The Telecommunications Association of Thailand under the Royal Patronage

Executive Summary Report

Whitepaper

Analysis Report on Problems, Obstacles and Recommendations Under the Topic of

"5G & Disruptive Technology supporting Thailand 4.0 : Challenges and Opportunities"

The Telecommunications Association of Thailand

under the Royal Patronage

Executive Summary Report

Whitepaper

Analysis Report on Problems, Obstacles and Recommendations Under the Topic of "5G & Disruptive Technology supporting Thailand 4.0 : Challenges and Opportunities"

June 2018

Introduction

This executive summary report is prepared with the intention to summarize an overall content from an analysis report on problems, obstacles and recommendations under the topic of "5G Disruptive Technology Supporting Thailand 4.0: Challenges and Opportunities", organized by the Telecommunications Association of Thailand under the Royal Patronage (TCT) in coordination with The Telecommunications Association of Japan (TTA) during "TCT/TTA Joint Seminar 2018". The objective of this seminar is to disseminate information and knowledge to the members of these two associations as well as any interested person while simultaneously providing suggestions in significant matters derived from such seminar to relevant government agencies to enable them to specify policy in information technology and communications development as well as to organize a plan to completely move forward Thailand into the era of "Thailand 4.0" within the near future. In addition, such recommendation from government agencies also bring about the cohesiveness and mutual support between the government sector and entrepreneur as they will consider these challenges and opportunities in jointly developing Thailand with an emphasis on digital technology under Thailand 4.0 policy framework.

Executive Summary

1. Government Policies:

Thailand has consistently endeavored to develop the nation especially in the area of telecommunication and has strived to become one of the "Smart Country" or "Smart Digital Thailand" with the ultimate goal in achieving "ICT for Sustainable Development of Nation". Main objective of such development is to enable the country to create and fully benefit from digital technology in the development of infrastructure, innovation, information, human capital and other resources necessary to move forward economic and social development of the nation to achieve sustainable growth and prosperity. Such principle has been identified into "Smart Thailand 2020" strategy to foster and strengthen operational efficiency of an entire government sector in promoting unlimited competitiveness of the business sector while elevating the quality of life of Thai citizens in general. This strategy can be divided into 4 major aspects as indicated below:

1. Smart Network Strategy: To develop infrastructure in terms of information technology and communication to be more efficient, more convenient and with greater speed that can encompass every facet while keeping abreast of state-of-the-art technology that can respond to every requirement of different sectors with the ultimate purpose in becoming the center of AEC.
2. Smart Government Strategy: To promote and encourage ICT to be utilized in the management and service of every sector while stressing on integrity and efficiency to elevate quality of life of people in general, including the utilization of statistics to plan and make necessary decisions in a more effective manner.

3. Smart Business Strategy: To support and promote ICT to be more competitive in an international arena. This can be achieved by enhancing the efficiency of entrepreneurs to be more self-dependable and improving their ICT skills and expertise to possess qualification that is in line with their professional standard and pertinent to the requirement of an industrial sector both at present and in the upcoming future.
4. Smart People Strategy: To foster balanced ICT foundation and development by promoting the use of ICT in management and integration with regard to effective meteorology and disaster warning system while simultaneously supporting education and instructional media via computer notebooks to improve the quality of life and ensure sustainable economic growth and development.

Nevertheless, although Thailand had consistently improved its ICT but such progress is relatively slow compared to that of other countries. As a result, the present government had specified a principal guideline or ICT development policy of Thailand for the next 20 years. Four major development plans comprise of 1) National Strategy (2017-2036) 2) Thailand 4.0 Policy 3) Digital Economy and Society Development Plan and 4) Telecommunications Sector Master Plan No.2. Major issues of each plan can be summarized below:

1.1 National Strategy (2017-2036)

National Strategy (2017-2036) is the master plan for long-term development of Thailand. The plan is also a reform of Thailand's administrative system to move the country forward in becoming one of the developed countries) National Strategy (2017-2036) consists of 6 major strategies as follows (1) national security (2) competitiveness enhancement (3) development and empowerment of human capital (4) broadening opportunity and equality in society (5) environmental-friendly development and growth and (6) reforming and improving

government administration. Strategies relating to the development of the country by employing ICT as a major tool comprise of an investment in the development of infrastructure in the area of transportation, security and energy, IT system, research and development, equal opportunity in education and learning, development of public communication to become a key mechanism in fostering the country's growth as well as an improvement of public service provided by government agencies.

However, after considering every 6 key strategies identified in the National Strategy, we found out that each strategy requires IT and communication as a major tool in human, system and operation development to achieve established goals and objectives. Different agencies have to set up their own strategy and guideline by adhering to the National Strategy as their master plan. Above all, the government sector must establish clear policy regarding "Human capital development" to support potential changes and new development which may arise in the future as well as to prepare their personnel to possess sufficient skills and expertise comparable to other developed nations in which such skills and expertise must be appropriate with the country's development plan in the next 20 years.

1.2 Thailand 4.0 Policy

Thailand 4.0 Policy is an economic model that aims to rectify, organize system, adjust direction and create opportunities to develop the country to achieve its prosperity, security and sustainability while being able to cope with new and fast-pacing challenges and threats of the 21st century. This policy will also enable Thailand to respond to any changes in economic structure to a "value-based economy" or "innovation-driven economy" in which main ideas will be changed: from the manufacturing of "commodities" to the manufacturing of "innovation", from driving the country by relying mainly on industrial sector to developing on technology, creative idea and innovation, from an emphasis on manufacturing products to an

emphasis on providing better service. Concurrently, the economic and industrial structure driven by innovation and value-added must be changed to that driven by high value or productivity. Four objectives of Thailand 4.0 are (1) economical prosperity (2) social well-being (3) raising human value and (4) environmental protection. Nonetheless, such value-based economy must be complimented by knowledge, creative ideas, innovation, science and research and development by employing ICT as a major developmental tool to achieve established goals, especially in the area of digital and internet that connect the operation of various equipment, agricultural intelligence and embedded technology. In achieving this, the development of knowledge, creative ideas, innovation, science, technology, research and development are deemed necessary and such development shall be further with targeted technology and industry to develop sustainably in the long run.

However, in a practical sense, these issues have never been clearly implemented. There is no key responsible party to drive such policies and; therefore, resulting in incongruity in the work process as well as the lack of adequate support and encouragement that enable the system to move forward. Also, other barriers include government policy obstructing the use of new technology in Thailand, law enforcement that is irrelevant to global changes and last but not least is a lack of support from efficient operators within the country. As a result, Thailand's competitiveness has declined in the level that it cannot compete with other countries any further.

1.3 Digital Economy and Society Development Plan (20-year period)

Digital Economy and Society Development Plan (20-year period) is defined as a transformed Thailand that maximizes the use of digital technologies in all socio-economic activities in order to develop infrastructure, innovation, data, human capital and other digital resources that will ultimately drive the country towards stability, wealth and sustainability. Four objectives of the plan include

- Elevate competitiveness of the nation with the use of innovation and digital technology as a major tool in the creation of production innovation and service.
- Create equal opportunity in accessing any information, news and services via digital media to elevate the quality of life of Thai people.
- Emphasize on human capital by encouraging people to possess knowledge and skills necessary for their living and occupation in the digital era.
- Reform work paradigm and service provided by the government sector with the use of digital technology and utilization of information to promote more transparent, efficient and effective operation.

Noticeably, Digital Economy and Society Development Plan is in line with Thailand's development direction or National Strategy while supporting an overall development of the country by utilizing digital technology to solve current problems and challenges Thailand is confronting at present. The plan also responds to any potential challenges in the future and supports the maximization of the dynamics of digital technology that in turn positively and negatively affecting economic and social structure to enable Thailand to tremendously benefit from the use of technology.

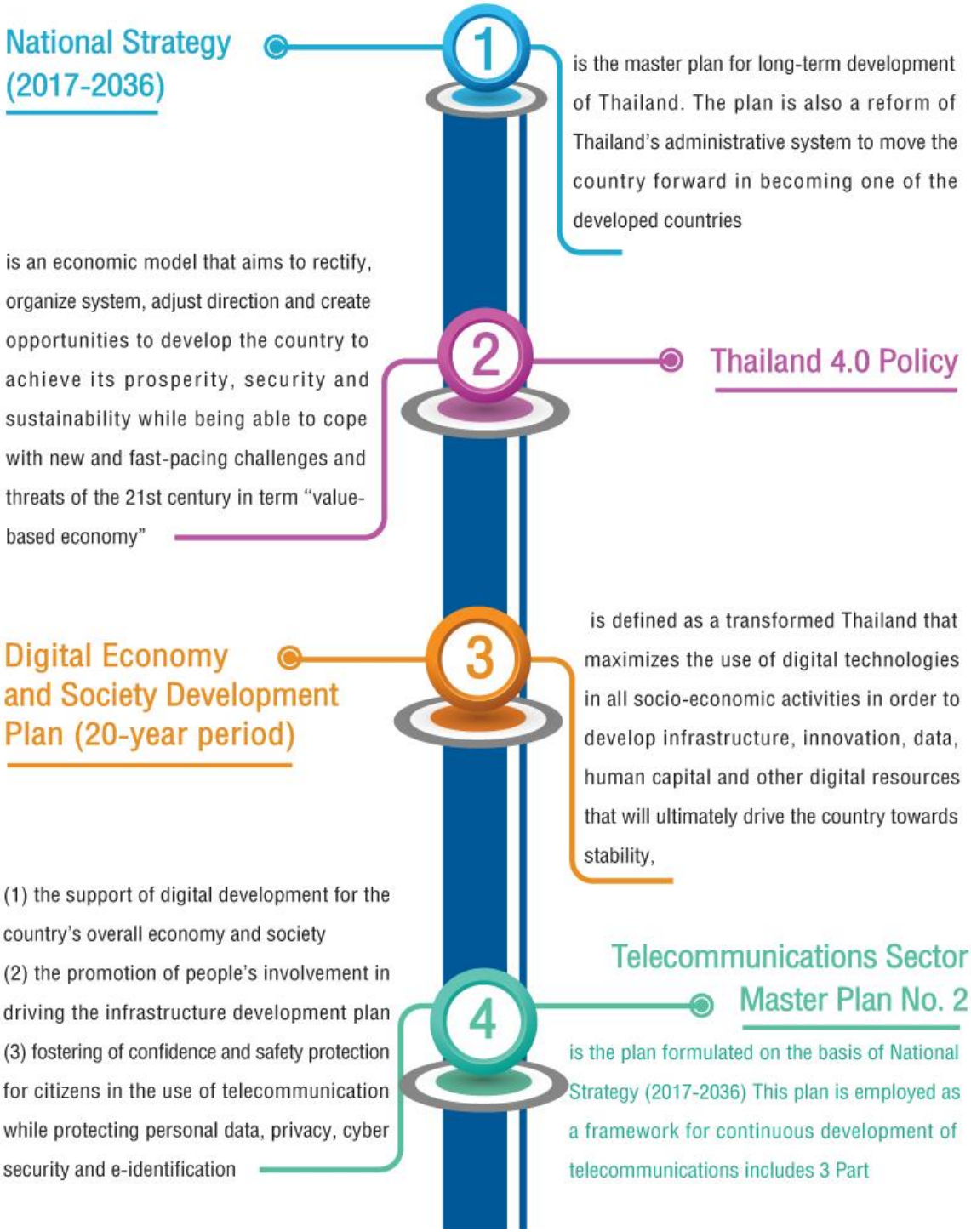
1.4 Telecommunications Sector Master Plan No.2

The Telecommunications Sector Master Plan No.2 is the plan formulated on the basic of National Strategy (2017-2036), the direction of National Economic and Social Development Plan No.12, Digital Economy and Society Development Plan, including the policy change to enable Thailand to become Thailand 4.0 with an emphasis on value-based economy. This plan is employed as a framework for continuous development of telecommunications from the first Broadcasting Master Plan to ultimately achieve balanced and sustainable development. Three major objectives of the plan include

(1) the support of digital development for the country's overall economy and society by integrating coordination from every sector for the development of efficient telecommunication infrastructure throughout the country

(2) the promotion of people's involvement in driving the infrastructure development plan based on the civil state approach, public opinion and consultation and mutual planning to solve any claims as well as consumer protection and

(3) fostering of confidence and safety protection for citizens in the use of telecommunication while protecting personal data, privacy, cyber security and e-identification to strengthen security in the use of telecommunication and electronic transaction as well as encouraging the research and development of mega trends such as big data & analytics, internet of things, future communications, cyber security and trust.


National Strategy (2017-2036)
1
is the master plan for long-term development of Thailand. The plan is also a reform of Thailand's administrative system to move the country forward in becoming one of the developed countries
is an economic model that aims to rectify, organize system, adjust direction and create opportunities to develop the country to achieve its prosperity, security and sustainability while being able to cope with new and fast-pacing challenges and threats of the 21st century in term "value-based economy"
2
Thailand 4.0 Policy
Digital Economy and Society Development Plan (20-year period)
3
is defined as a transformed Thailand that maximizes the use of digital technologies in all socio-economic activities in order to develop infrastructure, innovation, data, human capital and other digital resources that will ultimately drive the country towards stability,
(1) the support of digital development for the country's overall economy and society
(2) the promotion of people's involvement in driving the infrastructure development plan
(3) fostering of confidence and safety protection for citizens in the use of telecommunication while protecting personal data, privacy, cyber security and e-identification
4
Telecommunications Sector Master Plan No. 2
is the plan formulated on the basis of National Strategy (2017-2036) This plan is employed as a framework for continuous development of telecommunications includes 3 Part

From an analysis of policy that will release Thailand from the mid-income trap and heading toward one of the developed countries with stability, prosperity and sustainability; consequently, it is necessary to establish the Master Plan for a long-term development (20 years) as in many countries, resulting in their rapid development in terms of security, economy and society. Nonetheless, if Thailand intends to become Thailand 4.0, "digital technology" is a prerequisite as a development tool. In addition, strategic plans for the development of government sectors that are in parallel with National Strategy are also necessary. Development guidelines encompass an investment on the development of infrastructure, transportation, security and energy, IT system, research and development, equal opportunity in education and learning as well as public communication. All of these are regarded as a significant mechanism for the development of the country as well as the improvement of public service. Regardless of the country's strategic and development plan, the most important thing both government and private sectors have to cooperatively build on or develop hand in hand is the development of "human capital" to become well-equipped with adequate skills, knowledge and potential to support fast-paced digital development and changes. If human capital has not been developed, we cannot benefit from existing and potential digital technology in the development of the country. Besides, theoretically, it has been shown that regardless of its coherence with the National Strategy, the country's development plan of other sub-government sectors has not been appropriately conducted to render concrete outcome, including the lack of the host agency as a leader in promoting the use of development plans in practice that may result in the success or failure in achieving the objective of the country to become one of the developed countries later on.

2. Future trends of technology:

Future trends of technology development that can be employed as a tool to achieve objectives as established in Thailand 4.0 policy and need to be mentioned here are as follows:

2.1 Mobile Phone Technologies

Technological development of mobile phone that can be traced back to the second and 2.5 generations when only sound system and primary data transmission were only available and such technologies had many limitations. Next, wireless communication technology in the third generation was introduced which was classified as the development of wireless communication emphasizing on mixed services. Consumers could use both sound and data services more efficiently or benefited from clear telephone sound system. Consumers can also take advantage from multimedia and internet with a higher speed to be compatible with global roaming. For communication tools, smart phone and the fourth-generation wireless or 4G are viewed as another stepping stone of broadband mobile communication launched after an introduction of 3G system in which this technological development is an outcome of defective 3G system. Regarding 4G or also known as LTE or long-term evolution, it is the highest speed network with a combination of wi-fi and wi-max and the speed of data transmission is approximately 100 Mbps – 1Gbps. Frequency range of LTE falls between 1800 MHz and 2300 MHz (20 channels) and is distinguished in its three-dimensional virtual connection between phone users that enables data transmission speed to be 10 times faster than that of 3G. Phone users can watch their favorite programs via mobile phone or have conversation via video conference with high-definition (HD). The system is also designed to cover 4 wide ranges of area. Another interesting trend both at present and in the future is "the fifth- generation wireless communication system", a technology with the speed of data

transmission at 20 Gbps, which is 20 times higher than 4G. Currently, 4G wireless network uses 7-20 Mbps in downloading information but on the contrary, 5G uses only 1 Gbps in accomplishing the same task. Consequently, the use of 5G helps minimize time in accessing information from 50 milliseconds to only 1 millisecond. Moreover, 5G also emphasizes on global interoperability by employing harmonized spectrum usage. In the future, it is possible for doctor to perform a remote operation by simply watching video clip and then provides recommendation to doctor in remote area in real time manner.

5G is considered the foundation of internet of thing and machine to machine, a communication between equipment whether they will be tool, machine, vehicle or system in the building that installs electronic circuit, software center and connection network which facilitates prompt data transmission where time lag will be minimized and make possible some technologies that seemed impossible in the past; for example, remote control of surveillance camera or other appliances via mobile internet or mobile equipment for measuring stress level and heart rate that help reduce the occurrence of heart attack etc. Nevertheless, 5G technology can transform the city to become smart city by employing digital technology with city life to render more comfort and convenience. As a result, people can have an easy access to public service while data can be connected to facilitate more efficient service, better quality of life and security.

At ITU Telecom World 2016 forum, an important factor determining the future of 5G is "spectrum". Many countries must agree on the standard of spectrum to enable the use of equipment in every country and each country is required to set up its spectrum roadmap to support a systematic spectrum allocation. The spectrum that needs to be allocated for 5G shall be 3.5 GHz since it has not been widely used in many countries while 700 MHz frequency range is in the process of TV digital transformation before 5G can be put in place. As for Unlock 5G Spectrum Towards Sustainable Thailand 4.0 Forum, it was agreed that 5G will bring about 5 major changes; that is, unlimited connection, creation of economic innovation, expansion of

high-speed internet, the building of IoTs and industrial reform and the necessity to use new spectrum with wider band widths (below 1GHz, 1-6 GHz and higher than 6 GHz). This is the reason why Thailand needs frequency allocation plan and shall specify such allocation in advance to use that particular spectrum in telecommunication business. Afterwards, Thailand has to set up bidding period 3-5 years in advance to make operators be prepared for future investment and enable them to make efficient business plan. In turn, other technological development companies can be ensured of sufficient spectrum that can support new innovations.

From the forum of vision exchange of 5G technology and Thailand 4.0 hosted by Telecommunication Association of Thailand under the Royal Patronage (TCT) and Telecommunication Association of Japan (TTA), under the support of private sector and The National Broadcasting and Telecommunications Commission (NBTC), it had been concluded that the direction of 5G service must stress on fostering alliance and cooperation with other business or even with local administrative organization to create new solution for business and society. The format of business relation will be changed from B2C (Business to Customer) or B2B (Business to Business) to B2B2C or even B2B2G (government) etc. Thus, 5G is not viewed as only a communication between human to human but also includes communication between human to machine and machine to machine and not just a communication via mobile phone or tablet. 5G application will tremendously increase the utilization of telecommunication and this, in turn, may change people's way of life. Besides, 5G is related to government and industrial sector in that it is a significant tool for the country's development in many areas as well as a way to connect the entire world into one single system. Countries that are still underdeveloped will lose a great deal of opportunity in terms of social and economic sense. The most important thing for such preparation is a change in the thinking process of providing service to enable the communication system to respond to every aspect of users while the

society can efficiently benefit from 5G. Therefore, the notion of 5G needs to transform telecommunication services to the new platform and ecosystem.

The concept of SMART City by using 5G Technology (from :5G Impact on SMART Cities)

2.2 Disruptive Technology

Since the third Industrial Revolution in 1969 and an increasing role of IT as the major factor affecting changes, people's lifestyle has been altered while the evolution of technology has been unstoppable. Then, here comes the 4th industrial revolution that we currently live in where different technologies such as IT, computer and various fields of science have been combined. Such emerging technologies are called "Disruptive Technologies" that have been applied in every industry such as machine intelligent, ubiquitous web, mobile broadband, unmanned vehicle as well as software that can translate every language. These technologies are significant tools that provide people with an access to education, public health service

and digital revolution which ultimately creates job opportunities in the future. However, disruptive technology tends to affect many industrial sectors such as financial industry. At present, we are moving toward cashless society and cordless transactions that somewhat forcing banking industry to adapt and provide new services to respond to consumers' needs more effectively. In addition, a possibility of bankless era is imminent and it is only a matter of time. One emerging technology that is becoming well-known is live sports that will definitely affect the payment of membership fee of some movie websites and cable TV operators that charge on a monthly basis. As for real estate sector, Real Estate Tech (start-up technology for real estate) encompassing project management, various platforms and tools made for borrowers and agents enable these individuals to sell home more promptly compared to an old system that takes up to 70 days before every procedure can be completed.

2.3 Other Interesting Technologies

Other interesting technologies which are selected from 2 major factors; namely, 1) accessibility which considered from the number of consumers employing or relating to such technology and 2) impact/ value in that to what extent the technology will affect consumer groups and create business value. These 5 interesting technologies comprise of:

Voice & Visual Search: that will soon replace searching by typing since the lifestyle of consumers has been changed and everyone prefers more convenience, especially when Voice Personal Assistant (VPA) such as Alexa, Google Assistant, Bixby, Cortana and Siri are becoming more popular nowadays.

Conversational Platform: which is a platform used to have conversation with human being, known as Chatbot. In 2018, this Chatbot will be more popular among operators, especially those in e-commerce business because this platform can respond to customers automatically and in a timely manner while minimizing the expenditures of the call center.

Cryptocurrency: or "digital money" tends to be employed more frequently in most transactions while cash will be used less and less. Many foreign governments have consistently supported the use of digital money as a way to save maintenance and transportation costs as well as the cost of cash inspection.

Counterfeit Reality: or "virtual reality" is the content building by imitating actual incident, place and living things through the use of different technologies; for example, augmented reality, virtual reality or digital twin to render new and virtual experience to consumers such as the use of VR to build a model house to facilitate consumer's decision before actual construction begins.

Internet of Things: is the technology that facilitates the connection of equipment, acknowledges surrounding environment and then processing all data and information to respond or decide in real time and automatically; for example, the coordination of VPA operation such as Alexa or Google Home with other home automation appliances like security and access control system etc.

Nonetheless, an evaluation of the impact of these 5 technologies on major industries are as follows:

Retailing business: Voice and visual search technology will radically change the application for online purchase. Accurate and quick search of desired product will enable consumers to use such services more frequently, resulting in the expansion of such technology.

Regulatory agency: In terms of digital money and Fintech technology encourage relevant regulatory agency to study and set up a framework to monitor and control such technological use to be more secured and safe while the government can also maintain their benefit. When such technology is acceptable, there will be new business models and the utilization of technology for business purpose.

Media and movie are industries: tremendously affected by counterfeit reality. The use of such technology will enable virtual reality of the thing presented while bringing new experiences to consumers. However, counterfeit reality may lead to dissemination of false information that may affect credibility and reputation or the organization in the end.

Service business: like insurance business or credit card of which its product has been provided or introduced via call center will be replaced by Chatbot and may be elevated to virtual customer assistant to increase response speed as well as minimize expenditure of call center.

Manufacturing and real estate industries are major business sectors where IoT has an important role as it can apply various equipment to offer convenience and minimize operation costs such as home automation or smart factory's system. In addition, in combining IoT with AI system, this can increase speed in making decision and render every system to become more automatic.

Considering the government policy necessary for sustainable growth and development, we found out that there are 10 key industries the government needs to promote to expand Thailand's investment that will in turn encourage a leapfrogging development. Digital technology is a major tool in enhancing efficiency and effectiveness of agricultural-industrial and service sectors in manufacturing products and services while elevating competitiveness, job opportunity and systematic and sustainable support of regional economy. Such industries include (1) Next-generation automotive (2) Smart Electronics (3) Affluent, Medical and Wellness Tourism (4) Agriculture and Biotechnology (5) Food for the Future (6) Robotics (7) Aviation and Logistics (8) Biofuels and Biochemical (9) Digital or Creative and (10) Medical Hub.

Regarding the trend of 5G in the future, we found out that potential technologies advancement will become 5G network with high speed data transmission, resulting in a transformation better than 4G technology that ultimately results in market disruption in every industry. Apart from the speed in transmitting large-size data with a 100-times (at the minimum) higher capacity, 5G technology; therefore, acts as a catalyst of IT revolution that also affecting other industries as well.

The development of 5G, coupled with every service format on Cloud system will introduce new service that have never been offered before, including the development of on-demand application of an organization. Since such system is flexible and more readily to respond to every requirement of business and organization while being capable of processing

and storing large-size data; therefore, an organization can minimize a large amount of expenditures, introduce a new business with adjusted size and much more adaptable. Furthermore, 5G is an important tool that enables the organization to respond to new technology and innovation without being suffered with the loss of capital. This is due to the fact that the organization can benefit from efficient 5G network, so it does not have to deal with tremendous long-term cost. Apart from faster speed of data transmission, prompt response and higher efficiency of spectrum, appliances employed with 5G network require fewer energy compared to 4G, which is regarded as a prerequisite for the potential growth of the internet of things (IOT). 5G can resolve some 4G weaknesses such as a variety of appliance connection, efficient energy consumption and acceptable technical standard worldwide that may result in Smart City in the future. The most significant system of 5G generation is Blockchain where highly efficient internet connection supporting IOT, portable capacity and ability to retrieve data from other sources are necessary. Consequently, blockchain will facilitate operation and service within the organization. Cisco IOT had employed blockchain in constructing Smart City as an inspiration for future improvement. In this case, blockchain is utilized as a center in managing the city and introducing digital money for use in each city. Besides, blockchain minimizes expenditures of the organization; for example, data storage is that needs high security code to access and compatibility where each organization can use blockchain system in a different manner.

Currently, the majority of world citizens are aging citizens and that is also the case of Thailand as well. The aging society of Thai citizens will definitely impact economic condition in many areas such as consumption, savings, investment and finance of the country as well as manufacturing industry which has been directly affected by the decline of working group citizen. Working people have to take responsibility in taking care of these aging citizens. Fortunately, 5G technology helps improve quality of life, learning, accessibility and utilization of new media as well as promote lifelong learning of aging people and smart health program

to encourage good health condition, increase opportunity for medical service, reduce health problem of the general public by employing technologies such as medical grid, tele-medicine, ITEMS while implementing such technologies in Intelligent Transport System (ITS).

Farming and manufacturing sectors can benefit from 5G in adjusting agriculture production framework by turning primary agricultural products to processed agricultural products with higher value, better quality and acceptable standard. To achieve this end, technology and innovation that may enhance efficiency in farming, starting from manufacturing, maintenance and harvesting may be employed to increase product value in agricultural industry while minimizing production cost and increasing product yield per rai. Considering current farming process, network data center is required as part of production plan in order to provide production data. Zoning optimization technology and agricultural plan help facilitate the decision making while emphasizing on the use of data in analyzing the suitability of land use as well as product market. The use of IT will enable agriculturists to gain access to news and information promptly and thus, minimizing damages while enhancing efficiency. Moreover, there has been an introduction of precision farming and sensor technology such a weather sensor. Besides, sensor-installed robot, embedded system, satellite and autonomous drone that can monitor and collect field data, create a map that analyzing farming area, monitor chemicals in the air while installing sensor gas system in the drone and controlling chemical input, are also introduced. Nevertheless, these data can be processed with cloud computing system that can be promptly notified via mobile appliances.

3. Recommendations from Relevant Stakeholders

From an academic forum "TCT/TTA Joint Seminar 2018", organized by Telecommunications Association of Thailand under the Royal Patronage (TCT) and Telecommunication Association of Japan (TTA) with the topic of "5G & Disruptive Technology Supporting Thailand 4.0: Challenges and Opportunities" to be in line with the topic and technological trend that are now moving toward the development of the 5th generation wireless communication networks, both public and private sectors can employ the recommendations from this forum as guideline to adapt themselves in order to respond to any sudden and severe change. It has been predicted that when 5G technology is fully operated, it may render both positive and negative impacts to relevant parties in every service, industrial service and agricultural sector that is the backbone of the majority of Thai citizens. Thus, only significant recommendations from this seminar will be provided here and they can be summarized as follows:

3.1 Spectrum

Policy of spectrum management in telecommunication system of Thailand

The government sector shall organize data regarding the use of spectrum. This can be accomplished by clearly identifying agencies and business to acknowledge every responsible party in telecommunication industry. Spectrum related to security matters must be reserved for military use only etc.

- The government sector shall set up a clear spectrum roadmap that can support 5G service and facilitate future management of spectrum whether to specify any spectrum will expire in the next 3-5 years, and what is the future plan etc.

- After information system on the use of spectrum and the spectrum roadmap have been prepared, The National Broadcasting and Telecommunications Commission (NBTC) should perform the spectrum re-farming as currently Thailand still lacks sufficient spectrum. Therefore, the Commission shall allocate existing spectrum sufficient for consumption in order to move the country toward Thailand 4.0 policy as planned while ensuring the highest benefit and efficiency from the use of spectrum.
- The government sector shall review and set up a plan as well as permitting spectrum sharing and spectrum trading which are standard practice in various countries.
- Besides, the government shall review the bidding policy since spectrum is viewed as an important resource in the country's development, especially in 6 targeted industries as can be seen from two previous biddings, if the cost of spectrum is too high, then spectrum price barrier may take place and it cannot be used widely used in industrial sector. As a result, the promotion of industry 4.0 may be affected. Thus, the government shall review spectrum allocation by bidding method and establish clear objective to allocate spectrum use more efficiently, sufficiently and with reasonable cost for every relevant sector. The government shall not set its objective to seek its own benefits only.

Spectrum for public use

- Considerations on appropriate spectrum for railroad business or railway system are as follows: Railroad business in Thailand shall employ spectrum supporting LTE-R technology and currently, many countries start using such technology such as South Korea, China, Laos or other neighboring countries that become more interested in this technology. If Thailand employs GSM-R, our railroad system may not be compatible with that of other neighboring countries. Therefore, appropriate spectrum shall be considered based on spectrum harmonization along the railway route throughout ASEAN.

Spectrum for commercial purpose

- For future 5G service, there shall be a trial period before commercially operated in some areas such as Eastern Economic Corridor. The government sector shall allow the trial period to existing spectrum operators before specifying the bidding of spectrum.
- Spectrum shall be in the same standard as others countries to minimize cost of users. Spectrum allocation for 5G shall be identified for both low band (frequency lower than 1GHz), mid band (frequency between 1-6 GHz) and high band (frequency higher than 6 GHz). However, consideration shall be made with regard to service currently employing such spectrum. Clear spectrum roadmap; therefore, is required. Besides, Thailand has not established a clear vision of 5G that also encompasses the development of telecommunications and related industries. Consequently, the government and the National Broadcasting and Telecommunication Commission shall work closely to set up a plan for spectrum allocation and 5G vision of the country to promptly respond to any changes in telecommunication industry that may take place in the near future. DE Commission of Thailand shall emphasize on planning DE policy

to encompass every area while previously they had emphasized on net civil state more than other areas.

3.2 Infrastructure

Fundamental structure of mobile service system

- Thailand still lacks the cooperation in employing infrastructure, especially in the sharing of telecommunication signal towers of operators (Currently, Thailand has a total of 60,000 signal towers and if each operator has to invest in constructing their own signal towers, the cost in doing such thing will be very high). Consequently, the National Broadcasting and Telecommunication Commission shall consider an incentive or compensation system to infrastructure investors allowing other operators to share their own infrastructure; for example, the exemption of fees from revenues derived from infrastructure rental fees etc. Furthermore, the investor may establish the medium company to manage the infrastructure such as Tower Company and Fiber Company by starting from assets derived from joint operation agreement.
- The National Broadcasting and Telecommunication Commission shall reduce the steps in asking for permission to extend new cell sites. Existing regulations of the Commission have not facilitated network extension, especially in the extension of existing signal towers that have been shared since such request for permission has to go through various steps, starting from community hearing. Therefore, the National Broadcasting and Telecommunication Commission shall minimize steps or paper work in asking for permission; for example, if there is a permission for cell site extension by jointly employing existing signal towers, another community hearing must not be required. However, in case of installation of new signal towers, such community hearing is

necessary. Previously, there a lot of paperwork when setting up 1 cell site, but online permission shall be performed instead to enable Thailand to become Digital Thailand or e-regulator.

Management of infrastructure (telecommunication wires) on electricity poles

- The Provincial Electricity Authority (PEA) had been granted the policy from the government concerning the organization of wires on electricity poles; therefore, PEA has devised a plan to organize wires on electricity poles to ensure safety and only some power wires will be put underground. PEA's original plan was to manage only 1 percent of PEA's power wires to prevent any problems that may affect electricity users. As electricity operators cannot remove these wires on time; therefore, they had asked telecommunication operators to cooperate with PEA, starting from the removal of unauthorized wires from the electricity poles in which PEA shall survey and specify the appropriate weight of these wires that will be installed on the poles while simultaneously planning on wire installation on the electricity poles to prevent them from carrying too much weight than that prescribed in the safety measure. Such wires organization (the total distance of this project is approximately 300 kilometers and encompasses 74 provinces) will start in June 2018 by starting with unauthorized wires first. Afterwards, there will be wires merging and this can be done by resources sharing among different operators. However, the meeting had agreed that to accomplish this end, the government shall consider the readiness of investment in constructing electrical conduit system, rental fees of electrical conduit and/or rental fees of wires installation on electricity poles. As for higher expenditures owing to construction, rental fees of electrical conduit or those of wires installation on electricity poles, the government shall specify subsidization policy since these expenditures are extremely high and they have

not been included in the investment plan of operators at the beginning of this project. In addition, most operators do not have sufficient personnel or agency to take charge of wires removal which may result in higher cost for electricity users in such a highly competitive scenario. Besides, if the private sector has shared the infrastructure, apart from direct subsidization, the government and the National Broadcasting and Telecommunication Commission shall set up an incentive plan such as tax reduction or USO fees reduction etc.

The meeting also agreed that the government shall support the budget of electrical conduit; for example, getting USO money to support and propose the National Broadcasting and Telecommunication Commission to act as the representative or center of data base in the project relating to underground wire installation and enable Thailand Telecommunication Association to be responsible in supervising and calculating the reference price among operators which must not be the same rate for every operator.

The distribution of digital service to the general public

- Currently, Ministry of Digital Economy and Society (MDES) has implemented civil state internet project, comprising of 24,700 villages that had already been operated and viewed as an open access and at the moment is in the process of consulting with The National Broadcasting and Telecommunications Commission (NBTC) to organize border village internet project. Besides, there are up to 3,920 villages so remotely situated that the fiber cannot reach and USO has to take further responsibility. More than 15,000 villages are in the process of finding the best approach in cooperating with USO. The Ministry of Digital Economy and Society has welcomed a participation from any operators while the first-phase operation is still under the supervision of DE Ministry and

afterwards, it will be transferred to be under the direct responsibility of National Broadband Network Company (NBN Co.).

- The National Broadcasting and Telecommunications Commission (NBTC) has specified "Emergency and Disaster" spectrum to promptly respond to any unexpected incidents or disasters according to an emergency plan of the Disaster Prevention and Mitigation Plan. The Commission shall cooperate with operators in devising an incident plan and shall jointly practice such plan to precisely understand and conform correctly in case any emergency and disaster do occur. This also include the incident of Critical Information Infrastructure (ICC) so as to prioritize the steps in effectively handling potential threats, both in the government sector and operators.

  At present, operators from the private sector have completely specified guidelines in supervising critical infrastructure system within their organization. Nonetheless, one thing missing is the establishment of guidelines in responding to cyber threat since such threat is unpredictable and when it does take place in any system, it is hard to predict the next system that it will pose further threat, considering that current cyber threat does not come from the amateur any longer. On the contrary, cyber threat tends to be manipulated by an organization with clear and distinct network. Thus, mutual planning and cooperation between the public and private sectors in monitoring critical infrastructure is extremely significant. If the operator cannot help other operators in solving problems due to any legal restrictions of data sharing, then critical infrastructure in Thailand will be deprived of careful and systematic planning.

3.3 OTT (Over the Top)

- Currently, the government sector in Thailand is still unable to supervise and monitor OTT operators in other countries while operators in Thailand have to fall under the government's regulations and supervision and have to be accountable for revenue sharing while this is not the case with overseas operators, resulting in disadvantages in competition. Therefore, the National Broadcasting and Telecommunication Commission shall find the solution to help Thai operators to render equal competition as can be seen in Japan and India where overseas OTT operators have now been charged with taxes. Furthermore, the government shall specify measure to enforce a large number of overseas OTT operators to be regulated by the same regulation as Thai operators or they have to be enforced with similar tax system to minimize the advantages and disadvantages of local competition.

  However, such solutions have to take into account measures concerning market access as prescribed in free market agreement in which the supervision of OTT must be in line with Thailand's regulations under General Agreement on Trade and Service (GATS) established by World Trade Organization (WTO). Under GATS, Thailand has agreed to provide service in "accessing data base" and "online service" that is no boundary and fewer restrictions. Such agreement include services provided by OTT operators; thus, the restriction of extra taxes enforced only for those operators abroad may create negative impression that Thailand has not complied with the standard practice that may unintentionally damage the country's economic development. The government; therefore, shall establish measures in controlling overseas OTT operators to minimize these advantages and disadvantages between operators registered domestically and

those registered abroad without any registration while the majority of customers are in Thailand.

3.4 Industry Standard for 5G

- The public sector shall promote the use of unlicensed band in which LTE Unlicensed (LTE-U) technology will share 5GHz spectrum with Wi-Fi to facilitate faster LTE operation, especially with new equipment like smart devices, mobile or Customer Premises Equipment (CPE) of which their efficiency need to be consistently improved. This can be accomplished by employing LTE-U technology to add more channels and improve speed in data transmission since data usage on mobile phones has increased tremendously while spectrum allocation to add more channels to 3G/4G is a gradual process. LTE-U (or LAA: License Assisted Access) is the new technology for mobile phone network enabling more channels and faster speed in signal transmission via unlicensed band without asking for permission from the public sector. This can be viewed as an additional channel apart from using only LTE system (not replacing an existing system). Mobile phone users can simultaneously connect both LTE and LET-U systems, resulting in higher speed of data transmission. To achieve this end, relevant government agencies such as Ministry of Digital Economy and Society and the National Broadcasting and Telecommunication Commission and telecommunication operators shall participate in Wi-Fi alliance to support the use of unlicensed band such as 60 GHz and 5GHz etc.

3.5 e-Commerce / Fintech

- At present, the Revenue Department has drafted the bill to collect e-Commerce taxes overseas and has assigned the Director of the Revenue Department to draft details regarding tax collection procedures for further proposal. Nevertheless, such law has many loopholes and inconsistency in many areas; for example, if the transactions are performed abroad and how local company can collect taxes or if transactions are made locally but the company is in other countries and there is no representative in Thailand, how tax collection can be achieved etc. How concerned is the Revenue Department in this matter? In the end, many operators are being concerned with this law and think that it can be enforced only with companies registered in Thailand. This may result in inequality in competing with other foreign competitors. Besides, the government has been asked to support or promote the investment that will elevate efficiency of data center business and IP transit by allowing VAT exemption as in the case of Singapore.

3.6 Other supervisory issues

- The National Broadcasting and Telecommunications Commission (NBTC) shall review rules and regulations obstructing the country's development to become Thailand 4.0. Such obstacles include its own rules and regulations that specifies that KYC (know your customer) must be performed only at the operator's location which is inconvenient for customers. Consequently, the National Broadcasting and Telecommunication Commission shall seek other methods that support E-KYC instead of KYC at the customer service area while assuring confidentiality of information.

From recommendations mentioned above, it is evident that both public and private sectors must prepare for any changes in 5G digital technology that tends to be employed in the development of agricultural, manufacturing, commercial and service industries. Such technology will result in better quality of life, the change from city life to "Smart City", facility improvement in terms of education, productivity, health care, including the development of monetary format and service etc. These are by products from the use of 5G technology. Nonetheless, it is predictable that there will be emerging business that support 5G technology; however, some businesses may be affected that will impact competitiveness and survival amidst rapid and severe changes, especially in the financial sector that will have a direct impact on people. There might be any error due to the use of Fintech and security system and privacy of users' data may not be developed. Consequently, the government shall set up cyber security to foster confidence among citizens or cyber users and at present, the government is in the process of issuing Cyber Security Act B.E.... In addition, the government shall encourage the private sector to provide any suggestion in various issues to ensure the practicality of such act. Many operators may feel concerned of the government's authority in requesting information from the operators and there might not be a balance of power but only related government officer's judgement may be used as specified in Section 35 of such act.

4. Thailand in the Future

Amidst the global changes in the age of disruptive technologies, encompassing disruptive technology, disruptive innovation and disruptive business that currently destroy technological and business model and make them disappear fast as well as the introduction of some innovations that render changes to people's lifestyles, so there is a prediction that if 5G technology will be completely utilized in the near future, many changes may take place. Regarding financial issue, mobile payment may be used and change our society into Cashless Society. QR Payment may be employed as well as e-wallet that telecommunication operators have tried to make people accustomed to these services. In terms of education, long-distance learning may be applied to emphasize the notion that everyone has an equal right in learning anytime and anywhere and this will in turn promote learning based on people's interest. As for energy, human beings may create fusion nuclear energy and bring it to actual utilization in an efficient manner. In Thailand, there might be some potential changes that can be summarized as follows: the world may be characterized as a large free commercial zone called mega-FTA block that combines many small commercial zones into one single zone and that can replace and perform the duty of World Trade Organization (WTO). However, such free commercial zones may be reserved only to FTA countries and unfortunately Thailand has not been one of FTA members. The result that may follow is Thailand will completely turn into an aging society by 2015 and only 20 percent of Thai population will be over 60 years of age and by 2045, aging people in Thailand will increase to 36 percent while the total number of Thai population will drop to 63.8 million and Thailand will inevitable confront with severe labor shortage. Consequently, for the continued development of the country, one method that can be applied is to move people out from lower productivity business to the higher one instead. In the next 30 years, Thailand will be in the status of "Continuing Thailand, improved industry and modern agriculture-knowledge base service" in which each condition yields different result and require different labor market, education system and specific government's involvement. Thailand has

to adjust its traditional agriculture to modern agriculture and precision agriculture with an emphasis on water source management and efficient use of natural resources. Necessary measures shall be issued and enforced to enable safety food, research and development while promoting smart farmer and monitoring production factors such as fertilizer and pesticide to be in an acceptable level. Therefore, in the next 30 years, Thailand will face with 3 possible situations: one situation is that Thailand will change into the country with modern agriculture and knowledge-based service which is the most probable situation. In terms of future profession, in the year 2033, new professions such as virtual designer may replace existing ones and this new profession may require more creative ideas and flexibility compared to current practice, including virtual store manager, robot controller, drone machine controller and AR technology designer etc.

Not so many years from now, the number of Thai citizens may increase in a slower rate and is predicted that the growth rate will equal zero very soon. The number of Thai population will be stable at 65 million people while the slower birth rate will affect the aging framework of Thai citizens to rapidly become the aging society. In 2005, aging people in Thailand equal 10 percent of the entire population and in the next 30 years, aging people will be equivalent to 25 percent of the entire population or equivalent to 16 million people. When that time actually comes, the number of aging people will be higher than that of children. This speedy increase proportion may result in the change in economic interdependence between people with different age groups. Previously, children population have to depend on the working group per the aging group will be 2:1 in the next 30 years.

Future changes of Thai citizens may result in some implications of policies as follows:

1) Birth rate tends to decrease each year; therefore, the government does not have to worry about quantity but instead can emphasize on quality of new born children, especially in the area of mother and children's health. Similarly, fewer number of children population means the decline in the number of children in learning age; therefore, the government can pay more attention to education.
2) Although the number of working people tends to remain the same, but the requirement of labor to support the country's economic system will necessitate an "import" of foreign labor. Therefore, a systematic foreign labor management must be taken into consideration.
3) Aging group people increase substantially and Thai society becomes aging society. Welfare measures and projects for aging people, regarding general well-being or health shall start now and such development shall be in compliance with a rapid increase of aging people in the future.

Thailand's guidelines under 5G and Disruptive Technology

5G and disruptive technology change people's lifestyles and business platform under the context of climate change, aging society as well as an opportunity of modern service industry under the government's policy. Thus, there are 4 major technologies that will alter Thai people's lifestyles; namely, cashless society, healthcare, agritech and industry in which these 4 areas will emphasize on applying AI and Cloud Computing with AR and VR technologies by employing 5G technology to ultimately become "the Intelligent Innovative Mixed Use District".

Cashless Society: is a business and service revolution in many areas as can be seen from the introduction of prompt-pay, viewed as a flagship in banking industry. Many banks have started to lay off unnecessary staffs and turns to employ other service technologies, including an application of Wechatpay or Alipay technology introduced in China. Such technology results in a significant revolution in service as well as retailing and wholesaling businesses. In the future, customers will no longer buy merchandises from stores and these stores will become only a place for product showcase while these customers will buy merchandises via online or even virtual store where VR and AR technologies enable them to make virtual purchase.

Healthcare: Healthcare is one major area in applying technology since Thailand will become a perfect aging society soon; therefore, the format of technology must be appropriate for aging people's condition. Four major dimensions that technology can support lifestyle of the disabled and aging people include basic activities in daily life, healthcare and medicine, recreation hobby as well as sufficient economy.

Agritech: This application is very important in that Thailand is viewed at the kitchen of the world while an agricultural industry of Thailand is in the development process and prepare to employ high technology such as robot and IT in industry. Thus, agritech technology had been introduced to respond to the requirement of agricultural industry from the beginning to the end while emphasizing on an increase in productivity by minimizing expenditures and the use of resources such as energy, water and pesticides. More importantly, such technology helps improve the production quality and distribution. Furthermore, there will be the development of "Vertical Farming" in which robot will work hand in hand with IT system, resulting in fewer area for farming but higher productivity of products with quality pertinent to the market requirement.

Industry: Industry 4.0 is the new concept that can be compared to the most recent industrial revolution. The main point is technological development that can communicate with machine and production system of industrial automation to manufacture products to respond to various needs of consumers, while maintaining high production efficiency with the use of modern technologies such as 3D printing, industry 4.0 or industrial resolution in the 4th generation involves the use of internet in manufacturing procedure to support future changes in both supply and demand. Factors driving the world's demand in 2025 are indicated below:

- World population will increase to 7.9 billion, meaning that human beings need two and a half worlds to accommodate everyone, resulting in fewer resources. Therefore, there is an idea to send humans to live in another planet or find the best solution to conserve natural resources.
- Average income of citizen promotes a better quality of life. Middle class people and high-income people may reach 4.2 billion worldwide, resulting in different needs and requirements.
- Market sizes between 30 Triton USD and 34 Triton USD are not substantially different.
- More urbanization
- Climate and environmental problem will arise. There will be a need for higher energy consumption. Every country may minimize their gasoline consumption and replace it with renewable energy to reduce the risk of energy shortage while smart grid application will also increase.

The future of Thailand powered by 5G technology with digital services integrated into all sectors of society.

5. Summary and policy recommendations

To visualize Thailand's future direction, the integration of 5G and disruptive technology will be an important part of digital infrastructure which leads to the "Intelligent Innovative Mixed Use District". The development of digital technology that responds to severe climate change shall consider the need for higher water consumption including energy and food (WEF Nexus). In addition, the consideration of people's capability that will change to aging society and the consideration of cashless society shall be made as well. In terms of support provided to people, there shall be both economic and social development for people to gain access from various channels. The government shall provide support in education as well as public health, agriculture and welfare. Therefore, recommendations can be summarized as follows:

Recommendations regarding 5G Technology

1) The government shall establish clear policy in utilizing big data on 5G technology platform in order to develop or solve problem that respond to future requirement of the country. Four areas that need to be emphasized are cashless society, healthcare, agritech and industry.
2) The government shall promote education and select 5G criteria based on ITU guideline that will benefit 4 major industries of the nation.
3) Thailand shall allocate spectrum in telecommunication industry by clearly specifying in the spectrum allocation plan. Then, the government shall specify the bidding period 3-5 years in advance to enable potential operators to be well-prepared for any upcoming investment and to set up their business plan. This, in turn, will ensure other relevant companies with sufficient spectrum that can support their innovation.

4) Because 5G technology requires a very high initial investment. While most customers will still use 4G services, the coverage of 5G will start from areas with high traffic or limited areas that require 5G's unique capabilities. So, in the 5G auction It should not limit the amount of coverage. To motivate and respond to the needs of the user as a reality.

5) The government shall review and establish spectrum sharing plan as well as spectrum trading plan which is a common practice in many foreign countries. Besides, the government shall promote the use of unlicensed band where new technology like LTE unlicensed can be used with 5GHz and wi-fi to enable higher speed of LTE system, especially with newly introduced equipment.

Recommendations regarding Disruptive technology

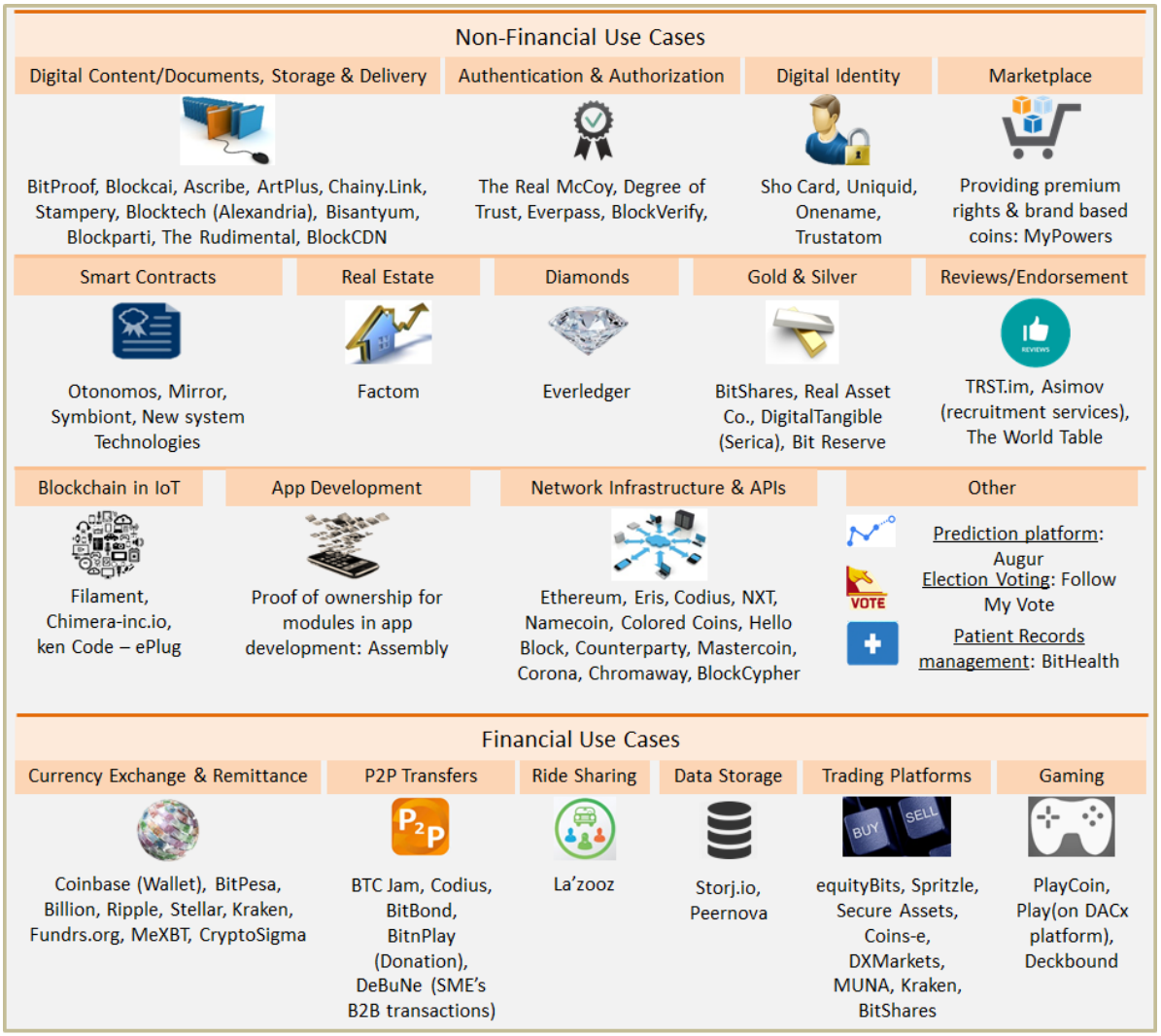
1) The government shall specify cyber policy to foster confidence among citizen or digital technology users.

2) The government shall create awareness of digital technology via people's network to enable them to apply and promptly respond to new technology while being adaptable to any potential changes.

3) The government shall support public service relating to welfare from the government sector by stressing on the benefits derived from digital technology to ultimately become the Intelligent Innovative Mixed Use District.

4) The government shall promote innovation or technology relating to healthcare to support aging society and agritech as well as to develop agricultural industry by emphasizing on internet of things (IOT) via AI processing system. Processed data will be shown in big data format on cloud computing under the support of digital fund for economy and society.

5) The application of national e-payment to support wholesale & retailing business while developing Thailand's digital money that will respond to the business sector in the future and will reduce the middle person in trading while being more convenient and can be employed in many business types. Concurrently, the government shall move national e-payment to Asian e-payment to respond more efficiently to ASEAN special economic zone.



The application of blockchain technology in financial industry and other industries

6) The government shall enhance efficiency in manufacturing and service industry by applying AI/Robot to further local innovation as well as to relieve tax measures to import state-of-the-art technology to respond to the requirement of industrial sector.

7) The government shall improve labor potential in manufacturing and service industry through professional training institution or short-term training from relevant agency to facilitate the application of digital technology in minimizing production costs.

Recommendations in specifying the most organization in driving Thailand toward becoming Thailand 4.0

The government shall support policy integration to enable concrete practice in which the Office of Digital Economy and Society shall take part in such movement, while emphasizing on 5G and disruptive technology in the area of agriculture, health, industry and financial technology to respond to smart city in the near future.

Recommendations in human capital development to support 5G technology

Human capital development is the most important factor in the development of the country. Therefore, preparations shall be made in 3 different levels; namely, 1) students and university students to be well-equipped with skills necessary for any potential changes through the government support of academic program as well as instructional media and promotion of innovation to encourage potential entrepreneurs in the future. 2) general public to be well-prepared of emerging technologies, build awareness and foster literacy through learning from local digital center and 3) labor sector or other related industrial sectors of which their efficiency and standard shall be developed via professional institutions as well as support of cyber security and data science through short-term training program.

Reference:

- Col. Dr.Settapong Malisuwan (2017), Disruption Part 3, NBTC Thailand.
- Dr. Thosapong Sirisamphan-Wong, Disruptive Technology and affect with Bureaucracy, 21st November 2018, Office of Public Sector Development Commission Thailand
- Dr. Somkiat Tangkitvanich, Future Thailand in Disruptive Era, TDRI Annul Public Conference 2018 Thailand
- Suryanegara, 5G as Disruptive innovation: standard and Regulatory challenges at Country level, International Journal of Technology (2016) 4: 635-642
- 5G: Issues & Challenges, ARCEP, FRANCE, March 2017
- Richard Adler Rapporteur, Preparing for a 5G World, The Aspen Institute, Washington D.C., 2016
- Competition conditions and governance guidelines in Over The Top: OTT , NBTC. Thailand
- Yosef Getachew, Alejandra Montoya-Boyer, Spencer Overton, 5G Smart cities & Communications of Color, Joint Center for political and economic studies, June 2017
- Smart cities Technology Roadmap, ATIS, 2017
- Anh Phan and Shoaib Tahir Qurshi, 5G impact on Smart Cities , ResearchGate, March 2017
- Andres Monzon, Smart Cities Concept and Challenges: Bases for The Assessment of Smart City Project, Springer, 4th International Conference, SMARTGreen 2015 and 1st International Conference VEHITS 2015, Lisbon, Portugal, May 20-22, 2015
- Ruisi He, and et al, High-speed Railway Communication from GSM-R to LTE-R, IEEE Vehicular Technology Magazine, September 2016
- The Impact of Technology on the quality and quantity of jobs, 2nd Global Commission of the Future of Work, Issue Brief#6, 15-17 February 2018
- http://www.bangkokbiznews.com/blog/detail/637375
- https://brandinside.asia/next-gen-5g-technology/
- https://brandinside.asia/what-is-5g-gsma/
- https://www.prachachat.net/ict/news-116469
- https://www.krungsrifinnovate.com/th/blog/investment/january-2018/innovation-will-change-5-industries.html
- http://www.brandage.com/article/269/FinTech

- https://www.mmthailand.com/tech_5g_iot/
- https://www.beartai.com/article/beartai-ict/136366
- http://www.theeleader.com/knowledge-update/5g-thai-chapter-1/
- https://thestandard.co/news-business-health-tech/
- https://www.facebook.com/thefuturesproject.co/
- https://thematter.co/pulse/smart-city/32385
- http://www.huawei.com/minisite/iot/
- http://www.nera.com/content/dam/nera/publications/2017/Thai_Version-Spectrum_Auction_Risks_Thailand.pdf

This Report is Prepared By:

The Telecommunications Association of Thailand under the Royal Patronage

Supported By:

สมาคมโทรคมนาคมแห่งประเทศไทย ในพระบรมราชูปถัมภ์

The Telecommunications Association of Thailand under the Royal Patronage