



DEPARTMENT OF SCIENCE AND TECHNOLOGY
PHILIPPINE COUNCIL
FOR INDUSTRY, ENERGY
AND EMERGING TECHNOLOGY
RESEARCH AND DEVELOPMENT
(DOST-PCIEERD)

DOST PCIEERD ETDD: Artificial Intelligence and Information & Communications Technology

Roadmapping Executive Report

FOREWORD

Creating a new momentum to achieve a strategic vision, the Department of Science and Technology Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST PCIEERD) is thrilled to share its latest formulation of roadmap and sectoral plan for artificial intelligence (AI) and information & communications technology (ICT).

This roadmap contains the Council's goal, objectives, and priority action plans that will bring people and information together to break down barriers as it articulates the competitive edge of AI and ICT in decision making, automation, predictive analysis and forecasting, and communication.

With this roadmap, we anticipate that more researchers, scientists, entrepreneurs, and readers will weigh in on the strengths and weaknesses of AI and ICT in the Philippines so they can make great strides and take definitive actions to enhance their current activities in businesses and industries. Further, it will inspire to develop specific research programs leveraging on these technologies aimed at achieving a better and more sustainable future for all.

As leader and preferred partner in enabling innovations, PCIEERD commits to extend its support to the country's S&T community through opportunities that will empower human resources, generate more S&T policies, strategies, and technologies for the welfare of all Filipinos.

By working with us, we can truly make genuine and meaningful change happen.

Thank you and *mabuhay tayong lahat!*



DR. ENRICO C. PARINGIT
PCIEERD Executive Director

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Introduction

Many things have been made possible through advancements developed through technology. One of the most prominent technologies nowadays and emerging its way to solve the problems of today, is Artificial Intelligence (AI), with Information and Communications Technology (ICT) providing the infrastructure needed to support it.

Our industry research on current market players in the AI sector - China, Canada, the US, the UK, and Singapore - reinforces the significance of a centralized national institution to support AI development. With the current capabilities and network that the DOST - ASTI has developed and fostered over the years, its reorganization as a main focal point for AI in the Philippines is fitting for the sector. This would allow effective management of the flows of technology and information, thereby enabling innovation.

With a roadmap that emphasizes allocation for basic research even with industry-driven approach, researchers would be better guided and organized as to where their research will be directed and eventually used. In this way, the possibility of R&D getting shelved will be minimal and the researchers are able to focus on their R&D without worrying about commercialization and eventual adoption.

The strategy for the development of AI in the Philippines can be divided into four parts: talent development, AI policy and data regulation, mission-driven programs and infrastructure. The strategy for talent development comprises two approaches: (1) the BigTech approach (2) the upskilling program approach. Through these, we hope to produce competent professionals and students adept in AI and data science techniques, to promote the growth of the various sectors. The mission-driven programs will be the drivers of AI development in the Philippines with applied and basic research on AI aligned to the respective missions of the program. For each mission, infrastructure, talent, and partnerships will be established to see the project through to a defined outcome.

Current State Review

The global artificial intelligence market size is expected to reach \$169,411.8 million in 2025, from \$4,065.0 million in 2016 growing at a CAGR of 55.6% from 2018 to 2025. Artificial intelligence has been one of the fastest-growing technologies in recent years. AI is associated to human intelligence with similar characteristics such as language understanding, reasoning, learning, problem solving, and others. Manufacturers in the market witness enormous underlying intellectual challenges in the development and revision of such a technology. AI is positioned at the core of the next gen software technologies in the market. Companies such as Google, IBM, Microsoft, and other leading players have actively implemented AI as a crucial part of their technologies.

The various technologies are sub-divided into machine learning, natural language processing, image processing, speech recognition, etc. In 2016, the machine learning segment dominated the market, in terms of revenue, and is expected to maintain this trend in the coming years, owing to increase in demand for artificial intelligence industry solutions.

The AI Hype Cycle summarizes various AI technologies in different stages based on their respective current development phase and market expectations. For practical efficiency, it is suggested in 2018 World AI Industry Development Blue Book to start with the profiles approaching the Plateau of Productivity. For competitive advantage, it is recommended to start with the profiles on the Innovation Trigger that will go through the hype cycle fast, such as chatbots, natural-language generation, AI-related C&SI services and AI developer toolkits.

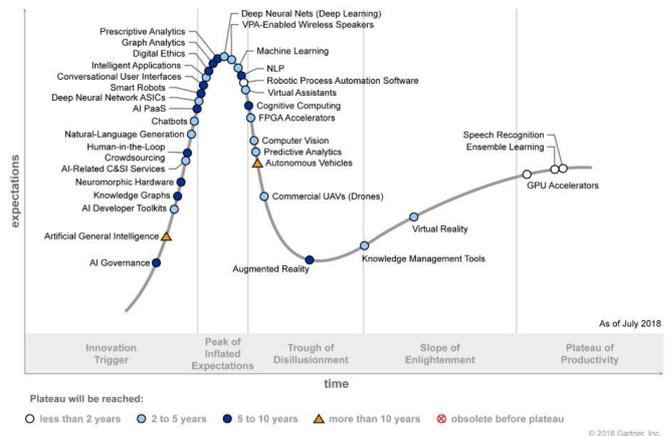


Figure 1. Hype cycle for artificial intelligence, 2018.

US\$4.07B	US\$169.4B	55.6%
Estimated global artificial intelligence market in 2016	Predicted global artificial intelligence market in 2025	Over the forecast period of 2018 to 2025, AI market is projected to rise at 55.6% CAGR

Current Local Capacity

The Philippines has also been doing its initiatives on the R&D of information and communications technology and artificial intelligence through the Department of Science and Technology (DOST).

Information and Communications Technology

ICT supports the development of effective and affordable Filipino-made innovations in ICT to enable adaptation to new ways of learning in the information age and to improve the skills of Filipinos that will boost the global competitiveness of human resources.

Projects	Duration	Budget (Php)	Description
ANEEME: Synthesizing and Sharing Animation Building Blocks for Rapid creation of 3D Motion Scenes	JAN 2016- APR 2018	4,932,297.00	ANEEME is a system for automatic skeletal rigging of 3D scanned humanoid objects such as toys, figurines, sculptures and even humans. Within minutes, the input can be easily incorporated and used to setup skeletal-based animations in most animation software applications.
Project Tick-Tock Tech Talk	MAR 2017- JUN 2018	4,986,031.96	Tick Tock Tech Talk is a modular listening material that serves as a mobile phone application. It contains recorded lectures and samples of verbal English communication. It intends to make listening and speaking fun and highly-educational. It also promotes long-term enhancement of oral skills.
PHL-MICROSAT Project 3	APR 2015- MAY 2017	6,284,085.00	<ul style="list-style-type: none"> • PHL-Microsat Distribution Site • PHL-Microsat Data Manager • Diwata-1 data processing scripts • This project is the development of a data processing, archiving and distribution subsystem of the satellite data acquired by the Ground Receiving Station of the Philippines Scientific Earth Observation Micro-Satellite in UP Diliman and Davao.
Marayum - A Community-built, Mobile Phone Based, Online Web Dictionary for Philippine Languages	2 Years (On-going)	22,251,826.00	<ul style="list-style-type: none"> • A website and a mobile phone application consisting of an offline and online searchable Asi-English dictionary consisting of at least 10,000 words including Cebuano and Ilocano. It also utilizes Natural Language Processing strategies.
Development of Error Resilient Joint Source-Channel Video Transmission System for High Efficiency Video (HVEC) Standards Over Wireless Channel	OCT 2018- SEP 2020	3,174,154.00	<ul style="list-style-type: none"> • An error resilient tool that will minimize the end-to-end distortions of channel codes that naturally occurs with source coding and channel coding, while making use of a wireless channel. This aims to benefit video coding policy makers such as Video Coding Expert Group (VCEG) or Moving Picture Expert Group (MPEG), and other researchers in the field of video coding and video transmission.

Artificial Intelligence and Data Science

Emerging fields in computer science with potentially broad applications in all aspects of life. Data Science is the use of Big Data in various forms, both structured and unstructured, to extract knowledge and insights, create visualizations, analytics, and computational models.

On-going projects	Duration	Budget	Expected Outputs
Capability Building in Artificial Intelligence (AI) through Training and Acquisition of High Performance Computing Device	NOV 2017- NOV 2019	46,798,058.80	1. 20 Trained participants from the academe, industry and government agencies
Enhancing Man-Machine Interaction through Intelligent Conversational Agents	NOV 2018- NOV 2019	3,565,512.00	Narrative-based dialogue model to enable chatbot to engage human users in dialogue Knowledge resources to support the conversation

DOST has also made key partnerships for capacity building for artificial intelligence and data science skills. One of which is a partnership formed with data science consultancy firm Thinking Machines, where the latter provides training programs and training repository to the government agency. This includes conducting seminars and conferences that aim to spread data science awareness and knowledge to interested participants.

Another valuable partnership is with MOOCs PH, a local start-up company that aims to centralize and deliver Massive Open Online Courses (MOOCs) and learning opportunities for the local market, and Coursera, a well-known online education platform.

The partnership launched an online Data Science scholarship for individuals that aim to jumpstart their careers in data science, and may include tracks in cybersecurity, artificial intelligence, and the like. The learning program is flexible as it allows students to learn from online courses and trainings developed by different top international universities at their own timeline. Its four modules include (1) The Data Scientist's Toolbox, (2) R Programming, (3) Getting and Cleaning Data, and (4) Exploratory Data Analysis. Advanced courses are also available for those who have completed the initial modules and want to further expand their learning.

The existence of these capacity building programs helps the country promote inclusivity of data science skills and knowledge acquisition. Although there are a few institutions that offer courses in data science, these are way too expensive and might not be accessible by a common Filipino who just wants to learn these skills but doesn't have the financial capacity to support education in these institutions. Through the initiatives provided by DOST and its partner institutions, knowledge sharing is more achievable without aspiring data scientists having to worry about how much they're going to have to pay for it.

Notable resource from DOST-ASTI

Established in 2014 at the Advanced Science and Technology Institute (ASTI) of DOST, the Computing and Archiving Research Environment (COARE) is a High-Performance Computing and Cloud facility that allows free access of its services to students, researchers, and data analysts.

On the commercial side, many industry players have also been driving investments into integrating AI into their regular systems. For example, in the financial services sector, the Bank of the Philippine Islands and BDO Unibank Incorporated have decided to utilize chatbots and AI applications in improving the quality of customer service and make administrative processes more efficient and streamlined.

Global Landscape

United States of America

Although the United States of America have long recognized the tremendous potential of Artificial Intelligence in enhancing their economic growth and national security, it was only in the recent administration that the President specifically identified AI as a research and development priority. Six key areas have been identified in the 2018 White House Summit on AI for the American Industry:

- Prioritizing funding for artificial intelligence (AI) research and development (R&D): The Trump Administration has prioritized funding for fundamental AI research and computing infrastructure, machine learning, and autonomous systems
- Removing barriers to AI innovation: The Trump Administration is enabling the creation of new American industries by removing regulatory barriers to the deployment of AI-powered technologies.
- Training the future American workforce: President Trump has taken Executive action to give the American worker the skills to succeed in the 21st century economy.
- Achieving strategic military advantage: The Trump Administration's National Security Strategy recognizes the need to lead in artificial intelligence, and the Department of Defense is investing accordingly

- Leveraging AI for government services: Executive departments and agencies are applying AI to improve the provision of government services to the American people
- Leading international AI negotiations: White House OSTP led U.S. delegations to the 2017 and 2018 G7 Innovation and Technology Ministerials, and is working with our allies to recognize the potential benefits of AI and promote AI R&D

The United Kingdom

Having published a cloud technology roadmap in 2011, the UK successfully reached all the goals by 2016. Moving forward, the UK, through their Prime Minister, announced last year that the UK would strive to become the world leader in the AI industry. Following this announcement, a Sector Deal for AI between the government and industry was agreed upon. The overarching goal of the deal is to create a business environment that secures the UK's position as the ideal place to start and grow an AI business. It includes concrete plans regarding education, economic growth, etc. AI solutions would target the key sectors: services, life sciences, agriculture, and the public sector. This Sector Deal positions the Artificial Intelligence sector to play a growing role in meeting this ambition - with a potential contribution of £200 billion or 10% of UK GDP by 2030. (GOV.UK, 2018)

The Sector Deal will invest over £1 billion to develop 5G mobile networks and extend full fibre broadband to build the next generation digital infrastructure. Apart from this, there are ten other infrastructure projects directed towards 5G, which total to an additional £5.8 billion in capital. Completion of all these projects may be observed as early as 2027.

The UK's short-term goals involve enabling a quality workforce as well as growing SME's. The plan does not only aim to raise the standard of education, but also attract top-class professionals in the field of ICT to the country. On the other hand, the growth of SME's is instigated by tax credits from the HMRC, the UK's department responsible for tax collection. VR/AR companies have the most significant tax credit rate with 33%, while AI companies are entitled to a 12% tax credit rate.

The UK's long-term goal is to put itself at the forefront of the artificial intelligence and data revolution as well as becoming the world leader in the way people, goods, and services move. (GOV.UK, 2019) The Alan Turing Institute is a premiere institution for AI R&D, with various programs designed to upskill students of various disciplines and deepen industry collaborations for AI in order to achieve this goal.

China

On July 2017, China announced its ambition to become the world's leader in AI academia, technologies and applications through its Next Generation Artificial Development Plan (State Council, 2017). In the Plan, China outlines three key steps on how she would approach this ambition:

- i. To match China's AI industry with global competitors by 2020
- ii. To become the global expert in targeted AI fields by 2025
- iii. To become the global center for AI innovation by 2030

Since the release of the Next Generation Plan, the government has published the Three-Year Action Plan to Promote the Development of New-Generation Artificial Intelligence Industry (State Council). This three-year plan outlines the short-term steps and goals that China wishes to achieve. These include:

- Developing networked products such as vehicles, service robots, and identification systems
- Developing AI's support system, including intelligent sensors and neural network chips
- Developing intelligent manufacturing
- Developing training resources, standard testing and cybersecurity

Although launched recently, the plan has already been delivering strong outputs with 32% of the companies adopting AI technologies compared to its competitors, who stagnant at the average of 20% despite having more established AI infrastructures (Boston Consulting Group, 2018). This success can be attributed to executives at Chinese companies who take active leadership roles in pushing for AI pilot or adoption, shorter-than-average innovation cycle and China's implementation approach which opts for smart and agile AI piloting over rigorous long-term planning.

China is the global leader in AI implementation, with approximately 85% of companies from major industries showing confidence in utilizing and innovating AI. Major industries include Consumer Goods, Energy, Financial Services, Industrial, Technology, media and telecom (Boston Consulting Group, 2018). PwC projected that China could reap a GDP boost of 26% by 2030, the greatest economic gains from AI across the world (PwC, 2017).

Singapore

The Singapore government launched Smart Nation initiative in 2014. This focuses on better living, stronger communities and create more opportunities for its citizens. Smart Nation is coordinated by the Smart Nation and Digital Government Office in the Prime Minister's Office. This focuses on 5 key domains: transport, home and environment, business productivity, health and enabled ageing, as well as public sector services.

Launched on May 2017, AI Singapore is a 5-year, S\$150 million national program to enhance Singapore's capabilities in AI: a government-wide partnership with 6 different organisations (IMDA, 2017). Singapore's AI vision focuses on AI research, address societal and economic challenges, and broaden adoption and use of AI within industry. The Roadmap outlines four (4) key initiatives (IMDA, 2017):

- Foundational R&D for other pillars of AI Singapore
- Grand Challenges to support multi-disciplinary research teams that use AI to tackle societal challenges in the world, which include health, urban solutions and finance
- 100 Experiments funds scalable AI solutions to industry-identified problems
- AI Apprenticeship of 9-month structured education program for capacity building

Barriers to Development

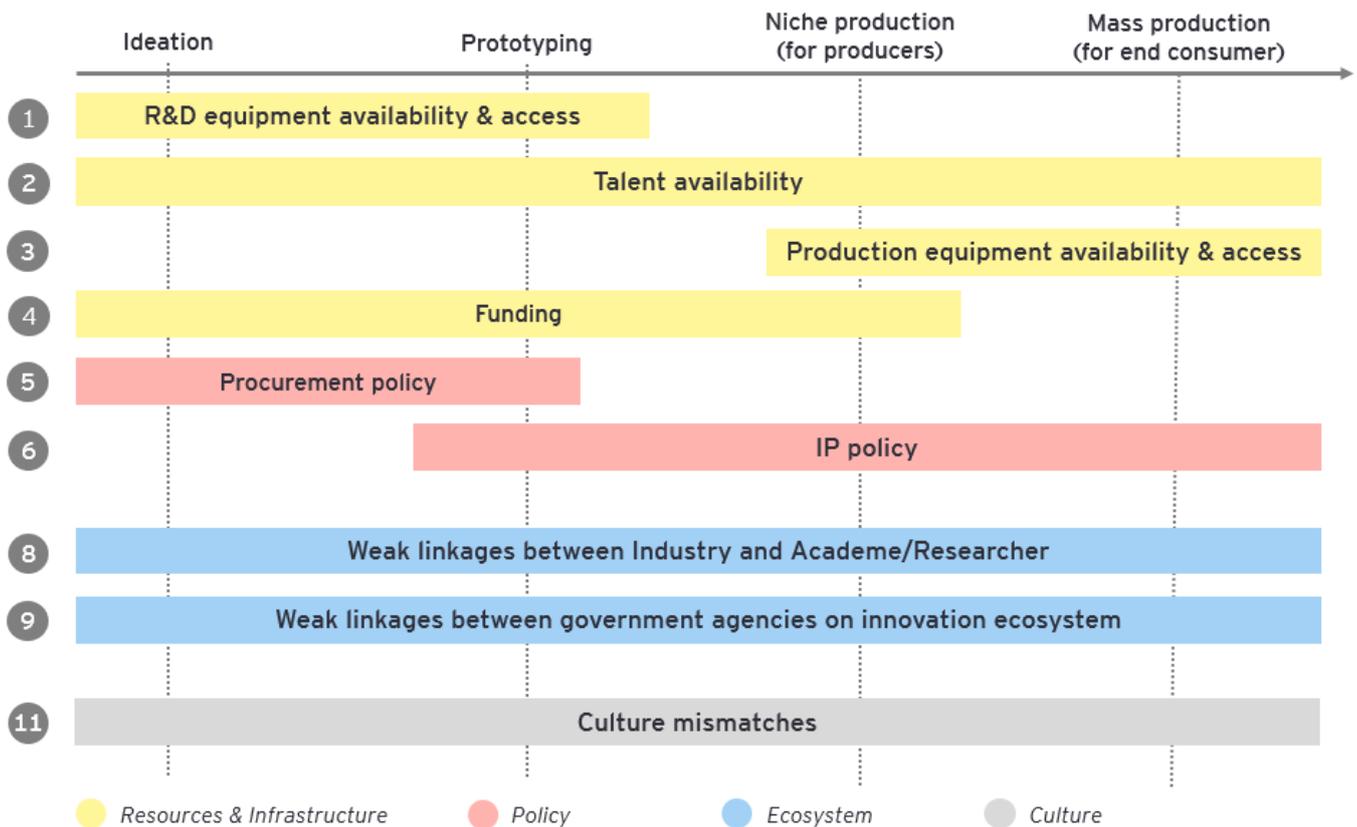


Figure 2. Barriers to development of AI and ICT.

Various challenges remain in the development of AI and ICT in the Philippines. Figure 2 shows the specific challenges faced by the AI and ICT sector in the Philippines in different phases of research and development. The challenges are also classified according to their nature as either resource and infrastructure, policy, ecosystem or culture.

Resources and Infrastructure

R&D equipment availability and access: This issue is relevant especially in the first phases of development, which are ideation and prototyping. A common challenge faced by researchers is the lack of facilities in their areas and inadequately equipped laboratories.

Talent availability: Similar to R&D equipment availability and access, the lack of talent availability is crucial for the phases of ideation and prototyping, although this also negatively affects the adoption of AI/ICT in industry. There is a lack of experts to train students in advanced techniques and concepts. The limited number of experts also limit the capability of the industry to capture higher-value segments in the value chain.

Production equipment availability & access: Smaller scale enterprises have difficulties in adopting new technologies in ICT development due to limited availability and access to production equipment. Interested parties find it more cost-effective to turn to China or other South-east Asian producers to scale up.

Funding: Researchers performing basic research find difficulty in securing funds to do basic or exploratory research because industry is only interested in funding tried and tested AI technologies that have a direct application on their business; however, this kind of research has strategic and capacity building benefits.

Policy

Procurement policy: Government procurement process is slow and tedious since it requires many documents and approvals before the actual acquisition can be done. The long time horizon needed for procuring the equipment may cause project timelines in R&D to be extended.

IP policy: Researchers are not knowledgeable enough about business and regulatory requirements for procuring IP and thus might not be able to obtain reasonable terms in industry partnerships since industry partners want as much control and monetization rights as possible over the technology.

Ecosystem

Weak linkages between industry and academe/researcher: Collaborations between industry developers and the academe usually arise from informal channels such as personal contacts, conferences, etc. There is no available ground to facilitate connection between the industry and the academe. The weak linkage causes R&D and skill development to be performed independently from industry outputs, causing low adoption of research results and skill mismatches.

Weak linkages between government agencies on innovation ecosystem: There isn't enough collaboration between different government agencies for R&D and innovation needs of researchers and private/public adopters.

Culture

Culture mismatches: The difference in cultures of researchers, academicians and industry players make collaboration among the parties difficult since there are often disagreements on the needs, timeline, and other aspects of cooperation that discourage the different parties from working together.

Upon a comprehensive review and understanding of both the local and global landscapes of AI & ICT, there are a lot of opportunities where the Philippines can progressively develop its infrastructural capabilities and the skills of its people. Although some difficulties still persist, we cannot disregard the potential of growth and expansion of local talent & expertise. In order to make this happen, the different stakeholders involved must be able and willing to contribute their resources and be open for collaboration with the others – thereby ensuring an environment that does not always just try to catch up with its peers, but stands out and flourishes in the global paradigm.

Strategy

Among the barriers cited in the previous section, these are the top challenges identified for AI and ICT.

- R&D equipment availability & access
 - The development of AI is dependent on supporting infrastructure such as universal data access, 5G, cloud storage, etc. Improvements on available infrastructure in different parts of the country and data sharing arrangements can significantly aid in the development of AI and ICT.
- Talent availability
 - There is an increasing demand for AI talents in various industry; however, the number of AI experts is very limited.
- Lack of funding for basic or non-commercializable research
- Lack of government directive and strategic direction
- Long processing time of IP applications
- Lack of industry collaboration (low readiness of potential adopters)

With a roadmap that emphasizes allocation for basic research even with industry-driven approach, researchers would be better guided and organized as to where their research will be directed and eventually used. In this way, the possibility of R&D getting shelved will be minimal and the researchers are able to focus on their R&D without worrying about commercialization and eventual adoption.

One of the key frameworks used in classifying the degree and type of support to be provided for different stages of technologies is the innovation matrix.

In the case of AI and ICT, innovations are supported by the six foundation pillars presented below the matrix. The innovation matrix attempts to classify research and development according to how well it serves to solve a specific problem and whether it falls under a domain where solutions can be expected to arise. Depending on where in this matrix the R&D falls, the responsibility for funding and enabling development may skew more towards the private sector (for sustaining innovation, where problem and solution domain are well-defined – e.g. anomaly detection for AML) or more towards the public sector (for basic research, where there is no well-defined problem and solution domain).

The strategy for the development of AI in the Philippines can be divided into four parts: talent development, AI policy and data regulation, infrastructure and mission-driven programs.

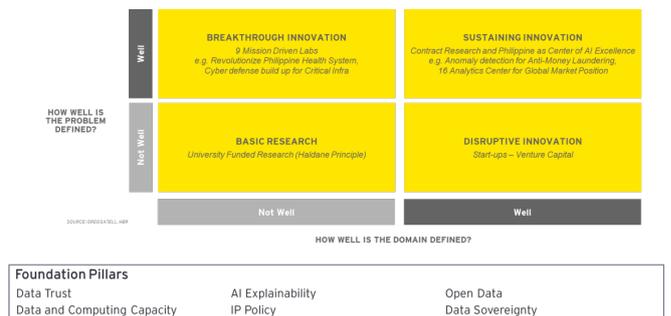


Figure 3: The 4 Types of Innovation give us a framework for how to strategize for or fund R&D depending on how well the solution domain and problem statement is defined.

Talent Development

The Philippines provides for 16-18% of the global outsourcing service market, with the market being led by the business process outsourcing (BPO), telecommunications, and financial services sectors. With the Department of Trade and Industry expecting the global IT-BPM market demand to double by 2022, the government agency is keen on sustaining their current market share and being more competitive in the global landscape.

The country has long established itself as a major BPO center internationally since the 2000s. However, the growth has been slow relative to countries in the nearby regions because these have made larger investments as well as the provided a wider range of incentives in support of their local BPO industries. With the Philippines failing to act on these initiatives employed by its neighboring countries as well as the threat of the industry being taken for granted by the administration, it is possible that we may be surpassed by relatively new players in the industry who may be just starting but can better capitalize on the industry's potential.

One of the main problems in the industry is the insufficiency of skill development in the country. Despite having the second largest BPO market in Asia, majority of the services being offered here focuses on the lower end of the value chain, particularly on Customer Relationship Management through contact and call centers, as shown in Figure 4. The higher-level services that entail more advanced skills (Knowledge Process Outsourcing) are not as widespread in the country, given the limited number of available professionals to serve the demand and attract investment. These types of services provide better in terms of value, and would maximize the revenues of the sector, as well as lower the threat imposed by automation on the economy.

This is the primary reason why we need more initiatives for talent development. There is a case to be made for developing a pool of talents with coding ability. This can be made a standard part of the curriculum as early as possible in the academic life of a student, and it can be enhanced and refined beyond graduation.

The strategy for talent development comprises of two approaches: (1) the BigTech approach (2) the upskilling program approach. Through these, we hope to produce competent professionals and students adept with AI and data science techniques, to promote the growth of the various sectors.

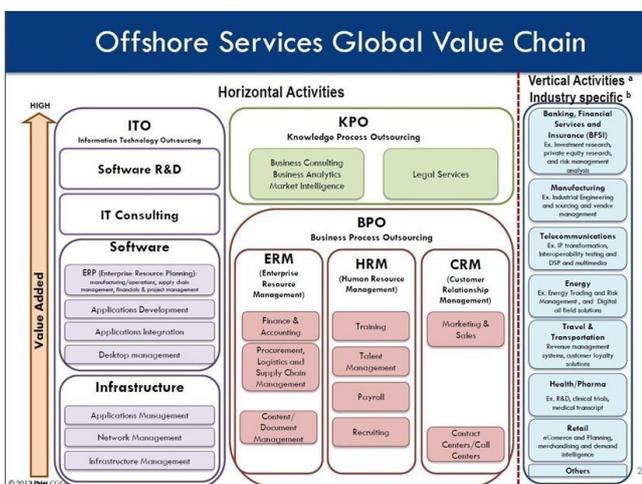


Figure 4. Offshore services global value chain.

The BigTech Approach

The BigTech approach is inspired by the IBM-PTECH program launched by IBM in the United States and spread to various countries, including the Philippines. It involves attracting international large tech companies to partner with local public schools for development of special AI-centered STEM curriculum spanning senior high school to first two years of college. With the partnership, the curriculum created will be tailored to the specific needs of the industry, equipping the students with the necessary technology and skills. Throughout the program, students will also be given opportunities to participate in internships to obtain real workplace experience, which will prepare the graduates to enter the workforce after graduation. Graduates of the program will be given an Associate's Degree in Applied Science, Engineering, Computers or other competitive STEM disciplines. The short-term objective for this approach is for partnerships to be established for 3 pilot schools in different cities. These pilot schools will serve as examples and promotions for the BigTech program and attract more schools and tech companies to participate in the program.

The Upskilling Program Approach

The main objective of the upskilling program approach is to upskill the current workforce to help employees adapt to the changing working environment because of automation. The upskilling program will be essential to workers in the IT-BPO industry since they are facing risks of losing their jobs because of process automation. Partnership with technology companies and universities offering AI courses are recommended for the training for AI. The government can offer scholarship programs to attract workers to participate in the upskilling program in exchange of applying the skills that they acquire from the program to Filipino companies.

AI Policy and Data Regulation

To sustain robust development of AI in the country, policies and regulations must be in place to guide AI practitioners and users. A set of inclusive policies can not only prevent the use of AI for malicious intent, but also protect and support the industry. In addition to this, DOST must participate in national policy initiatives such as the execution of DICT's National Cybersecurity Plan 2022, which includes the updating of policies on protecting digitized transactions and electronic documents.

The development of AI is grounded on the availability of data. The key in implementation of open data is to first establish a framework for data security and management. A broader scope of open data will help both researchers and industry adopters produce more accurate results from AI algorithms. Standards on open data must be formulated to ensure timely updating of available data. To further expand the publicly available database, a public-private data sharing framework has to be in place to serve as basis for possible contributions by the private sector to the public database.

IP Policy as it relates to AI must also be given special attention, as the ambiguity surrounding IP-sharing negotiations is a common hurdle and deterrent for researchers from seeking out meaningful industry relationships.

Lastly, it is necessary to conduct awareness programs and events to promote the use of available facilities and data, as well as to inform the audience about established policies and frameworks.

Mission-driven Programs

The major theme for AI in the Philippines will be composed of 7 mission-driven programs:

1. AI for Banking and Finance

AI technology presents an opportunity for the unbanked population to be able to subscribe to financial services. Risk assessment of customers can be performed through analysis of unconventional data such as social network data, crop turnover, etc. for applicants with limited credit history. AI for financial purposes can also be targeted to various industries such as financing for agricultural value chain and critical health financing.

2. AI for Government Operations and Services Delivery

With AI's ability to process large volumes of data efficiently, it can be used to sift through citizens' data to enhance the delivery of government services, improve allocation and management of resources, and make government operations more efficient. AI will have applications in traffic optimization, surveillance, combating fraud in the tax system, and managing health records.

3. Cyber Defense Build-up

As the Philippines heads towards Industry 4.0, cyberattacks would grow in comparable complexity and volume. AI could provide instant cyberattack alerts and detect patterns of cyberattacks to enhance cybersecurity across technological sectors.

4. AI for Creative Industries

Although unconventional, AI can also aid in the creatives process by enabling automation of parts of creative work to enable teams to focus on more complex tasks. It can also aid in visualization of creative designs to ensure appropriateness of product for mass production.

5. AI for Energy

As the energy suppliers look into alternative sources of energy such as renewable energy, applications of AI in the energy sector also prove to be essential. AI can play a role in the development of renewable energy by incorporating data analytics on the identified environmental factors necessary in the modeling of renewable energy produced in a certain location.

6. Advancing Agriculture

Agriculture is one of the key economic drivers in the Philippines. AI applications in agriculture can help boost the country's agricultural value chain and improve the economy. Smart agriculture initiatives can improve agricultural produce and help farmers prevent undesired losses. Advances in satellite imaging with applications in crop mapping and weather forecasting are opportunities for quick adoption of AI in agriculture.

7. Revolutionize Healthcare

These programs will be the drivers of AI development in the Philippines with applied and basic research on AI aligned to the respective missions of the programs. For each mission, infrastructure, talent, and partnerships will be established to see the project through to a defined outcome. The resources for each project can be centralized into a laboratory dedicated for the accomplishment of the mission, and these laboratories can be established in different parts of the country in different institutions most suited to the purpose. This is to ensure talent development is spread throughout the Philippines.



Figure 5. Four outputs of mission-driven programs.

These programs will be the drivers of AI development in the Philippines with applied and basic research on AI aligned to the respective missions of the programs. For each mission, infrastructure, talent, and partnerships will be established to see the project through to a defined outcome. The resources for each project can be centralized into a laboratory dedicated for the accomplishment of the mission, and these laboratories can be established in different parts of the country in different institutions most suited to the purpose. This is to ensure talent development is spread throughout

In contrast to DOST projects which have relatively short durations, the mission-driven programs serve as long-term initiatives and directions for the application of AI towards developing these important pursuits. These will have no specific duration since further needs of improvement to industry processes are always emerging. The programs are not designed to solve just one specific problem, but to address any AI improvements that can be used for the field.

Each mission can only be accomplished through collaboration between the adopter (Industry or Government), the researchers, and academe.

- The adopter will provide the context for the research and refinement for eventual use, as well as partial funding and other resources, as they will eventually be the beneficiary of the research and development. This is mostly expected to be Industry, but Government itself can also be a consumer of AI technology for programs such as AI for Government Service Delivery and Cyber Defense Build-up.
- The researchers will inject the knowhow and will facilitate the development to the adopter's specifications.
- The academe will provide the manpower and retain the knowledge gained for use and dissemination in other projects.

Overall, these programs should serve as common and uniting goals for the academe, industry and government in the research and development of AI technology.

Program roadmaps can be found in the subsequent section, while technology roadmaps can be found in the Appendix of this report.

Infrastructure

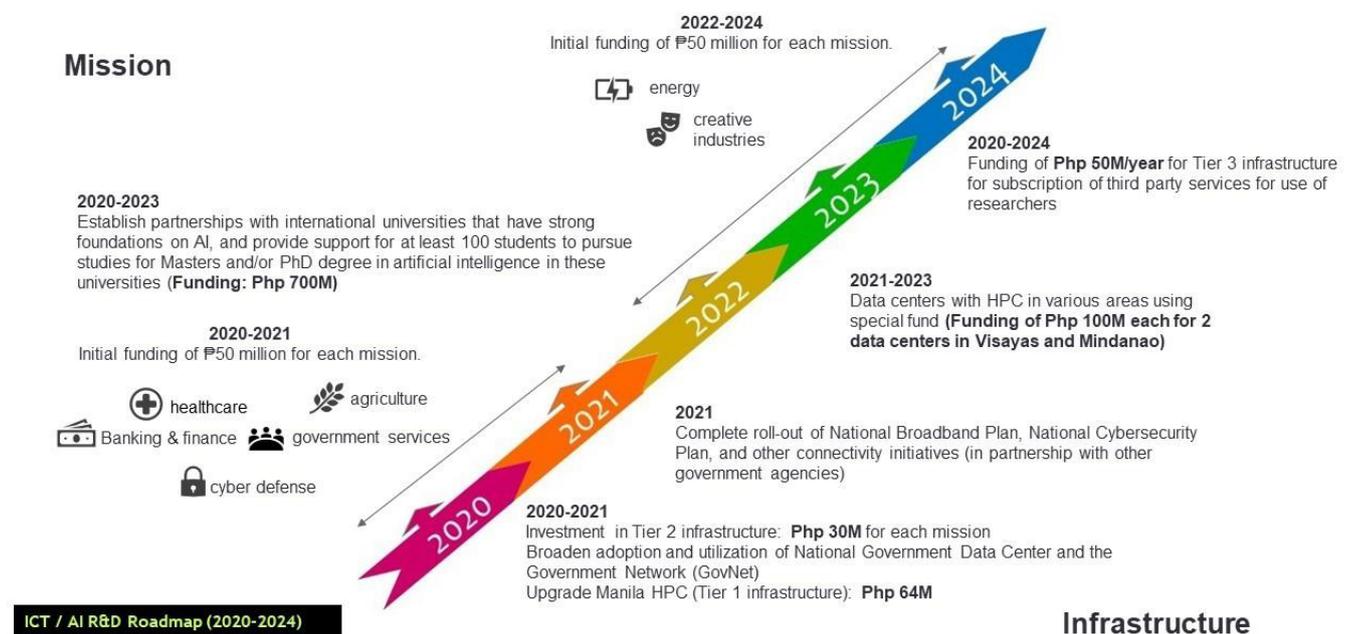
Lack of appropriate connectivity and computing infrastructure is one of the challenges faced by both research and industry sectors of AI. The government currently has efforts in expanding the reach of internet to the whole country with the roll-out of National Broadband Plan, National Cybersecurity Plan, and other connectivity initiatives by the Department of Information and Communications Technology (DICT).

For computational infrastructure, a 3-tier division is suggested to match each researcher to the computing infrastructure that he/she needs to increase efficiency.

The first tier will be the national super computer, which will consist of high performance computers (HPC) to be used by researchers in need of high computing power to perform complex algorithms. Tier two consists of infrastructure needed for development of mission-specific technology. These will be used by researchers and industry developers for progressing in each mission. Tier three infrastructure does not refer to specific hardware but instead cloud platforms and services that can be used for entry and exploratory level AI researchers. These will be subscriptions to third party cloud services that are commonly used by researchers.

Strategic Direction for Infrastructure Roadmap:

General investments in support of the different missions nationwide



Business Case

A core team led by a mission director will be needed for each of the mission-driven programs. The mission director needs to have exposure to both the industry prioritized by the mission and AI technology, and have a broad perspective of the future development objectives of the industry. The mission director will be tasked to create short-term mission milestones for the mission so that the short-term projects can converge into the long-term objectives.

A core team led by a mission director will be needed for each of the mission-driven programs. The mission director needs to have exposure to both the industry prioritized by the mission and AI technology, and have a broad perspective of the future development objectives of the industry.

The mission director will be tasked to create short-term mission milestones for the mission so that the short-term projects can converge into the long-term objectives. In the long run, it is necessary in all missions to train AI talents and AI developers in respective fields to further progress the integration of AI into the different missions. AI Talent refers to individuals who have the ability to recognize and execute opportunities for AI-based solutions for use in the operations of their company. AI developers refers to individuals who can build algorithms, models for a specific purpose from scratch or out of components for general application.

Banking and Finance

Mission-driven Programs



PILOT (2020-2021)
Close collaborative program with primary adopter, **BSP**, to develop solutions on:

- Active surveillance, detection, and mitigation of money laundering and fraudulent transaction in payments and virtual currency (2021)
- Shift from rule-based model to AI-based detection to reduce false positive rate by 30-50%
- Use of self-learning models incorporating probability concepts

EXPAND (2021-2022)
Close collaborative long-term program with secondary adopters, **universal banks, commercial banks, thrift banks, and rural banks** to adopt solutions on active surveillance and detection of money laundering and fraudulent transaction in payments piloted in 2020-2021.

CAPACITATE (2024)

- 250,000 AI talents in banking and finance industry, among which 12,000 are high-level AI developers
- Experts employable not just by BSP but by all financial institutions, including major banks with shared services in the Philippines

AI Talent refers to individuals who have the ability to recognize and execute opportunities for AI-based solutions for use in the operations of their company. AI developers refers to individuals who can build algorithms, models for a specific purpose from scratch or out of components for general application.



2022-2024
Use of inputs from Mission Core Team and Service Delivery Teams in:

- Embedded/ladderized program** for AI for **business/finance/econ** undergraduates
- AI upskilling course** for **business/finance/econ bank personnel**

2022-2023
Formation of standards on deployment of AI for financial applications

- Policies on Data Privacy and Data Exchange

2021

- Investment in necessary skills and expertise to pursue mission and programs: Policy, Infrastructure, Technology
- Mission Core Team will be supported by **Service Delivery Teams** who will work on the primary needs of the adopter and work with the researchers to deliver the outputs necessary to allow basic and application research

70% Mature/Mainstream Application

- Cybersecurity
- Machine Learning
- Pattern Recognition
- Natural Language Processing

30% New/Basic Research

- Quantum Secure Communications

2020-2021

- Formation of **Core Team** under the leadership of a **Mission Director for Banking and Finance**
- Build relationship with BSP and secure MOU

ICT / AI R&D Roadmap (2020-2024)

Infrastructure

The banking and finance sector is one of the biggest adopters of AI technology due to its need to develop accurate models using large datasets.

A pilot application can be done through collaboration with the Bangko Sentral ng Pilipinas (BSP) in developing solutions for surveillance, detection and mitigation of money laundering and fraudulent transaction in payments. Supervised learning techniques such as support vector machines, random forest and unsupervised learning techniques such as clustering, social network analysis and autoencoders are new ways of detecting fraudulent transactions.

The use of AI-based detection models incorporated with self-learning capabilities can significantly increase the accuracy of money laundering detection.

In the medium term, adopters of solutions on anti-money laundering AI tools can be expanded to secondary adopters such as universal banks, commercial banks, thrift banks and rural banks.

Government Services

Mission-driven Programs

Government Services

CAPACITATE (2023-2024)

- 150,000 AI talents available for government services, wherein 7,000 are high-level AI developers dedicated for Government Service Delivery
- Employable by BIR, NEDA, SSS, GSIS, DOLE, and LGUs

AI Talent refers to individuals who have the ability to recognize and execute opportunities for AI-based solutions for use in the operations of their company. *AI developers* refers to individuals who can build algorithms, models for a specific purpose from scratch or out of components for general application.

EXPAND (2022)

- Close collaborative long-term program with secondary adopters, NEDA, SSS, GSIS, DOLE to develop solutions on:
- Credit scorecard development to understand financial intervention already made (2022)

PILOT (2020-2021)

Close collaborative program with primary adopter, BIR, to develop solutions on:

- Data platform for mass registration of MSME/informal sector.
 - Data for tracking of grants/subsidies, impact monitoring and developing a simpler tax compliance requirements, such as pay as you go model.
 - Main users of platform: BIR, NEDA, SSS and DOLE.
- Reduce manual audit by increasing data collection coverages and matching protocols, in lieu of tax returns
- Application of Big Data and machine learning techniques to detect, estimate and predict taxability/tax base of online businesses, including non-Philippine resident platforms

2020-2021

- Formation of **Core Team** under the leadership of a **Mission Director for Government Services**
- Build relationship with BIR and secure MOU

2020-2022

- Investment in necessary skills and expertise to pursue mission and programs: Policy, Infrastructure, Technology
- Mission Core Team will be supported by **Service Delivery Teams** who will work on the primary needs of the adopter and work with the researchers to deliver the outputs necessary to allow basic and application research

2021-2023

- Formation of standards on deployment of AI for government service delivery applications
- Policies on Data Privacy and Data Exchange

2022-2024

- Use of inputs from Mission Core Team and Service Delivery Teams in:
- **Embedded/laddered program** for AI for **undergraduates interested in pursuing civil service accreditation**
 - **AI upskilling course** for **civil servants**

- 70% Mature/Mainstream Application**
- Computer systems and architecture
 - Social Data Science
 - Cybersecurity
 - Machine Learning
- 30% New/Basic Research**
- Quantum Secure Communications



ICT / AI R&D Roadmap (2020-2024)

Infrastructure

Efficiency of government services can be significantly improved with the help of AI technology. From chatbots to cloud storage to big data processing, AI can provide a whole line of support for government services.

Expansion in the medium term will include extending long-term collaboration programs with secondary adopters (BIR, NEDA, SSS, DOLE, GSIS) and extending application of AI to credit scorecard development.

In the pilot phase, primary adopter is identified to be the Bureau of Internal Revenue (BIR). A possible use case of AI will be on developing data platform for mass registration of MSME/ informal sector wherein data collected will be beneficial to users such as BIR, NEDA, SSS and DOLE. Big data and machine learning techniques can also be applied to detect, estimate and predict taxes based on online businesses (including non-Philippine resident platforms).

Advancing Agriculture

Mission-driven Programs

Advancing Agriculture

EXPAND (2021-2023)

Close collaborative long-term program with primary adopters, **DTI and DA**, to develop solutions on:

- Crop mapping, predictive analytics for supply-demand management for 3 additional crops nationwide (2022-2023)
- Precision farming for enhancement of crop harvest for these 3 crops (2023) – crop rotation, optimum planting and harvesting time, water management

As well as secondary adopters, **rural banks** to develop solutions on:

- Alternative risk assessment methods for agricultural lending

PILOT (2020-2021)

Close collaborative program with primary adopter, **LBP**, to develop solutions on:

- Application of satellite imaging and processing techniques to agriculture (computer vision, big data)
 - Satellite images for crop mapping and weather/ disaster forecasting
 - Enhancement and refinement of the data for use in yield prediction and disaster risk measurement
 - Predictive analytics for supply-demand management
- Alternative risk assessment methods for financial and insurance services to farmers (statistics, machine learning)

CAPACITATE (2024)

- **50,000** AI-capable agriculturists and agronomists, of which **2,000** are high-level AI developers
- Employable by **LBP, DA, DTI, and private Agri institutions**

AI Talent refers to individuals who have the ability to recognize and execute opportunities for AI-based solutions for use in the operations of their company. **AI developers** refers to individuals who can build algorithms, models for a specific purpose from scratch or out of components for general application.

2022-2024

Use of inputs from Mission Core Team and Service Delivery Teams in:

- Embedded/ladderized program for AI for agriculture/agribusiness undergraduates
- AI upskilling course for lenders, insurance providers, cooperatives, and government service delivery personnel in the Agri sector

2021-2023

Formation of standards on deployment of AI for agricultural applications

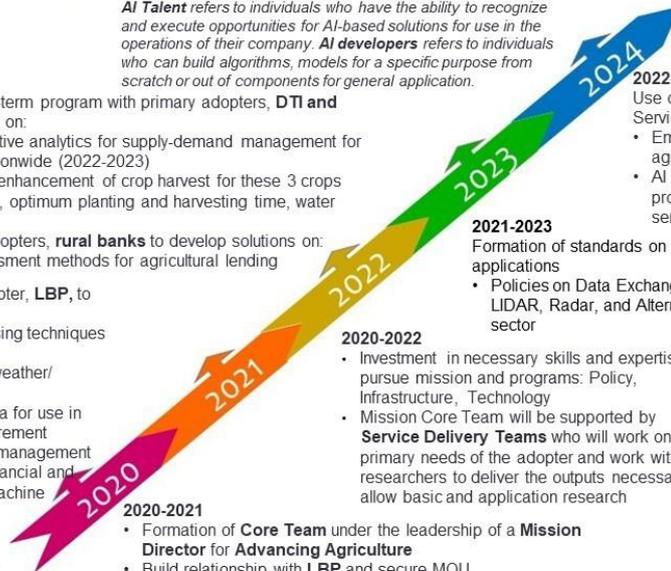
- Policies on Data Exchange/Open Data for Satellite, LIDAR, Radar, and Alternative Data concerning the Agri sector

2020-2022

- Investment in necessary skills and expertise to pursue mission and programs: Policy, Infrastructure, Technology
- Mission Core Team will be supported by **Service Delivery Teams** who will work on the primary needs of the adopter and work with the researchers to deliver the outputs necessary to allow basic and application research

2020-2021

- Formation of **Core Team** under the leadership of a **Mission Director for Advancing Agriculture**
- Build relationship with **LBP** and secure MOU



ICT / AI R&D Roadmap (2020-2024)

Infrastructure

70% Mature/Mainstream Application

- Computer vision
- Machine learning
- Graph analytics

30% New/Basic Research

- Predictive analytics
- Deep neural network

As one of the key economic drivers in the Philippines, improvements in agriculture driven by AI can significantly boost the Philippine economy.

Currently, DOST-ASTI possesses satellite images which is used by DATOS in crop mapping and weather/ disaster forecasting. With further improvements and refinements of the technology, these data can be used for yield prediction and for disaster risk measurement so that farmers can take early action in anticipation of calamities. The same models will also allow easier access to funds for farmers since these can also be used by financial institutions to perform more reliable risk assessments for loans to farmers. This will encourage more lending to the latter.

For the short term pilot program, the primary adopter is determined to be LBP. The close collaborative program will develop solutions on application of satellite imaging and processing techniques to agriculture. These technologies can be applied to perform yield prediction, disaster risk measurement, weather/disaster forecasting and predictive analytics for the farmers. Moreover, these can also serve as alternative risk assessment methods for financial and insurance services provided to the farmers. In the medium term, expansions of the pilot phase initiatives to more adopters such as the Department of Trade and Industry (DTI) and Department of Agriculture (DA) and secondary adopters such as various rural banks will aid in both agricultural production and agricultural lending.

Cyber Defense

Mission-driven Programs

Cyber Defense

CAPACITATE (2024)

- Functional National Cyber Command that will conduct active surveillance and defense against cyber threats, investigate breaches, and remain at the forefront of **R&D (led by DOST)**.
- **150,000** AI talents with **7,000** AI developers specializing in cyber defense housed with the National Cyber Command as well as distributed throughout **DICT, NPC, DND, DILG, and the private sector**

AI Talent refers to individuals who have the ability to recognize and execute opportunities for AI-based solutions for use in the operations of their company. AI developers refers to individuals who can build algorithms, models for a specific purpose from scratch or out of components for general application.

CREATE (2023-2024)

Co-sponsor the creation of the National Cyber Command with the **DICT, NPC, DND, and DILG**, where the research function will be led by **DOST**. This body will conduct surveillance and defense against cyber threats, adopting the research output and best practices developed by the Cyber Defense Core Team (2023)

EXPAND (2021-2023)

Secondary adopters: At least three **LGUs** and/or **GOCCs**

Application of solutions on:

- Surveillance, prediction, and prevention of online and offline cyber threats to citizen's privacy (2021)
- Cyber security for various government services (2021)

As well as application of solutions on:

- Critical infrastructure security (2022)

PILOT (2020-2021)

Close collaborative program with primary adopter, **NPC**, to develop solutions on Surveillance, prediction and prevention of online and offline cyber threats to citizen's privacy (2020)

2020-2021

- Formation of **Core Team** under the leadership of a **Mission Director for Cyber Defense**
- Build relationship with **NPC** and secure MOU

2020-2022

- Investment in necessary skills and expertise to pursue mission and programs: Policy, Infrastructure, Technology
- Mission Core Team will be supported by **Service Delivery Teams** who will work on the primary needs of the adopter and work with the researchers to deliver the outputs necessary to allow basic and application research

2022-2023

- Upgrade of Cyber Defense Core Team into National Cyber Command, in collaboration with DICT (network), NPC (privacy), DND (national security), DILG (internal security and LGU), and a new entity dedicated to data-driven businesses

2022-2024

Use of inputs from Mission Core Team and Service Delivery Teams in:

- **Embedded/ladderized program** for AI for **computer science/software engineering/IT undergraduates**
- **AI upskilling course** for those in **cybersecurity, investigative, and national defense** fields

70% Mature/Mainstream Application

- Data science
- Defense and security
- Public policy

30% New/Basic Research

- Quantum Secure Communications/Quantum cryptography



ICT / AI R&D Roadmap (2020-2024)

Infrastructure

Along with the advances in AI technology, computer systems are also more prone to cyberattacks. Application of AI to cyber defense can improve the security of confidential information and prevent system malfunction due to computer virus.

Pilot program in the short term will start with collaboration with the primary adopter, National Privacy Commission (NPC), to develop solutions on surveillance, prediction and prevention of online and offline cyber threats to citizen's privacy. Following the pilot program, expansion of the initiative will involve extending to secondary adopters (LGUs and/or GOCCs) for adoption of cyber security technology for various government services, as well as application of solutions on critical infrastructure security.

To further strengthen cyber security, the formation of the National Cyber Command is recommended. It will be composed of the DICT, NPC, DND, DILG and DOST, where the research function will be led by DOST. This body will conduct surveillance and defense against cyber threats, adopting the research output and best practices developed by the Cyber Defense Core Team.

Other Roles

Department of Science and Technology (DOST)

To expedite the development of AI technology and applications in the Philippines, special funding from the department is needed for researches that has no industry applications yet but has the potential of being a gamechanger in the future. For AI technologies ready for industry application, the department can help bridge the gap between technology providers and users. Some roles that DOST must fulfill are as follows:

- Fund research efforts in mission-driven programs
- Initiate partnerships to expedite development of AI in targeted industries
- Pilot implement open data

Industry/Government as Adopters

The growth of the AI sector in the country must be supported by sufficient demand of AI technology. AI can be utilized for process automation not only in the various industries, but also in the government. The roles of the industry/government as adopters are as follows:

- Actively find and involve themselves in mission programs that will be value-adding to their companies
- Participate in programs such as Balik Scientist, stakeholder meetings, and the like to be involved in research and development discourse
- Support employees to participate in upskilling programs

AI Technology Companies

AI companies are the producers of AI technology and applications. As AI experts, the roles of AI companies are as follows:

- Initiate and participate in opportunities that will allow industry to constantly interact with research and academe (e.g. IBM funding and partnership with local schools for PTECH and upskilling programs)
- Participate in programs such as Balik Scientist, stakeholder meetings, and the like to be involved in research and development discourse

Researchers and Academe

Researchers and academe work hand in hand in the training of new AI talents and researching on emerging AI technology. The following roles are expected from the researchers and academe:

- Actively participate in mission-driven programs
- Host AI laboratories for equipment, training

Department of Information and Communications Technology (DICT)

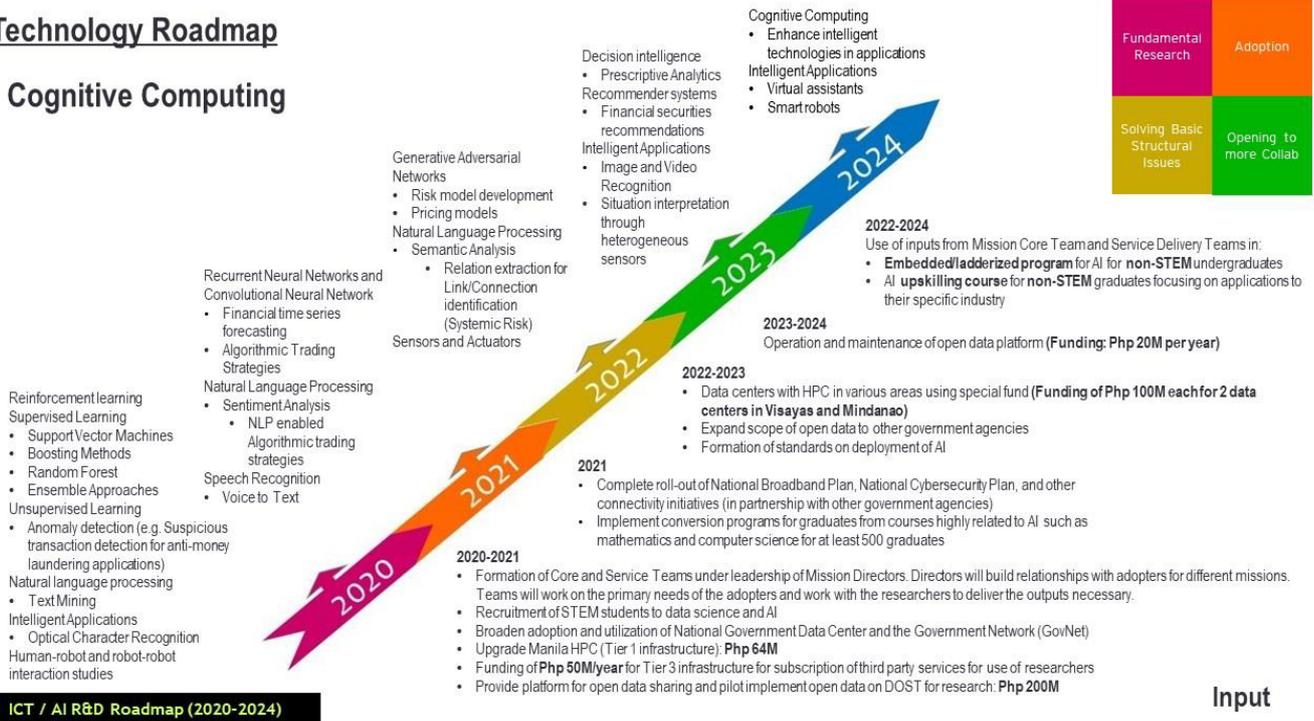
The DICT is the executive department of the Philippine government responsible for the planning, development and promotion of the country's ICT agenda in support of national development. ICT infrastructure plays an important role in the development and application of advanced technologies. Roles expected from DICT are as follows:

- Invest in infrastructure needed for data, computing and communications
- Security standards, AI regulations, Open Data
- Develop data trusts

Appendix: Roadmaps

Technology Roadmap

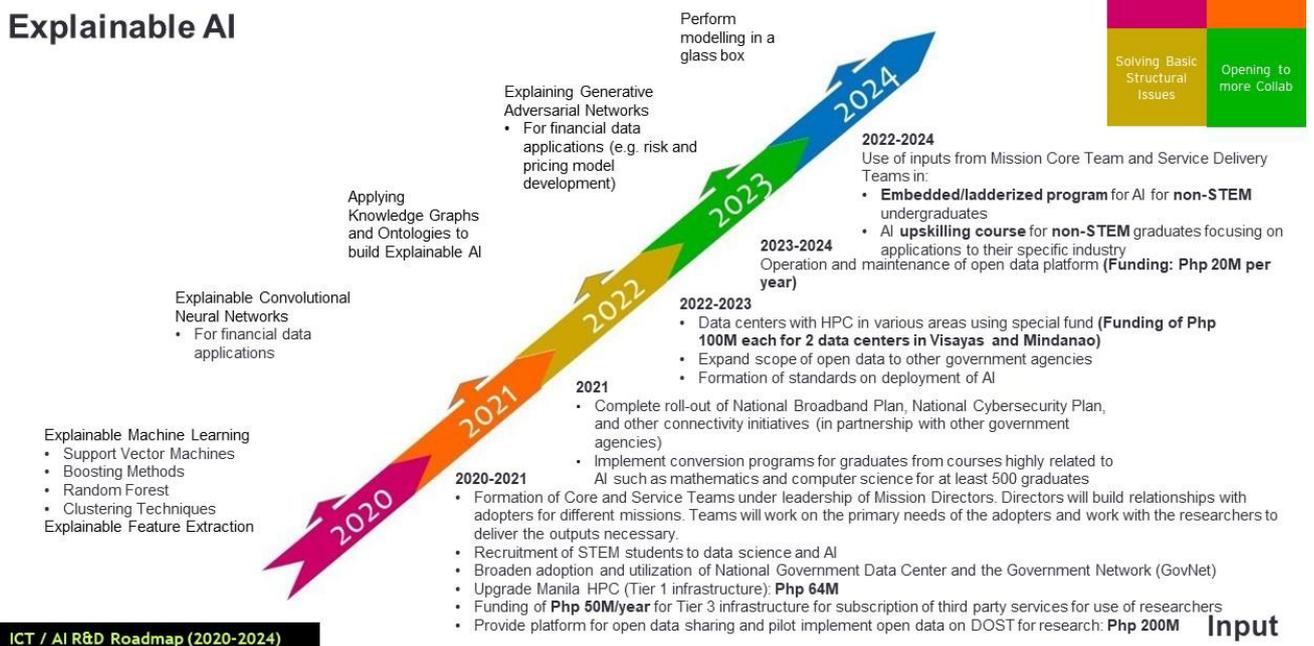
Cognitive Computing



Input

Technology Roadmap

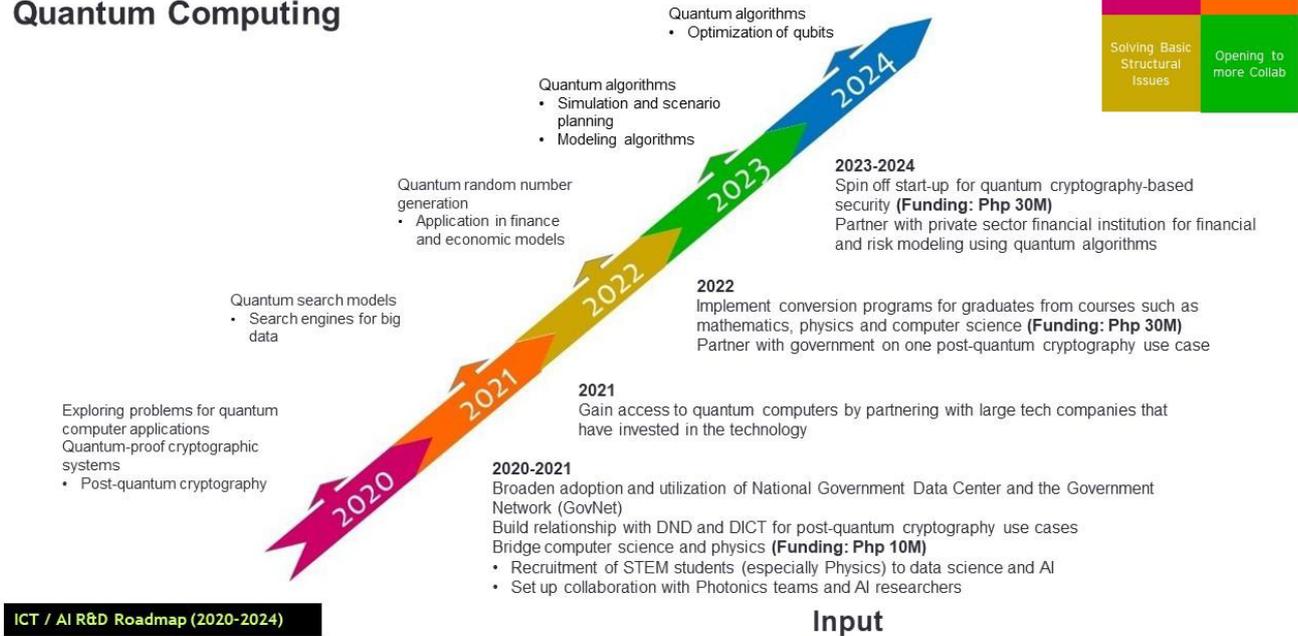
Explainable AI



Input

Technology Roadmap

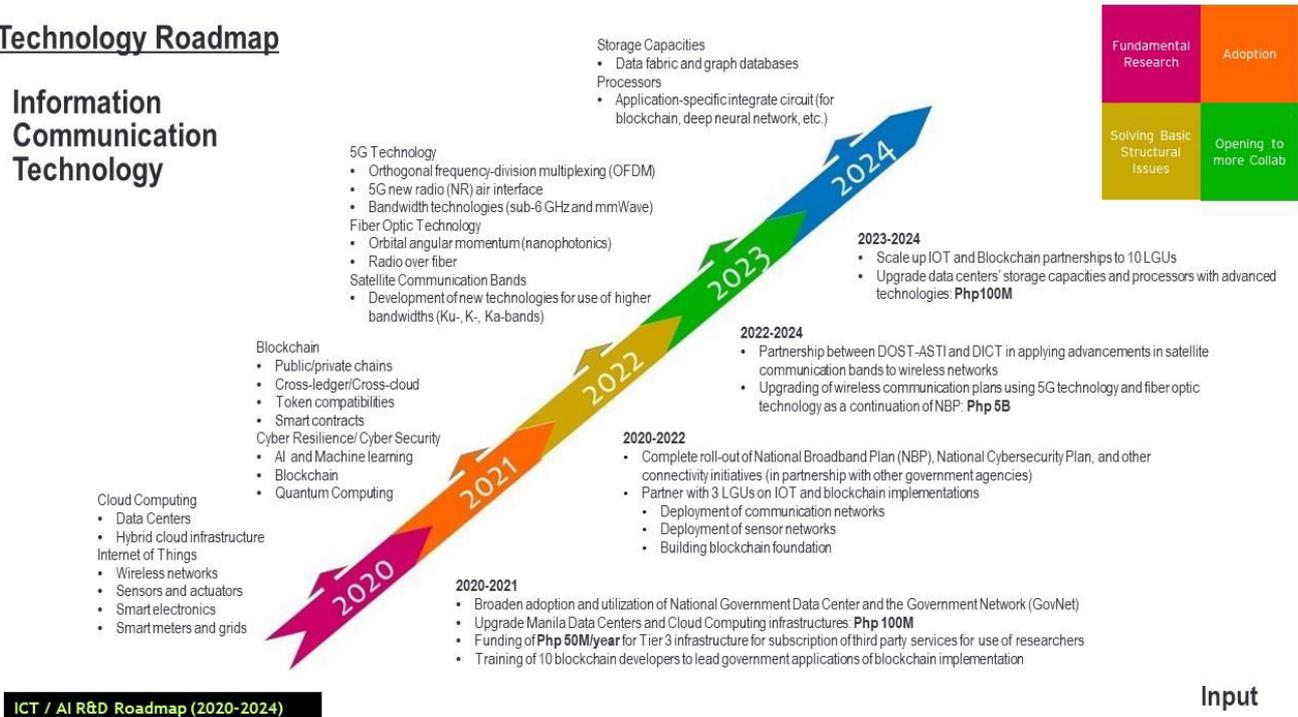
Quantum Computing



Input

Technology Roadmap

Information Communication Technology



Input

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