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

DOST PCIEERD ETDD: Formulation of Roadmap and Sectoral Plan for Five Emerging Technologies

Space Technology Applications

Final Report

SGV
Building a better working world

FOREWORD

Building a space capable nation to address climate change, disasters and calamities, the Department of Science and Technology Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST PCIEERD) presents its latest formulation of roadmap and sectoral plan for space technology applications.

This roadmap serves as a guide to develop priority research programs that are aligned under the Harmonized National Research and Development Agenda (HNRDA). It contains vital steps and milestones to achieve the council's goals and bring research ideas into fruition.

This work also highlights the increasing relevance of space technology applications and its importance in disaster mitigation, natural resources management, food production, human protection, ships and aircraft navigation, and enhancement of co mmunication. With the growing demand of space technology but only few key players in the industry, it is important to fortify the country's space capability and build more local and international partnerships.

As leader and preferred partner in innovation and transformation, the council will remain steadfast in protecting and elevating the lives of many Filipinos by harnessing the potentials of emerging technologies, expand technology development and innovation for the industry, energy, and develop S&T int erventions and solutions to generate more opportunities and achieve economic sustainability. By working with us, we can truly make innovation work for the people.

DR. ENRICO C. PARINGIT
PCIEERD Executive Director

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Introduction

Developments in Space Technology in the past were driven by national government initiatives in the USA and the Soviet Union after the Second World War, beginning with the development of rocket propulsion to get simple devices and humans into orbit. The objective was pure scientific discovery – conducting experiments in microgravity and exploring the conditions beyond Earth's atmosphere. In the 1970s, the Space Race between the USA and the Soviet Union led to the two countries pioneering space exploration and achieving milestones of scientific discovery at massive costs. Nevertheless, the incremental discoveries made in the course of space exploration led to the development of multiple technologies that have become indispensable to us in our everyday life.

The commercial application of space technology began as early as the 1960s, when satellites were used to broadcast television, radio, and other data signals for ordinary consumers. Weather satellites also took hold to improve meteorology for public and commercial interests. From the 1970s onward, the private sector took to developing satellites for commercial purposes.

But the biggest milestones have since come to pass in space exploration, with private companies achieving technically and commercially feasible space launches at a fraction of the cost of prior missions. With this, space has become more accessible to the common man, and a greater number of researchers can participate in space exploration and the space economy.

The Space Technology Landscape

In 2018, the global space economy was valued at US$360B, having grown by 3% from previous year valuations (Figure 1). The industry can be broken down into two major areas: the satellite and non-satellite industries, with the former generating 77% of the entire space economy's revenue.

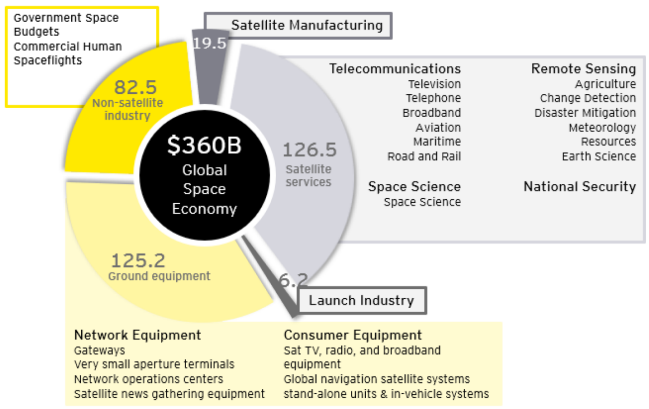


Figure 1. The Satellite Industry in Context, 2018.
Source: Bryce Space and Technology, 2019.

Declining Costs of Space Missions and Services

Space explorations and R&D were once within the purview only of rich & developed first-world countries. The high investment costs and risks of space technology make it inaccessible to developing countries who would rather prioritize investments in agriculture, health, & education than in space technology. However, this landscape has changed in the recent years. Private companies attempting to launch space missions have achieved lower costs per kg by betting on reusability and the use of commercial-off-the-shelf components. From a $23,750 cost per kg for the Saturn V in 1967, SpaceX was able to draw down the costs to $1,200 per kg for the Falcon Heavy in 2018 (Figure 2).

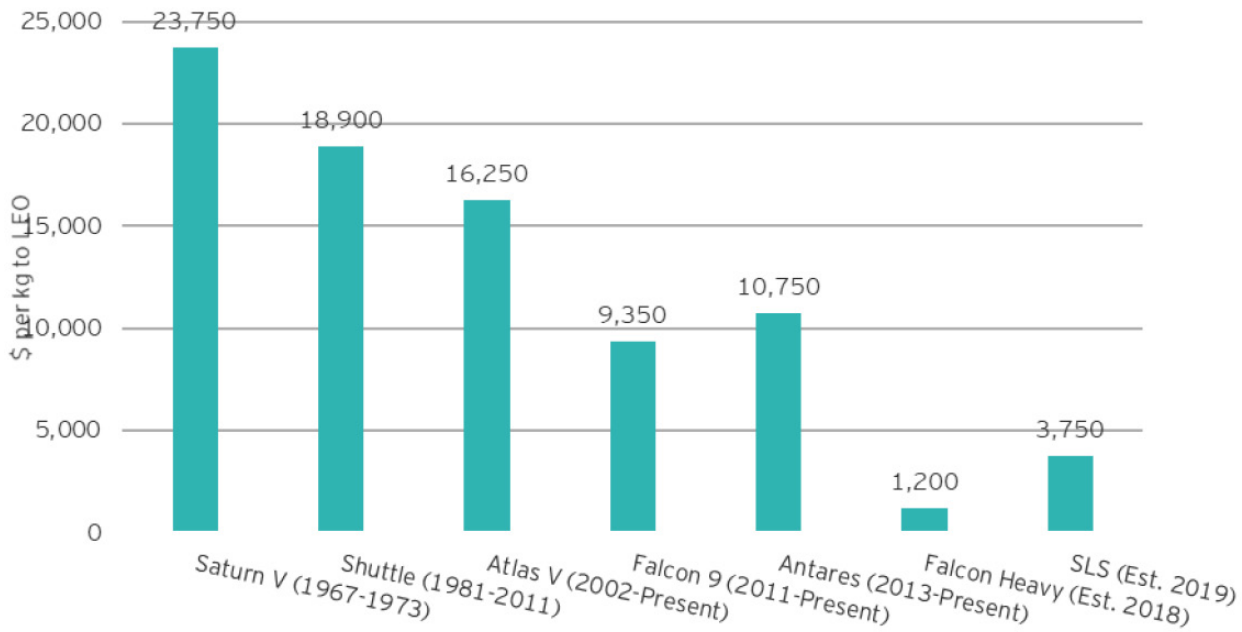


Figure 2. Satellite Launch Costs ($ per kg to LEO)
Source: NASA, ESA, Space News, 2018.

Satellite manufacturing costs for building & management have also substantially declined in the past years, the cost of a minimum viable satellite having decreased from $150 Million in 2005 to $810,000 in 20202, making production less difficult and more economical (Figure 3). In terms of satellite services, connectivity through satellite has historically been the least favored channel to connect to the internet due to notoriously slow speeds and high costs. However, competition from affordable satellite constellations is set to change that.

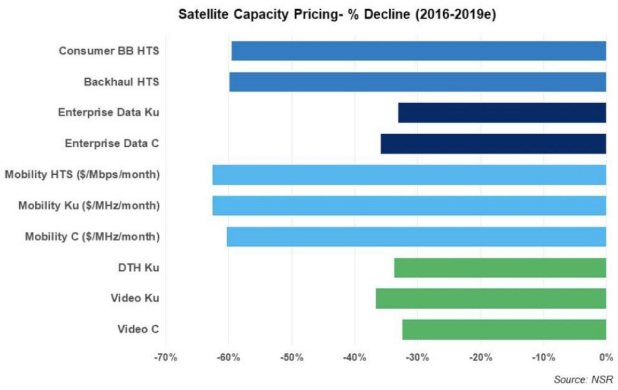


Figure 3. Satellite Capacity Pricing Decline
Source: NSR

Space Economy Value Chain & Risk Assessment

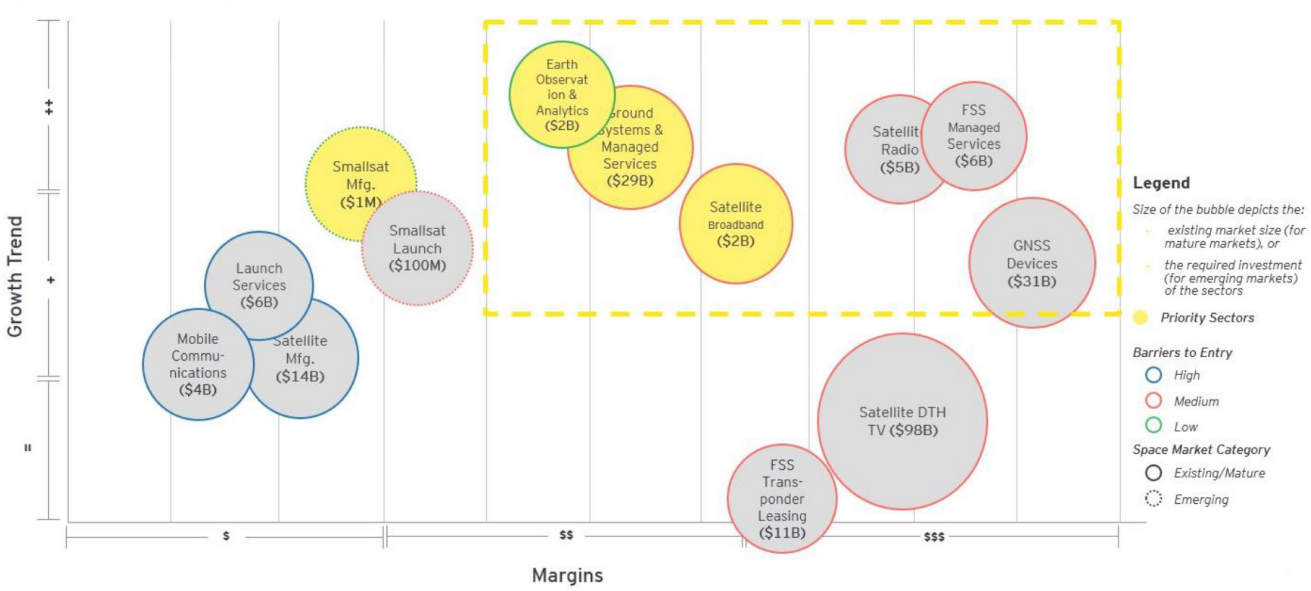


Figure 4. Space Economy Value Chain
Source: Global Space Industry Dynamics, Bryce Space and Technology, 2017

The diagram above shows (Figure 4) various mature & emerging space markets plotted according to growth trend, margins, and corresponding market size (for mature markets) or required investment (for emerging markets). Emphasis is given to those sectors highlighted in yellow & those in the upper right hand corner. It is noticeable that although these markets are not at the higher end of market size (versus Satellite DTH TV for example), they exhibit high growth and high margins due to increasing relevance of various applications & relatively low investment risk (Figure 5). It is especially noted that the segments on Ground equipment, Satellite services, and National security exhibit the lowest risks in terms of asset intensity, demand, and regulation. Due to these favorable risk environments, there is more competition in the ground equipment market.

	Risk assessment of market segments and business models for five discriminators							
	Launch industry	Satellite manufacturing	Satellite services	Ground equipment	National security	Crewed and robotic space science and exploration	Space tourism (incl. habitation)	Energy, mining, processing and assembly
Product/technology	◑	◔	◑	◑	◑	◑	◕	●
Asset intensity	●	◕	◑	◔	◑	●	●	●
Demand	◑	◔	◔	○	◔	◕	◕	●
Competitive landscape	◑	◑	◔	◕	◔	◑	◕	◑
Regulation	◕	◑	◕	◔	◑	◑	◕	◕
Risk summary	◕	◑	◑	◔	◑	◕	◕	◕

Table 1: Risk assessment of market segments and business models for five discriminators
Legend: ○—Low Risk ●—High Risk

Figure 5. Risk Assessment of Space Economy Sectors
Source: European Investment Bank, 2019

Of the markets depicted, four of these stood out to where the Philippines can participate significantly and eventually be able to gain a foothold and grow in the respective markets (highlighted in yellow in Figure 4). These markets have also been identified with respect to the country's current capabilities in space technology and development as well as other considerations in terms of operations and possible limitations. Each will be discussed in depth in another section.

Commercial Investments in the Global Space Landscape

Most notable in recent trends is the shift towards smaller-scale 'lean' satellite production. The comparative ease of production, shortened time, cost, and maintenance demands required by production, launch, and operation of micro- and nano-satellites has made it a more attractive alternative to typically large satellite systems. Driven by demand from the United States of America (USA), China, nano-satellites are expected to account for the largest proportion of spending in the coming years, followed by reusable launch vehicles for low Earth orbit (LEO) launches.

A total of 1,700+ small satellites were launched in the 7 years beginning 2012 to 2019. Of these, 389 have been launched recently in the year 2019. The average smallsat mass has gradually increased, now averaging at 109kg – nearly a 2x increase from 2018, and a 6x increase from 2017.

In the early years, smallsat launches have been dominated by either academic or government (civil or military) applications. However as we can see in Figure 6, commercial smallsat launches have substantially increased through the recent years, growing from 6% in 2012 to 52% in 2019, effectively leading the small satellite space. Launches by the academic segment follow, also growing in proportion recently. Other operators providing smallsats are those in the government for civil & military applications. Majority of these are from USA, China, Russia, Japan, and India (Figure 7).

The global space landscape is now dominated by commercial powerhouses – Space X, Northrop Grunman, Viasat, Virign Galactic, Aerojet Rocketdyne, to name a few. Space X is currently valued at $33 Billion, engaging in human spaceflight & satellite communications, having recently launched a LEO constellation of 482 satellites as of June 2020 and a manned mission to the ISS also in the same month. In the area of national security, Northrop Grunman & Aerojet Rocketdyne, which are valued at $59.6 Billion and $3.4 Billion respectively, engage in running missions to launch military satellites and resupplying the ISS, to name a few.

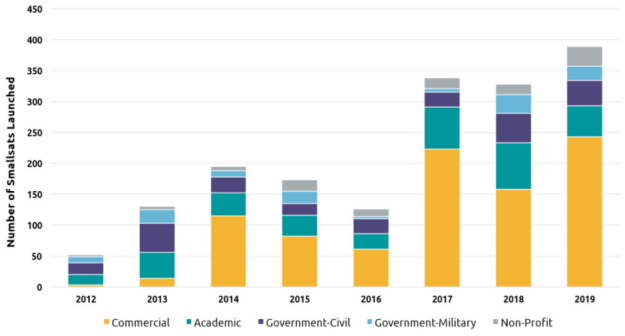


Figure 6. Small Satellites Launched, by Use
Source: Bryce Space & Technology: Smallsat by the Numbers, 2020.

Applications of small satellites vary – the usual include remote sensing, technology development, communications, and for scientific purposes. Technology Development has consistently covered a major proportion of total satellites launched, averaging around 40% of total. Smallsats for remote sensing application increased in launch from 2014-2017, but has since declined in proportion in the past two years. Although remote sensing applications still comprise a large proportion of the number of smallsats launched, this paves the way for satellite launches for other purposes.

An emerging entrant in the small satellites segment is smallsats for Communications purposes, gradually growing in proportion from around 10% to 38% of total in 2019.

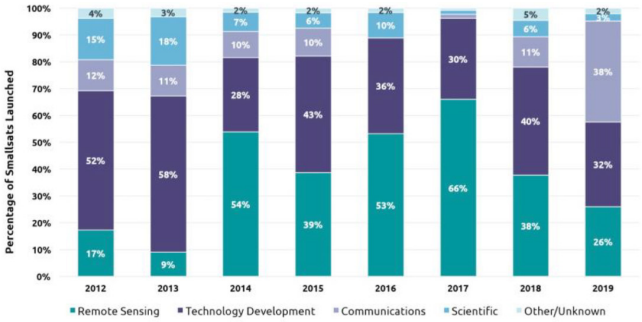


Figure 7. Number of Small Satellites Launched, by Operator Type
Source: Bryce Space & Technology: Smallsat by the Numbers, 2020.

Direction of Other Space Agencies

Following the trend of the commercial sector emerging in the global space landscape, NASA is taking strides to transform how they deal with the commercial space community. There are three key themes in how the space agency is engaging with commercial ventures:

- **Private sector role as partner rather than contractor.** Transforming a customer-contractor relationship to becoming partners, collaborating & cost-sharing in the exploration of new space technologies and applications.
- **Government purchase of services instead of hardware.** An example of which are Commercial Resupply Services contracts agreed upon to provide delivery services of cargo to the International Space Station, where the government pays for the services instead of the development & operation of hardware.
- **Creating broader opportunities for innovation.** Innovation that encompasses the needs and interests of everyone involved, not just NASA (e.g. NASA Centennial Challenges, IPP Seed Fund to seek collaborations with private sectors and other Federal labs to address common interests & scientific problems)

On the other hand, the direction of space agencies in the Middle East reflect in part the vision of the head of the government, and in part the drive for defense and deterrence. The Australian Space Agency has also been active in engaging with the industry, with the Statements of Strategic Intent and Cooperation promoting industry investments in facilities, people, and R&D into the growth of the national space sector. Companies who have expressed their intent to support & cooperate include Airbus, Lockheed Martin, Boeing Company, Maxar Technologies, and Thales Australia.

Trends in Satellite & Space Tech Manufacturing

The European Investment Bank in its paper on the Future of the European Space Sector (2019), identified some key technology trends in space technology that disrupt the space and space application market. Among the ten they identified, the others including advanced telemetry and change detection, we highlight five trends that can be especially relevant for the Philippines (Figure 8).

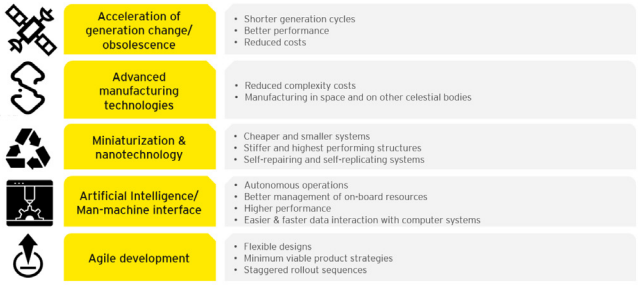


Figure 8. Trends in Satellite & Space Tech Manufacturing
Source: European Investment Bank

Acceleration of generation change emphasizes the rapid obsolescence of technological components in the market, making this a significant issue for programs and projects that have a long timeline. With this rapidness should come an equally fast & flexible response through agile development. Advanced manufacturing technologies yield to reduced complexity costs, as it enables the creation of components in one piece, without the need for multiple parts & their combination to function. Following the same logic with small satellites, miniaturization and nanotechnology allows for advancements in the space industry through smaller, more affordable, and more accessible systems.

Emerging Fields in Space Technology

New business services have since evolved from the traditional space landscape. These emerging "NewSpace" fields are enabled through innovations that allow a "significant reduction in cost, the provision of new products and services, and a broadening of the customer base (EIB, 2019)3." As seen in the Figure 9, some of these areas including SmallSat Systems, Geoinformation, data and services, and smallsat EO constellations have commercialization potential. Investments in the space arena have substantially grown from EUR 1.1 Billion in 2000-2005 to EUR 8.5 Billion in 2012-2017, reflecting increased interest and investments in NewSpace categories. Investments in NewSpace categories vary depending on the maturity level of each – as the field gets more mature, the more commercial & institutional investors venture in them, while emerging areas get their funds from companies & start-ups who are keen in exploring these new business areas (e.g. venture capital firms, angel investors).

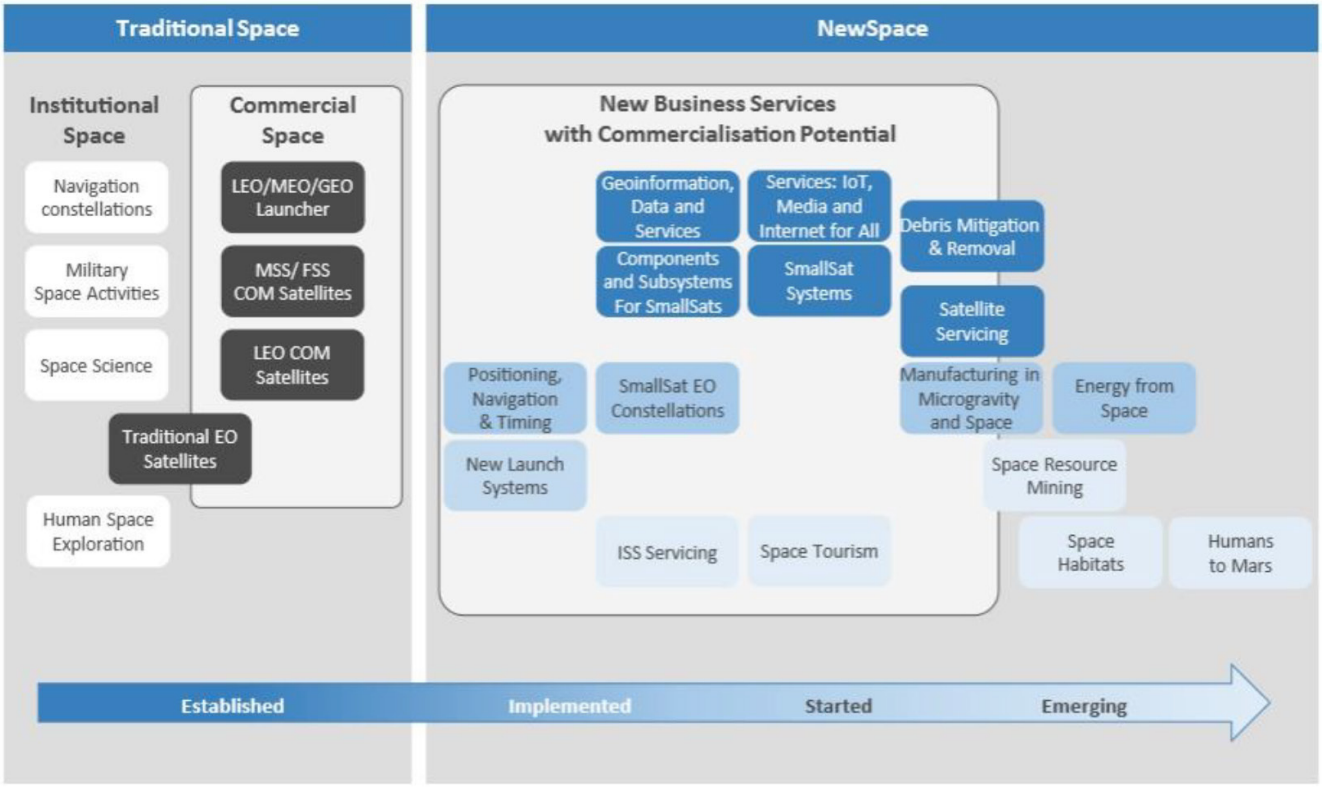


Figure 9. Space Economy Landscape
Source: European Investment Bank

It is important to understand that the areas in NewSpace evolved from those mainstream technologies that have been developed and honed over the course of space technology development. Innovations in small satellite EO constellations stem from the mastery of the technology of the traditional EO satellites that have been in orbit for decades. Explorations in the areas of space tourism, space resource mining, and space habitats have descended from successful human space travels and advanced studies in space science. Competencies & knowhow in these fundamental technologies are crucial in furthering innovations in the space landscape.

Other countries have begun their explorations in the NewSpace segment. An example of which is Australia, which includes Position, navigation and timing, space situational awareness, and debris monitoring in its National Civil Space priority areas. Australia has established collaborations with industry and government agencies in identifying & investing in areas of opportunity for these priorities.

Strategy & Direction for the Philippine Space Agency

Objectives

In lieu of a dedicated space agency, DOST and its many arms have funded, managed, and implemented the projects, R&D, and initiatives under the National Space Development Program. To focus and streamline government-led space programs and initiatives, they sought to create a dedicated Philippine Space Agency (PhilSA) to manage, coordinate, and centralize alignment in national policies and priorities in space and space technology developments. Our strategy is crafted with the PhilSA positioned to be at the forefront of developing the policies and programs related to space S&T applications.

In light of the current capabilities of the country and the trends surrounding the global space technology landscape, we arrive at two overall objectives for our strategy:

Space sovereignty and self-sufficiency

One of the main thrusts of the Philippine Space Policy is the promotion of national sovereignty and security towards the attainment and protection of national interest. Part of this is the ability to design, develop, and build space tech capacity internally, without being dependent on assistance, influence, or participation of other nations.

This may involve considerable investment and expense compared to the mere purchase of commercially-available space solutions, but the expertise to be gained in the development and protection, as well as the confidence in the security and integrity of the locally developed solutions, will be invaluable to the country.

In the past decades of space & satellite explorations, the country has been able to launch & deploy its satellites in cooperation with international space agencies such as NASA and JAXA and foreign research institutions like the Tohoku and Hokkaido Universities of Japan (e.g. Diwata-1 microsatellite).

The creation of PhilSA enhances the resources available in empowering and advancing the local space landscape. Space efforts have been decentralized in the past decades with R&D for space technology & applications spread out across the different arms of DOST (e.g. PCIEERD, ASTI) and various universities, making it difficult for the space sector to embark upon the journey to space sovereignty and self-sufficiency. PhilSA allows this sense of unification and consistency that will organize preexisting & planned STA initiatives and align them towards a national strategy that prioritizes Philippine interest above all.

Crucial to the development of the country's space industry, is the assurance that the space assets that the country builds and acquires are protected from any potential threat that may arise. The transformation of the global space landscape from being traditionally military- and defense-focused to the spread of commercialization gave rise to a more competitive and potentially precarious environment for both companies and countries alike. Being able to protect the sovereign space assets is a must in developing a secure sovereign space industry.

Our primary bets are chosen with the overarching thinking that they will help boost the Philippine space landscape from where it is now to one of the most promising spacefaring countries in the international scene.

Build the Philippine Space Industry for maintenance, repair, and overhaul (MRO), assembly integration, and testing (AIT), and satellite servicing

Taking into consideration the movement of global trends in demand and innovation, participation in the satellite service sub-sector could prove to be the most cost-effective and lucrative entry point into the global industry. The Philippine's advantage is in the newness of its space sector. Presently, the country has no tangible space sector, as space-related research and activity are limited to DOST- and academic institution-led projects. With the creation of PhilSA, DOST-ASTI, PhilSA, and their selected partners are able to set and control the direction of the country's space sectors growth to fit regional and global demand. In doing so, there is a better chance of securing the private sector investment, support, and partnerships essential to scaling the sector, and in creating a robust space ecosystem.

The first step towards this is in cementing the PhilSA's linkage with the Philippine aerospace industry. In 2013, it held a 0.15% share of the country's GDP, and was initially projected to grow to a 0.57% share by 2022. However, this projection may not be achieved due to the adverse impact of and the uncertainty brought about by the global pandemic to the aerospace industry. Regardless, the overarching objective is to see the country become a major hub for original equipment manufacturing (OEM) of parts, and for maintenance, repair, and overhauling (MRO)—both activities that contribute significantly to the global space industry's total generated revenue.

The Philippines already hosts at least three (3) Tier 1 aerospace suppliers. Through this, the Philippine space sector can enter the global arena through the satellite service and manufacturing workstreams. Most of local STA activity takes place in the realm of research that is used in conversation efforts or DRM. In linking the space and aerospace industries, there is an opportunity for the former to scale outwards into more revenue-generating activities, which in this case will be MRO.

Further industries that will benefit from linkages to the space sector include the automotive, ICT, and electronics industries. Concurrent to advancements in the space sector, these adjacent industries will have more opportunities to expand their markets to include products and services which have emerged from the space technology developments. Investments in the Space sector are expected to generate a multiplier effect on adjacent industries in the country.

The key impact areas in the policies set forth for PhilSA will center around research and innovation, efficiency gains, commercial activity, national economic growth, and cost avoidance. More specifically, the six (6) key development areas will include the:

1. Preservation and enhancement of the country's national security;
2. Development and utilization of STA to enhance hazard management and disaster mitigation strategy to ensure the nation's resiliency to climate change;
3. Stimulation of rapid scientific growth through the conduction of R&D endeavor in vital areas of space science, technology, and allied fields;
4. Creation of a robust and thriving space industry to support the local space program through private sector involvement and cooperation;
5. Development of expert manpower, curriculum, and education materials at all levels; and
6. Becoming of a key player in the ASEAN and global space community as a service and manpower-provider.

Immediate focus is on national security and development and the mechanisms that will enable effective delivery of public service in an archipelagic nation. Hazard management and climate studies are covered in cooperation with PAGASA. The primary bets in the following section are selected considering these development areas and how these sectors will contribute to each KDA & the overall growth of the STA landscape in the country.

Primary bets

Earth Observation & Analytics

Although the existing market for earth observation is not that large relative to other existing markets like Satellite DTH TV and Satellite Manufacturing, it is identified as one of the priority sectors for the country because of its high growth trend and average margins *(see Figure 4 in the previous section)*. The barrier to entry is also low given the existing efforts and initiatives that the country has for earth observation data collection and processing through DOST – ASTI. As EO and EO-driven data analytics is not that mature yet, there is nowhere to go but up in venturing into this market.

The Philippines possesses several data sources and repositories for satellite and ground data, all hosted under DOST-ASTI. To optimize current and future utilization and distribution of data, the development of the local space sector would benefit from the organization of existing datasets according to format, function, purposes. The immediate impact would be the increased ease of data navigation by data processors, researchers, individuals, and organizations looking to make use of the data. The medium-term impact would be that the initial data organization would facilitate a quicker data migration into a single, integrated data hub and/or repository. Overall, the vision is to make EO-driven analysis mainstream, not just for academic and research purposes but also for government and industry use & decision support. For this to happen, it will require the accessibility & affordability of the datasets, and the ability of individuals and entities to apply this to their operations.

DOST-ASTI, through the local Diwata and Maya satellites, and foreign satellite subscriptions, collects and processes a variety of data contributing to research in Earth observation, environmental management, vegetation indices, land cover, water quality, and disaster risk management (DRM). Presently, the data and capabilities are applied mainly in DRM. Applications of satellite data and its processing can extend further into the priority programs of the national government for wider reach and expansion, as outlined in the section above.

Earth observation placed in the context of national government priority programs opens up a lot of use cases that will enhance the quality of public service provided to the people. An estimation of the economic benefit of selected public services using downstream EO services was made to show incremental values that may be realized, amounting to a total of 934.61 Billion Php, broken down as follows *(see Appendix for detailed calculations):*

- 171.82 Billion Php in Real Property Tax collections if tax assessment is supplemented by more accurate data provided by satellite use,
- 3.69 Billion Php incremental savings for the use of Digital Data Imaging Technologies through Project DIME versus the costs of traditional audit of government projects,
- 99.1 Billion Php in GDP increase if smuggling is curbed through enhanced monitoring in the customs, and
- 660 Billion Php incremental increase in AGRI-AGRA loans to support agricultural value chain financing.

The derivation of these estimates can be found in the annex of this work.

This economic benefit fares far from the estimated costs incurred for satellite imagery and potential investment for local EO capability. Subscriptions to satellite imagery providers reach to about 70 Million Php annually, combining costs from Planet (25 M), Kompsat (10 M), and DigitalGlobe/ Maxar Technologies (35 M). A rough estimate for the development of an Optical-Infrared satellite costs around 1.75 Billion Php, with accompanying programs costing 600 Million Php in the course of 10 years.

The flexibility of EO allows it to be applied to various government programs, including but not limited to: agriculture, banking & finance, customs, government services, national security, and public works. The underlying concept revolves around the idea of a more timely, accurate, and efficient monitoring & surveillance of government assets that are intended to be provided necessarily in the form of public service.

Satellite Communications

Existing communications infrastructure in the form of both wired and wireless terrestrial technologies, have limitations in terms of universality and reliability. Terrestrial infrastructure can't reach the most rural and remote areas since not all terrain are suitable for the heavy equipment & facilities required to enable full coverage and interconnectivity. Being physically dependent also increases the exposure to natural and man-made disasters and may lead to broadband communication issues at a time when stable and dependable connections are needed most.

Satellite communication provides the reinforcement needed by terrestrial communications infrastructure. The main objective in selecting Satellite Communications as one of the country's primary bets is the deployment of broadband communication system to all regions of the Philippines, especially the rural and remote areas, ultimately becoming an active player in the Space Communication Network in the long run.

In a study conducted by We Are Social4, it found that 73 Million of the Philippines' total population are considered internet users, reaching a penetration rate of 67% as of January 2020. This means that over 35 Million of Filipinos are still unreached by existing broadband infrastructure. As seen in the Philippine Integrated Infostructure map below Figure 10, there is a considerable area that are still unserved, mostly in the northern Luzon areas in regions I, II, and CAR and provinces in Visayas and Mindanao. There are also underserved areas of the country which may be reached by broadband services, but such may not be enough to serve the needs of the population.

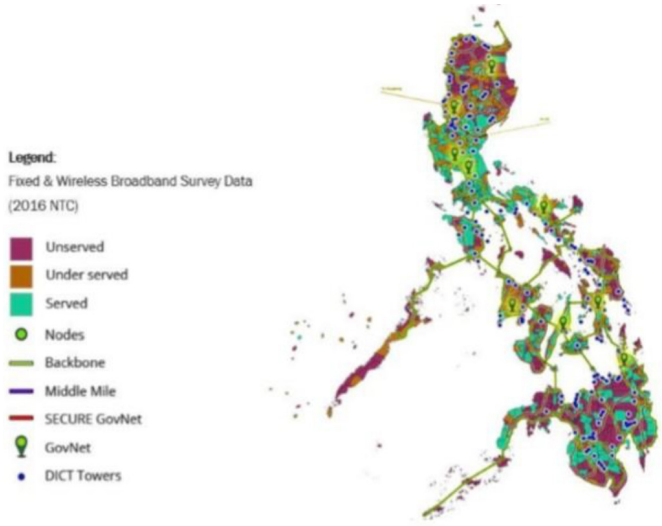


Figure 10. The Philippine Integrated Infostructure (PhII) Overview Map
Source: National Broadband Plan, DICT

More than rural connectivity, satellite communication is also seen to support complex ground station networks for military and other civilian uses such as education, government internal communication, and disaster risk management. In the context of these primary government functions, it is crucial to have a reliable and consistent network connection that would allow for smooth and secure communications needed for rapid, effective, and efficient government response.

Broadband communications will be the convergence point of resources from the Philippine Space Agency, the Department of Information Communication and Technology (DICT), and the Department of Science and Technology (DOST). Public-private partnerships on last mile delivery can be covered by DICT, while non-commercially available solutions can be covered by DOST. Application and geographic areas are wide range. Hence, PhilSA and the consortium should focus their efforts in order to realize benefits by government and citizens. Application areas include education, health and disaster/emergency response, and overall national security and development.

Various studies have reported on the economic impact of increasing broadband penetration. Statistical analysis & econometric models conducted found that a ten-percentage point increase in broadband penetration yields to 0.32 – 0.70% increase in GDP growth for developing countries (World Bank, ITU). Variances were observed in the studies due to methodological shortfalls such as data availability and aggregation limitations. Applying this range in the local setting, increasing broadband penetration of the Philippines to full nationwide coverage leads to a Php 679.2 Billion incremental GDP.

The International Telecommunication Union breaks down this economic impact into four types (Figure 11): 1) the construction of broadband networks which creates direct jobs & contributes to the economy, 2) increase in firm productivity for businesses, 3) increase in household real income for households, and 4) consumer surplus expressed as the difference between willingness to pay & actual price of broadband.

Costs for network expansion to enable nationwide coverage will cost around Php 2-4 Trillion using traditional methods like DSL, Wi-Fi, and LTE for the terrestrial equipment and facilities. On the other hand, estimated investment for local satellite communication capability through GEO and LEO communication satellites is much cheaper than the traditional, playing around Php 10 Billion with variations caused by differences in mass, launch vehicle, transmitter power, bandwidth, and the like *(see Appendix for more details)*. The cost of the latter is easily covered by the incremental benefit above.

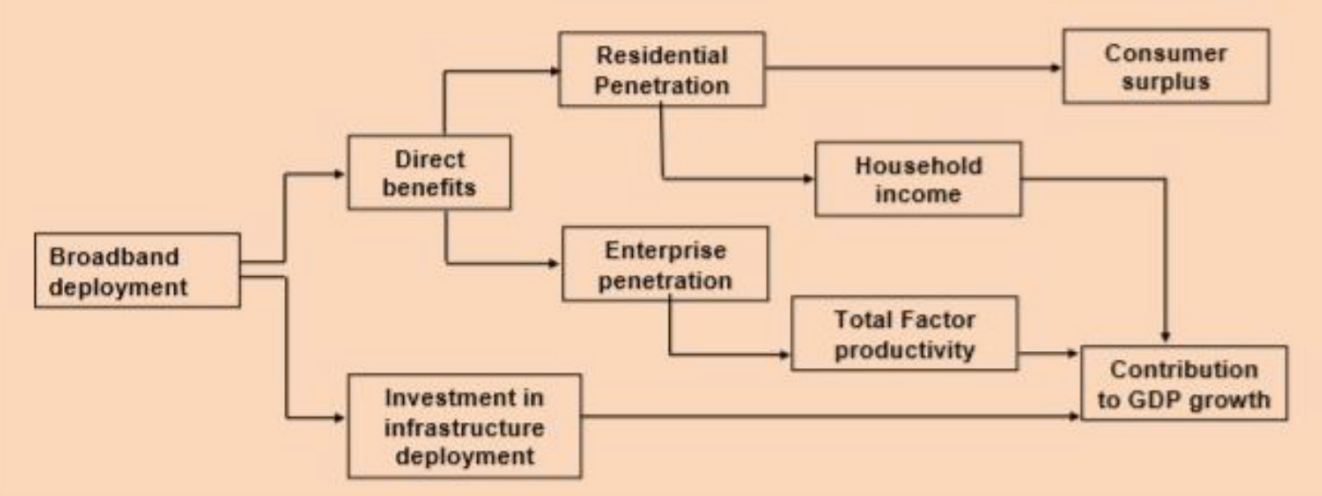
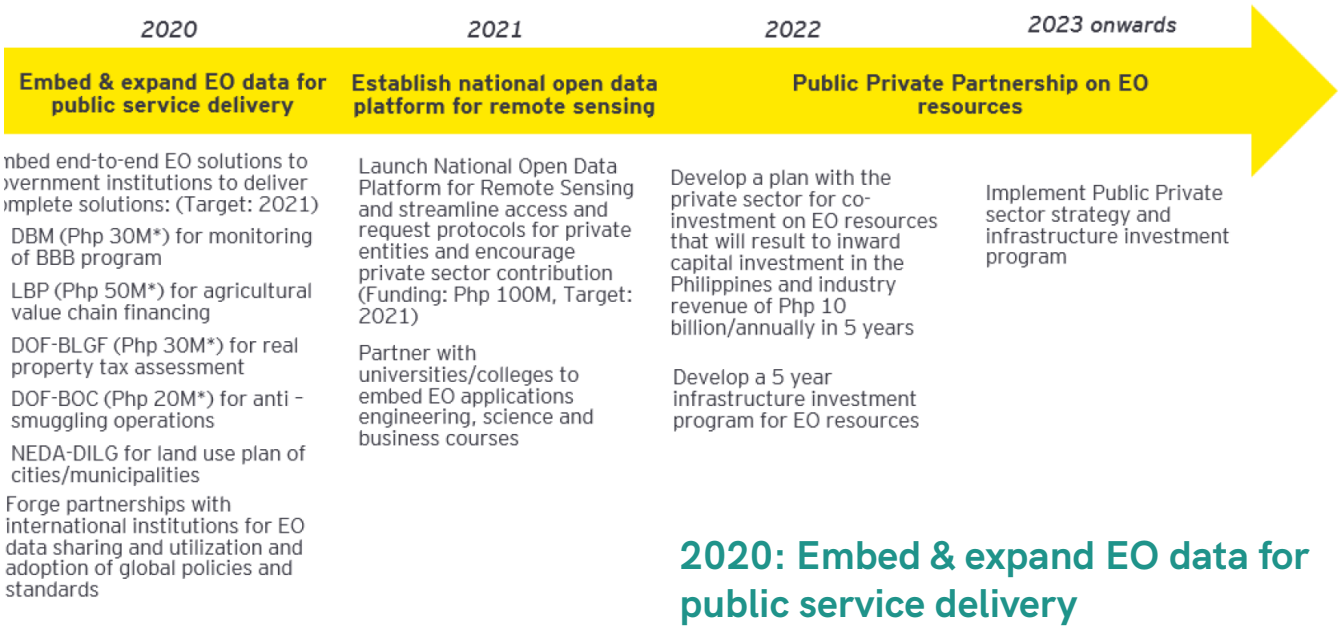


Figure 11. Economic Impact of Broadband Deployment
Source: ITU

Action Plan

Workstream 1: Earth Observation & Analytics



With the primary objective of becoming best-in-class on EO analytics adoption, the strategy for earth observation will take a program-based approach that is focused on maximizing the applications and use cases that EO can provide. These are foreseen to be for use by:

Military. Remote sensing to monitor sovereign territory, assets, and threat detection.

Civil services. Remote sensing for broad risk assessment, governance, and situation monitoring.

Private sector. Remote sensing for risk assessment, economic assessments.

2020: Embed & expand EO data for public service delivery

The focus for the initial years will be to embed end-to-end EO solutions and deliver data science products and services linked to national government priority programs, including the following:

Department of Budget and Management (DBM) for monitoring of the Build, Build, Build program

Project DIME, or the Digital Imaging for Monitoring and Evaluation, was a collaboration between DOST and DBM with the purpose of monitoring and evaluation of high-value projects through geospatial monitoring. It is meant to more accurately measure and predict the cost-effectiveness of technological interventions in DBM's project management of forest rehabilitation, post-disaster monitoring, national irrigation systems, and infrastructure development.

This project makes use of Digital Data Imaging Technologies, which provides a more efficient way of monitoring & evaluation versus the traditional audits. Given that infrastructure is one of the biggest priorities for the Philippines through the Build, Build, Build (BBB) program, extending the scope and timeframe of Project DIME to the high-value government projects included in BBB will improve the monitoring mechanism of not just DBM, but other agencies who also have a stake in the status & completion of these projects.

Land Bank of the Philippines (LBP) for agricultural value chain financing

The Land Bank of the Philippines has since been threatened by President Duterte that the Bank will be abolished if they do not prioritize service to the interests of farmers and fisherfolk, which is LBP's primary mandate. Capitalizing on local expertise on Geographic Information Systems (GIS), Remote Sensing (RS), Artificial Intelligence (AI) and Data Science through the DATOS Project, the use of EO solutions for yield estimates, land availability, risk assessment, and crop mapping can help enhance LBP's financial services to the agricultural sector and the value chain analysis.

This partnership can help create models that the Bank can use to assess and monitor performance and risks of related agricultural crop exposures in the loans that it provides.

Rate (RPTAR) in FY 2015 only reached 79% nationwide, with uncollected potential revenues amounting to 13.08 Billion Php (BLGF).

Department of Finance (DOF) & Bureau of Local Government Finance (BLGF) for real property tax assessment

Real property taxes comprise a large portion of the revenue obtained by LGUs from its constituents. However, collection is not maximized as it should, leading to revenue gaps & lost in every region of the country. The Real Property Tax Accomplishment Rate (RPTAR) in FY 2015 only reached 79% nationwide, with uncollected potential revenues amounting to 13.08 Billion Php (BLGF).

Using EO technologies, this collection can be improved with a better and more efficient system for monitoring the conditions of real properties and the circumstances surrounding assessment thereof.

Department of Finance (DOF) & Bureau of Customs (BOC) for anti-smuggling operations

Another potential use case for EO technologies in the context of government programs is the anti-smuggling operations regularly conducted by the Bureau of Customs, under the supervision of the DOF. According to a study done by the Center for Research and Communication Foundation, Inc. of the University of Asia and Pacific, 904.6 Billion Php worth of products were smuggled from 2011 to 2015. This amounts to a 495.5 Billion Php loss in the GDP of the Philippines (PNA).

Through these use cases, satellite data and applications from the use of earth observation will be part of the norm in supporting and enhancing day-to-day operations of the government. If these projects come into fruition & visibly become successful in providing public service, more public and private institutions will avail the use of earth observation technologies in furthering their own agendas.

DOST should continue forging and strengthening its partnerships with international institutions for EO data sharing and utilization and adoption of global policies and standards. Learning from the knowledge and experience gained by countries who have long made their strides in space technology, it is crucial for the Philippines to connect with the international community, especially those with mature satellite and space technology ready for its various applications, to guide the country into developing its own path in the industry.

2021: Establish national open data platform for remote sensing

A National Open Data Platform for Remote Sensing should be launched to supplement the increase in demand for EO that emerged from the success of the use cases in government. The platform should be able to streamline access and request protocols for private entities and encourage private sector contribution. This must be operated in harmony with the Open Data Philippines (ODPH) initiative which collects and publishes data that government agencies generate from their operations, projects, and the performance of their respective mandates, such as statistics and key performance indicators.

DOST should be mindful of continuously updating their database in order to enable and further research and development. In line with this, regulations must be developed and implemented in order to govern the collection, distribution, and use of data generated from earth observation.

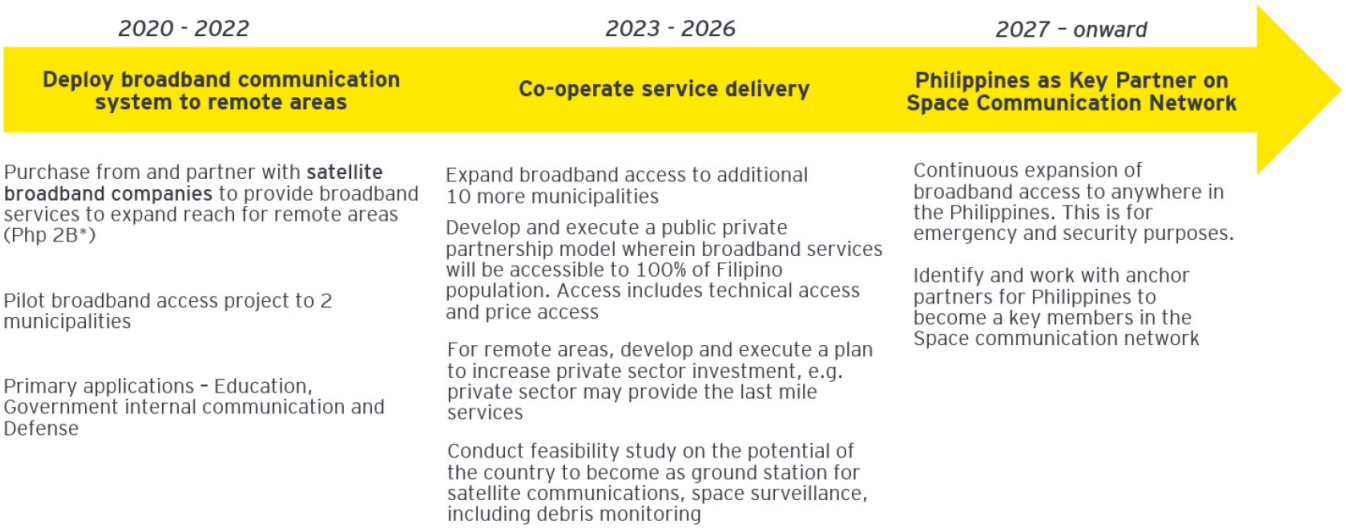
With both the public and private sectors on board, it will be essential to partner with colleges and universities to embed EO applications in engineering, science and business courses. Through this, interest and competence will be honed early on for the students who may wish to advance their studies and pursue careers in satellite data applications and space technology.

2022 onwards: Public-Private Partnerships on EO resources

Having established relationships with institutions in both public & private sectors, there is a need to formalize these liaisons into a framework that will be easy to replicate for current and future public-private engagements involving EO satellite data use. For these years, the government should develop a plan with the private sector for co-investment on EO resources that will result to inward capital investment in the Philippines, potentially contributing industry revenue of Php 10 billion/annually in 5 years.

A 5-year infrastructure investment program for EO resources should also be developed to boost capability & enable more advanced applications for earth observation. Private companies that are targeted for collaboration include data analytics companies and conglomerates in the utilities, communications, and transport industries where EO analytics can be easily applied.

Workstream 2: Satellite Communications and Ground Services



Amid a global pandemic, broadband connectivity becomes all the more essential as people, businesses, and government institutions turn to more virtual means of communicating. Unfortunately, some parts of the Philippines are still unreached by existing terrestrial communications infrastructure. The strategy for satellite communications and ground services take into consideration this shift in the way of living and aim to provide broadband anywhere in the Philippines.

These will benefit and will be for use by:

Military. Surveillance and secure communications. Proportional investment needed in security of physical and cyber assets.

Government services. Communication and broadband for remote areas.

Education. Communication and broadband for remote areas.

2020 – 2022: Deploy broadband communication system to remote areas

Beginning an effort to reach the most rural and remote areas in a faster way, the government should purchase from and partner with satellite broadband companies & telecom providers similar to the likes of PLDT, Globe Telecom, and Dito Telecom (local) and Oneweb, Starlink, or Astranis (international) to provide broadband services & expand reach. This will be initially piloted to two (2) hard-to-reach municipalities to be able to test deployment and improve current strategies for future reference.

Primary applications will be for education, government internal communication, and defense purposes. Reliable broadband connection is a big help in enabling distance learning and inclusive widespread communication for the rural areas of the country.

2023 – 2026: Co-operate service delivery

Having the experience in providing access to the pilot municipalities, this project can now be expanded to additional 10 more municipalities that need broadband connectivity in their respective areas. The municipalities will be assessed and chosen based on criteria including location, demographics, and current broadband penetration.

It will be difficult to sustain this framework in the long run if the funding support will only come from the government. In these years, the focus will be on developing and executing a public private partnership model wherein broadband services will be accessible to 100% of Filipino population. This accessibility does not just refer to the technical accessibility, but price accessibility as well, that is, these services should be available to the public at a price that is within their purchasing powers. With technical and financial support provided by the private sector, the government will be able to efficiently manage its resources and ensure a dependable communications system for its citizens at the same time.

With the projects in place to improve and expand broadband access in the country, the potential of the country with regard to becoming a ground station for satellite communications should be assessed in the form of a feasibility study. This will be able to provide a holistic assessment of the Philippines and render decision support for future investment plans and strategies of the local space agency.

2027 onwards: Philippines as Key Partner in the Space Communication Network

The pursuit for a 100% connected Philippines is a constant effort to ensure that all areas have access to information when needed. This is especially important in times of an emergency of national defense and security. Terrestrial communication infrastructure may not be that reliable during these times.

The country should continue building local capability and connect with anchor partners in the private and public sectors, locally and internationally, for it to be involved and relevant in the global space communication network.

Workstream 3: National Capability for Build, Operate, and Launch of Satellite Systems

The most important element as the country embarks upon sharpening its competencies and experience in earth observation and satellite communications is the corresponding & consistent conduct of capability building programs that will ensure sustainability of space technology efforts.

2020 – 2022: Build capability for EO, communication, and positioning, navigation, and timing

In conjunction with the establishment of the Philippine Space Agency, the years 2022-2023 will be to construct the Philippine Space Tech Center in Clark City to produce small satellites with strategic partnerships. It will have ground station capabilities and will include the following features:

- Clean room
- Thermal chambers
- Spacecraft and instrument level testing area
- Mechanical design
- Mission design and engineering
- Space electronics

This facility will serve as a central unit for production of the satellites and will enable easier monitoring of their progress and development. Through this, more satellites for public & private use will be produced and launched into orbit, expanding the coverage of the existing satellites and maximizing use and processing thereof.

The facility will also house more advanced infrastructure in ground services, where further R&D and training can be centralized.

The Center's testing environments and services will be made accessible to academic researchers and industry players (e.g. electronics industries, ICT) who wish to explore and partner with PhilSA in developing their capabilities in space technology. There is no denying that collaborations have always played a huge role in furthering knowledge and innovation. This is primarily why DOST has continuously worked and engaged with different players from both the local and international community for the development of space technology in the Philippines.

The Philippine Space Tech Center will serve as a hub in breeding these strategic partnerships with the academe and industry in the common interest of STA development. The government should also begin research & development and upskilling for satellite builds in these years to be ready for future innovations laid down in the next years. Specifically, the following are targeted to be achieved:

5 MSs/PhDs for Satellite ECE (Php 35M)
5 MSs/PhDs for Space assets security (physical and cyber security) (Php 35M)
1000 engineers with satellite build training (Php 500M)

2023 – 2026: Develop satellites locally to build capability and attract anchor investor

For these years, the aim is the local development of satellites which will test and enhance the capability of local researchers. The satellites that will be developed are those that will support the aforementioned Philippine bets – earth observation and satellite communications, respectively:

Optical-Infrared Satellite

The Optical-Infrared Satellite will be built with the goal of setting up capability for support operations for satellite manufacturing. This satellite can provide data for applications in agriculture, forest, coastal, and land monitoring, climate studies, disaster management, and national security. Beyond these applications, the entire process of developing the optical-infrared satellite using local skills and talent will serve as valuable experience in providing support services in the future.

The process will not only engage the academe in the capacity build of its researchers, but also the industry in expanding the market of local manufacturing companies to include parts and components for satellite building. The development of this satellite aims to produce the following:

- 20 talents for Satellite Optics and Satellite Engineering
- 5 partnerships to upskill local manufacturers for satellite supplies

GEO Communications Smallsat

Following prioritization for satellite communications, the GEO communications smallsat will be developed and launched for military and national security applications. Being primarily for the purpose of security and defense, the development of this satellite will be in partnership with the Department of National Defense to ensure that technical specifications are in line with the country's current defense capability and requirements.

Similar to the optical-infrared satellite, this will involve both the academe and industry in the R&D and training of human resource to be ready for local development. The production of the GEO communications smallsat aims to produce the following outputs:

- 20 talents for Satellite communications ECE
- 5 partnerships to upskill local manufacturers for satellite supplies
- Upgraded ground station capabilities

The government's potential partners for satellite development include universities honing skill and interest for satellite development (e.g. University of the Philippines, Caraga State University, Mindanao State University) and private companies beginning in the sector closest to space, the aerospace industry (e.g. SSTL, Airbus, MOOG).

2027 – 2029: Establish satellite manufacturing and launch services

Having the capacity to produce locally by this time, the country can improve its ground tracking capabilities to venture into more advanced space technology areas such as space debris management. An unintended outcome of the global rise in STA participation is in the space pollution of the Earth's immediate outer space region. There are over 130 million satellites, rocket pieces, and collision fragments orbiting the Earth at vast speeds, posing a looming threat to satellite operations and dependent industries. Given the cost, importance, and growing traffic of satellite and space activity, the demand for space waste management has risen significantly. In 2019, IBISWorld estimated the business to be worth some US$52.9B annually.

The management of space debris includes tracking, netting, and harpooning rubbish found in the low-Earth orbit. With its satellite and data processing capabilities, the Philippines can participate in the expanding industry through contributing to debris tracking services. This can be pursued in partnership with Japan's AstroScale—one of the largest providers of space debris management and disposal service globally.

In the process of building capability, the government may attract an anchor investor who will begin investments for commercial satellite development, covering facilities, training, and eventual commercial adoption. This includes the provision of technology transfer activities, financing support, and easy connection to customers. The anchor investor is crucial in establishing credibility and faith in the system and will build a degree of confidence for future subsequent investors.

The capability building efforts of the country are visualized through the Satellite Build Training Program. The program has two tracks: one for capability build for local production, and another for advanced capability building – both with execution timelines of 3 years.

Track 1: Capability Build for Local Production

The first track is primarily a workforce build program. Its main objective is to have an in-house pool of talent for the local production of satellites and eventually, launch capability. It aims to produce 1000 engineering graduates with capability and experience in satellite construction. This will serve as a talent base that will be used as a selling point for international STA companies to invest in R&D and manufacturing in the Philippines.

The Space Tech Center in Clark will serve as the training facility for students who wish to expand their classroom trainings in their respective universities into a more practical learning experience. This is modeled after the concept of the Stamina4Space Program, where students will have hands-on experience in designing, developing components, and assembling satellites.

Modules can be introduced for different aspects of space technology, including payloads, bus development, ground control, and launch and propulsion. Similarly, graduates from this program can be deployed to various regions to conduct the next batches of trainings.

Track 2: Advanced Capability Building
The second track is meant to enhance the exposure of local experts to the global space landscape. By bringing these local experts to the international scene, they will be able to take home skills & know-how gained from different countries as inspiration for the development of STA in the Philippines. This track aims to produce the following human capital:

- 5 MSs/PhDs for Satellite ECE (Php 35M)
- 5 MSs/PhDs for Space assets security (physical and cyber security) (Php 35M)

Filipino scientists engaged in satellite studies and development can be brought to other countries to enhance their knowledge and improve their expertise against the global space landscape. This includes participation in seminars, conferences, partnering with universities and research institutions for immersion, etc. Among their responsibilities will be forging international relationships, remaining up to date with the latest direction, and leading local teams to keep up with global standards.

In view of the Balik Scientist Program, this track is aimed at producing scientists who are capable of bringing new technologies for use & application in the local setting, and leading programs to further instill the knowledge and experience they gained abroad to the scientific community here in the Philippines.

Conclusion

The global space industry has undergone significant transformation since its inception in the 1960s. Initially embarked upon in pursuit of national defense and military superiority, innovations within the industry have now been serving a multitude of functions across several other industries. The space industry has been travelling up an upwards growth path that is forecasted to carry on well into the 2030s. The value contributed towards economic growth is undeniable. But even more significantly is the value contributed to the improvement of lives and communities through space technology and its applications.

Upon a comprehensive review of the development pathways of global and regional leaders in the space industry, we identified several opportunities for the Philippines to expand its space sector into the local and international economy, namely in the Earth Observation & Analytics and Satellite Communications segments. Consistent efforts in capability building for the build, operation, and launch of satellite systems should also be in place and prioritized to ensure sustainability in the development of STA in the country. To realize this ambition, simultaneous preparation in the key areas identified, public and private sector collaboration, and stakeholder cooperation are crucial.

Through the development of the local space industry, adjacent industries like the aerospace, automotive, ICT, and electronics industries will also be able to open their markets to more opportunities connected with the space industry. These industries can take advantage of advancements in the space industry to enhance their own business models to adapt and cater to the needs of their customers, needless to say including the space industry itself.

The Philippine Space Agency may have just begun its formalization in the recent years, but the country's efforts in exploring space technology and its applications go way back through the Department of Science and Technology and other collaborating agencies. With the Philippine Space Agency at the forefront in the development of STA in the country, efforts and initiatives in STA in the past and the future will be aligned to a unified national strategy that prioritizes Philippine interest above all.

The ideal outcome of this roadmap and sectoral plan is to make the Philippines a globally recognized spacefaring nation in the long run, having capitalized on local talent development and public & private sector involvement. In the time when the country succeeds in doing so, the goal is to be of service to other countries, both developing and mature, in achieving out-of-this world ambitions and advancing the space industry not just at the national scale but at the global standpoint.

Annex

I. Cost-Benefit Computations

A. Real Property Tax

	Philippines	UK	US	Australia	SG
GDP-USD	330,910	2,828,000	20,500,000	1,420,045	364,139
GDP-LC	16,545,500	2,209,375	20,500,000	2,088,301	498,821
Total Tax	2,773,050	678,681	5,263,255	487,078	66,363
Total Tax of Total GDP	17%	31%	26%	23%	13%
RPT	59,786	62,763	524,075	29,232	4,440
RPT of Total Tax	2%	9%	10%	6%	7%
RPT of Total GDP	0.36%	2.84%	2.56%	1.40%	0.89%

SUMMARY	Php '000 000
Target %	1.40%
Target	231,604
Increment	171,818

Targets
Year 1: **Php 34.36B** or 20%
Year 2: **Php 85.91B** or 50%
Year 3: **Php 154.64B** or 90%

In the table above, effective RPT Rate was obtained as percentage of Total Tax and of Total GDP5. For the Philippines, the calculations arrived at values of 2% for RPT to Total Tax and 0.36% for RPT to Total GDP, both substantially lower than what was computed for its peer countries.

Among the countries in the benchmarking exercise, the effective RPT rate of Australia is observed to be an appropriate target for the Philippines in terms of relativity of real property taxes to total tax & relation of total tax to GDP.

Taking 1.40% as target, this arrives at an incremental collection of around Php 171.82 Billion annually if such target percentage is reached.

Targets are set gradually over three years, with 20% aimed to be achieved in the first year, 50% in the second year, and 90% in the third year. This is meant to set reasonable expectations and not overwhelm the parties involved as the projects are implemented. The same are applied for the other use cases.

B. Agricultural Loan Evaluation Support

Earth Observation data can support loan evaluation through crop mapping, yield estimates, land availability, and risk assessment. As of June 2019, AGRI-AGRA loans have a target of P1386.1 billion. As of that date, banks have only complied with P726.1 billion out of its total available funds6. These lead to an incremental increase of P660 billion annually, if targets are to be reached.

Targets
Year 1: **Php 132B** or 20%
Year 2: **Php 330B** or 50%
Year 3: **Php 594B** or 90%

C. DBM-DOST Project DIME

The annual cost for Project DIME was Php 15.2 Million when it was started in 2018. Without it, high-value projects of different government agencies all over the country would still be assessed through costly traditional audits. Assuming a 1% cost of auditing project completion, multiplied to total budget of projects under Project DIME of Php 370.5 Billion, we arrive at cost of Php 3.705 Billion annually.

Compared with Project DIME's annual cost of Php 15.2 Million, there is the potential to realize incremental savings of Php 3.69 Billion per year.

Targets
Year 1: **Php 20B** or 20%
Year 2: **Php 49.5B** or 50%
Year 3: **Php 89B** or 90%

D. Customs & Smuggling

According to a study done by the Center for Research and Communication Foundation, Inc. of the University of Asia and Pacific, Php 904.6 Billion worth of products were smuggled from 2011 to 2015, amounting to a 495.5 Billion Php loss in the GDP of the Philippines8. Using the aforementioned figures, the annual incremental loss due to smuggling is 99.1 Billion Php.

Targets
Year 1: **Php 0.74B** or 20%
Year 2: **Php 1.85B** or 50%
Year 3: **Php 33.2B** or 90%

E. Communications

Various studies have reported on the economic impact of increasing broadband penetration. Statistical analysis & econometric models conducted found that a ten-percentage point increase in broadband penetration yields to 0.32 – 0.70% increase in GDP growth for developing countries.

The Philippines' broadband penetration rate is currently at 67%, having 73 Million internet users in the country10. Applying the assumption above for GDP increase, pushing penetration up to 100% will return an incremental GDP contribution of Php 679.2 Billion annually.

Assuming a 3-year rollout, contribution may be as appears on the right.

Targets
Year 1: **Php 136B** or 20%
Year 2: **Php 340B** or 50%
Year 3: **Php 611B** or 90%

II. Satellite Communication Costs

Costs for network expansion to enable nationwide coverage will cost around Php 2-4 Trillion using traditional methods like DSL, Wi-Fi, and LTE for the terrestrial equipment and facilities. These costs are estimated from an OECD paper on The Evolving Role of Satellite Networks in Rural and Remote Broadband Access, with data on cost per user for every Mbps that the technology provides.

For the use of satellite broadband communication, the traditional method of satellite-based broadband service delivery is a large geostationary satellite. Having been operational since the 2000s, these satellites are known for their longer usable lives compared to other means. However, disadvantages are also present including higher latency, higher risk, higher cost due to complexity, higher transmission power requirements, and a limited bandwidth. In the current market, launch cost for GEO satellites is $30,000 per kg. Indonesia's Nusantara Satu, a geostationary communication satellite built by SSL, cost $230 Million (Php 12 Billion) in total.

The latest developing concept for satellite-based broadband is GEO small satellites. They are projected to be operational in 2021 with longer usable life and lower cost, but higher latency, transmission power requirements, and a limited bandwidth. Launch costs for such a satellite may be around $10 Million, given the market price for launches to GEO and an estimated mass of 350kg, which follows the planned specifications of the Astranis MicroGEO Satellite Project. The Project pooled funds amounting to $108 Million (Php 5.7 Billion) as of February 2020 to complete the satellite needed to provide 7,500 Mbps of Internet connection to Alaska.

The LEO constellation system is the latest concept being tested for commercial viability, projected to be operational in 2020. It has lower cost and latency but has shorter usable life and has complex ground station requirements. Launch costs per kg are lower for LEO satellites (at approximately $5000 per kg), but the sheer number of satellites required for the constellation bring up launch costs significantly. The cost is significantly higher as this method of satellite broadband delivery by nature covers the entire globe and does not scale to just a specific part of the world. As a comparison, OneWeb has so far launched 74 satellites (out of a planned 648) at a cost of around $3 Billion (Php 156 Billion), while Starlink's completed network (of around 12,000 satellites) is expected to cost $10 Billion (Php 520 Billion) in total.

In an extensive survey of small satellite missions with the intent to derive a cost model through analogy, RAND Corporation found that the average NASA small satellite mission costs $145 Million (Php 7.5 Billion).

Using the foregoing figures, we estimate the cost of satellite communication delivered via smallsat GEO to be around Php 10 Billion, with variations caused by differences in mass, launch vehicle, transmitter power, bandwidth, and other satellite specifications.

III. Policy Paper: Sovereign Satellite for Communication as a Response to Defense and Civilian National Policies

This policy paper recommends DOST's Sovereign Communications Satellite Program as a strong support to the nation's thrust towards national security and universal broadband access and connectivity.

Existing communications infrastructure in the form of both wired and wireless terrestrial technologies have limitations in terms of universality and reliability. Terrestrial infrastructure can't reach the most rural and remote areas since not all terrain are suitable for the heavy equipment & facilities required to enable full coverage and interconnectivity, and the sparseness of some remote villages may not justify the cost of additional backhaul to cover a wider area. Being dependent on terrestrial infrastructure also increases the risk associated with natural and man-made disasters and may lead to broadband communication issues at a time when stable and dependable connections are needed most.

Satellite communication provides the reinforcement needed by terrestrial communications infrastructure. Aligning with the national agenda, these are the areas where DOST's Communications Satellite Program can be a support or an answer to some of the items laid out in these plans or roadmaps:

Military & Defense Applications

- Self-Reliant Defense Posture Program *(Department of National Defense)*. This program aims for the country to be self-sufficient in its basic military requirements through local manufacturing of national security needs, including tactical communications equipment, weapons, and ammunitions. With a sovereign communications satellite, DOST can further support this by providing communication services that ensure security & control over critical military information.
- National Cybersecurity Plan *(Department of Information Communications and Technology)*. Military information, among others, necessitates a high degree of data privacy and reliability for critical ICT infrastructures & the government's information assets. Part of this is to secure military systems to defend the military network from potential cyber-attacks. Having a sovereign satellite reduces reliance on & exposure to foreign networks.

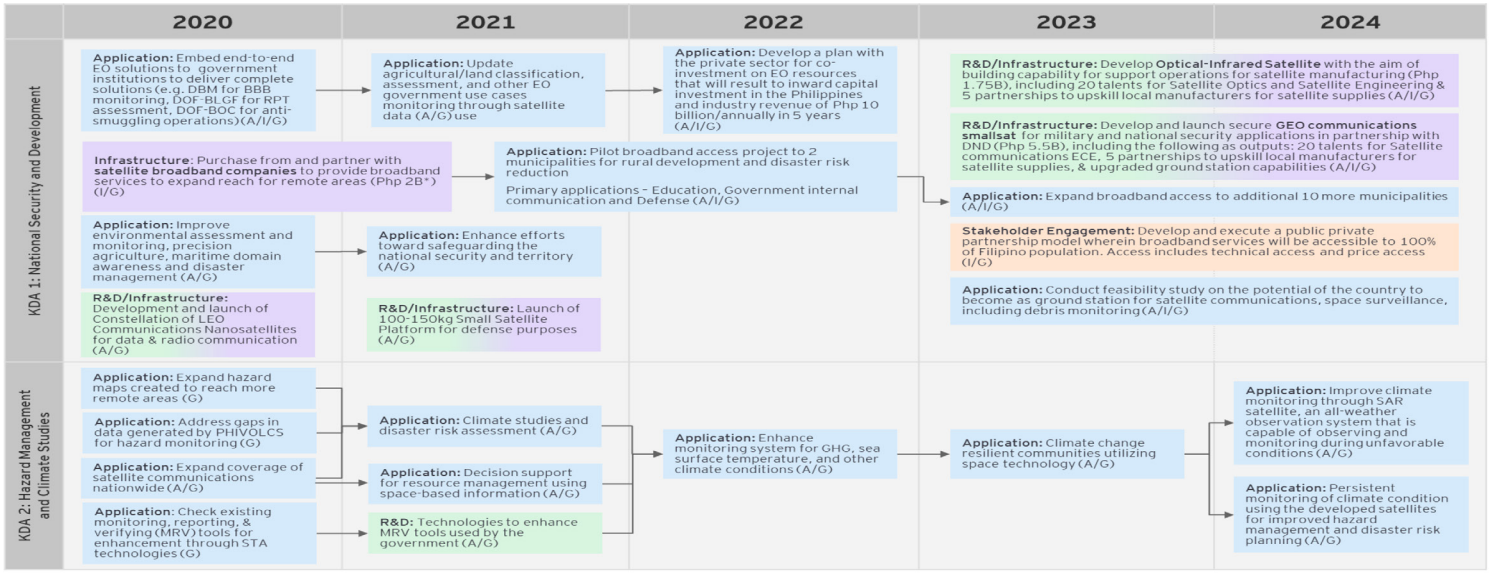
Civilian Applications

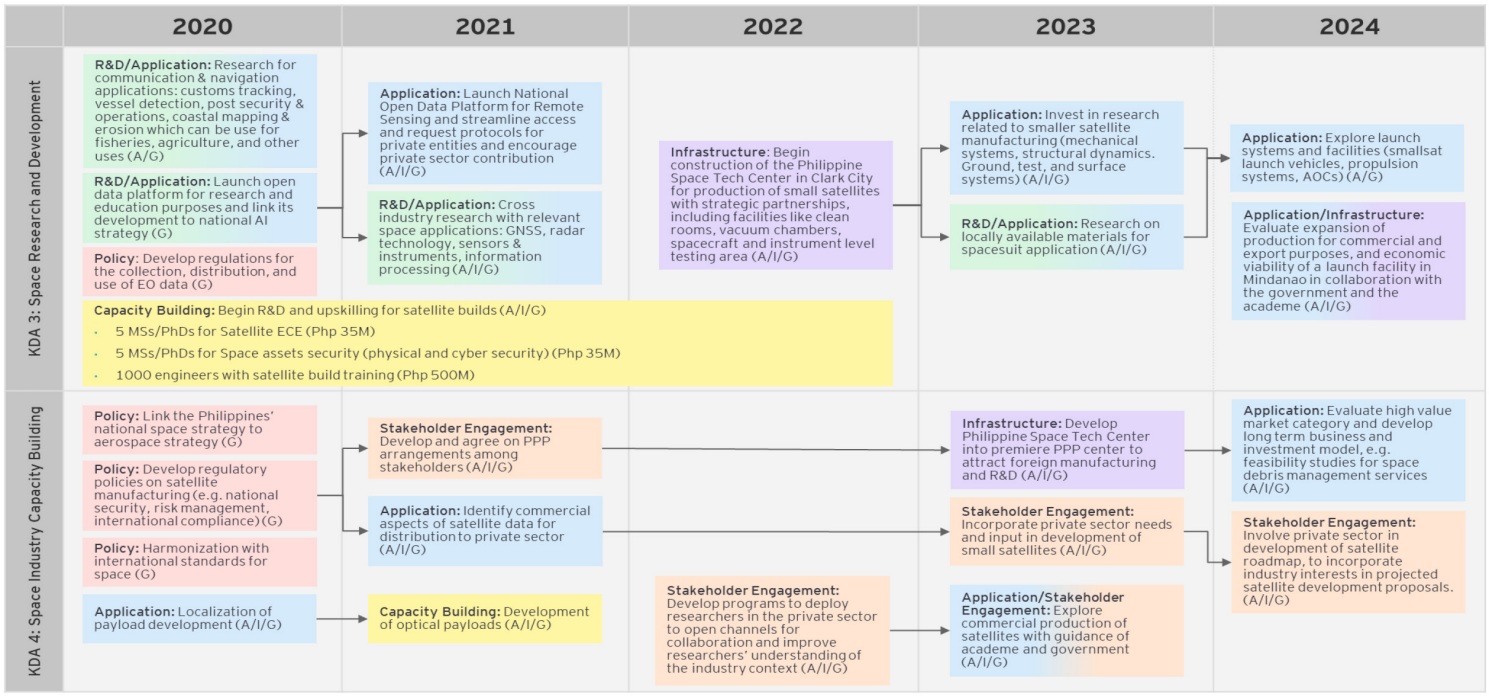
- National Broadband Plan *(Department of Information Communications and Technology)*. Part of the implementation plan in the Philippines' NBP is the leverage on satellite and emerging technologies use to enhance connectivity in geographically-isolated areas. The DICT, in cooperation with USTDA, is now in the process of approval for a feasibility study for the procurement, launching, & deployment of a sovereign communications satellite. DOST & PhilSA can complement this endeavor in its own pursuit of a locally developed satellite, through the provision of the required research & development assets.
- National Disaster Risk Reduction and Management Plan *(National DRRM Council)*. The NDRRMP emphasizes the importance of a reliable and disaster-resilient communication infrastructure to lessen Filipinos' vulnerability to hazardous events. In the event of a disaster, terrestrial facilities may be unavailable to dependably provide communication services – upon which satellite communication can fill in and deliver the vital information needed for rapid, effective, and efficient disaster response.

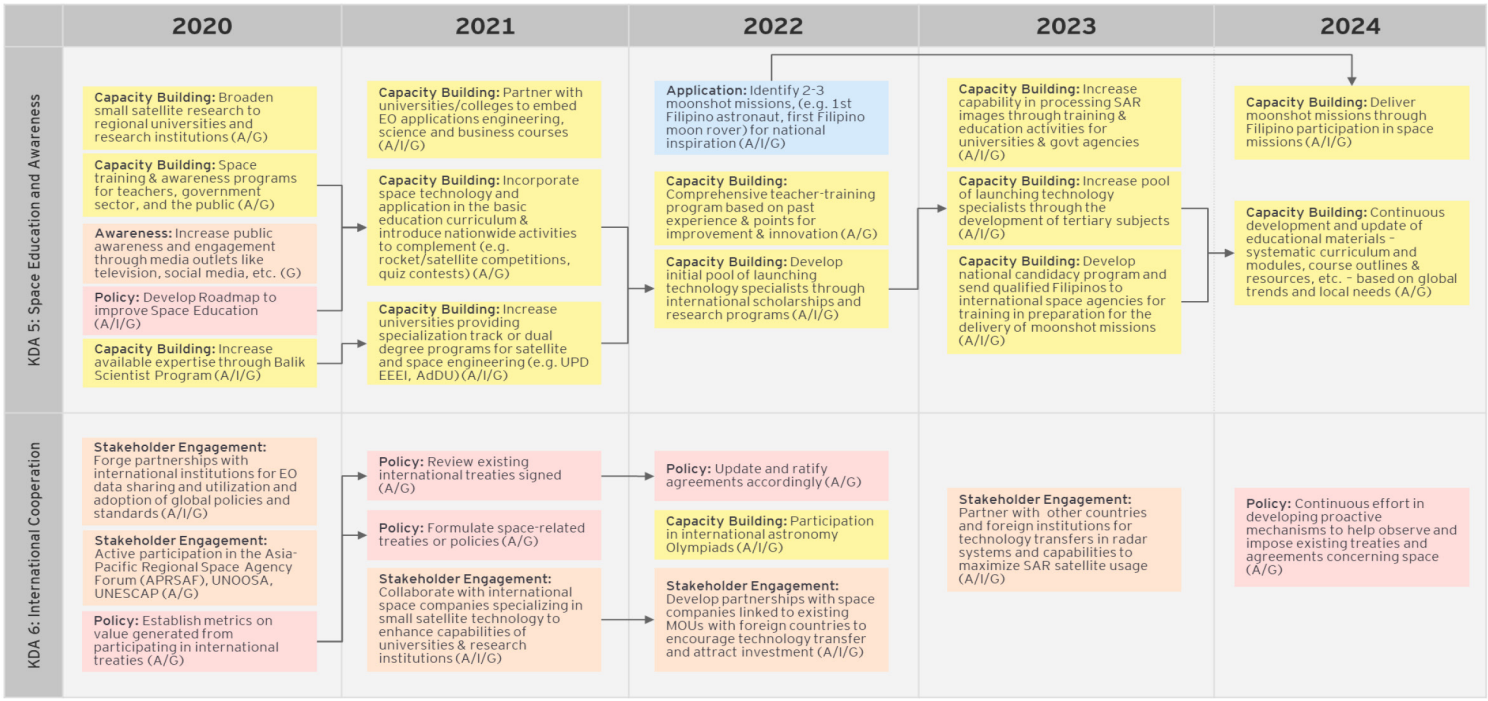
Other countries emphasize the use of satellite broadband in their national connectivity plans. These include the United States, Kenya, Brazil, Malaysia, the European Union, and Australia. They all possess a common denominator in their communications infrastructure, and that is the combined and complementing use of terrestrial and satellite technologies to enhance connectivity and enable full coverage in their respective countries.

With the recognition of the importance of satellite technology and its various military and civilian applications, the Philippine government must employ a holistic approach in its process of developing a sovereign communications satellite for the country. More than the cooperation required from different government agencies specializing in their particular fields, partnerships must also be made between the public and private sectors to facilitate funding and ultimately close the connectivity gap in remote areas of the country.

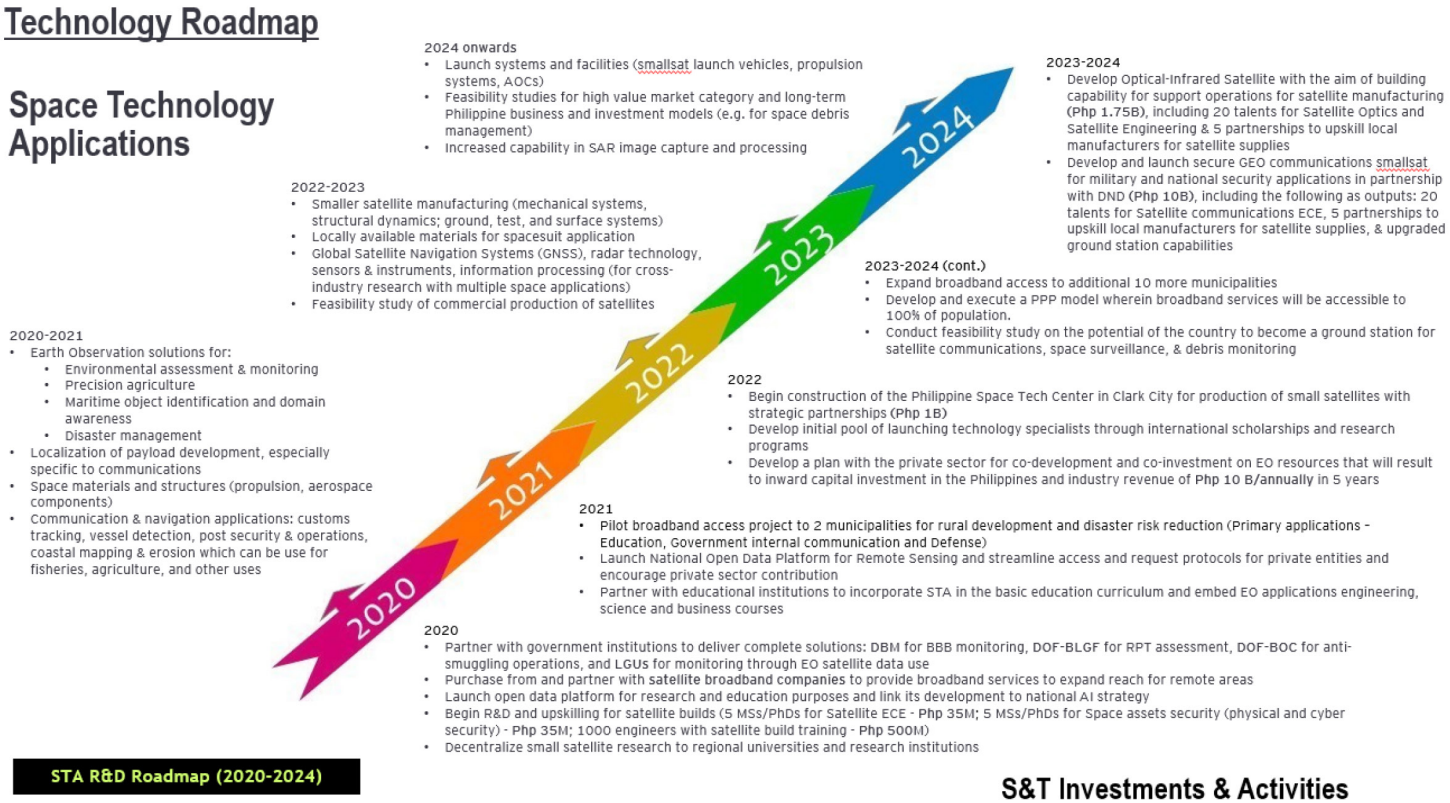
IV. Roadmap per KDA



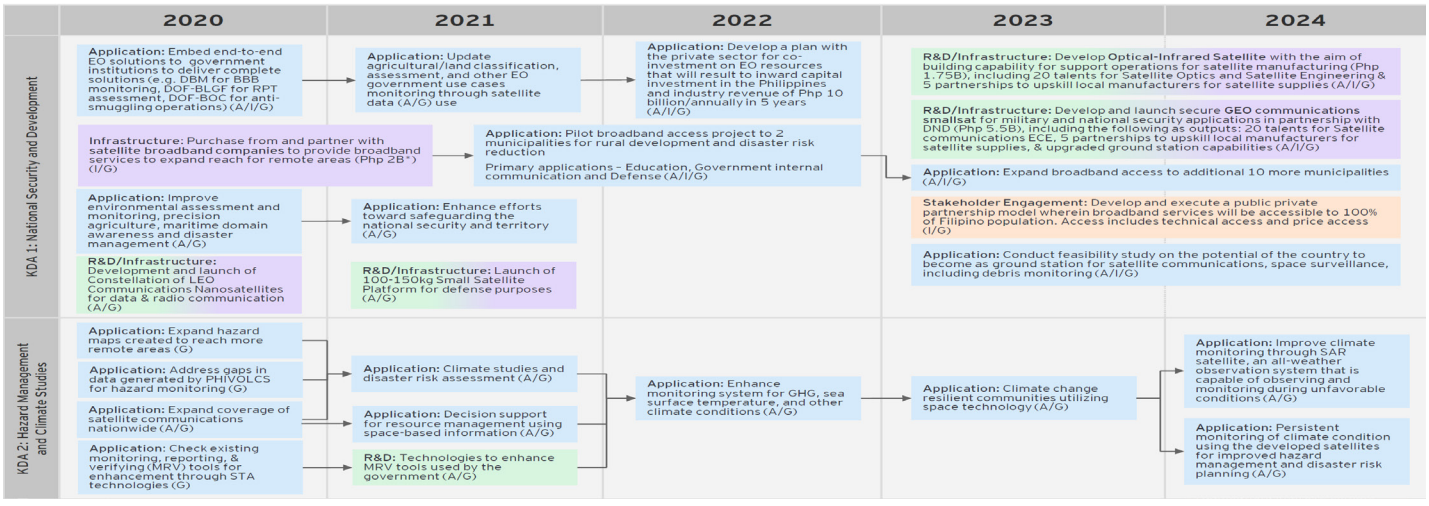

2020
2021
2022
2023
2024
KDA 3: Space Research and Development
R&D/Application: Research for communication & navigation applications: customs tracking, vessel detection, post security & operations, coastal mapping & erosion which can be use for fisheries, agriculture, and other uses (A/G)
R&D/Application: Launch open data platform for research and education purposes and link its development to national AI strategy (G)
Policy: Develop regulations for the collection, distribution, and use of EO data (G)
Application: Launch National Open Data Platform for Remote Sensing and streamline access and request protocols for private entities and encourage private sector contribution (A/I/G)
R&D/Application: Cross industry research with relevant space applications: GNSS, radar technology, sensors & instruments, information processing (A/I/G)
Infrastructure: Begin construction of the Philippine Space Tech Center in Clark City for production of small satellites with strategic partnerships, including facilities like clean rooms, vacuum chambers, spacecraft and instrument level testing area (A/I/G)
Application: Invest in research related to smaller satellite manufacturing (mechanical systems, structural dynamics. Ground, test, and surface systems) (A/I/G)
R&D/Application: Research on locally available materials for spacesuit application (A/I/G)
Application: Explore launch systems and facilities (smallsat launch vehicles, propulsion systems, AOCs) (A/G)
Application/Infrastructure: Evaluate expansion of production for commercial and export purposes, and economic viability of a launch facility in Mindanao in collaboration with the government and the academe (A/I/G)
Capacity Building: Begin R&D and upskilling for satellite builds (A/I/G)
5 MSs/PhDs for Satellite ECE (Php 35M)
5 MSs/PhDs for Space assets security (physical and cyber security) (Php 35M)
1000 engineers with satellite build training (Php 500M)
KDA 4: Space Industry Capacity Building
Policy: Link the Philippines' national space strategy to aerospace strategy (G)
Policy: Develop regulatory policies on satellite manufacturing (e.g. national security, risk management, international compliance) (G)
Policy: Harmonization with international standards for space (G)
Application: Localization of payload development (A/I/G)
Stakeholder Engagement: Develop and agree on PPP arrangements among stakeholders (A/I/G)
Application: Identify commercial aspects of satellite data for distribution to private sector (A/I/G)
Capacity Building: Development of optical payloads (A/I/G)
Stakeholder Engagement: Develop programs to deploy researchers in the private sector to open channels for collaboration and improve researchers' understanding of the industry context (A/I/G)
Infrastructure: Develop Philippine Space Tech Center into premiere PPP center to attract foreign manufacturing and R&D (A/I/G)
Stakeholder Engagement: Incorporate private sector needs and input in development of small satellites (A/I/G)
Application/Stakeholder Engagement: Explore commercial production of satellites with guidance of academe and government (A/I/G)
Application: Evaluate high value market category and develop long term business and investment model, e.g. feasibility studies for space debris management services (A/I/G)
Stakeholder Engagement: Involve private sector in development of satellite roadmap, to incorporate industry interests in projected satellite development proposals. (A/I/G)

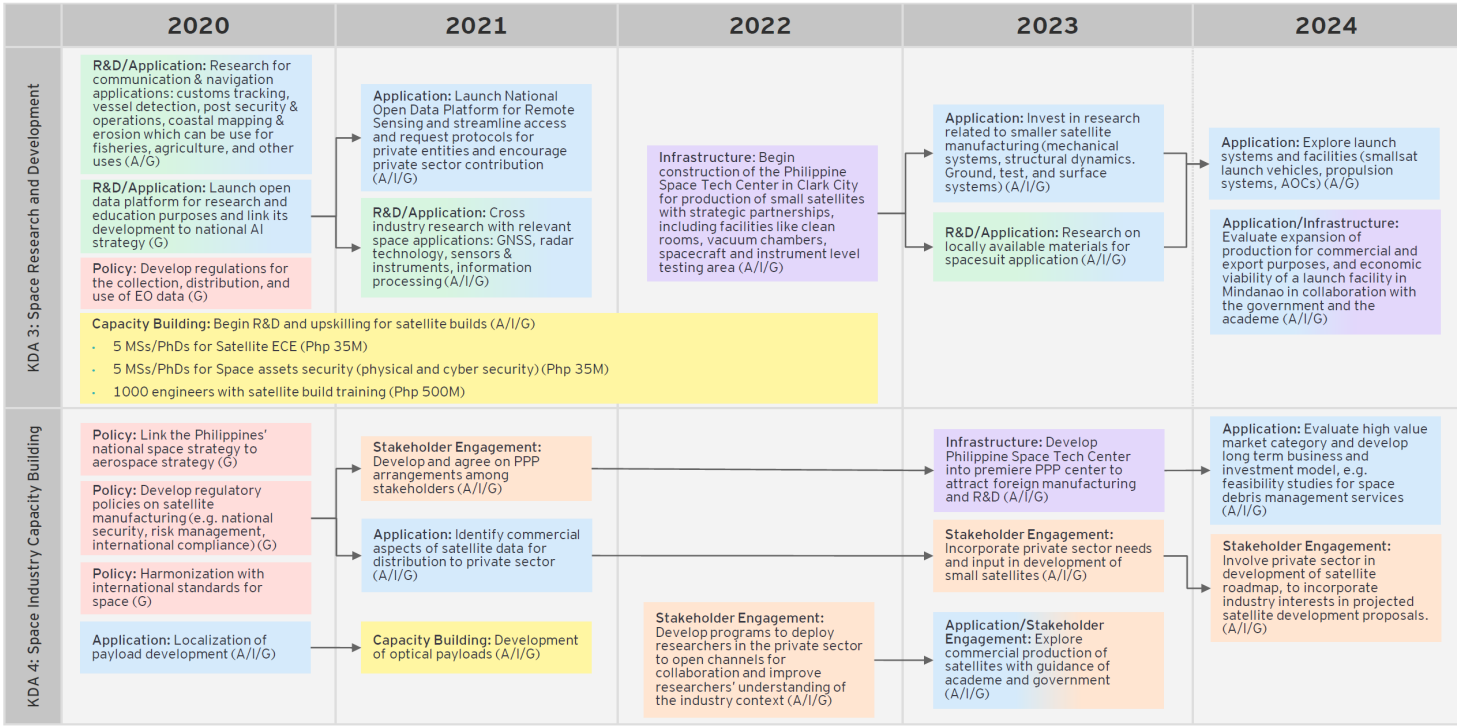

2020
2021
2022
2023
2024
KDA 5: Space Education and Awareness
Capacity Building: Broaden small satellite research to regional universities and research institutions (A/G)
Capacity Building: Space training & awareness programs for teachers, government sector, and the public (A/G)
Awareness: Increase public awareness and engagement through media outlets like television, social media, etc. (G)
Policy: Develop Roadmap to improve Space Education (A/I/G)
Capacity Building: Increase available expertise through Balik Scientist Program (A/I/G)
Capacity Building: Partner with universities/colleges to embed EO applications engineering, science and business courses (A/I/G)
Capacity Building: Incorporate space technology and application in the basic education curriculum & introduce nationwide activities to complement (e.g. rocket/satellite competitions, quiz contests) (A/G)
Capacity Building: Increase universities providing specialization track or dual degree programs for satellite and space engineering (e.g. UPD EEEI, AdDU) (A/I/G)
Application: Identify 2-3 moonshot missions, (e.g. 1st Filipino astronaut, first Filipino moon rover) for national inspiration (A/I/G)
Capacity Building: Comprehensive teacher-training program based on past experience & points for improvement & innovation (A/G)
Capacity Building: Develop initial pool of launching technology specialists through international scholarships and research programs (A/I/G)
Capacity Building: Increase capability in processing SAR images through training & education activities for universities & govt agencies (A/I/G)
Capacity Building: Increase pool of launching technology specialists through the development of tertiary subjects (A/I/G)
Capacity Building: Develop national candidacy program and send qualified Filipinos to international space agencies for training in preparation for the delivery of moonshot missions (A/I/G)
Capacity Building: Deliver moonshot missions through Filipino participation in space missions (A/I/G)
Capacity Building: Continuous development and update of educational materials - systematic curriculum and modules, course outlines & resources, etc. - based on global trends and local needs (A/G)
KDA 6: International Cooperation
Stakeholder Engagement: Forge partnerships with international institutions for EO data sharing and utilization and adoption of global policies and standards (A/I/G)
Stakeholder Engagement: Active participation in the Asia-Pacific Regional Space Agency Forum (APRSAF), UNOOSA, UNESCAP (A/G)
Policy: Establish metrics on value generated from participating in international treaties (A/G)
Policy: Review existing international treaties signed (A/G)
Policy: Formulate space-related treaties or policies (A/G)
Stakeholder Engagement: Collaborate with international space companies specializing in small satellite technology to enhance capabilities of universities & research institutions (A/I/G)
Policy: Update and ratify agreements accordingly (A/G)
Capacity Building: Participation in international astronomy Olympiads (A/I/G)
Stakeholder Engagement: Develop partnerships with space companies linked to existing MOUs with foreign countries to encourage technology transfer and attract investment (A/I/G)
Stakeholder Engagement: Partner with other countries and foreign institutions for technology transfers in radar systems and capabilities to maximize SAR satellite usage (A/I/G)
Policy: Continuous effort in developing proactive mechanisms to help observe and impose existing treaties and agreements concerning space (A/G)

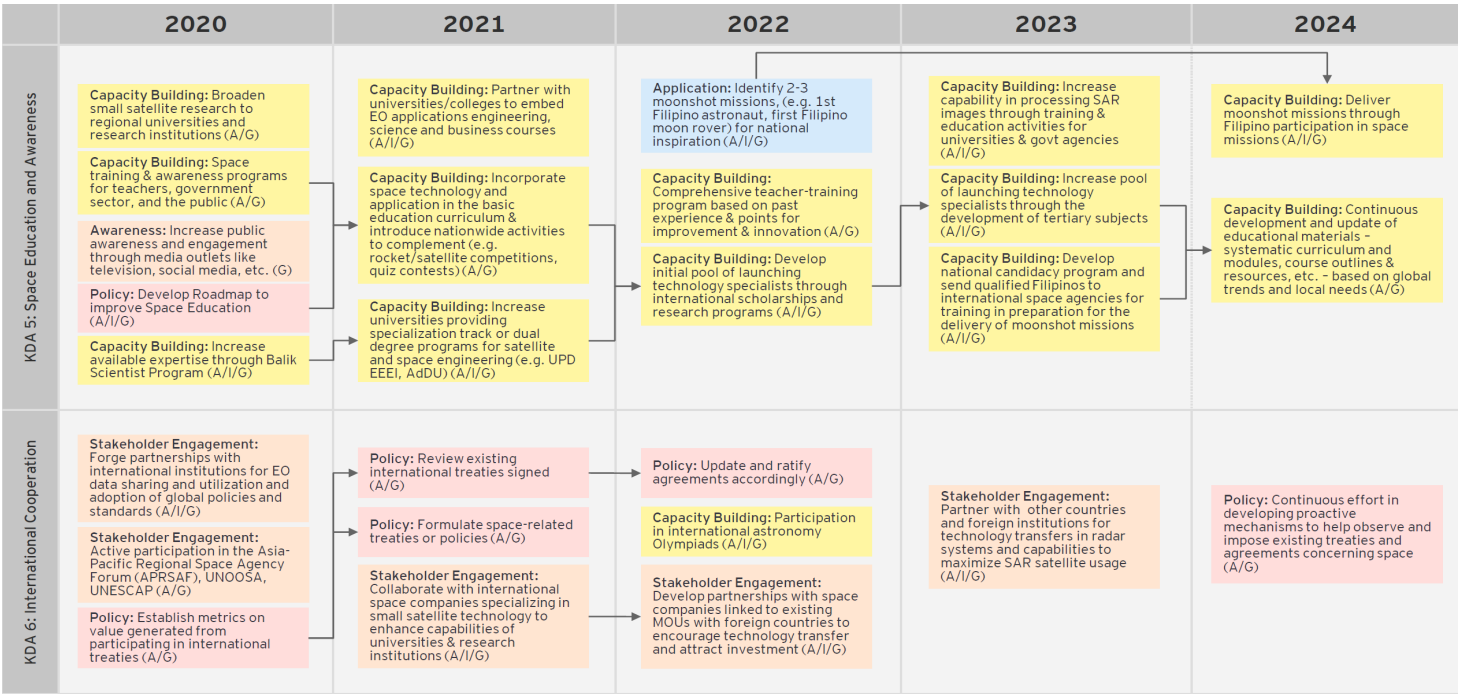
V. Technology Roadmap



VI. PhilSA Space Roadmap




2020
2021
2022
2023
2024
KDA 3: Space Research and Development
R&D/Application: Research for communication & navigation applications: customs tracking, vessel detection, post security & operations, coastal mapping & erosion which can be use for fisheries, agriculture, and other uses (A/G)
R&D/Application: Launch open data platform for research and education purposes and link its development to national AI strategy (G)
Policy: Develop regulations for the collection, distribution, and use of EO data (G)
Application: Launch National Open Data Platform for Remote Sensing and streamline access and request protocols for private entities and encourage private sector contribution (A/I/G)
R&D/Application: Cross industry research with relevant space applications: GNSS, radar technology, sensors & instruments, information processing (A/I/G)
Infrastructure: Begin construction of the Philippine Space Tech Center in Clark City for production of small satellites with strategic partnerships, including facilities like clean rooms, vacuum chambers, spacecraft and instrument level testing area (A/I/G)
Application: Invest in research related to smaller satellite manufacturing (mechanical systems, structural dynamics. Ground, test, and surface systems) (A/I/G)
R&D/Application: Research on locally available materials for spacesuit application (A/I/G)
Application: Explore launch systems and facilities (smallsat launch vehicles, propulsion systems, AOCs) (A/G)
Application/Infrastructure: Evaluate expansion of production for commercial and export purposes, and economic viability of a launch facility in Mindanao in collaboration with the government and the academe (A/I/G)
Capacity Building: Begin R&D and upskilling for satellite builds (A/I/G)
5 MSs/PhDs for Satellite ECE (Php 35M)
5 MSs/PhDs for Space assets security (physical and cyber security) (Php 35M)
1000 engineers with satellite build training (Php 500M)
KDA 4: Space Industry Capacity Building
Policy: Link the Philippines' national space strategy to aerospace strategy (G)
Policy: Develop regulatory policies on satellite manufacturing (e.g. national security, risk management, international compliance) (G)
Policy: Harmonization with international standards for space (G)
Application: Localization of payload development (A/I/G)
Stakeholder Engagement: Develop and agree on PPP arrangements among stakeholders (A/I/G)
Application: Identify commercial aspects of satellite data for distribution to private sector (A/I/G)
Capacity Building: Development of optical payloads (A/I/G)
Stakeholder Engagement: Develop programs to deploy researchers in the private sector to open channels for collaboration and improve researchers' understanding of the industry context (A/I/G)
Infrastructure: Develop Philippine Space Tech Center into premiere PPP center to attract foreign manufacturing and R&D (A/I/G)
Stakeholder Engagement: Incorporate private sector needs and input in development of small satellites (A/I/G)
Application/Stakeholder Engagement: Explore commercial production of satellites with guidance of academe and government (A/I/G)
Application: Evaluate high value market category and develop long term business and investment model, e.g. feasibility studies for space debris management services (A/I/G)
Stakeholder Engagement: Involve private sector in development of satellite roadmap, to incorporate industry interests in projected satellite development proposals. (A/I/G)


2020
2021
2022
2023
2024
KDA 5: Space Education and Awareness
Capacity Building: Broaden small satellite research to regional universities and research institutions (A/G)
Capacity Building: Space training & awareness programs for teachers, government sector, and the public (A/G)
Awareness: Increase public awareness and engagement through media outlets like television, social media, etc. (G)
Policy: Develop Roadmap to improve Space Education (A/I/G)
Capacity Building: Increase available expertise through Balik Scientist Program (A/I/G)
Capacity Building: Partner with universities/colleges to embed EO applications engineering, science and business courses (A/I/G)
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Capacity Building: Develop national candidacy program and send qualified Filipinos to international space agencies for training in preparation for the delivery of moonshot missions (A/I/G)
Capacity Building: Deliver moonshot missions through Filipino participation in space missions (A/I/G)
Capacity Building: Continuous development and update of educational materials - systematic curriculum and modules, course outlines & resources, etc. - based on global trends and local needs (A/G)
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Stakeholder Engagement: Active participation in the Asia-Pacific Regional Space Agency Forum (APRSAF), UNOOSA, UNESCAP (A/G)
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Stakeholder Engagement: Partner with other countries and foreign institutions for technology transfers in radar systems and capabilities to maximize SAR satellite usage (A/I/G)
Policy: Continuous effort in developing proactive mechanisms to help observe and impose existing treaties and agreements concerning space (A/G)

Roadmap
Key Development Area Matrix

KDA 1
National Security and Development

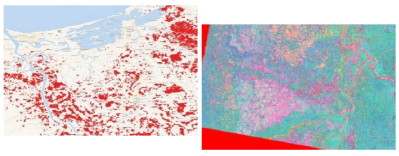
Satellite Development and Launch

Optical Infrared Satellite	building capability for support operations for satellite manufacturing
GEO Communications Smallsat	military and national security applications in partnership with DND

Utilization of Satellite Data to Improve Public Service

Improve environmental assessment and monitoring, precision agriculture, maritime domain awareness, disaster management, and other national government priority sectors

KDA 2
Hazard Management and Climate Studies



Expansion of hazard maps to reach more remote areas

Enhancement of the monitoring system for greenhouse gases, sea surface temperature, and other climate conditions

Development of climate change resilient communities utilizing space technology

KDA 3
Space Research and Development

Philippine Space Tech Center
in Clark City for the production of small satellites with strategic partnerships

Cross industry research with relevant space applications

Communication & Navigation	Radar technology, sensors & instruments, information processing
GNSS	

Open Data Platform

- Link development to national AI strategy
- Initially for research and education, consider to expand for commerciality

SURREY SATELLITE TECHNOLOGY LTD

Know How and Technology Training with SSTL for development and launch of defense microsatellite

Roadmap
Key Development Area Matrix

KDA 4
Space Industry Capacity Building

National Space Strategy ⟷ National Aerospace Strategy

- Harmonize and promote tax (CITIRA) and non-tax (PH innovation Act) incentives
- Develop programs to deploy researchers in the private sector to open channels for collaboration and improve researchers' understanding of the industry context
- Identification of commercial aspects of satellite data for distribution to private sector
- Develop Philippine Space Tech Center into premiere PPP center to attract foreign manufacturing and R&D
- Involve private sector in development of satellite roadmap, to incorporate industry interests in projected satellite development proposals

KDA 5
Space Education and Awareness

Education Aspect

	Space-related topics in the basic education curriculum & enhancement through nationwide events
	Comprehensive teacher-training program based on past experience & points for improvement & innovation

Developing pool of specialists in satellite ECE and cybersecurity through international research programs, and pool of capable workforce through hands-on satellite build programs

Identification and subsequent delivery of moonshot missions for **national inspiration**	**1st Filipino astronaut**	**1st Filipino moon rover**

KDA 6
International Cooperation

ROSCOSMOS · UK SPACE AGENCY · JAXA · NASA · इसरो isro

Maximization of existing MOUs with international space agencies by developing linkages to and agreements with their private sector counterparts

Continuous effort in developing proactive mechanisms to help observe and impose existing treaties and agreements concerning space

Collaborate with international space companies specializing in small satellite technology to enhance local capabilities

Participation in international astronomy Olympiads to boost education and awareness

Acknowledgement:

Roadmaps crafted by: SGV & Co.

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