field of startups, for example, the absolute number of startups dealing with artificial intelligence in Israel is second only to the US and is similar to the corresponding number in China[19].

Figure 1. Total estimated equity investments in AI start-ups, by start-up location

2011-17 and first semester 2018



Source: OECD estimates, based on Crunchbase (July 2018), www.crunchbase.com.

As stated above, in recent years there has been considerable activity in both the business sector and the government sector to promote the field of intelligent technologies, for example, the high level of investments in startups. Positive efforts in various directions are taking place in industry, academia and government. It is evident that these have intensified, particularly since this initiative was launched and even more so towards the end of 2019, following this initiative's operations, which accelerated and pushed a variety of relevant entities to engage in this issue. These decentralized efforts are important. They constitute an excellent starting point, and must be continued.

2. Weaknesses and Challenges

However, Israel also has major weaknesses in the field, mainly due to its small size as well as other constraints that may prevent us from being a major player in the field of artificial intelligence. Failure to solve these problems may cause the emerging Israeli high-tech industry, in the field of artificial intelligence, to perish before it reaches critical mass.

18 OECD (2018), Private Equity Investment in Artificial Intelligence http://www.oecd.org/going-digital/ai/private-equity-investment-in-artificial-intelligence.pdf

19 ROLAND BERGER GMBH & ASGARD. (2018). Artificial Intelligence – A strategy for European startups. p.17.

Along with the high potential described above, there are major challenges and gaps resulting from Israel's characteristics as well as the existence of entire areas in which Israel is very far from the world leading nations. Among the significant challenges that Israel must overcome in order to achieve the goal of global leadership, is the fact that Israel is a small country with very limited resources in comparison to the leading players. The capital that Israel can allocate to the field of intelligent systems does not even come close to the sums possessed by the superpowers, and even if the volume of investments had been unlimited, the amount of relevant human capital (engineers, scientists, academics, and technology experts) is limited in light of Israel's absolute size. As a result, there are areas in which Israel is far from the forefront of knowledge, since only a few people engage in these areas, if at all. Beyond the size of the techno-scientific community in Israel, this also brings out the fact that specialization in some of these areas requires the establishment and maintenance of very expensive infrastructure, the construction cost of which constitutes an entry barrier for a country the size of Israel.

Another challenge is the digital divide in Israel. The country is small and relatively isolated, which leads to less competition in the application worlds, and entire sectors of the country that are less digitalized than others. As a result, there is a digital divide in government services and other sectors in Israel in comparison to developed Western countries. This is reflected, for example, in the gap between Israel and other Western countries in areas such as digital payments and shared transportation, in which Israel has the potential to become a leader (the knowledge exists, and in this case the small size of the country actually constitutes an advantage). Bridging the digital divide in comparison to the other developed countries is a prerequisite for integrating intelligent systems in the various sectors in the country.

V. The Founding Logic of the Initiative

It is crucial to ensure that the State of Israel leverages its initial base in the field of artificial intelligence in order to become a global leader. Past experience in the cyber and security fields shows that a collection of sporadic efforts is not enough to make Israel a power in the field. There is a need to centralize efforts into an integrated and powerful comprehensive plan, which will be conducted with a cohesive and cross-sectoral national outlook of all the infrastructure, resources and efforts invested. Otherwise, even if we do reach the forefront in certain areas, we might not reach the critical mass required to bring about a revolution that will create a sustainable ecosystem, which is essential for Israel to realize the vision of global leadership and to enjoy its fruits.

Artificial intelligence and intelligent systems are core technologies, and therefore Israel must establish itself as a leader in these fields in order to ensure its security, economy and the well-being of its citizens. With the right strategy, intelligent systems can be revolutionary at a national level, significantly raising the level of public services and products such as health, education, transportation and security, increase productivity, and enable the formation of highly useful products and solutions for markets in Israel and abroad. In general, it has the potential to significantly improve life in Israel. The purpose of the national initiative is to address the deficiencies required to complete the leap to technological and security resilience in the age of intelligent technologies, which in turn will be an engine of economic and social growth for the entire economy, as explained below.

Objectives of the Initiative

1. **Ensuring Technological Resilience**

   Investment in Israeli leadership in the field of intelligent systems is critical to preserving the relevance of the Israeli high-tech industry and innovation and ensuring that it does not degenerate, in a manner that will fatally harm both the Israeli economy and the national security which relies on technological superiority. Reform is required in academia, the models used today are not adapted to the nature of research and practice in the field of intelligent systems. At the same time, it is necessary to increase the attractiveness and continuity of the Israeli technological ecosystem, fight the brain drain and encourage the return of Israeli researchers and experts to Israel.

2. **Ensuring Techno-Security Strength**

   Israel's technological superiority is a cornerstone of security theory and a condition for ensuring the existence of the state. Following Israel's success in positioning itself as a leader in the field of high-tech, in general, and cyber, in particular, it must prepare for the next stages of the computing revolution by developing and harnessing secured intelligent systems to advance Israel's unique security needs. In the post-industrial information age, power is directly affected by the ability to collect, process and use data, whether for purposes of intelligence, defense or offense. In addition, the emerging trend of integrating robotics and autonomous tools into the battlefield is gaining momentum and requires Israel to develop knowledge and capabilities in the field. These are only a few examples of the effects of artificial intelligence applications on security. Without the additional investment required to create the critical mass in the field of intelligent systems, and without building the techno-security capabilities with an outlook of two decades ahead, we will lose the advantage we have accumulated and our status as technological leaders, and suffer the resulting security implications.

3. **Opportunity for Economic Growth**

   According to the market estimates presented above, if the State of Israel manages to provide, for example, only 5% of the growth in the global AI market, this will translate to annual revenues of 30-40 billion USD. Even 1% of global growth will be of significant macroeconomic value. This is a rare economic opportunity for Israel. It is noteworthy that in the two areas in which Israel has dedicated sufficient effort to becoming a major player in the global market – weapons and cyber systems – Israeli exports amount to almost 10% of the global market.

4. **Opportunity to Improve the Well-Being of Society**

   Artificial intelligence technologies do not only herald innovation or development in the high-tech industry, but rather the entrance into a new era in which advanced information and computing infrastructures will change the patterns of human activity in all areas of life. Therefore, proper planning and investment by the State in artificial intelligence technologies, and their integration into the economy, will streamline and optimize public services and move forward entire sectors such as medicine, transportation, agriculture, and other traditional industries, in a way that increases economic productivity and the well-being of all citizens. This is an opportunity to promote an economy of growth and efficiency, even in sectors to which Israeli innovation has not yet penetrated.

The Central Idea

The central idea behind the current initiative is to turn the Israeli size disadvantage into an advantage. Precisely because of the country's small size, it is possible in a short time to bring about a coherent program, in which all ecosystem actors will participate, and in which all participants will benefit and improve their situation thanks to the ability to share and cooperate with the other elements.

The catch however is that collaboration between different entities in charge of different areas is often contrary to human and organizational nature. We believe – and this belief is strengthened by looking at the lessons learned from the cyber revolution – that the small size of Israel, the broad familiarity of the leaders in each sector with their counterparts in other sectors, and the sense of unity of fate, all give the State of Israel the opportunity to advance faster in the field, compared to the rest of the world.

For Israel to be able to leverage its existing basis and its relative advantages, it must also be able to face its challenges well, since although in some indices Israel's absolute position in comparison with the rest of the world is satisfactory, **it is not in itself enough** to form a sustainable ecosystem in the field of artificial intelligence in Israel, which will also allow Israel to reap the required security, economic and political fruits.

This requires a national strategy and additional investment to develop the necessary critical mass in physical infrastructure, human capital, data accessibility, and R&D in the field of intelligent technologies. In addition, enabling conditions must be ensured, such as cyber security and an adequate ethical and regulatory framework, as well as building strengths in all sectors and incentives for collaborations between them in order to establish the desired ecosystem. All of these will make it possible to reduce the gap between Israel and the leading global players and gain a relative advantage in the worlds of technology and high-tech in a way that will ensure our spot in the global race, which is critical to Israel's economy, society, and national security.

In formulating the required strategy, we are, formally, somewhat behind most countries of the world. Official strategy papers for artificial intelligence (including the allocation of government budgets) have already been published not only by the major superpowers (such as the United States, Russia and China), or even "medium-sized" countries (such as the United Kingdom, France and others), but also by small countries (such as Finland, Singapore and others). However, as stated above, based on similar and successful experience in the last decade in the field of cyber, we believe that the "small-size advantage" works in our favor and gives Israel the ability to concentrate all those involved in the field in a single initiative and to formulate a coherent plan in which each entity contributes its share in coordination with the other entities. In general, we can say that we started the race after some of the players, but the conditions in Israel allow us to run faster.

VI. Recommendation for a Government Resolution

1. National Priority

Declaring that the areas of intelligent systems and artificial intelligence are a critical infrastructure for the future of the country and a national priority.

Founding logic: This is an issue that, beyond being vital for Israel's national security and its economy, has a proven potential to revolutionize all areas of life in the country and bring about a significant increase in the well-being of its citizens. The uniqueness of the field of artificial intelligence is that it is an "**infrastructure of infrastructures**". **Leadership in this field is a condition and basis for leadership in any technological field in the future, and for the preservation of the Israeli high-tech sector**. The State of Israel, where security and the economy are based on a techno-scientific advantage, must establish itself as a leader in the field of artificial intelligence. The role of the state in this context is not only to solve "market failure" but to create a state infrastructure that will enable and encourage the achievement of the **leadership goal** in the field, through an integrative national view of all sectors.

In parallel with the construction of the state infrastructure, the field of artificial intelligence in Israel should also be promoted through **the development of foreign relations and the establishment of international collaborations** that will help Israel establish global leadership in the field. Creative development of artificial intelligence-oriented foreign relations in a variety of contexts such as academia, trade, and even foreign aid, can help Israel accelerate its techno-scientific progress in the field, create economic opportunities and gains for the Israeli economy, and thus Israel will be able to brand itself as a world leader in the field in a way that would also gain political benefits in other contexts.

2. National Plan

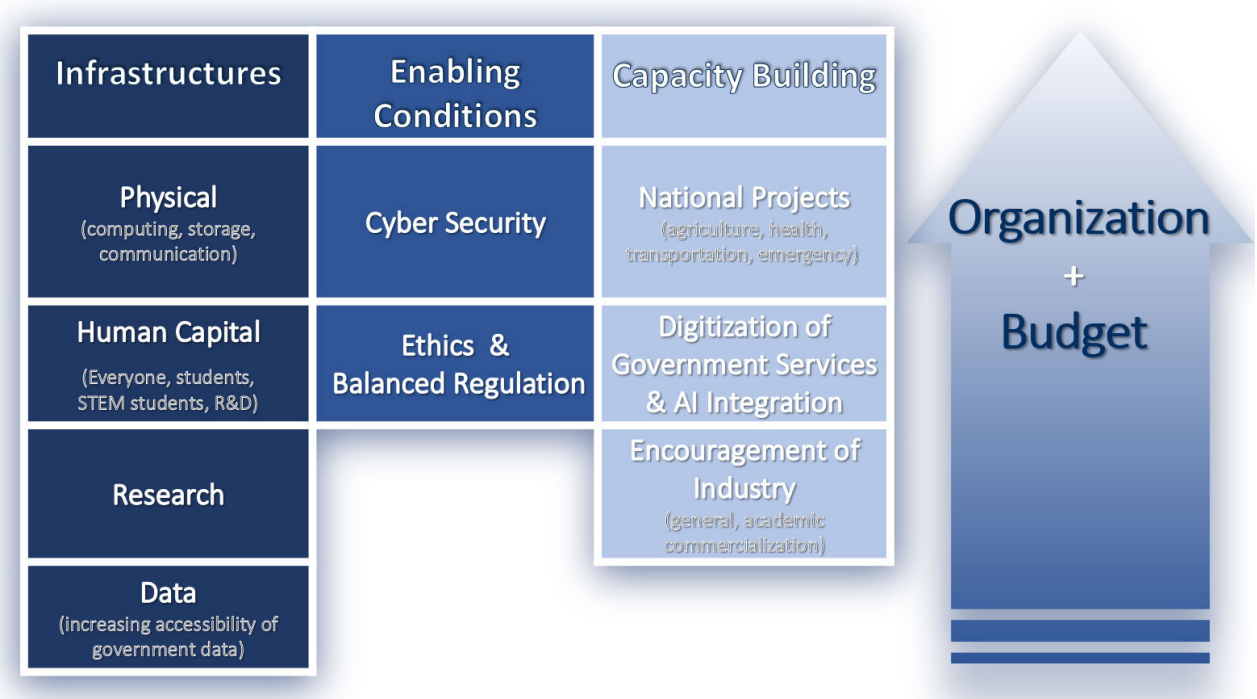
Establishment of a national plan to create a complete and sustainable ecosystem around the area of intelligent systems.

Founding logic: In order to succeed in building Israeli **leadership** at a global level in the field **over time**, and in light of innovation, complexity, and the fierce global competition in this area, a comprehensive national strategy to create a sustainable ecosystem in the field of intelligent systems must be adopted. This should be carried out with the aim of harnessing all sectors of the economy – government, security, industry and academia, to a united national effort, and not to settle merely for distributed local efforts. This will also reflect the advantage of Israel's small size, which allows for faster inter-sectoral organization than in other countries. It is worth noting that in the past, the State of Israel has succeeded in revolutionizing and consolidating an entire ecosystem around areas it has defined as a national priority, such as cyber and defense exports.

Plan components:

The plan is made up of three interwoven axes. The first axis focuses on the basic infrastructures essential for the development of the field of intelligent systems in Israel, namely: computing infrastructures, human capital, data, and research in the relevant fields. The second axis focuses on conditions that will enable optimal activity on the basis of these infrastructures, which are cyber security designated for the age of intelligent systems and the creation of an adequate ethical and regulatory environment, that does not hinder innovation and technological development of a new field still in its infancy. The third axis is dedicated to building national capacity by binding together all the sectors, industry, academia, security, and government, into a complete and sustainable ecosystem. In this facility, the plan sets out the steps to be taken in each sector to advance it through the assimilation of intelligent systems, and to strengthen its interfaces with the other sectors, including the proposal of national projects in the fields of health, transport, security, and agriculture. The expected benefits of these projects are twofold. By launching them in order to meet a national need in their field, they will constitute a catalyst for the formation of an entire ecosystem around them, which will lead to the development of modern technologies, cultivation of the professional workforce and inter-sectoral cooperation.

Details of the full national plan are given below in Part VII, p. 27.



3. **Budgeting the Plan**

In order to implement the proposed plan, the Israeli government has to allocate a budget of NIS 10 billion over the years 2021-2025 (5 years) in the following manner:

A. To allocate approximately NIS 1 billion per year from the existing civilian R&D government budget (which is about NIS 10 billion a year) in favor of the new national effort in the field of intelligent systems. This budget will be managed by the entities that currently allocate the budgets for civilian R&D (the Planning and Budgeting Committee, the Israel Innovation Authority, the Ministry of Science and Technology) according to their share of the budget, and with the consent and coordination of an Intelligent Systems Administration, to be established in the Prime Minister's Office (see next section – Directing the Plan).

B. An additional NIS 1 billion per year, to be handled by the new Intelligence Systems Administration.

Founding logic: The civilian R&D government budget in Israel, about NIS 10 billion, constitutes approximately 14% of total national expenditure on R&D in Israel, which is approximately NIS 60 billion (it should be noted that in real terms, the current government budget is very similar to the civilian R&D government budget in the early 1990s, *i.e.* the Israeli government did not increase it over the past two decades, but back then it accounted for about 80% of total R&D expenditure. Over the last two decades, R&D funding by the business sector has increased, and therefore that same government budget currently constitutes only about 14% of the total expenditure).

In order to create a real revolution in Israeli hi-tech, and especially in the various sectors of the economy, about 20% of the government's budgets for civilian R&D must be diverted to the new field. We believe that a diversion of 10% of the existing budget and an addition of approximately 10% in new funds are the right ratios to create the essential infrastructure for the entire economy, which will leverage the business sector budgets even more with orientation to the field of intelligent systems, in a way that will revolutionize our reality.

Government budgets will focus on all the infrastructures that the state must establish in order for the business sector to invest more and more in the field, and most importantly, as shown in the plan – physical infrastructure, human capital infrastructure, research and academic infrastructures, capacity building and ecosystem-building national projects.

4. **Directing the Plan**

Establishment of a National Administration for Intelligent Systems in the Prime Minister's Office.

Founding logic: In order to establish and implement a national program on a scale designed to change the country's economy and security and form the critical infrastructure for the country's future, a dedicated administration must be established in the Prime Minister's Office. It should work with and through government bodies and in front of the entire economy to lead the ecosystem and the expected revolution.

Functions of the administration:

A. Implementing the government resolution and leading the National Plan for Intelligent Systems based on the recommendations of the initiative.

B. Managing the additional budget for the plan (beyond pooling the current resources).

C. Providing recommendations to the government on an integrative policy on the subject.

D. Establishing, leading and integrating Israel's international connections in the field of intelligent systems and artificial intelligence.

E. Any other function assigned to it to promote said subject.

Staffing: The administration shall be a professional body, and therefore the majority of its personnel should come from the techno-strategic worlds of artificial intelligence. A dedicated salary scale needs to be structured for its staff in order to create the capability to draw the best and most suitable personnel in the country.

Importance: It should be noted that the sub-team dedicated to the government sector, which consisted of government representatives, was largely of the opinion that no special organization is required, and that it is sufficient to rely on existing entities to implement the recommendations. A minority of the team members believed that a special organization was required for the field of intelligent systems, but that it should be established within the existing entities.

Having carefully considered and examined this recommendation, after consulting many persons who know and understand very well how the government works, and relying on our own extensive experience in the subject, we reject this position. In our understanding, this view stems from a significant underestimation of the depth of the revolution of artificial intelligence technologies and their impact on the entire nation and state, and from the natural fear of government bureaucrats for establishing a new dedicated administration and field.

In our viewpoint, the national mission of making Israel a world leader in the field of intelligent systems goes beyond the designation of existing entities, which, in any case, lack the tools and professionals required to carry out this mission. Accordingly, we conclude that beyond harming the important national mission, the very dispersal of roles and functions between existing entities may hurt their currently defined designated role.

A professional national administration in the Prime Minister's Office is critical to the success of the national mission to build a complete, harmonious and efficient ecosystem[20]. The dispersal of efforts and resources in the field without a systemic integrated viewpoint of a national administration will be ineffective, will miss the mark, and will hinder the consolidation of the required ecosystem. Therefore, if it is decided not to establish a dedicated administration in the Prime Minister's Office, any additional investment in the field should be seriously considered, as this may be a futile investment.

20 The model we recommend is very similar to the one used in Singapore.

5. **Advisory Committee**

Establishment of a 5-member non-governmental advisory committee to the Prime Minister.

Founding logic: Implementing the recommendations will be a real challenge for the government and the state. Difficulties in defining the objectives and how to implement them, the pace of global change which will be hard for the government to catch up with, oppositions by government entities due to such interests and others, which already exist, as early as the formation stages of the initiative – all of these require, along with the establishment of a strong intelligent systems administration in the Prime Minister's Office, the existence of an external advisory committee to the Prime Minister, which can externally monitor the success of the initiative, recognize any problems that may arise and warn the Prime Minister of significant delays.

VII. Details of the National Plan

1. Infrastructures

A. Computing Infrastructures

Summary: Physical infrastructure, in general, and computing power, in particular, are prerequisites for research and development, as well as for the growth of human capital required in all areas of intelligent systems. The expansion of the use of artificial intelligence in the coming years will be accompanied by a growing need for computing, storage, and communications resources, as well as energy sources. While some of the computing needs for artificial intelligence at the national level can be acquired as a service in the global market, some must be located in Israel for independence, survival, and emergency availability, and to enable the development of human and technological knowledge infrastructure in the field.

We recommend setting up a local Israeli cloud as well as an High-Performance Computing center (HPC) in Israel, which will include both a supercomputer and a laboratory which will enable Israel to train researchers and developers and preserve a critical mass of knowledge in the field of HPC. In addition, interfaces for quantum computing must be developed. The cloud and the HPC center will both be shared by the civilian government entities and the defense system, while maintaining a separation between the civilian infrastructure from the security infrastructure in each of them, for the purposes of compartmentalization.

Physical infrastructure, in general, and computing power, in particular, are prerequisites for research and development, as well as for the growth of human capital required in all areas of intelligent systems. Intelligent technologies require a lot of computing power, memory components that can handle vast volumes of information, fast connectivity, and more. The expansion of the use of artificial intelligence in the coming years will be accompanied by a growing need for computing, storage, and communications resources, as well as energy sources. While some of the computing needs for artificial intelligence at the national level can be acquired as a service in the global market, **some must be located in Israel, function even in cases of emergency, survive and remain accessible** (including in terms of communications and power supply). The national strategy must holistically handle the computing, storage, communications, and energy infrastructures, in addition to the treatment of information (data types and their accessibility, both for research purposes and for day-to-day operations). Our recommendations are as follows:

1) **A local Israeli cloud must be established**. This cloud will be common for civilian government entities and the defense system, while separating the civilian part from the security (for the purpose of compartmentalizing classified security activities). While the government may not be able to set up a cloud independently initially, international companies such as Amazon, Microsoft, Google or other companies that provide public cloud services, may find it worthwhile to share the cloud with the military and defense systems (*i.e.* a national project with a military executive administration). This may strengthen the companies' willingness to establish a private public cloud in Israel. The government cloud will also provide services to research and development entities that are not government entities but participate in grants from the Israeli research systems (the Planning and Budgeting Committee, the Administration for the Development of Weapons and Technological Infrastructure, the Israel Innovation Authority, the Ministry of Science and technology, etc.). Parties who receive grants from these entities will be able to benefit from access to the information as well as the computational infrastructure of the cloud.

2) **A High-Performance Computing center (HPC) must be established**, which will include both a supercomputer and a laboratory through which researchers and developers can be trained and which will develop and maintain a critical mass of knowledge in the field of HPC. The laboratory will serve entities that receive approval to access the government infrastructure, as well as research authorities and entities that receive government grants. The implementation of this center also requires two separate infrastructures, one for civilian needs and the other for military needs, with the military infrastructure benefiting from proximity to the civilian infrastructure and commercial technologies.

   The civilian supercomputer will serve a number of needs: (1) It will provide a solution to the computing needs of the industry and academia; (2) It will train users from academia, government and industry; (3) It will renew the industry revolving around the computer in Israel. There has been some development in Israel in the field of semiconductors, as well as in the field of algorithms and data extraction, but the overall systemic capacity is lacking. Criticism has already been voiced that Israel exports artificial intelligence used by other countries but does not itself implement local solutions.

3) **Quantum computing interfaces must be developed.** There is a worldwide consensus that quantum technology is a field which is expected to have a decisive impact on science, economy, and security in the coming years. As stated above, the quantum computing sub-team was a joint team of both the initiative and the TELEM forum[21]. The team has completed its work and its recommendations were approved by the TELEM forum even before the publication of our report. It should be emphasized here that we find all of these recommendations acceptable in their original formulation. Therefore, in this report we have addressed only the additions required beyond the recommendations approved by TELEM[22].

As the technologies that enable the use of quantum routines in the framework of conventional supercomputing evolve, infrastructure is needed to create interfaces between supercomputing and quantum computing, in order to maximize quantum sensing capabilities, secured communication, and quantum computing.

The establishment of the infrastructure mentioned above in Israel's territory entails significant advantages:

- **Development of a human and technological knowledge infrastructure** in the field will enable the training of key and operational personnel. In addition, another area of research will be created, in which Israel will have the opportunity to innovate and lead trends in the world.

- **Emergency availability** – a computing infrastructure physically located in Israel is also available in times of emergency and can be converted to security needs if necessary[23].

- **Flexibility and independence** – infrastructure located in Israel will allow for flexibility in the definition of research priorities and the availability of computing capabilities without any dependence on a foreign entity. The data required for some of the computing operations must remain within the borders of Israel, and therefore these operations must take place in Israel's territory. Any registration or computational operation made outside the borders of the state may expose Israel's data to use by hostile elements. In addition, researchers affiliated with the Israeli security system may find it difficult to be granted time at global high-performance computing centers, or alternatively they can be harmed by a boycott (such as BDS) or an embargo, restriction of applications or the use of cloud resources by the host nations. Furthermore, there is a concern that the cloud provider will make the information hostage in order to increase the cost of use or bind Israel to it.

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21 See footnote 6.

22 See the explanation and details in the full report "Recommendations of the Examination Committee – Quantum Science and Technologies – TELEM", and in the chapter "Report of the Sub-team on Computing Power and Quantum" below in this the report (Part II – Sub-Team Reports).

23 Similar to the American model – Mass Open, in which the American Air Force financed a substantial part of the construction costs, in exchange for the ability take over the resources in times of emergency.

In a study by Tortoies[24], published in December 2019 and comparing the capabilities of 54 countries in the field of artificial intelligence, the State of Israel is ranked 12th out of the 54 participating countries. The study examines 7 parameters associated with the following categories: Implementation, Innovation, and Investment.

In our opinion, the State of Israel has the potential to raise its profile in the field of artificial intelligence if three main issues are addressed:

- **Infrastructure** – rank 36 of 54;
- **Operating Environment** – rank 50 of 54; and
- **Government Strategy** – rank 46 of 54.

In order to position Israel among the top ten nations in the field of artificial intelligence, it must address these weaknesses as soon as possible. These are changes that can be made within a relatively short period of time, while changes in other areas require a longer-term investment. These are necessary and substantial changes, and a renewed and adjusted annual investment is required in order to preserve them. The State of Israel cannot afford to ignore the grave points of failure mentioned above and must act to correct them as soon as possible.

B. Human Capital Infrastructures

Summary: The State of Israel will set an overarching goal to make data-literacy widely accessible to all its citizens, by creating a continuum in learning the language of data as a core subject from elementary school, through high school and university, and into the economy. A combination of intelligent data-based technologies in all areas of life makes data a key resource, and data literacy (the ability to understand data and use it for various purposes) becomes an essential skill. This will become required in every field and sector within a decade as a condition for participation in a modern economy and society, and for creating demand for the development of additional intelligent technologies to strengthen and propel the entire ecosystem in a positive feedback loop. At the same time, **advanced training and degrees designed for the fields of artificial intelligence will be promoted and developed**. These are necessary but unsatisfactory conditions, as **another reform that is required is in academia, which will ensure that lecturers in fields related to artificial intelligence will also be allowed to work in industry, and the scope of their academic and pedagogical duties will be reduced accordingly**. Technological leadership depends on the consolidation of the basics of excellence in academia led by leading researchers and professors, but the current outdated employment model for academic staff leads to the opposite result in exacerbating the shortage in academic staff in the field of artificial intelligence. Without changing the model, Israel risks a brain drain, the deterioration of academia and losses to innovation and the high-tech sector that constitute a major relative advantage for the country.

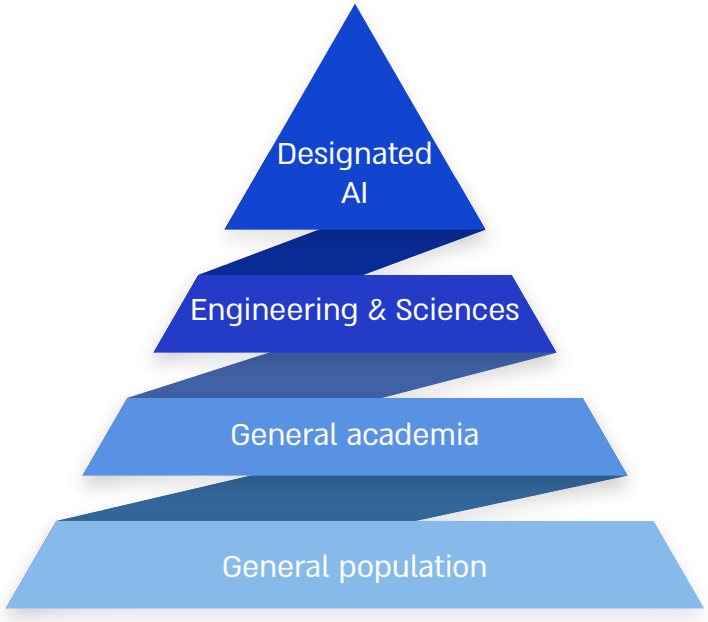
The combination of intelligent data-based technologies in all areas of life makes data a key resource, and data literacy (the ability to understand data and use it for various purposes) becomes an essential skill, which will become required in every field and sector within a decade. From improving the operational efficiency of small businesses through large industries, to the creation and streamlining of new government services, direct and dramatic effects on the economy, welfare, and security are expected. Understanding the language of data is essential, not only to develop advanced capabilities and technologies, but also to simply use them.

Since these technologies are integrated in every field, **data literacy** is a condition for participation in the modern economy and society. Beyond the immediate improvement, data literacy also creates a demand for the development of additional intelligent technologies and skilled technological personnel, and ultimately for the propelling and strengthening of the entire ecosystem in a positive feedback loop. Therefore, **we recommend that the State of Israel set as its overarching goal to make data-literacy widely accessible to its citizens** in order to enable them to integrate into the workforce and enjoy improved public services while at the same time ensuring the human-technological capital potential essential to establishing Israeli leadership in the age of intelligent technologies. To do this, the following steps are to be taken:

24 Mousavizadeh, A., Mostrous, A. & Clarck, A. (December 3, 2019). The arms race. *Tortoise*. https://members.tortoisemedia.com/2019/12/03/global-ai-index/content.html?sig=zrv_2APk-pArLwoI2dhta6CnXR-Z3S3cs-8udIU7ZIY

1) **Teaching data literacy by creating a continuum in learning the language of data from elementary school, through high school and university, and into the economy.**

There is a worldwide trend (in countries such as Finland and Singapore, for example) in the creation of frameworks for the development of literacy and even training in artificial intelligence, which are intended for different populations in the country – pupils, students, business-sector employees, and even pensioners. Training programs for the entire population in Israel should be constructed according to the following division:



Elementary → High school | Training for non-tech-savvy adults

A) **General population:**

(1) **Artificial intelligence as a new core subject in the education system – from elementary school to high school:** basic principles in data science and machine learning should be combined as core content alongside Hebrew, mathematics, and English starting in elementary school. **A basic level for compulsory matriculation examinations should be defined, with an option for increased matriculation examinations in this subject**[25], either as a separate subject or as part of the matriculation examinations in computer sciences. The curriculum should address in detail the unique ethical issues that arise in the field. In this context, a fundamental problem in the ability to adopt this recommendation should be considered, which is an objective shortage of teachers for this subject, which does not yet exist. This problem is familiar for new technological fields. It has also occurred in the field of cyber, which has entered into the curriculum. The education system will have to invest in innovative teaching methods using virtual dimensions as well as carry out extensive teacher training with the assistance of industry as a precondition for adopting this recommendation.

25 New profession for increased matriculation – an option for matriculation examination at the level of 5 units or more in artificial intelligence should be enabled, and the integration of artificial intelligence contents in increased matriculation examinations in computer science should be considered.

(2) **Training in the economy for the general population: The entire economy, including the government and each and every one of the citizens, must be educated and trained to consume artificial intelligence applications and services**. In must be internalized that artificial intelligence is a kind of "new electricity" – it affects all areas of life and therefore it must be used daily by the general public[26]. We recommend that Israel develop a program similar to the Finnish program to encourage a lifelong learning reform in the field of artificial intelligence, both for the graduates of the education system in which artificial intelligence contents will be assimilated and for the rest of the non-tech savvy population, which constitutes the majority of the workforce in today's economy[27].

B) General students in higher education institutions:

(1) **The psychometric test** will include a chapter that examines basic knowledge, understanding and analysis of data.

(2) **Each degree** will include a course in data literacy and data analysis, as well as a course on the use of artificial intelligence tools, as compulsory courses alongside or as part of the courses currently offered in research methods.

C) Students for degrees in engineering and sciences (STEM):

(1) **A division of advanced and technological courses** in data science and machine learning will be included in all the engineering and exact science degrees.

D) Designated training for specialization in the fields of artificial intelligence:

(1) **Offering designated degrees in artificial intelligence** or artificial intelligence tracks for computer sciences.

(2) **Establishment of a dedicated division for graduate degrees in artificial intelligence.**

(3) **Creation of dedicated frameworks for leading experts from various fields for training in artificial intelligence and data science**, such as artificial intelligence for medicine. Until these frameworks are developed in Israel, a national program is required, as part of which Israeli experts in various professions will be sent to leading universities abroad to receive fully-funded multi-year training in artificial intelligence that is designated for their professions.

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26 Finland's national artificial intelligence strategy is unique as it recognizes the state's small size and its limitations in the global race for the development of artificial intelligence technologies. Taking that into consideration, the goal in Finland is to generate a competitive advantage through AI literacy education, whereas the national goal that was set is to make the country a world leader in consuming and using artificial intelligence in a way that will promote: (1) an efficient public sector; (2) competitive business and industry; (3) a proactive society that functions well and enjoys greater well-being thanks to the use of AI. For more information on the Finnish strategy, see Appendix C.

27 Some of the training that should be considered are: Basic, online and free course in Hebrew/English without any requirements for prior knowledge or programming skills in order to get acquainted with the concept of artificial intelligence and its potential uses, in a similar style to the Finnish course Elements of AI. Finland was the first country to launch, as a national initiative, a free online basic course of about 60 hours of study and practice at a personal pace and without any prior knowledge requirements. By September 2020, the program already had over 500,000 graduates worldwide. | Online/Hybrid training courses in artificial intelligence for those with a programming background (similar to the tracks offered in Singapore, see: https://resources.new.datacamp.com/resources/static/a71082d2ccdc681cab7bf8eea45b499a/AI_Singapore.pdf | Encouragement to update the professional training in the economy to the era of AI and the changes it will create in the labor market.

2) Reform in the academic employment model:

Technological leadership depends on the consolidation of bases of excellence in academia led by leading researchers and professors, but the current employment model for academic staff does not yield the desired result and endangers the future of innovation and technology in Israel. The irrelevance of the outdated model, which raises more difficulties than rewards, is particularly noticeable when considering the academic staff in the fields of artificial intelligence, who are in huge demand outside academia, and even outside Israel, which threatens the continuity of research in Israel and, consequently, the existence of the industry in the country. Due to the acute shortage of academic personnel in the field of artificial intelligence, commercial companies "steal" the academic staff, and this phenomenon harms both the research and the process of training new academic personnel who will train future generations. In order not to cut the branch on which the industry sits, it is imperative to change the model for employing professors of artificial intelligence in academia and industry. We believe that faculty members in fields related to artificial intelligence should be allowed to work in industry as well, and their academic and pedagogical duties should be reduced accordingly[28].

Another issue that requires a radical solution concerns the universities' technology transfer companies. Here, too, we recommend changing the formula and allowing professors a significant percentage of the IP, much higher than the customary rates today, when they wish to set up or join a company to commercialize their knowledge. In contrast to the current situation, it seems to us that if the researcher does not need funds from the university for the purpose of establishing the company, such a researcher should be allowed to keep up to 80% of the IP rights and 20% should go to the university[29].

Without this significant change, Israel risks brain drain, the deterioration of academia and the loss of the innovation sector that is the main relative advantage of the country. If the proposed pilot in the field of artificial intelligence is successful, it will be possible to expand it to other areas where there is an acute shortage of skilled personnel.

28 For example – 20% of their position at their university and 80% in industry.

29 See details below in the section on Capacity Building and Flagship Projects under the title "Empowering the Industrial Sector and Strengthening Industry-Academic Relations".

C. **Research infrastructures**

Summary: 4-6 academic research centers for artificial intelligence in various fields should be established in order to leverage the relative advantages of the various universities, promote research and significantly increase the pyramid of practitioners in the field, from students to leading experts and researchers. The establishment of research centers is an integral part of the consolidation of the ecosystem in the long term, as they are the scientific infrastructure on the basis of which technological leadership will be developed and human capital for research and industry will be trained.

The establishment of 4-6 academic research centers will significantly advance both the research and the training of human capital in Israel. The research centers will help to significantly increase the pyramid of practitioners in the field, from the base of undergraduate students all the way to leading researchers, in a way that will qualify human capital for research and industry. The establishment of research centers is an integral part of building the long-term ecosystem, as they are the scientific infrastructure and the basis on which technological leadership will be achieved. Therefore, they should be established according to the following guiding rules:

1) All the centers to be established will be university centers in collaboration with colleges, and will pool together and focus on the topics in which academia is required to promote groundbreaking and long-term research.
2) Similar to cyber, in order to optimize and utilize resources in the best way, the research centers in the universities should be directed to leverage the unique areas of strength for each university and to jointly create a complete and leading ecosystem.

D. **Data Infrastructures**

Summary: Government-national data must be made accessible as a basic and necessary condition for the advancement of all sectors in Israel and for the establishment of the ecosystem. Due to problems of accessibility and mainly bureaucratic barriers, only a small portion of the information potential in Israel is utilized. This prevents the improvement of public services, and mainly harms basic and applied research as well as Israeli industry. In order to realize the economic, social, and security potential of the data stored in government ministries, it is imperative to find a solution that will enable the sharing of information, making it accessible to the Israeli economy and companies. In our opinion, this can be achieved through a combination of regulation and technological tools, including homomorphic encryption[30]. **A national infrastructure for the management and accessibility of information** between private, security and government entities in Israel and abroad must be established.

Data accessibility: as the saying goes, information is the fuel that drives the entire ecosystem. Although Israel is a small country, when it comes to storage of digital data, Israel has a lot of information in certain areas. However, considerable parts of that data are scattered and buried (data silos), are not normalized, are untagged and are even exposed to biases. Due to accessibility problems and mainly bureaucratic barriers, only a small portion of the information potential in Israel is utilized, preventing the improvement of public services, and mainly harming basic and applied research as well as Israeli industry. Therefore, **making the government-national information accessible is a basic and necessary condition for the promotion of all sectors in Israel and for the establishment of the ecosystem of intelligent systems**.

1) **Access to national data:** Utilizing the high potential of data stored in the various government ministries constitutes a national opportunity to improve many areas through artificial intelligence. To this end, a solution must quickly be found to the challenge of sharing information and making it accessible to the Israeli economy and companies for the purpose of promoting the economy, by combining regulation and technological tools[31].

2) **Establishment of a national infrastructure for managing data and making it accessible** to private, security and governmental entities[32] in Israel and abroad. There is no need to concentrate the information in a single database, each entity will keep its information in its possession, but there will be a mechanism that will allow access to the databases to each entity according to its permissions. Some of the data (to be determined by the state) will be accessible to all citizens.

3) **Examining homomorphic encryption applications** will make it possible to process encrypted data from various sources without concentrating the data or breaking the encryption, as a potential solution to many barriers to information sharing, especially in areas where the challenge stems from the need for anonymization, privacy, confidentiality, etc. The ability to process under encryption without the need to break it enables, for the first time, to realize meaningful, profitable and secure collaborations between database owners and potential users or even providers of data processing services or computing platforms that are not sufficiently secured. Both data owners and model

30 **Homomorphic encryption** makes it possible to search a given database and intersect the information with data located in a different database, all while the information is stored in an encrypted manner, and without the need to break the encryption.

31 Another example of a technological solution that could reduce the accessibility problem, in addition to the homomorphic encryption mentioned above, is a "national AI machine for applications". In order to circumvent barriers regarding accessibility of information as a result of bureaucracy, privacy, etc., it is possible to build a kind of generic machine to which any party can submit a request to output queries/applications on various repositories using a generic form. The machine will not have direct access to the information stored in the databases themselves, which will remain in the possession of the original entity to which they belong, but it will be able to create and run (either for free or for a fee) the algorithm required to create the requested output. Such a project could also be a national project (see below).

32 The option of sharing "sterilized" security information should be examined with the defense forces as part of the effort to make the national data accessible.

owners will have the ability to control the needs for which their property is used. This will make it possible to extract the use of sensitive models while fully protecting intellectual property as well as extracting sensitive or confidential information while maintaining its end-to-end protection for the purpose of improving models or generating insights from a secured link, maintaining the compartmentalization between a variety of sensitive databases.

2. Enabling Conditions

A. Cyber Security and Artificial Intelligence

Summary: In any field where intelligent technologies are to be incorporated (including as a result of the recommendations of this report), leading to greater dependence on computers, it is essential to ensure that the systems are secured. The Israel National Cyber Directorate will initiate a program to update and adapt the cyber security methodology in Israel to the era of intelligent systems. The substantial knowledge and reputation that Israel has accumulated in the field of cyber security constitutes an advantage which Israel must leverage to brand itself as a leader in the security aspects of intelligent systems.

The global trend of using artificial intelligence is further increasing the dependence of government, industry, and virtually every citizen on computers, thus creating new vulnerabilities to cyber-attacks. Therefore, changes in perceptions and practices in cyber security are required in the age of intelligent systems. It is imperative to build a comprehensive assessment plan for this era, taking into account the impact of the use of intelligent technologies both when used to improve defense capabilities, and against defense systems. The importance that the initiative attaches to the field of cyber security is expressed in its title "**Secured Intelligent Systems**". This distinction leads to two immediate conclusions:

1) In any field in which intelligent technologies will be integrated (including as a result of the recommendations of this report), leading to a greater dependence on computers, **it is essential to ensure that the systems are secured**.

2) **The Israel National Cyber Directorate must initiate a plan to update and adapt the cyber security methodology in Israel to the age of intelligent systems**. The substantial knowledge and reputation that Israel has accumulated in the field of cyber security constitutes an advantage which Israel must leverage to brand itself as a leader in the security aspects of intelligent systems.

B. Ethics and Regulation

Summary: For those involved in the development of intelligent systems and data handling in general, an ethical framework and minimal regulation needs to be formulated in order to enable innovation and continued Israeli leadership in the field, while maintaining clear and appropriate ethical and regulatory rules. The experience worldwide indicates that when it comes to evolving technologies, regulation and rules that are too strict can stunt innovation in the development and growth stages. We recommend a balanced approach that could become a role model for other nations. In doing so, the guiding ethical principles formulated in the field of artificial intelligence should be adopted, and self-regulation should be encouraged through the use of tools for risk assessment and early identification of ethical challenges in the development and production stages. Such tools, for example, were developed within the framework of the initiative[33]. The intelligent systems must also incorporate ethical constraints and define prohibited behaviors, as well as assimilate the ethical rules as part of the training and learning process of the personnel who deal with artificial intelligence systems.

The use of large-scale data poses new challenges in the field of human and civil rights, the protection of democracy, and so on. In addition, the profound implication of using artificial intelligence is that machines will replace some of the decisions currently made by humans, and therefore the ability of humans to control them and predict the consequences of their actions will decrease. **To this end, clear rules must be defined for what is allowed and what is forbidden in the field of development and production of intelligent systems and data handling in general. It is necessary to formulate new and adapted ethics and regulatory**

33 See details in Part II, in the report of the sub-team on Ethics and Regulation.

frameworks that will make Israel a leader in the field. The experience worldwide indicates that when it comes to emerging technologies, over-regulation and rules that are too strict can stifle innovation in the development and growth stages[34]. Therefore, Israel should take a balanced approach that can become a model for other nations to emulate, in accordance with the following guidelines:

1) **The guiding ethical principles[35] in the field of artificial intelligence should be adopted:** fairness, accountability, protection of human rights, cyber and information security, safety, and maintaining a competitive market.

2) **It is necessary to formulate an approach to regulation that promotes balanced intervention**. Regulation can be carried out with a variety of tools, from ethical norms to legislation and for each case, the tool must be adapted to the level of risk posed by the use of artificial intelligence. In general, **it is recommended to establish regulation only in the minimum manner required**, in order to enable Israel's innovation and continued leadership in the field, while maintaining clear and appropriate ethical and regulatory rules.

3) **To encourage self-regulation, Israel should encourage the use of tools for risk assessment and early identification of ethical challenges during the development and production stages**, such as the two-stage tool formulated by the sub-team that dealt with the subject. The tool makes it possible to identify places that are prone to failure across the development and production chain of the intelligent system, as well as to assess the degree of impact and the risk that results from this.

4) **The ability to assimilate ethical rules in the algorithms of the learning systems, or as part of the training process of the artificial intelligence systems, needs to be developed**. Regardless of the goal function and desired behavior on the part of the machine, it is necessary to incorporate ethical constraints and define forbidden behaviors in the intelligent systems.

5) **Israel must integrate into the relevant international forums and influence the norms that are being formed in them, so that these norms are consistent with its interests.**

6) **The ethical rules must be taught and assimilated as part of the training and learning process of those involved in artificial intelligence systems**.

34 Stifling regulation, which would suppress innovation altogether, should be avoided. See criticism of drastic damage to the economy, competitiveness and innovation in the EU following the application of GDPR regulations: https://www.datainnovation.org/2019/06/what-the-evidence-shows-about-the-impact-of-the-gdpr-after-one-year

35 For further details on the guiding ethical principles defined by the sub-team on Ethics and Regulation, see "Chapter 2 – Ethics and Artificial Intelligence" in the team report in Part II.

3. Capacity Building and Flagship Projects

A. Empowering the Industrial Sector and Strengthening Industry-Academic Relations

Summary: We recommend streamlining the engagement processes between academia and industry in areas related to artificial intelligence, by creating a "Green Track" that bypasses technology transfer companies, in order to simplify engagement with the universities and to facilitate commercialization through them. In this way it will be possible to promote basic research, applied research and R&D and human capital collaborations between academia and industry, while overcoming the barriers arising from the current structure of the technology transfer companies. Additionally, the R&D budgets of the Israel Innovation Authority should be increased for the specific needs of development and promotion of special programs in the field of intelligent systems.

In order to promote basic research, applied research, R&D and human capital collaborations between academia and industry, the following steps must be taken:

1) **Facilitating commercialization through the universities:** in order to streamline the engagement process between academia and industry in a way that will deepen and expand the scope of collaboration between the sectors, artificial intelligence-based application developers will be offered a "green track" that will bypass the technology transfer companies of the universities. As part of this track, a researcher who relinquishes the university's aid will be able to hold 80% of the rights and royalties, while 20% will be transferred to the university (5% will be returned to the researcher's department and 15% will be transferred to the university itself). This will make it possible to overcome the barriers arising from the current structure of the technology transfer companies.

2) **Facilitating contact with the universities:** despite the praiseworthy activity that has been conducted in the field recently, we believe that in order to produce a catalyst that will significantly promote the transfer of technologies from academia to industry, a sweeping rule should be established for the next five years. According to this rule, once there is an engagement agreement between an industrial entity and a university, the agreed terms of the contract will be the only binding terms that apply for both parties, even if they do not comply with the regulations of the university or the technology transfer company, provided that the terms of the agreement do not violate any law. In other words, in addition to compliance with Israeli law, the engagements will be exempt from complying with any regulation set by the universities or their technology transfer companies (other than the distribution of royalties detailed above) for a period of 5 years.

3) **Increasing the R&D budgets of the Innovation Authority for the specific needs of development and promotion in the field of intelligent systems.**

B. The Government Sector

Summary: In order to save time, costs, bureaucracy and resources, intelligent technologies must be integrated in government ministries to improve the work of the ministries themselves, the interface of each ministry with the other ministries, and to make all government systems accessible to businesses and individuals alike in a way that will help overcome the efficiency divide in the Israeli economy. The return on investment and the profit from it will be reflected both in the improvement of GDP and welfare, and in the reduction of the direct budget cost, since the intelligent machines are more efficient and cheaper than the skilled personnel who are required today. As a preliminary step and a prerequisite for the integration of intelligent systems, **the digital divide must be addressed, by urgent completion (with the setting of a binding schedule) of the digitization of government services.**

To save time, costs, bureaucracy and resources, intelligent technologies must be integrated in government ministries to improve the work of the ministries themselves, the interface of each ministry with the other ministries, and to make all government systems accessible to businesses and individuals alike. The aim should be such that digital communication with the general public replaces, as much as possible, the need to physically meet or make phone calls in order to receive the desired service (of course "human contact" will remain a solution for vulnerable populations or the few problems for which the machines will not find a solution). The return on investment and the profit from this move will be reflected both in the improvement of GDP and welfare, and in the reduction of the direct budget cost, since the intelligent machines are more efficient and cheaper than the skilled personnel who are required today[36]. To do this, the following steps should be taken:

1) **Closing the digital divide: the process of basic digitization of government services must be completed as soon as possible (with a binding timetable)**. Despite the actions taken by the government in the field of digitization, there is still a significant digital divide in the work of government ministries and the public sector in general and in the interface between them and citizens. As a prerequisite for integrating intelligent systems in the government sector, it is essential to transition to digital forms that can be filled out on the relevant website so that they are saved, updated and available for retrieval by the intelligent system.

2) **Artificial intelligence must be integrated in the government sector in order to overcome the efficiency divide in the Israeli economy:** for 40 years, there has been a gap of about 30% between the standard of living in Israel, measured by GDP per capita, and similar countries in the OECD[37]. Without an accelerated increase in productivity[38], the growth rate in the economy will decrease significantly from 3.5% per year in the last decade to about 2.3% per year in the next decade[39], and the gap in GDP and standard of living between Israel and similar countries will increase to 35%[40]. This will mean that the State of Israel will be unable to provide a high standard of living for its citizens and address its social problems. Promoting innovation and productivity of the entire economy requires a government investment in information and communication technologies (ICT) to promote digitization and efficiency in the public sector[41]. Following this, the business sector will also be expected to update its digital infrastructure, in order to maintain an efficient interface with the updated public sector.

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36 We can see that in Sweden, which is similar to Israel in terms of growth characteristics and population growth, extensive investment in public sector digitization has directly affected growth due to the streamlining of public and private sector, and especially in the areas of trade and professional services. Data from the Government ICT Authority indicate that, on average, transition to digital services reduces the cost of services provided by telephone by 20%, and the cost of services that require physical attendance is times 50 lower (this data was taken from an e-government presentation of the Government ICT Authority at the conference "Smart Government – Innovation and Entrepreneurship in the Public Sector", which was held at the Jerusalem Institute for Policy Studies on November 18, 2019).

37 The customary comparison with the OECD average is misleading because it includes poorer countries, and therefore a comparison with a group of strong countries with conditions similar to those of Israel is preferable. Examples of such countries are Austria, Denmark, the Netherlands, Finland, and Sweden, which are characterized by higher per capita GDP and productivity than Israel, and with lower poverty rates. See: Eckstein, Z., A. Lifschitz, S. Menahem-Carmi & T. Kogot (Nov 2019), "Strategy for Economic Growth 2019", Aaron Institute for Economic Policy, Policy Paper 2019 .03 (Hebrew).

38 The growth engines for reducing the gap are an increase in the employment rate or an increase in productivity, *i.e.* in product per hour worked in Israel. Compared to leading OECD countries, the employment rate in Israel has almost reached its peak as a growth engine, while the productivity gap is only growing in a way that establishes it as an obstacle to growth. The high productivity and innovation in Israeli high-tech are directed outwards and do not permeate the rest of the economy, where there is a low level of ICT.

39 Eckstein *et al.* (2019), "Strategy for Economic Growth 2019".

40 Eckstein, Z. (2019), "Economic Strategy for Promoting Investment in the Economy", presentation in the Aaron Institute Conference 2019. Slide 12 (Hebrew).

41 Today, the amount of capital per capita invested by the Israeli government in ICT is only 42% of the average of similar OECD countries (Israel is third from the end) and the gap is expected to continue widening. See Eckstein *et al.* (2019). Strategy for Economic Growth 2019.

3) **The investment required in the development of the field of artificial intelligence in Israel must be leveraged in order to accelerate the growth of efficiency and productivity in the economy and reduce the gap with similar countries in the OECD**. With relatively small investments, it will be possible to integrate intelligent systems, which will be at the service of the citizens 24/7, every day of the week, into identification and identity verification processes. Later, the machine can easily guide a written or spoken conversation between a person and a machine that understands the questions asked in a natural language (in many languages) without any human involvement ("chat bot"). During the call, the machine will search the required data in the cluster of documents, which will all be stored in digital repositories, and with the aid of algorithms it will retrieve the right documents for review, evaluation, and handling.

4) **Technological "taskforces" for government ministries**: faced with complex needs or challenges that involve a technological layer, government ministries should be allowed to assemble ad hoc heterogeneous thinking and task teams, including experts from industry and academia, in order to formulate a specific technological policy aimed at solving the challenge. We are aware that this recommendation is problematic because it requires a large pool of professionals at the government's service, but it is an international trend which, in our opinion, is inevitable.

C. National Capacity Building (Flagship Projects)

Summary: Building capacity and national projects in the fields of health, transportation, security, and agriculture, must be promoted. These are fields in which Israel has a suitable basis for integrating intelligent systems and a relative global advantage. National projects in these areas will be able to meet real needs in the country and actually become a platform around which an entire ecosystem will be formed. This will enable a stable long-term state of economic and social growth and will also provide a basis for realizing Israel's relative advantages at the global level. In addition, we also recommend considering a project in the field of government digitization (where we don't have a relative advantage, but we believe that through using artificial intelligence we will be able to bridge Israel's large gap in relation to advanced countries).

Building a national capacity is based, among other things, on locating key sectors in which a massive integration of intelligent systems will meet a real need in the sector and turn it into a locomotive that will help in creating a revolution at the national level. National projects in these sectors are excellent platforms for initiating, consolidating and accelerating the entire ecosystem. A national project binds industry, academia, government, and sectors of the economy into a single innovative system and enables a stable long-term state of economic and social growth. The selected areas – health, agriculture, transportation and security – are sectors that combine: (1) an area in which Israel has an advantage and a suitable basis for the integration of intelligent systems; (2) a relative global advantage; and (3) an entire ecosystem can be built around them. The projects are detailed below.

1) **Health**

We recommend that Israel lead a revolution in the field of health, which will change and improve medical care, streamline the entire health system and launch a comprehensive ecosystem that will give all its partner sectors the opportunity to export the technologies and services developed within it to the outside world. Israel needs to utilize intelligent technologies at the national level to launch a national array of services – remote patient management; streamlining of triage and treatment work in emergency medicine departments, in a way that will ease the burden on hospitals; and for the production of comparative quality indices for the evaluation of clinical outcomes. To this end, **the barriers of privacy, regulation and bureaucracy regarding information sharing must be urgently removed: collaboration between organizations, HMOs, research institutions and hospitals must be encouraged; European or American regulations must be adopted; and specialized and complementary training of human capital in medical AI must be created, in order to form a critical mass** of physicians, health professionals, and information scientists, who will lead the research, application in the field and train the next generation of medical information specialists.

The medical databases in Israel grant it a relative advantage that shrinks over time. The source of Israel's advantage is its central health system which is based on centralized information infrastructure of a permanent population with a genetic heterogeneity that is relevant to the wider world, and which is under continuous monitoring made possible due to Israel's identification method, which is unique in the world. This identification method enables one-to-one identification through an individual's ID number and the information about them, which is accumulated in the various health systems throughout their life. However, regulatory and privacy constraints, the need to be protected from lawsuits, etc. make the use of these repositories almost impossible.

Despite the above, there are many other problems in the health system that artificial intelligence could solve or significantly reduce, from hospital congestion to early detection of various diseases. These challenges are not unique to Israel, and finding solutions for them or groundbreaking ideas to deal with them will not only save an enormous amount of resources in the domestic aspect, but will also turn Israel into an attractive center for investment, attracting experts, research and business collaborations that will significantly advance the entire Israeli ecosystem. Israel has the opportunity to lead a revolution in the field of healthcare, for which it must invest resources at the national level and launch a groundbreaking national flagship project that will reform and improve medical care, streamline the entire health system, and launch an entire ecosystem that will allow all partner sectors to export the technologies and services developed as part of it.

Taking into account all these considerations, we propose the following project:

A) National project to revolutionize the Israeli health services:

(1) **An intelligent systems-based array that will enable remote patient management as well as streamlining the triage and treatment work in emergency medicine departments**. This will be reflected in **reducing the burden on hospitals through intelligent technologies that will strengthen community medicine** by promoting virtual doctor visits; **alleviate the congestion in the emergency rooms** through the use of automated tools for quick and accurate assessment of patients upon their arrival (past data processing, current image and acceptance indices); and **alleviate the congestion in the wards** by enabling alternatives to hospitalization including home hospitalizations, with a special focus on internal wards, rehabilitation wards and geriatric wards.

(2) **Production of comparative quality indices to evaluate clinical outcomes.**

B) In order to realize the project, the following issues must be addressed:

(1) The barriers to information sharing (privacy, regulation and politics) need to be resolved urgently. Today it is much easier to obtain medical information for analysis and processing from various entities abroad than it is from the HMOs in Israel. The state must create the regulatory and economic infrastructure that will enable the information to be made accessible for everyone, defined by the state, according to clear rules. It is important to emphasize that since most of the information is not in the hands of the government, but in the hands of private entities, the government has to create an accessible framework through incentives and not through coercion. Technology can also help here, for example homomorphic encryption applications (see our above reference to data infrastructures, at p. 34) as a possible solution to the sharing challenge.

(2) **Cooperation between organizations, HMOs, research institutions and hospitals should be encouraged**. The government should increase and deepen the initiatives and encouragement to establish collaborations that will contribute to the consolidation of the complete ecosystem in the field of medicine, both within Israel and outwards, internationally.

(3) **Adoption of the rules of European (CE) or American (FDA) regulation**, since Israeli companies will have to comply with them in any case. There is no need for Israeli regulation beyond that.

(4) **Dedicated and complementary human capital training in the field of medical AI:** It is necessary to create a critical mass of physicians, other health professionals and information scientists to lead research in the field and train the next generation of medical information specialists. To this end, it is recommended:

- **To expose all students** to the subjects of big data, AI and machine learning, as part of enrichment courses at the medicine school.

- **Perform in-depth training (probably at least one or two years) for about 15%** of all students with a suitable background (graduates of information systems studies and/or military units such as 8200). In this period, which means a medical student extends their studies to nearly ten years, they should be granted a tuition scholarship + tax-exempt subsistence scholarship of NIS 10,000-12,000. Clearly, entering such a subsidized track will be accompanied by a multi-year commitment to work in the public system.

- **Post-doc physician training at leading centers abroad**. It is advisable to issue a public declaration and a selection process of ten young physicians with a **suitable background in the core professions and leadership qualities** – and to fund their study abroad at leading institutions.

2) Agriculture

Summary: We recommend promoting a national project to develop a system based on intelligent systems for the early detection of pests and diseases in agricultural crops, along with integrating intelligent systems in the agricultural sector for optimal utilization of natural resources and inputs to ensure optimal food production. In an age where food security, water management and other areas of agriculture are becoming acute global challenges, Israeli solutions based on intelligent technologies will meet both local and global needs, in a way that will make Israel a global model and exporter of knowledge and technologies in this essentially humanitarian field.

In an age where food security, water management and other areas of agriculture are becoming acute global challenges, Israeli solutions based on intelligent technologies will meet both local and global needs, in a way that will make Israel a global model and exporter of knowledge and technologies in this essentially humanitarian field. There are a few notable relative advantages that increase Israel's potential to become a global leader in the field:

- The agricultural sector in Israel is a technological leader when compared to the rest of the world and is open to the adoption of new technologies.
- In agriculture, there are fewer barriers relating to regulation, privacy, etc., than in other areas, so it will probably be easier to promote a flagship project in the field in an effective way that will enable technological realization and even breakthroughs relatively quickly.
- In any case, the agricultural sector produces a great amount of data, and Israel has accumulated a great deal of experience and knowledge (concentrated in the Agricultural Research Organization – Volcani Center) in the field of data collection and its integration into decision-making systems. This fact, alongside the presence of global experts in the field of pests and agricultural engineering in Israel, gives it the potential to bring about global breakthroughs in the field of artificial intelligence in agriculture.

The flagship project to revolutionize agriculture is comprised of two parts:

A) **Development of a system based on intelligent systems for the early detection of pests and diseases in agricultural crops.** The benefits of this project will be improvements in food security by reducing food loss and damage to its quality as well as minimizing harm to the environment by reducing the use of toxic pesticides and workers. In addition, it will be possible to draw lessons from this project concerning the health of not just plants, but also humans, in an environment where sensitivity to privacy and regulation will not constitute too great a restrictive burden on development.

B) **Integrating intelligent systems in the agricultural sector for the optimal utilization of natural resources and inputs to ensure optimal food production (Precise Agriculture).** This project will make it possible to optimize the utilization of land and water resources, increase crops, improve food quality, increase farmers' profits and reduce environmental pollution.

3) Transportation

Summary: Of the many options that intelligent systems can be used to solve acute transportation problems, we have chosen to recommend, as a first step, the installation of intelligent traffic lights throughout a pilot metropolitan area. We chose this for the purpose of dealing with the traffic congestion issue, which is the most serious and urgent transportation problem that requires a solution in Israel in general and in Gush Dan (the central area of Israel) in particular. Integrating a unified artificial intelligence system across the Metropolitan traffic lights system in this area will allow all traffic lights to respond in real time to the changing traffic dynamics and to regulate loads more efficiently for the benefit of all road users. A flagship project that harnesses these technologies to solve the traffic congestion problem will benefit citizens, streamline the economy and increase productivity by reducing wasted time and resources, reduce the number of road accidents and therefore, casualties, and contribute to the environment by reducing air pollution due to a decrease in the number of polluting vehicles in use.

The field of transportation is complex and includes a variety of problems that can be promoted through artificial intelligence. However, it is clear that the most serious and urgent issue is the problem of traffic congestion in all the cities in Israel and especially in Gush Dan. This is a national challenge that manifests itself in harming the daily lives of citizens, reducing productivity in the economy, and in general, creates

a huge waste of time, resources, and even human lives due to an increase in the number of accidents resulting from more and more citizens being on the road for longer periods of time. Many intelligent technologies are designed to solve transportation problems, such as intelligent traffic lights systems, smart charging systems for electric vehicles, autonomous vehicles, and shared transportation. These include a huge collection of sensors, command and control systems, and data. A flagship project that will harness these technologies to solve the traffic congestion problem will benefit citizens, streamline the economy by reducing wasted time and resources in a way that will increase productivity, reduce the number of road accidents and therefore casualties, and contribute to the environment by reducing air pollution, by reducing the number of polluting vehicles in use.

The flagship project to solve the problem of traffic congestion:

A) **Stage A: intelligent traffic lights systems throughout a pilot metropolitan area.** As a first step in dealing with the traffic congestion issue, it is necessary to transition to a intelligent traffic lights systems in the areas of all the local authorities in the congested area. Integrating a unified artificial intelligence system across the metropolitan traffic lights system in this area will allow all traffic lights to respond in real time to the changing traffic dynamics and to regulate loads more efficiently for the benefit of all road users.

B) **Stage B: Metropolitan traffic centers.** Following the implementation of the intelligent traffic lights system, and based on the joint work between different local authorities that will be required due to its deployment, we recommend setting up metropolitan traffic centers in order to optimally address transportation issues that exceed the boundaries of any specific city, and therefore require coordination at the metropolitan level.

4) Security

Summary: A strategic plan and significant state investment are required to exploit the potential inherent in the field of artificial intelligence (especially in the fields of intelligence superiority, operational intelligence, autonomy and swarms, and efficiency in general), generating a significant leap forward in the operations of the defense forces' and in contributing to Israel's national security. **Assessments and capacity building in the areas of security capabilities must be combined with the overall national effort in the field of intelligent systems by strengthening collaboration between security, industry and academia, training skilled personnel, and formulating a sustainable ecosystem around a national project to establish a common security-civilian system for smart and safe state management, both in routine and emergency conditions.** The system will monitor, collect and analyze data from all relevant entities in the country in routine conditions, in such a way that will allow for optimal preparedness in times of emergencies and optimal decision-making during such conditions.

The defense forces have been successfully promoting artificial intelligence solutions in various areas for several years. However, in preparation for the next multi-year plan, there is a general recognition among the defense forces that a strategic plan and significant state investment are required to utilize the potential inherent in the field of artificial intelligence, to generate a significant leap forward in the defense forces' operations and contribution to Israel's national security. Intelligent technologies and systems are the foundation for achieving intelligence superiority, operational intelligence, autonomy and swarming capabilities, and for streamlining in general. In addition to the clear benefit to national security, a smart combination of preparing the defense system and building its capabilities as part of the overall national effort in the field, will help advance the State of Israel to the position of a global power in the field of artificial intelligence; by strengthening collaborations between security, industry and academia, training skilled personnel and consolidating a sustainable ecosystem around a joint security-civilian project for routine and emergency periods. Beyond the flagship project, combining the defense system in the national enterprise will also contribute to the economy beyond direct security, but also in the areas of infrastructure and skilled manpower training:

A) **Shared computing infrastructure** – the required collaboration between the defense and civilian sectors is also expressed in the sharing of infrastructure, and in the fact that the Israeli cloud and the HPC center to be established in Israel will be shared by civilian government entities and the defense forces, with the required separation between the parts for compartmentalization purposes (for more information see the detailed discussion regarding the computing infrastructure above, at p. 27).

B) **Training of skilled personnel**: The scope and quality of personnel in the field of artificial intelligence in the IDF must be increased significantly. The skilled personnel will constitute a security force multiplier in the coming years, and will later integrate into the national ecosystem and strengthen it with the experience and the capabilities acquired during their military service. To this end, the IDF needs additional personnel in the field as detailed below:

- Soldier-students in the field of Data Science (DS).
- Programmers at Data Engineer level, while tracking programmers for DS in a structured classroom funded by the IDF.
- Data Analysts.
- Taggers: increase trained personnel in this area.
- Increasing the staff in the School for Computer Professions by 30%.

As for the national project in the field of security, we have deliberately chosen a project that concerns the entire public, and is related to the management of the entire population and all sectors in an emergency. Pure, more classified security projects were naturally not included in this document.

C) **National project - Command and control of a smart and secure city/state in emergency and routine periods:** Significant breakthroughs in artificial intelligence allow for more accurate predictive capabilities and better ways to deal with new situations that were not expected in the first place. These capabilities can and should be used to prepare for a variety of emergencies, from natural disasters to security threats when dealing with the enemy. A unified dual system based on intelligent technologies, for command and control at the service of the civilian sector in routine periods, and at the service of the security sector in emergency periods, will enable optimal preparedness and readiness in routine periods, as well as optimal decision-making in emergency periods. This system, which will be active constantly, at all times, will monitor, collect and analyze data from all relevant entities in the country in routine periods in preparation for emergencies that may arise. A national project in this field will promote a complete and sustainable ecosystem around it, as part of which close cooperation will be carried out between all sectors (security, industry, academia and government), skilled personnel and experts in relevant technologies will be trained, and, of course, advanced technologies will be developed in fields that serve both the civilian sector and the security sector:

- Flow of information sources – live information sources and access to additional information sources.
- Structuring the different types of information.
- Information processing that combines complex analytics and algorithms.
- Classification of insights and providing accessibility to relevant entities.
- Implementation of active operations in synergy and coordination between all means (swarms).

5) **The Government Digitization Project**

As stated, initially we considered defining a national project in the area of finances as well, but it became clear to us that the State of Israel has no advantage over the world in this particular field, and that in the financial sector the market takes its course. However, we believe that if we carry out all the other projects described above, such a strong ecosystem will be formed in the country that it will bring the global business sector to invest in Israel in the particular area of development of intelligent systems in the financial sector. A similar phenomenon occurred during the cyber and fintech revolution that we underwent about a decade ago.

During our work, it became clear to us just how much Israel is lagging behind in the field of digitization of the government sector. As a preliminary step and a necessary condition for the integration of intelligent systems, **the digital gap must be addressed. This can be achieved through the urgent completion (with the setting of a binding schedule) of the move to basic digitization of government services. We therefore recommend, regarding the activity defined above (in the discussion on the "government sector" on pp. 38-39), with government digitization at its center, as another flagship project of this initiative.**

Appendixes

Appendix A – The Definition of Intelligent Systems

After the Industrial Revolution, the computing revolution penetrated all areas of our lives and became the dominant technology in them. In the first stage, "the computer as a platform" made new computational and management capabilities accessible within systems and later – networks. In the second stage, "cyberspace" added almost complete connectivity to computer and communication networks and made the Internet accessible to almost any place and person. Minimization and cost reduction of computational and memory components, along with the ability to store and process information at unprecedented volumes and speeds, have driven far-reaching changes in the industrial world, the economy and the fabric of life, in a way that affects our lives as individuals, society, and country. **Today, the world is approaching the third stage of the computing revolution, the stage of "intelligent systems", in which computerized systems will generate new knowledge and function independently and "intelligently".** The techno-scientific basis for the maturation of this stage is the combination between the significant progress of the recent years in Artificial Intelligence (AI), and especially in the field of Deep Learning, and the unprecedentedly accelerated and minimized computing, communication and processing capabilities, including quantum technologies.

Under the title of "Intelligent Systems", the current initiative refers to acquiring the capabilities Israel requires in the following fields:

1. **Machine Learning and Data Science:**

   These are the building blocks of artificial intelligence (AI) technology, the purpose of which is to grant computers the ability to perform tasks in a way that would have required intelligence had they been performed by humans, for example – understanding text, speech, video, images, the ability to draw conclusions and recognize rules, to think strategically, and more. The ability to perform these tasks automatically will lead to many applications in which the computer will replace human beings and even surpass them (in terms of processing time, memory, cost, etc.). Artificial intelligence technologies based on algorithms that learn from data are already required today in almost every field, and there is global recognition of the prominent place that they will have in decision-making as the digital world continues to evolve. Learning through tagged data is called supervised learning, where the machine, based on a preliminary statistical model, optimizes the model and polishes it by examining thousands of examples. On the other hand, in view of the increasing amounts of untagged data (from networks, infrastructure, IoTs, the Internet, etc.), Unsupervised learning is developing, in which the machine develops its own model for performing the operation based on a larger amount by orders of magnitude of data and examples. One of the most advanced and promising directions in the field of artificial intelligence is **deep learning** technology, where instead of relying on "pre-dictated algorithms" to perform actions, there is an attempt to mimic the process of the human brain by training the machine for action, feeding it data and analyzing its performance. Deep learning is done through many layers of artificial neural networks, each of which handles a simple computational task in the information processing process, with the aim of enabling them to jointly perform a complex operation. A combination of deep learning systems and other learning methods that allow gaining analytical insights, identifying exceptions and supporting "automated" decision making will be at the core of development in the field.

All of the learning methods mentioned above require massive amounts of data and computing power. The immense increase in the amount of available information that is created and stored in organizations and companies, along with the increase in computing power that enables its rapid processing, all while producing insights that are often unachievable by the human brain, led to the creation of a new discipline called **Data Science (DS)**. DS allows for the deduction of insights, value, and benefit to security, the economy and society from utilizing the vast amount of information that is gathered, including the pieces which are seemingly unrelated to one another. The integration of AI techniques, with the ability to access and process big data (DS), opens up exceptional opportunities in a variety of fields, including medicine, intelligence, transportation, city management, communications, and more. Additionally, this technology is changing the way science and research are conducted, and therefore whoever leads this learning competition will gain multidisciplinary superiority for decades to come.

2. Autonomous and Robotic Systems:

Autonomous systems are "robotic" systems that can sense, analyze, make decisions, and perform a variety of actions independently, while interacting effectively with humans and other robotic systems. For example, one such system, around which a huge global industry is currently being built, is the autonomous vehicles system. There is great potential for the application of such systems, from home-cleaning robots, through assistance systems for aging population, to systems for improving supply mechanisms, defense systems, and much more. The development of these systems also relies heavily on computing, sensing and learning capabilities, along with the development of smart sensors. The technologies required are, first and foremost, deep learning and computational infrastructure, but also algorithms to support decision-making, engineering of complex systems, learning materials, improving emotional intelligence and artificial consciousness capabilities, improving the human-machine interface, and more.

3. IoT and Sensors:

The computerized communication space is rapidly evolving towards the Internet of Things (IoT). Many systems in almost every field are becoming small computer systems that are interconnected (connectivity), with processing capabilities (computer) and sensing capabilities (sensors). Since 2011, there are more devices in the world that are connected to networks than there are human beings[42]. Today there are about 17 billion devices connected to the Internet, and the expectancy is that by 2025 their number will be doubled to 34 billion[43]. The connectivity between the systems themselves and between them and key factors (command and control, operation), will yield much information, but at the same time would also lead to challenges of collecting, storing, authenticating, and analyzing the information. There will be further challenges in constructing data and component networks; automation of operation and repair; cyber security; standardization and protocols; unification and balance between hierarchies of elements and uses, nanoengineering, as well as aspects of privacy, ethics, law, psychology, and more. The ability to represent the complex physical world through a perfect digital model, which allows the examination and solving of complex problems (logistical and others), while examining possible solutions in real time, will continue to grow, and with it new business opportunities will emerge, including security capabilities related to future battlefields.

42 Broadband Commission for Digital Development, 2012, p. 6.

43 Knud Lasse Lueth, State of the IoT 2018: Number of IoT devices now at 7B – Market accelerating. *IoT Analytics*.

4. **Distributed Intelligence:**

The field of networks is developing at a very fast pace. Many applications are based on "Network Intelligence", which is formed not in its endpoints or in a central "brain", but rather in the interaction between the elements – *i.e.* in the network itself. The ability to store, encode, validate and share information efficiently and securely on such a network relies on new technologies such as Block Chain, and grants the network as a whole survivability and task completion capabilities, even if end units are damaged along the way. Examples of applications that rely on distributed intelligence capabilities include swarms of unmanned aerial vehicles (drones), swarms of detectors from various fields, advanced radio networks and more. The ability to design and control the engineering of such networks is essential for many future applications in the fields of security and emergency, environment protection, medicine and others. The IoT field is also expected to integrate into the trend of distributed intelligence and create intelligence that is not located at a single endpoint but in the integration of all elements in the system. This field, which is in its infancy, requires the development of knowledge and capabilities to design, construct and analyze networks of all kinds, with an emphasis on the "intelligence" of the network itself.

5. **Computation and Information Infrastructures and Quantum Technologies:**

The development of all the technologies mentioned above and their use depends on physical infrastructure, and in particular computing infrastructure (whether in multi-core supercomputer arrays, quantum computing that allows certain computational operations to be performed with ultra-high efficiency, or any other computing infrastructure) and information infrastructure (both for its secure transmission and for its creation). The field of Quantum Information Science (QIS) includes three sub-fields: the creation of quantum information (quantum sensing), its transmission (quantum communication) and its processing (quantum computing/simulations). Thus, for example, quantum communication enables the realization of communication channels that are immune at the physical level, even when facing unlimited computing power. The areas of quantum sensing, which are the more mature layer of this technology, allow for superior precision and levels of performance, which already today lead to operational results in security applications, as well as in various and diverse civilian uses. Such infrastructures require knowledge and capabilities in hardware, energy, communication networks, algorithmics, and more. It is important to note here that quantum technologies are not limited to computing but are also of great importance in other areas (such as IoT, for example) that include quantum encryption, quantum communications, quantum devices, algorithmics and others. Recognition by nations and international entities, corporations and companies of the enormous potential inherent in the quantum field, as well as of the limitations of those left behind, has led to a race to achieve "quantum superiority" backed by vast investments in support of overt national programs as well as classified development efforts for security-related applications.

The huge increase in computing power has led to a situation where various learning algorithms have already begun to penetrate all areas of life. Their understanding requires mastery not only of technological disciplines such as computer sciences, mathematics and engineering – but also of social, legal, business and even philosophical aspects. **It is important to understand that this is not the development of another field or area in the high-tech industry, but rather the beginning of a new era in which advanced information and computing infrastructures will enable the application of intelligent technologies and systems that will be integrated into all areas of life (economy, health, education, transportation, government, security and more) and change the patterns of human activity as part of their operations. Those who are able to master the intelligent technologies and be the first to derive value from them, will lead the world and dictate the rules of the game later in the race. Those who do not will be left behind, at the mercy of the first group.**

Appendix B – Future Global AI Market Value Estimates

McKinsey (April 2018)[I]: AI COULD POTENTIALLY CREATE 3.5 TRILLION UDS TO 5.8 TRILLION USD IN ANNUAL VALUE IN THE GLOBAL ECONOMY. These figures are not forecasts for a particular period in time, but they are indicative of the considerable potential for the global economy that advanced analytics represents.

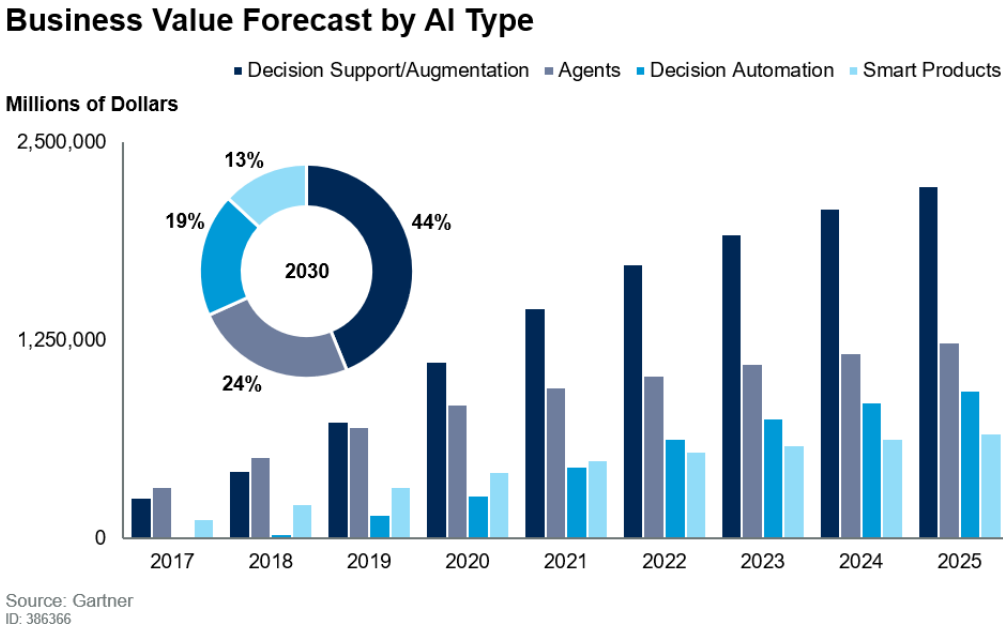
Gartner (April 2018)[II]: Global business value derived from artificial intelligence (AI) is projected to total 1.2 trillion USD in 2018, an increase of 70 percent from 2017. AI-derived business value is forecast to reach 3.9 trillion USD in 2022.

Forecast of Global AI-Derived Business Value (Billions of USD)

	2017	2018	2019	2020	2021	2022
Business Value	692	1,175	1,901	2,649	3,346	3,923
Growth (%)		70	62	39	26	17

Source: Gartner (April 2018)

Gartner (August 2019)[III]: **Worldwide Business Value by AI Type (Millions of USD)**

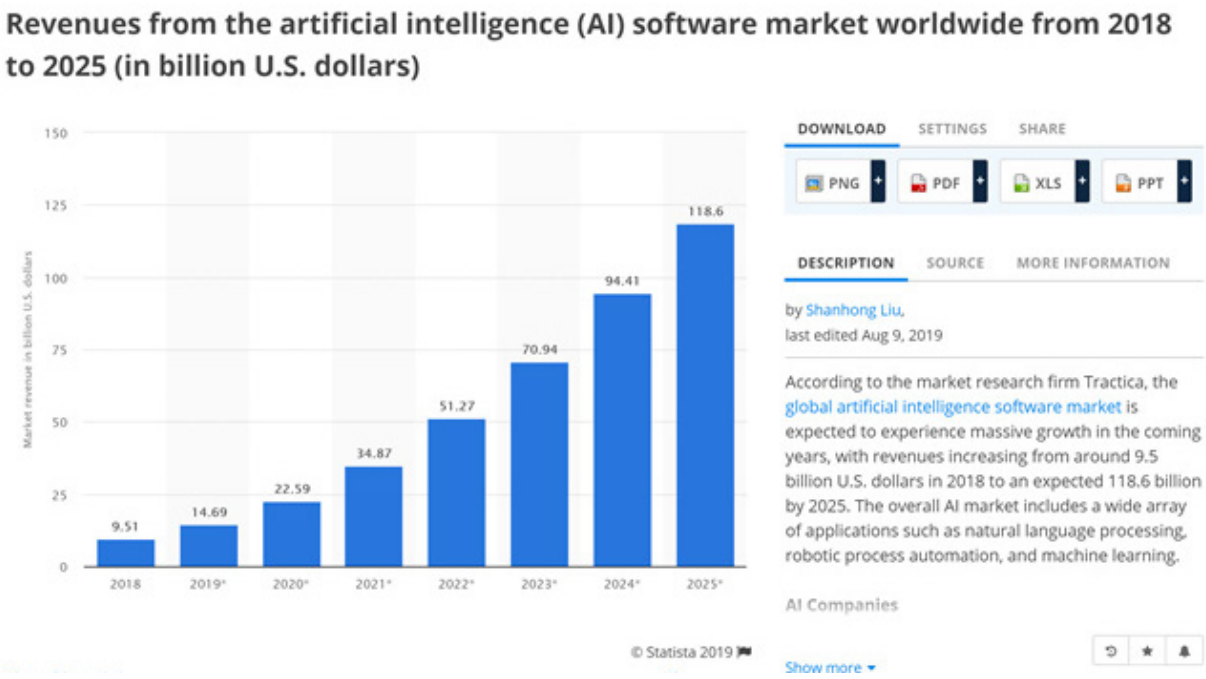


I McKinsey Global Institute (April 2018). NOTES FROM THE AI FRONTIER INSIGHTS FROM HUNDREDS OF USE CASES.

II https://www.gartner.com/en/newsroom/press-releases/2018-04-25-gartner-says-global-artificial-intelligence-business-value-to-reach-1-point-2-trillion-in-2018

III https://www.gartner.com/en/newsroom/press-releases/2019-08-05-gartner-says-ai-augmentation-will-create-2point9-trillion-of-business-value-in-2021

Global artificial intelligence software market is expected to experience massive growth in the coming years, with revenues increasing from around 9.5 billion USD in 2018 to an expected 118.6 billion USD by 2025.

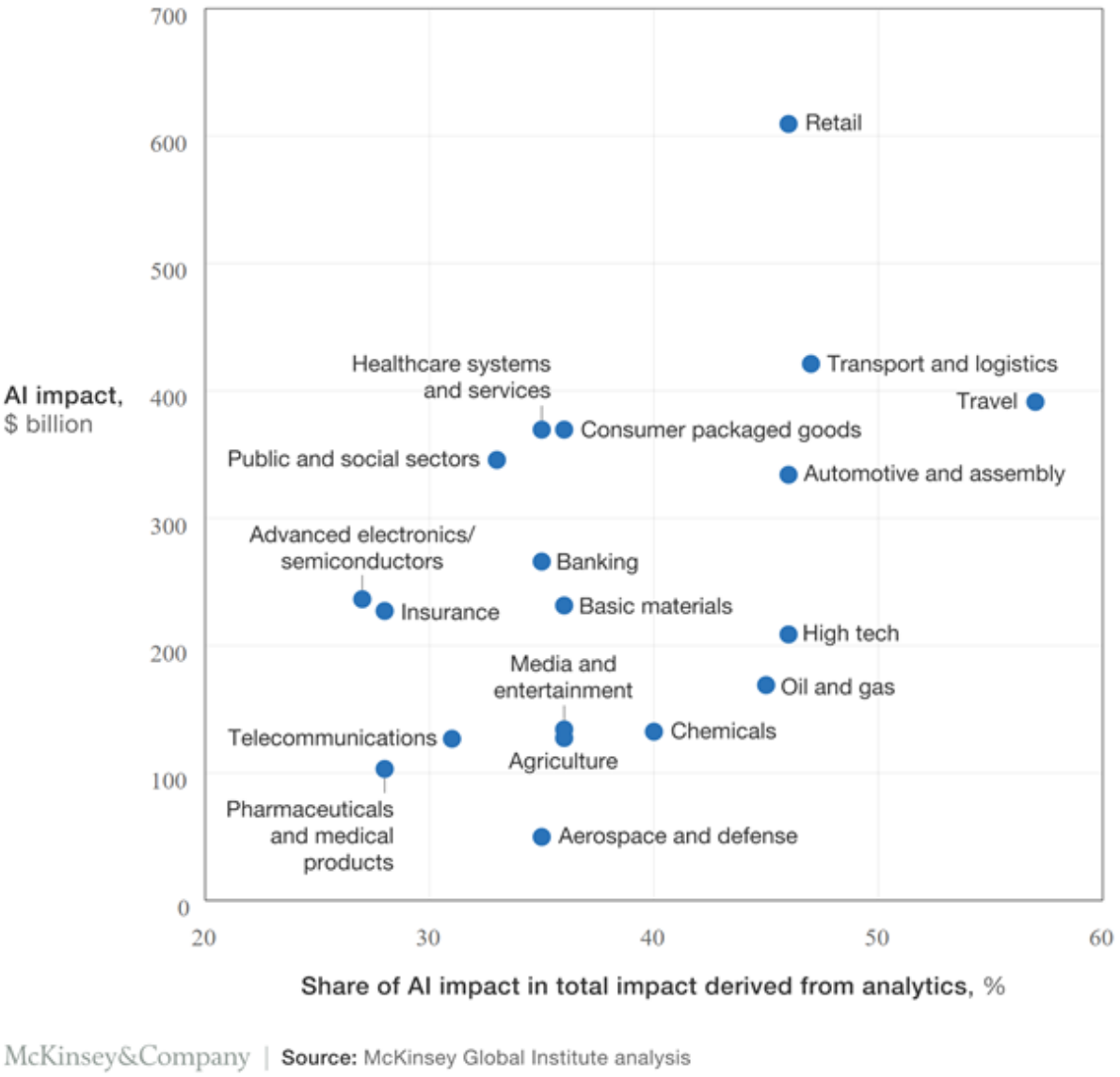


Sources: Statista (Aug 2019); Tractica (2019)

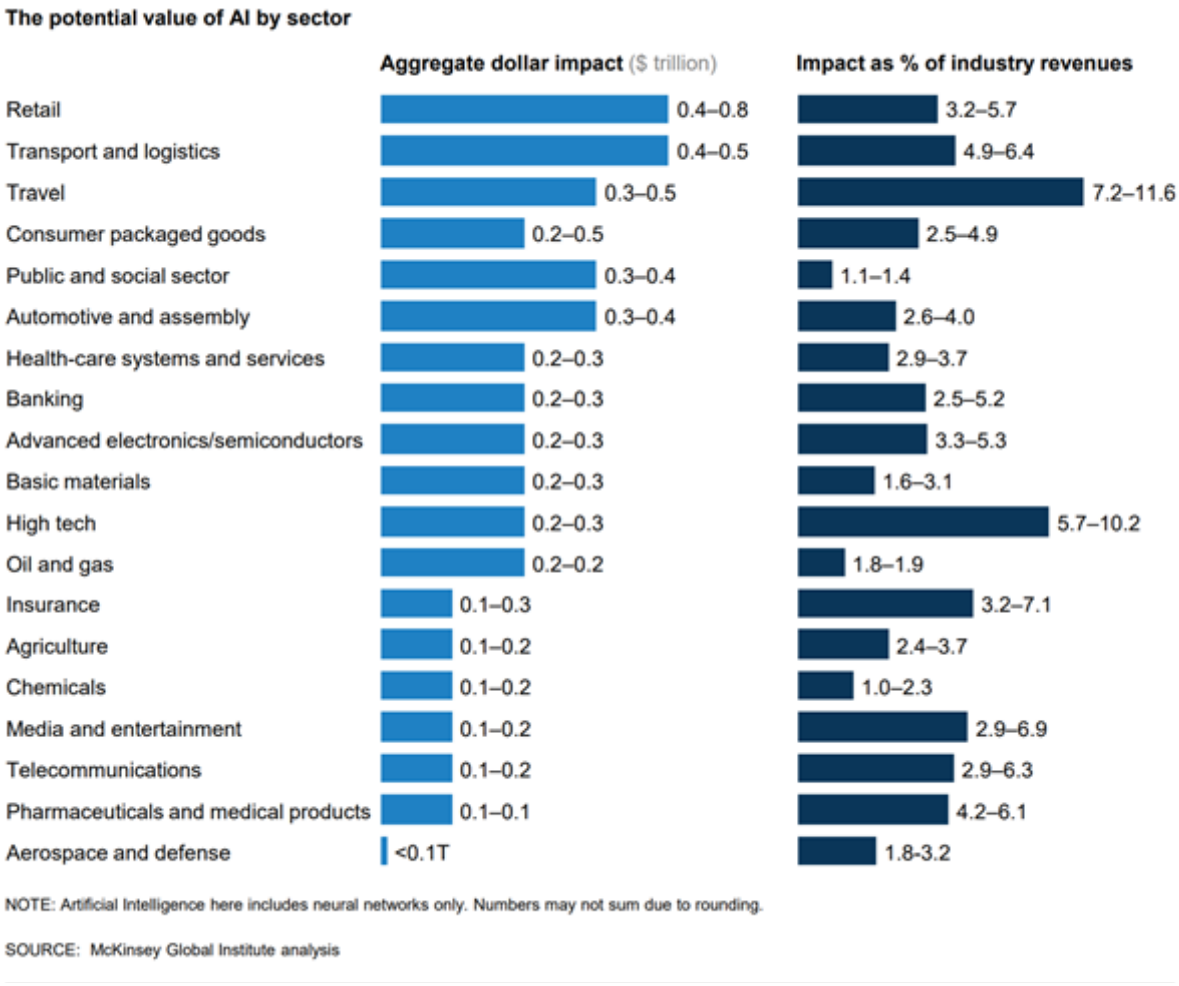
- IDC predicts worldwide spending on cognitive and Artificial Intelligence systems will reach 77.6 billion USD in 2022[IV].
- Statista (February 2019): The annual global funding of AI start-ups experienced a high growth of over 70% average growth rates from 1.7 billion USD in 2012 to 15.2 billion USD in 2017.

IV Columbus, L. (March 27, 2019). Roundup Of Machine Learning Forecasts And Market Estimates For 2019. *Forbes.* https://www.forbes.com/sites/louiscolumbus/2019/03/27/roundup-of-machine-learning-forecasts-and-market-estimates-2019/#6478f86f7695

AI has the potential to create annual value across sectors totaling 3.5 trillion USD to 5.8 trillion USD, or 40% of the overall potential impact from all analytics techniques:



McKinsey (April 2018). p.18

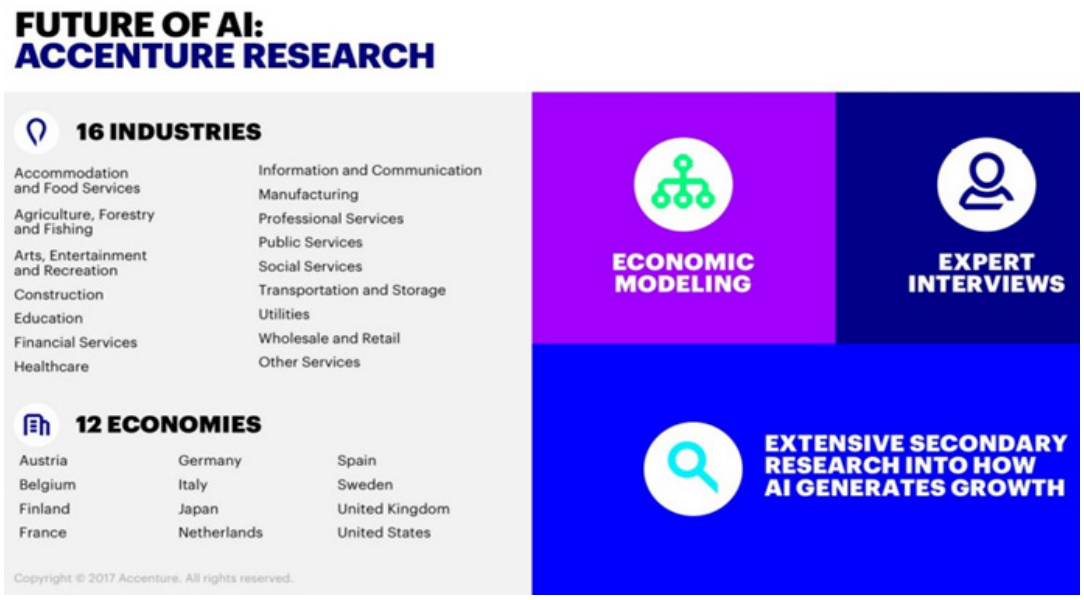


"The value, as measured by percentage of industry revenue, varies significantly among industries, depending on the specific applicable use cases, the availability of abundant and complex data, as well as on regulatory and other constraints.

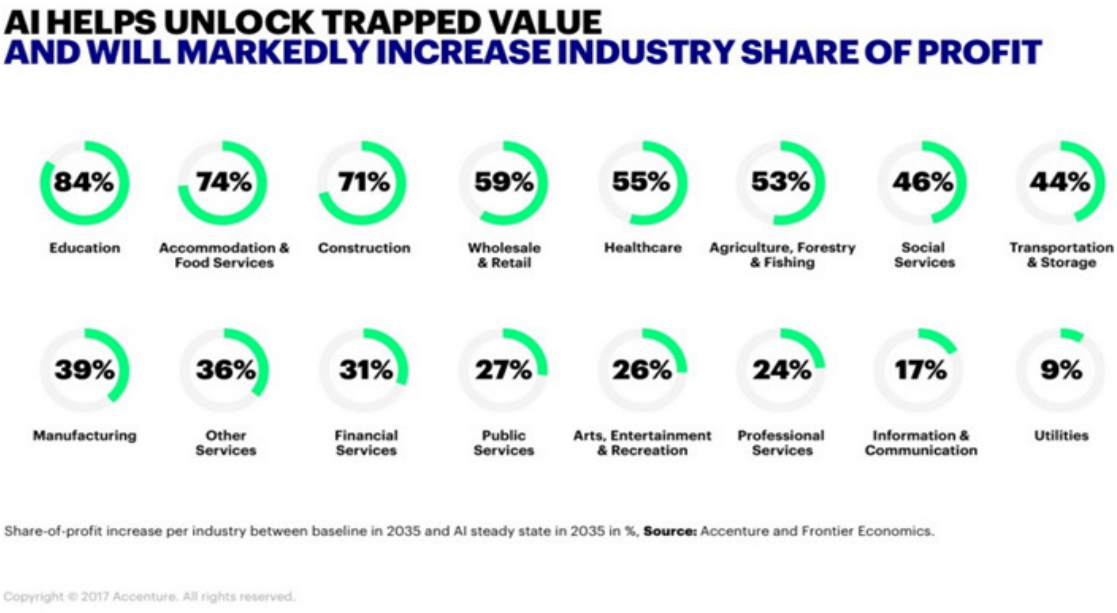
These figures are not forecasts for a particular period in time, but they are indicative of the considerable potential for the global economy that advanced analytics represents. [...] Some of this value will be captured in a variety of ways, for example it may result in more valued products and services, revenue growth, cost savings, or indeed consumer surplus. While the aggregate numbers may appear modest, in some use cases the advancements amount to radical transformation."

McKinsey (April 2018). pp. 17-18

A report by Accenture from 2017[v] examines the potential of AI to promote 16 industries in 12 developed economies which together generate more than 50% of the world's economic output (Israel is not included):



Accenture research shows that AI has the potential to boost rates of profitability by an average of 38 percent by 2035 and lead to an economic boost of 14 trillion USD across 16 industries in 12 economies by 2035. But this will only happen if organizations adopt a people-first mindset and take bold and responsible steps to apply AI technologies to their business.

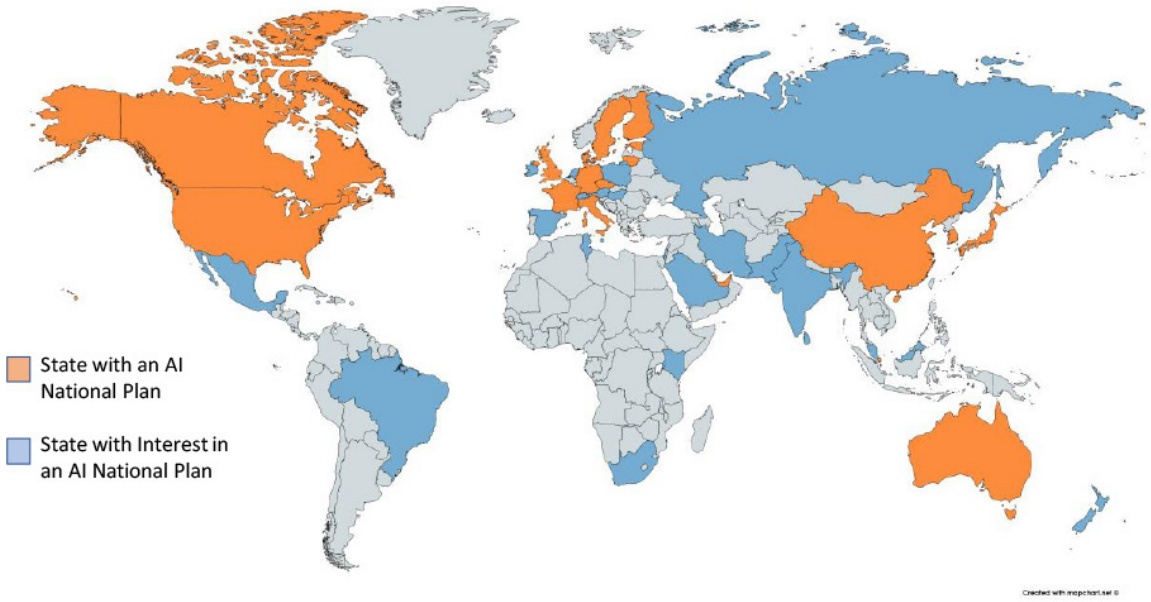


v Purdy, M. & Daugherty, P. (2017). How AI boosts industry profits and innovation. *Accenture*. https://www.accenture.com/fr-fr/_acnmedia/36dc7f76eab444cab6a7f44017cc3997.pdf

Appendix C – State Strategies and Investments in AI around the World

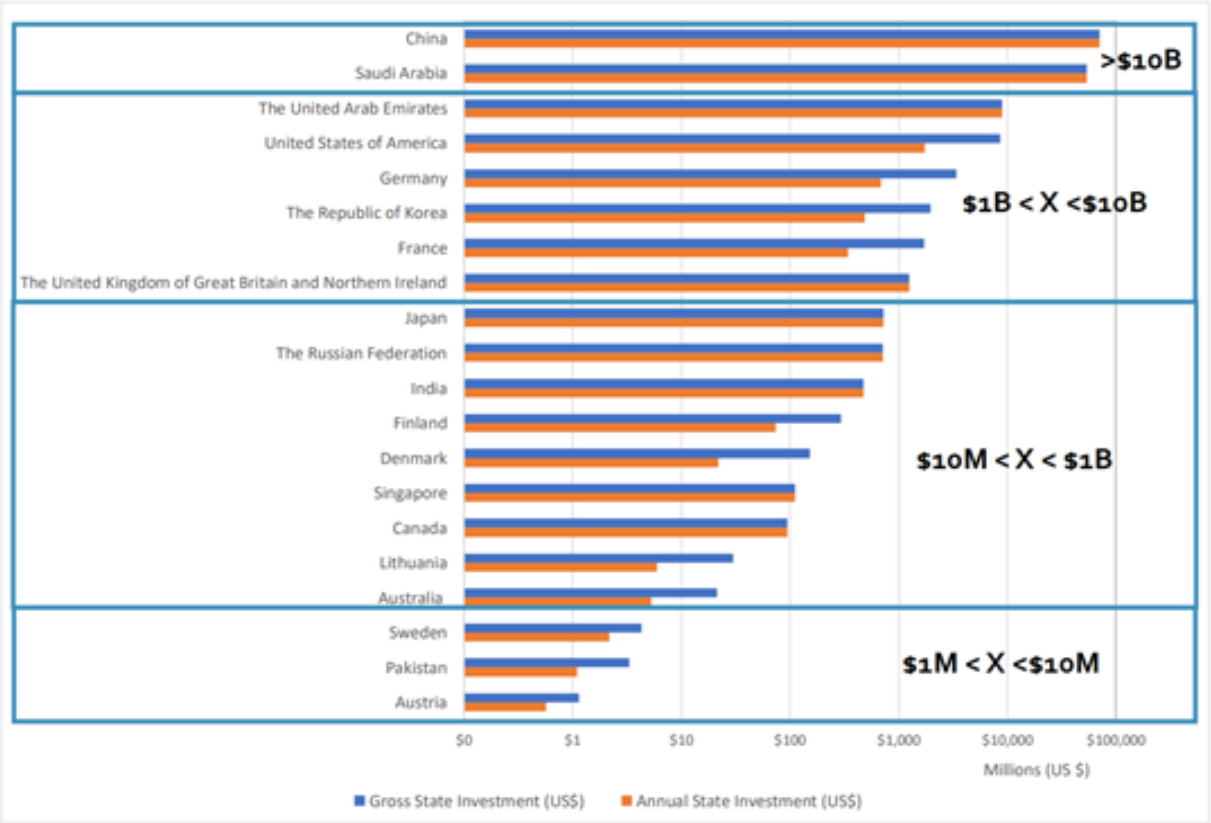
In recent years, there has been a growing recognition among governments that artificial intelligence is a strategic technology and the basis for a variety of future technological developments. Accordingly, alongside self-investment in the private sector, many nations have been initiating and implementing national plans, strategies, and investments in the field of artificial intelligence. A study by FuturGrasp[44] in collaboration with the United Nations Interregional Crime and Justice Research Institute (UNICRI) and its Center for Artificial Intelligence and Robotics found that from early 2017 to June 2019, 41 of the 193 UN member states expressed willingness to invest in the field of AI and develop it at the national level. Of these, 19 published a national plan and 20 made national investments that, overall, were estimated at about 152 billion USD. The following are three graphs from the study, which summarize the global trend:

States with or having demonstrated interest in an AI national strategy or plan

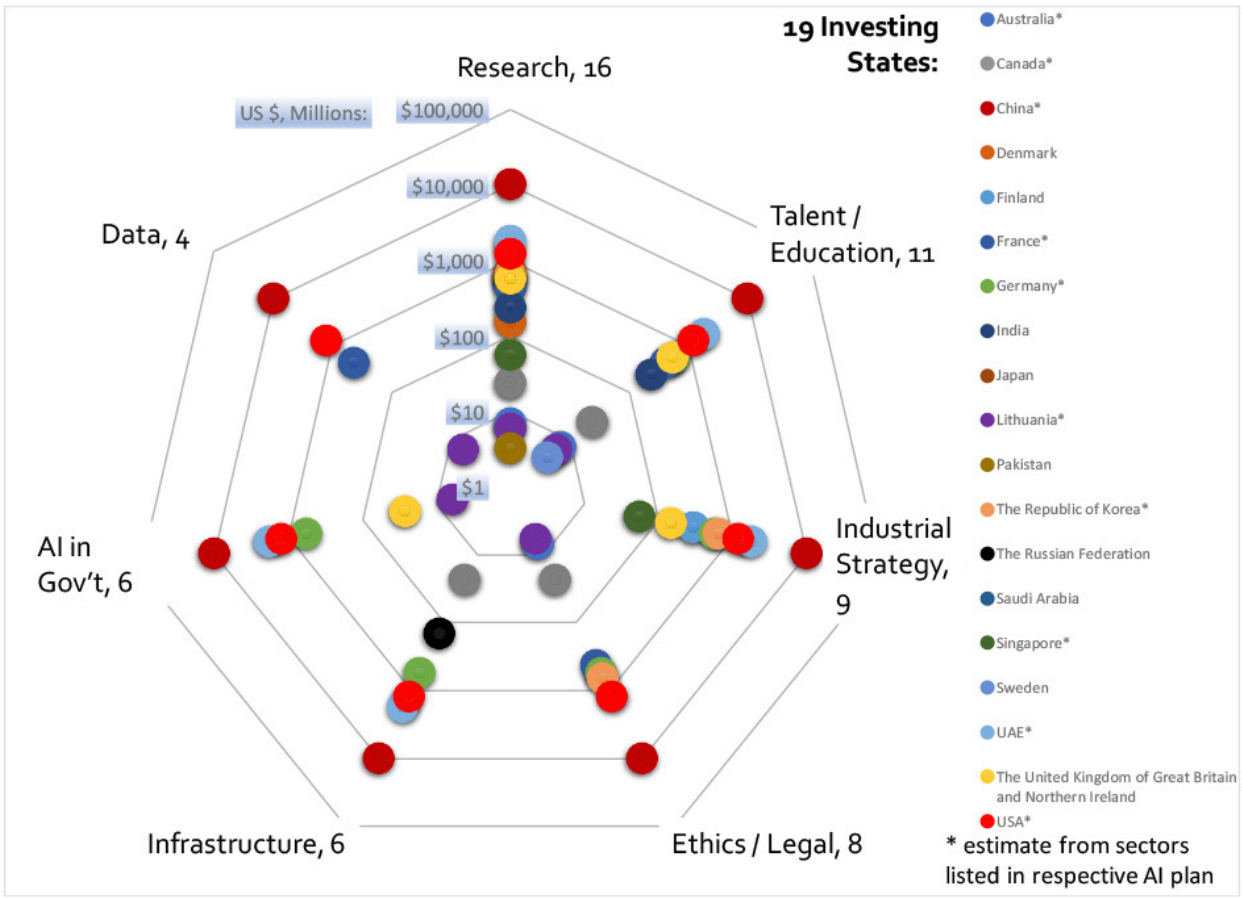


44 Campbell, T. A. (August 2019), *Artificial Intelligence: An Overview of State Initiatives*, FutureGrasp, https://irp-cdn.multiscreensite.com/9297f8c7/files/uploaded/Report_AI-An%20Overview%20of%20State%20Initiatives_FutureGrasp_8-18-19_A4.pdf

AI investments by states for which government-sourced AI investments were identified

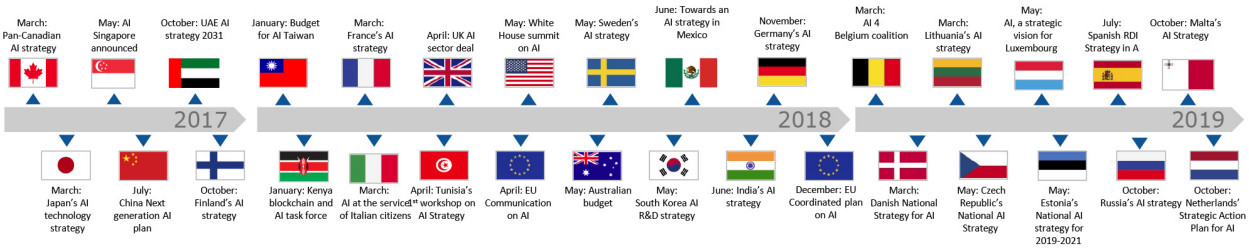


State Investments by AI Sector



Numbers next to each spoke label denote how many States are investing in each Sector.

It is important to emphasize that the field of artificial intelligence is in full swing, and the changes therein occur and are measured in months. Therefore, in the six months that have passed since the publication of the report, additional states have published national plans and some of the states have even updated their original plans. Today there are about 30 countries with national programs.



Source: a presentation by the Israel Innovation Authority, based on: Politics=AI, Tim Dutton, 2018 + European Commission data 2019

Beyond plans and investments at the state level, regional initiatives also emerge. In December 2018, for example, the European Union published a joint plan for the development of artificial intelligence in the EU (Coordinated Plan on Artificial Intelligence "Made in Europe")[45]. One of the objectives of this plan was to have all EU member states publish their national strategies in the field by mid-2019. Furthermore, the European Commission has pledged to invest EUR 1.5 billion by 2020, which is 70% more than it invested between 2014-

45 "Digital Single Market - Artificial Intelligence": https://ec.europa.eu/digital-single-market/en/artificial-intelligence#Coordinated-EU-Plan-on-Artificial-Intelligence

2017, as a supplement to the national investments of EU member nations. In addition, at least EUR 7 billion of the Union budget (2021-2027) will be invested in artificial intelligence under Horizon Europe and Digital Europe Programme in AI[46] programs. In May 2018, an announcement on the subject of artificial intelligence was made on behalf of the Nordic-Baltic cooperation led by Sweden, with the aim of ensuring the preservation of the Nordic and Baltic countries' status as leaders in the field of digital development in Europe[47].

The following is an overview of national investments in a few of the leading nations:

China

China was one of the first countries to publish a national AI strategy. In July 2017, China released the New Generation Artificial Intelligence Development Plan[48] and announced the ambitious goal of becoming a world leader in artificial intelligence by 2030, and developing a 150 billion USD industry in the field[49]. However, since China does not publish its budget, it is difficult to accurately estimate government investment in the field. In the United Stated it was estimated that in 2017 Chinese government investments reached about 12 billion USD, and that by 2020 they will increase to at least 70 billion USD[50]. In January 2018 it was reported that China intends to invest 2.12 billion USD in the establishment of a technology park dedicated to the development of artificial intelligence, where 400 companies will operate to produce the annual output of approximately 7.4 billion USD[51]. A review published by FuturGrasp relied on an estimate that China's government would invest approximately 70 billion USD for this purpose[52]. Recently, however, there have been allegations that these estimates are not sufficiently substantiated. An institute at Georgetown University published a study in December 2019 estimating that the Chinese government's annual investment in R&D in the field of artificial intelligence amounts to several billions rather than tens of billions as claimed by common US estimates[53].

46 Member States and Commission to work together to boost artificial intelligence "made in Europe". https://ec.europa.eu/commission/presscorner/detail/en/IP_18_6689

47 Sweden to lead AI cooperation in Nordic-Baltic region, https://www.government.se/press-releases/2018/05/sweden-to-lead-ai-cooperation-in-nordic-baltic-region/

48 China's New Generation of Artificial Intelligence Development Plan. https://flia.org/notice-state-council-issuing-new-generation-artificial-intelligence-development-plan/

49 Campbell, T. A., Artificial Intelligence: An Overview of State Initiatives, *FutureGrasp*, August 2019, https://irp-cdn.multiscreensite.com/9297f8c7/files/uploaded/Report_AI-An%20Overview%20of%20State%20Initiatives_FutureGrasp_8-18-19_A4.pdf | China wants to be a $150 billion world leader in AI in less than 15 years https://www.cnbc.com/2017/07/21/china-ai-world-leader-by-2030.html

50 Analytics Insight. (November 18, 2018). Artificial Intelligence, China and the US – How the US is losing the technology war? https://www.analyticsinsight.net/artificial-intelligence-china-and-the-us-how-the-us-is-losing-the-technology-war/

51 The Race Towards Intelligence: China Will Establish a USD 2 Billion Technology Park for the Development of Artificial Intelligence. (January 3, 2018) https://www.themarker.com/wallstreet/1.5597136

52 Campbell, T. A. Artificial Intelligence: An Overview of State Initiatives, 2019 *FutureGrasp,* August 2019, https://irp-cdn.multiscreensite.com/9297f8c7/files/uploaded/Report_AI-An%20Overview%20of%20State%20Initiatives_FutureGrasp_8-18-19_A4.pdf

53 Chinese Public AI R&D Spending: Provisional Findings. (2020). CSET Issue Brief. https://cset.georgetown.edu/wp-content/uploads/Chinese-Public-AI-RD-Spending-Provisional-Findings-1.pdf

United States

In 2016, the United States published several reports with policy recommendations for national preparedness in the field of artificial intelligence[54] in general and in the areas of R&D[55] and economics[56] in particular. Since then, artificial intelligence has taken a growing place in US national security strategies from 2017, and in 2018 the Department of Defense announced that it will invest approximately 2 billion USD over five years to advance the field of artificial intelligence[57]. However, it was not until February 2019 that the American national strategy plan (American AI Initiative) was launched by a presidential executive order. This was done due to the expression of criticism and fears that, despite the high amount of investments in the private sector and the occupation of various government agencies in the field, the US lags behind China in terms of the national investment and strategy. The strategy presents 5 main objectives: (1) Investment in AI R&D; (2) Unleashing AI resources; (3) Setting standards for the development and use of AI; (4) Building the AI workforce; (5) Operations in the international arena to preserve the advantages of the American artificial intelligence. The presidential executive order did not allocate additional budget for the implementation of the strategy and instead instructed the various federal agencies to prioritize artificial intelligence and allocate resources to this area from existing budgets[58]. For the first objective, in June 2019 the administration published an update to the National Strategic Plan for R&D in the field of artificial intelligence[59], which was originally formulated in 2016. The program sought to promote eight strategic issues including: long-term investment in R&D; human-AI collaborations; safety of use and protection of systems; ethical, legal, and social aspects; public data and testing infrastructures; standards for measuring and evaluating technologies; understanding requirements for AI R&D workforce; strengthening the cooperation between the public sector and the private sector. In March 2019, the US launched a portal that would centralize all government initiatives related to the field of artificial intelligence, under the name of AI.gov[60]. In May 2019, the Senate introduced the Artificial Intelligence Initiative Act, which seeks to produce a coordinated national strategy and allocate 2.2 billion USD over 5 years to train human capital and accelerate the responsible delivery of AI applications by government agencies, academia and the private sector for 10 years[61].

In the 2020 budget, the US has allocated about 1 billion USD for civilian R&D in artificial intelligence and another amount of at least 750 million USD for defense R&D in the field[62]. In February 2020, the White House announced that "in a time of great power competition", the resources allocated to research and development in artificial intelligence and quantum computing will increase significantly within the R&D budget for 2021 and will be doubled by 2022, "to maintain its [US] global leadership in science and technology for generations to come"[63].

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54 *Preparing for the Future of Artificial Intelligence.* October 2016, Executive Office of the President National Science and Technology Council Committee on Technology, https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf

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59 "The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update," Select Committee on Artificial Intelligence of the National Science & Technology Council, June 2019, https://www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf

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62 The White House. (February 11, 2020). President Trump's FY 2021 Budget Commits to Double Investments in Key Industries of the Future. https://www.whitehouse.gov/briefings-statements/president-trumps-fy-2021-budget-commits-double-investments-key-industries-future/

63 *Ibid.*

Russia

Russian President Vladimir Putin has declared that "artificial intelligence is the future, not just for Russia but for all of humanity" and that "whoever rules this sphere will be the ruler of the world"[64]. In 2018, the state investment in R&D in the field of artificial intelligence was only about 12.5 million USD[65]. In October 2019, the Russian National Strategy for the Development of Artificial Intelligence (NSDAI)[66] was published for the period until 2030. The strategy states that the Russian government will allocate the resources required for its implementation, but no amount is mentioned. Publications from May 2019 claimed that the approval of the strategy formulated in those days would result in a government investment of 1.4 billion USD over 6 years[67]. In addition, on the same month it was reported that the Russian government investment fund will allocate an additional 2 billion USD raised from foreign investors to promote Russian companies in the field of artificial intelligence[68].

Germany

Germany released its national strategy for artificial intelligence (AI Made in Germany) in December 2018. The strategy set three objectives: (1) To establish Germany and Europe as global leaders in the development and use of artificial intelligence and to ensure Germany's competitive capability in the future; (2) To ensure the responsible development and use of artificial intelligence in a manner that will serve the good of society; (3) To integrate artificial intelligence in the society in an ethical, legal, cultural and institutional terms in the context of a broad societal dialogue and active political measures[69]. The German government will allocate 3.4 billion USD by 2025 to implement the plan in the expectation that the business sector will invest an equal amount and enable the implementation of the national plan through 6.8 billion USD [70].

France

The French national strategy "AI for Humanity" was published in early 2018[71], and as part of it, EUR 1.5 billion will be allocated over 5 years for the purpose of research related to AI and assistance to French startups. The French strategy dedicates an entire section to the issue of ethics in the field of artificial intelligence and also focuses on the potential of artificial intelligence in four main areas – health, transportation, environment, and security[72].

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65 Bendett, S. (April 4, 2018). In AI, Russia Is Hustling to Catch Up. https://www.defenseone.com/ideas/2018/04/russia-races-forward-ai-development/147178

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69 German Federal Ministry for Economic Affairs and Energy, "Federal government adopts artificial intelligence strategy," November 16, 2018. https://www.de.digital/DIGITAL/Redaktion/EN/Meldungen/2018/2018-11-16-federal-government-adopts-artificial-intelligence-strategy.html

70 J. Miley, "Germany Boosts AI Research With €3bn Funding Injection,". November 16, 2018. Interesting Engineering. https://interestingengineering.com/germany-boosts-ai-research-with-3bn-funding-injection

71 AI for Humanity - https://www.aiforhumanity.fr/en

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Finland

In December 2017, Finland published a national strategy with the objective of becoming a leading nation in artificial intelligence applications (Finland's Age of Artificial Intelligence: Turning Finland into a leading country in the application of artificial intelligence)[73]. Finland recognizes its small size and its limitations in the global race for the development of artificial intelligence technologies, and therefore it consciously chooses to emphasize its objective of becoming a leading country as a consumer of artificial intelligence applications. Finland strives to reach the age of artificial intelligence with an efficient public sector, a competitive business sector and a proactive society that functions well and enjoys greater well-being thanks to the use of AI. In 2018, the government approved the strategy and detailed plans for its implementation, as well as published a comprehensive report examining the effects of artificial intelligence on the economy and employment, on changes in the labor force and labor market, on education and training, and on ethics[74]. It is estimated that by 2030 the artificial intelligence economy will account for 30% of GDP in Finland[75].

In June 2019, Finland published an updated national plan (Leading the way into the era of artificial intelligence – Final report of Finland's Artificial Intelligence Programme 2019)[76] that outlined the 11 key steps to achieving national goals: (1) Enhance business competitiveness through the use of artificial intelligence; (2) Effectively utilize data in all sectors; (3) Ensure AI can be adopted more quickly and easily; (4) Ensure top level expertise and attracting first-rate experts; (5) Make bold decisions and investments; (6) Build the best public services in the world; (7) Establish new models for collaborations; (8) Make Finland a forerunner in the age of artificial intelligence; (9) Prepare for artificial intelligence to change the nature of work; (10) Steer AI development into a trust-based, human-centered direction; and (11) Prepare for security challenges.

In February 2018, the government of Finland allocated approximately 200 million USD under the AI Business Programme, which will be distributed by 2022 as grants and incentives to the business sector for the development and use of artificial intelligence[77]. Beyond that, it is not clear what the total government investment in artificial intelligence in Finland is, but from the details presented under Article 5 "Bold Decisions and Investments" in the updated national plan (2019) it seems that the investments amount to tens of millions of dollars[78].

South Korea

As early as 2016, the Korean government announced that it would invest approximately 863 million USD in the field of artificial intelligence over 5 years. In May 2018, the government released a national plan under which it will invest 2 billion USD by 2022 in order to establish itself as one of the four leading countries in the world in the field of artificial intelligence. The program focuses on human capital, technology, and infrastructure, and includes clear objectives for strengthening R&D, training professional human capital, encouraging the establishment of startups and companies in the field of artificial intelligence, as well as major projects in medicine and drug development, national security, and public safety. In addition, South Korea emphasizes smartening the chip industry and has allocated about 1 billion USD for the development of AI semiconductors by 2029[79].

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For details and elaborations of the national strategies and government investments in the field of artificial intelligence of all countries that have published their national plans or budgets dedicated to the field until the first half of 2019, see the full review of FutureGrasp from August 2019:

Artificial Intelligence: An Overview of State Initiatives

https://irp-cdn.multiscreensite.com/9297f8c7/files/uploaded/Report_AI-An%20Overview%20of%20State%20Initiatives_FutureGrasp_8-18-19_A4.pdf