NCKU SPACE

AN INTERNATIONAL SYMPOSIUM

CELEBRATING THE NCKU ANNIVERSARY 2017

Conclusions, Policy & Strategic Recommendations

November 8-11, 2017

Tainan,Taiwan

Acknowledgment

The success of the Kick-off International Symposium of the NCKU Space 2017 was lay on the full support from the National Cheng Kung University (NCKU), notably the personal commitment of NCKU President, Prof. Su Huey-Jen, NCKU Executive VP, Prof. C.H. Huang, and Executive VP, Prof. T. Y. Chen. For this, we would like to express our utmost gratitude to these personages. We are equally grateful about the support of the Ministry of Science and Technology (MOST), National Applied Research Laboratories (NARLabs), National Space Organization (NSPO), and National Chung San Institute of Science and Technology (NCSIST). Furthermore, it was a great honor for us to receive the kind regards from Bureau Français de Taipei (de facto French Embassy), Belgian Office in Taipei (de facto Belgian Embassy) and its Flanders Investment & Trade Office. The representatives from these foreign offices have shared their precious time with us by attending various academic sessions and social activities during the NCKU Space 2017 which delivers encouraging signals to the future NCKU Space events. During the NCKU Space symposium, we had the privilege to welcome a number of international keynote speakers, namely Petr Havlik, European External Action Service (EEAS), European Union, Gaële Winters, von Karman Institute for Fluid Dynamics (VKI), Yu Takeuchi, Japan Aerospace Exploration Agency (JAXA) and Keio University, and David Kuan-Wei Chen, Institute of Air and Space Law (IASL), McGill University, and Xavier Liao, Ghent Institute for International Studies (GIIS), Ghent University. The information and insights offered by these individual academia and experts brought the light to the participants of the NCKU Space 2017 about the relevance between Taiwan's national space technological and industrial developments and the international astropolitical dynamics, vibrant global space economic activities, and the significance of the global governance on space activities. It was impressive to hear the NCKU and other Taiwanese academia when they demonstrated the solid research capability of and for Taiwan's future space capabilities building and space industrial development. Furthermore, it was wonderful that a number of Taiwanese space relevant companies, including companies linked with the European Chamber of Commerce, Taiwan (EECT) attended the keynote speech session, round table forums and the business networking activities during the NCKU Space 2017. Their enthusiasm and stimulating proposals is bringing Taiwan's space industries and business opportunities to a new scale and height. Hence lots of hopes but also works will need to be endeavored in the future. Last but not least, the warmest thank should go to the enthusiast participation and the assistance provided by the colleagues, students and staff members of the Department of Aeronautics and Astronautics, NCKU. Without them, the event would never attain its fine end.

Prof. Jiun-Jih, MIAU

NCKU-Space Organizer

Dept. of Aeronautics and Astronautics,

NCKU, Taiwan

Dr. Xavier L.W. LIAO,

NCKU-Space Co-Organizer

Ghent Institute for International Studies
Ghent University, Belgium

Executive Summary

This final report of the NCKU Space Kick-Off International Symposium (November 7-9, 2017) consists of 1) the factual elements of the Kick-off International Symposium of the NCKU Space, or NCKU Space I, 2017; 2) the highlights of all the keynote speeches, academic presentations and the experiences sharing from the Taiwan's space-related industries who attend the NCKU Space I; 3) the notes about the two Forums organized by the NCKU I which address the issues of a) the future of Taiwan's national space capabilities building and its space industry development; b) the likely perspectives for the NCKU Space II and beyond.

During the one and half days international symposium, the invited international experts and local participants jointly studied the theme of this symposium, **'Toward the International Cooperation for Taiwan's Space Economy & Technology Development'.** The participants from Taiwanese space community that covers the academia, the representatives from Taiwan's space related public services and private sector have thoroughly follow the themes of the symposium to explore the issues to (1) continue the legacy of Taiwan's continuous space capabilities development; to (2) study smart and coordinated national space policies for Taiwan's future space capabilities and utilities development; to (3) promote international cooperation to enhance Taiwan's space economic and technological development among the domestic stakeholders and international partners. Therefore, this report also notes the conclusions and the policy and strategic recommendations jointly proposed by the participants.

General Conclusions

The general conclusions highlighted Taiwan's space community shall continue its long-run endeavors to build Taiwan's national space technological capabilities by incubating its future space industry. Nevertheless as noted, with Taiwan's particular nationhood situation in the arena of international astropolitics, a smart and comprehensive capabilities building is deemed necessary by strengthening on upgrading Taiwan's existing ICT technologies, R&D human capitals to assist the national space capabilities development and its space industrialization. Furthermore, the technological and service niches and the suitable market position for Taiwan's future space industry are recommended to be further explored and evaluated. Finally, like in all other countries of the world, public awareness about the benefits of space technologies and applications, and the risk and costs related to space safety issues seems still missing in Taiwan. To this lacking of general public awareness and supports, the national authority has been hurdled to allocate necessary financial means in order to accelerate the national space capabilities development and to grow its space industrialization. As pointed put in one of the joint policy and strategic recommendations from the symposium participants, it will be vital that universities, public services and private sector should work together to enlarge the space technological applications services toward its own citizens, the regional service network, and the business partners in the different national and regional markets of the global space economy. With such integrated ecosystem of the labor-division among universities, public services and private sectors, the domestic space industries will be able to start up and grow steadily, therefore to expand its economic dimension.

Space Policy & Strategic Recommendations

1. **Taiwan's unique situation in the international astropolitics**

   Two primary decades of Taiwan's space technological development and capabilities building were noticed hindered by its particular situation in international politics, likewise in the regional geo- astropolitics. Taiwanese and international attendees of the symposium commonly recognized there will be hardly any significant breakthrough in the near future regarding such difficult situation. Yet, the participants unanimously shared the same viewpoint and encourage Taiwan should grow its economic strength by developing space industrial products and services to serve and improve peoples' daily for by-passing the international and national astropolitical hurdles.

2. **Continuous governmental supports are indispensable**:

   The international experts of the NCKU Space 2017 unanimously recognized the fact that none of any country's government in the world will totally free their hands from their national space technology and industrial development. For the national security and interest causes, and social economic benefits, all spacefaring nations, emerging powers and spacefaring countries' governments remain as the owner, user and clients of their own supported space industry. Hence, national government and its public services entities are the key to guarantee a steady development and grow of their national space technological research, applications and extensive economic activities. With the astropolitical hurdles, steady governmental policy and finance supports are absolutely indispensable to sustainably grow Taiwan's national space strength building. It is also a matter of Taiwan's national competitiveness of the future generations are at sake vis-à-vis the other regional competitors' harsh challenges.

3. **Develop Taiwan's space tech niche toward the global market through the SME**

   Driven by the proactive and breakthrough force of small and medium size enterprises (SME), SME has been reviewed and recognized in the developing and industrialization path of many liberal spacefaring countries. This SME-led industrial and business development model for space sector was noted considerably applicable by the international experts to the case of Taiwan's future space industrial development and space economic activities growth. It was recommended that Taiwan's government, space technological research community, and private sectors should be aware and needed to make a good use of such strength and developing modality. More efforts in incubating start-up and spin-off companies that develop space capability building and applications were recommended during the NCKU Space 2017.

4. A **UP-UP-UP Space Industry / Space Economy Development Model**

   Due to Taiwan's international astropolitical situation, universities and scientific research institutes enjoy a neutral stance and the optimal position to initiate, grow and

sustainably maintain a **U**niversity-**P**ublic Services/**U**niversity-**P**rivate sector/**U**niversity-**P**eople friendly integrated ecosystem to develop and improve Taiwan's continuous space capabilities building and avoid the hurdles the country often encounters in the arena of international astropolitics. Such neutral and nutritional ecosystem is supposed to gather all domestic and international partners to jointly develop and grow Taiwan's space industry by interconnecting Taiwan and its regional space application networks and markets, and finally to position Taiwan's space technological niches and commercial strengths in the global space economy. Such cooperative modality was recommended to be implemented in the future event.

5. **Taiwan space industry development** matters to **global space governance**.

   Although nowadays Taiwan possesses and operates its own space assets and enjoys numerous space tech application services, Taiwan, as a non-UN nation has been excluded from the equal right to have free access to the public goods of satellite orbital slots and satellite frequency spectrum attributed by the UN Specialized Agency-International Communication Union (ITU). The country is also lacking of the chance to fulfill the duty as a part of the global space community that should participate the space safety missions, e.g. space debris mitigation and space awareness capabilities building. Such broadened space security issues effectively concern Taiwan's satellite constellation, its operation and its extended applications for its people's daily lives. Therefore, Taiwan's and international space community need to be greater aware about the relevance between Taiwan's space capability building and global governance on space activities.

'NCKU Space' - 2017 International Symposium

'Toward the International Cooperation for Taiwan's Space Economy & Technology Development'

What is NCKU Space?

The ***NCKU Space*** is a new research and educational initiative supported by Taiwan's National Cheng Kung University (NCKU) – a university renown as the cradle for Taiwan's aerospace capabilities building and space related industry development. A recent successful story of the NCKU was the achievement of a space Cube Sat launch that was in part of the QB50 international consortium.

The initiative of the ***NCKU Space*** naturally occurred after the university's three-decade successful experience in participating Taiwan's indigenous space capabilities development from the 1990s. Nowadays, in additional to the existing educational and research missions, the ***NCKU Space*** looks for exploring other modalities to improve Taiwan's national space capabilities, grow the space related national economic and industrial strengths, explore new space related technological products and services prototypes in order to generate more benefits from the outcomes of the space technological research and the extensive applications. Furthermore, in the particular context that Taiwan is preparing the future 'Third 15-Year National Long Term Space Development Program' (the 3rd NLTSDP, likely to be implemented in 2019-2033), the ***NCKU Space*** also aims to study two broadened questions on 1) how to make Taiwan's space capabilities and utilities higher, farther, greater, as well as 2) how to make them safer, smarter, and suitable to people's needs and sustainable to the national long-term interests. Last but not least, the initiative of ***NCKU Space*** is taken in accordance with the new situation that global space activities have become ever congested, contested and competitive because of the increasing number of space countries and the popularized utilities of space technologies and their applications. Such new reality compels all nations, including Taiwan, to think beyond their respective national interests so are encouraged to take into account the global issues related to safety, security and sustainable interests for all concerned parties in time. For this, the ***NCKU Space*** tends to bring Taiwanese stakeholders and international partners to be connected with each other by organizing scholarly discussions and dialogues among stakeholders related to the national space technological and commercial development. Such international forums are particularly vital to stimulate the awareness and interests of Taiwanese young generations to not only enjoy the excitement in developing space technological and industrial capabilities but also to learn how to overcome the long-term societal, economic, and generational challenges.

In sum, the NCKU will pursues the objectives to (1) continue the legacy of Taiwan's continuous space capabilities development; to (2) study smart and coordinated national space policies for Taiwan's future space capabilities and utilities development; to (3) promote international cooperation to enhance Taiwan's space economic and technological development among the domestic stakeholders and international partners.

Who attend NCKU Space Symposium?

A kick-off event of the ***NCKU Space*** will be organized in form of international symposium dedicated to the theme of ***Toward the International Cooperation for Taiwan's Space Economy and Technology Development'***. This kick-off event will be held on **November 8-9, 2017** as one of the celebrating activities for the 86th NCKU Foundation Anniversary. The kick-off symposium enjoys the full supports from the space related governmental institutions, namely the National Space Organization (NSPO), Tainan Municipality and local space related business community. International scholars and experts from different space nations, such as Canada and Japan, and those from the international space cooperation organizations, *i.e.* the European Union (EU) are invited to present different approaches about their respective space development policies and implementation models notably focused on the international space cooperation activities. Taiwanese participants will present its successful space stories.

Initiatives regarding potential international collaboration projects will be discussed under the following frameworks. (1) Further endeavors for Taiwan's space capabilities development; (2) Smart space policies for Taiwan's future space capabilities and utilities development; (3) Sustainable mechanisms to enhance Taiwan's international space cooperation among Taiwan's domestic stakeholders and with foreign partners. All participants are invited to join the debate about the future national space capabilities development. In this regard, two discussion panels that involve local and international participants are expected to offer an outlook on the status quo, the technological developing trends, and the future perspectives of Taiwan's space programs in the context of the growing global space activities.

2017 'NCKU Space' International Symposium Program

November 8, Wednesday

1. **Venue for the morning sessions: Tainan Laboratory of National Center for Research on Earthquake Engineering, Kuei-Ren Campus of National Cheng Kung University**
   (會議地點:台南市 國家實驗研究院 地震中心 成功大學歸仁校區)
2. **Venue of the afternoon sessions: Department of Aeronautics and Astronautics, National Cheng Kung University**
   (會議地點:台南市 大學路 成功大學自強校區 航空太空工程學系)

Date/Time	Theme	Speaker(s)
09:00-9:20	**Opening Remarks**	Prof. Huey-Jen Jenny SU, President NCKU
9:20-10:10	Keynote speech 1 : **The Emerging Global Space Activities, their opportunities, implications and challenges**	Xavier L.W. LIAO, Ghent Institute for International Studies (GIIS), Ghent University, Belgium
10:10-10:30	Coffee Break	
10:30-11:20	Keynote speech 2: **a. Incubating Space Industry in Taiwan;** **b. Constellation of small satellites to promote space industry in Taiwan;** c. **Taiwan needs national space laws and current issues on Taiwan's space laws**	a. Shiann-Jeng YU, Deputy Director General, NSPO b. Chia-Ray CHEN, NSPO c. F. T. HWANG, NSPO
11:20-12:10	Keynote speech 3 : **International Cooperation and Legal Development of Space Activities: Japanese perspective**	Yu TAKEUCHI, JAXA / Keio University, Japan
12:10-14:00	Lunch and tour to ASTRC	
14:30-15:20	Forum I: **Academia Presentations** **a. Toward the Space Clusters Development Model in Taiwan;** **b. Lean Satellites and NCKU Space;** **c. Challenges of Taiwan's Space Technology and Industry: Hybrid Rocket Development as an Example;**	a. Jiun-Jih MIAU, Dept. of Aeronautics and Astronautics, NCKU b. Jyh-Ching JUANG, Dept. of Electrical Engineering, NCKU c. Yei-Chin CHAO, Dept. of Aeronautics and Astronautics, NCKU

	d. The development of the space plasma and optics instruments in NCKU; **e. Development of Miniature Electric Propulsion System in Taiwan**	d. Alfred Bing-Chih CHEN, Institute of Space and Plasma Sciences, NCKU e. Yueh-Heng LI, Dept. of Aeronautics and Astronautics, NCKU
15:20-15:40	Coffee/Tea Break	
15:40-16:05	**. Industry Presentations** **a. A startup view on the future of Space in Taiwan** **b. Empower the Space Cluster Technology in Taiwan—what we see from LiscoTech** **c. Initiating the "Taiwan Space Business Incubation Center"** **d. Global AIS/APRS TRACKING SYSTEM FOR MARINE AND LAND SAFETY APPLICATIONS: YUSAT-1 CUBESAT** **e. Taiwan First Commercial SAR Constellation Satellite Mission**	a. Jordan VANNITSEN,CEO of ODYSSEUS Space b. Jack CHEN, General Manager of LiscoTech c. Kuang-Han KE , Gran Systems Co., Ltd., & MZone MakerSpace d. Teng-Ying TAI, MoGaMe Mobile Entertainment Co.,Ltd e. Nick L. YEN, Trident Pacific Inc.
16:05-16:55	Keynote speech 4 : **European and Belgian space capabilities development: an economic, technological and international approach**	Gaële WINTERS, Von Karman Institute for Fluid Dynamics (VKI), Belgium
16:50-17:10	**Discussion I**	Chaired by Jiun-Jih MIAU
18 :30-20 :30	***NCKU Space*** Kick-Off Networking Dinner at Shangri-La Far Eastern Hotel[+]	Hosted by Professor Woei-Shyan LEE, Dean of College of Engineering, NCKU

[+]With invitation

November 9, Thursday

Venue: Department of Aeronautics and Astronautics, National Cheng Kung University

Date/Time	Theme	Speaker(s)
09:00-09:50	Keynote speech 5 : **Space : New Frontiers, New Business Opportunities**	Giuseppe IZZO, Vice-Chairman of the European Chamber of Commerce of Taiwan, ST Microelectronics VP of Asia-Pacific region.
09 :50-10 :40	Keynote speech 6 : **Space Strategy for Europe**	Petr HAVLIK, Senior Policy Officer, Space Task Force, Security Policy and Space Policy, European External Action Service (EEAS), European Commission
10:40-11:00	Coffee Break	
11:00-11:50	Keynote speech 7 : **A Holistic Approach to National Space Law and Policy Education and Capacity-Building: The McGill Model**	David Kuan-Wei CHEN, Institute & Space Law and Centre for Research in Air and Space Law, McGill University, Canada
11:50-12 :30	Panel discussion: **Perspectives on Taiwan's Space Capabilities Development: Educational & Research Approach : Toward the *NCKU Space* II and a NCKU Space Education and Research Program**	Chaired by Jiun-Jih MIAU and Xavier L.W. LIAO

ANNEXE: An Overview of Keynote Speeches, Presentations, and Round Tables

I. Keynote speeches on Space Policy and Space Industry Development

Five international keynote speakers from Ghent University (UGent), Japan Aerospace Exploration Agency (JAXA) and Keio University, von Karman Institute for Fluid Dynamics (VKI), and European External Action Service (EEAS) shared their insights and viewpoint regarding the current global trends for the use of outer space, regional space cooperation and national polices on space capability development and industrialization.

Dr. Xavier L.W. Liao, Institute for International Studies (GIIS), Department of Political Science, Ghent University presented '**the Emerging Global Space Activities, their opportunities, implications and challenges'.** Dr. Liao's talk was dedicated to explore likely aspects the future NCKU Space can develop its focused missions of space relevant education and research activities, innovative business and industrial cooperation, and national and international space policy studies. Hence, we look at the new situation in which the increase number of countries, international organizations, and private sectors have starting a new global 'space race' in order to fulfill their respective national power, interests, and capabilities. Simultaneously, the growing space activities are opening new opportunities for reducing the gap between the advanced and developing countries, stimulating industrial innovations and global space economy, and helping to deal with the sustainable matters, *e.g.* climate change, ever efficiently. To all the above issues, international cooperation is constantly addressed. Hence, we are tempted to study how countries and the academia, *e.g.* Taiwan and NCKU Space, can overcome the challenges from the competition-cooperation ambiguities while developing the national space capabilities and different space related activities in the new space era.

Yu Takeuchi, Faculty of Law (Institute of Space Law), Keio University, Japan Management and Integration Department, Human Spaceflight Technology Directorate, Japan Aerospace Exploration Agency (JAXA) share a Japanese perspective on the **International Cooperation and Legal Development of Space Activities: Japanese perspective** He recognized, throughout this history, international cooperation is playing pivotal role for advancing its major development as well as capacity building. In his talk, he focuses on the historical framework of international cooperative activities in space domain based on Japanese experiences, in order to elaborate their role and mechanisms. The speech stresses the contribution of legal instruments to international cooperation, particularly in the context that this year the international space community is celebrating the 50th anniversary of the Outer Space Treaty (OST) of 1967, the fundamental rules of space activities. Based on this legal instrument, international community have been employing for further development of international cooperation.

Gaele Winters, Director, von Karman Institute for Fluid Dynamics (VKI) takes an economic, technological and international approach to present **European and Belgian space capabilities development**. He points out that technology development and science in space, planetary missions, space exploration, etc. is in Europe mainly driven by the programs of the European Space Agency ESA. The key characteristic of ESA's industrial policy is an enabler for growth and the competitiveness of the European industry. Since the implementation of the Lisbon Treaty in 2009, the European Union is a new actor on the European space scene. The link between policymaking and a strong space agency is a prerequisite for ensuring the EU autonomy in strategic domains. The second part of the intervention will focus on the Belgian case. Belgium is in particular interesting, because the (relatively small) country continues to invest a large part of its gross national product in space activities. By zooming in on the von Karman institute for Fluid Dynamics, emphasizes will be put on the importance of continuous education and research for the development of a sound space policy and for the benefit of the society. Finally, the necessity of international cooperation in the space domain will be highlighted. Besides an important noble side of international cooperation, working together is necessary to make our efforts in space more effective and efficient.

Petr Havlik, Senior Policy Officer, Space Task Force, Security Policy Directorate, European External Action Service, presents Space Strategy for Europe provides a summary of the "Space Strategy for Europe". The EU has the global navigation program Galileo and the Earth observation and monitoring program Copernicus, which serve governments, science as well as industry and the general public to contribute to economic growth in Europe. The EU is very much concerned by the issue of space debris and underlines the importance of the Transparency and Confidence Building Measures and of promoting principles of responsible behavior in outer space. The EU actively participates in the work of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). The EU is preparing its participation in the UNISPACE+50, a special segment of the 61st session of COPUOS and the EU will contribute to building a comprehensive Space2030 agenda to support the Sustainable Development Goals.

Kuan-Wei Chen, Centre for Research in Air and Space Law, McGill University, Montreal, Canada presents the McGill Model regarding **A Holistic Approach to National Space Law and Policy Education and Capacity-Building** in which he noted that the development and use of space applications and technology can meet a variety of national economic, social, scientific and/or strategic needs and interests. Having clear and coherent national space law and policy is integral to ensure the furtherance of such national needs and interests, for which are in line with a State's international obligations and commitments, and will also go a long way to establish transparency and build confidence in the global outer space arena. Proper capacity-building and education in space law and policy are hence essential for

spacefaring and aspiring spacefaring States. Alongside developing space applications and technology, States must cultivate and possess the competent professionals and tools to make national space laws and policies that are reflective of national conditions and responsive to evolving national needs and interests. With over 65 years of experience, the McGill Institute of Air and Space Law and its research arm, the McGill Centre for Research in Air and Space Law, are recognized worldwide as an institution of excellence in space law and policy education and outreach. Valuable lessons can be learned from McGill's approach to education and training conducted through a neutral and comparative lens. Only with this strong multidisciplinary and global perspective, future policy-makers, space professionals and students will be able to address issues and concerns in the final frontier where the actions of one State can have global implications and consequences for the security and sustainability of activities of all States, and humanity, in space and on Earth.

II. Taiwan's Space Capabilities Development

Three distinguished speakers from Taiwan's Space Agency - National Space Organization (NSPO) present the successful accomplishments, current present progress and future perspectives about Taiwan's endeavors on developing the country's space capabilities and industrialization.

Dr. Shiann-Jeng Yu, Deputy Director General of **National Space Organization (NSPO)** of **the National Applied Research Laboratories (NARLabs),** presented **Incubating Space Industry in Taiwan.** He shares the insights about the successful experiences of Taiwan's Space Agency, NSPO that has been developing Taiwan's space technologies and promoting the space industry in the last three decades. As a result, NSPO has successfully operated the satellite programs, FORMOSAT-1, FORMOSAT-2, FORMOSAT-3 and FORMOSAT-5. In order to facilitate the space capabilities in Taiwan's local companies, NSPO opened technology transfer or collaboration opportunities for developing critical components in each satellite programs. NSPO coordinated Taiwan's domestic companies to join to develop components, such as on-board computer, antennas, spacecraft mechanical Structure, etc. In the indigenous satellite program FORMOSAT-5, more local companies involve from spacecraft components to payloads. However, the critical mass is not enough to make Taiwan's space industry to grow. In this presentation, he also introduced a NSPO's new small satellite program which is under the support of the National Flagship Plan. This satellite program is mainly to incubate local space companies and nurturing space talented persons through the developments of constellation of microsatellites, CubeSats and sounding rockets. Due to the lack of space law in Taiwan, some space activities are restricted. The studies of Taiwan's space law were therefore also discussed in this presentation.

Dr. Steven Chia-Ray Chen, NSPO of NARLabs presents the new national space program to promote the **Constellation of small satellites to promote space industry in Taiwan.** NSPO has received a new program funding from Taiwan government since March 2017, which is aimed at building a sustainable Taiwan's space industry. The small satellites project plays the role to lead the development of Taiwan space industry. There are two major goals for this project. The first goal is to cooperate with domestic academia and industry to develop the space components, subsystems, system, and forming space industry in Taiwan. The second goal is to deploy a cluster of satellites for remote sensing and store-and-forward communication services with of global coverage and revisiting Taiwan area many times per day. In order to reach these two goals, eight satellites will be developed and launched before the end of 2024. The small satellites project started from 2017 and aims to launch first two satellites in 2021. Flight demonstration of self-reliant key components, satellite system, and mission concept in 2021 is important. It will be the first space program in Taiwan aiming to the promotion of space industry locally.

Dr. Feng-Tai Hwang, Division of Systems Engineering, NSPO shares his viewpoint about that **Taiwan needs National Space Laws and Issues on Taiwan's Space Laws.** He states that space law, a research field combining both theories and practices, has been developed abroad for decades. Many countries have their own national space laws, but it is still a new area for Taiwan. This short talk is mainly concerned with the relevant issues of Taiwan's national space laws. Three topics were covered in this talk. First, the space policy and space technology development in Taiwan were introduced briefly. Second, why Taiwan needs national space laws was explained from the two different points of views. Third, three important issues of Taiwan's space laws, which are the structure of national space laws, level for headquarter of space affairs, and the competent authority of space activities, were addressed. Some observations in this regard and a proposed action were finally given in the end of this presentation.

III. Space Technology Development Panel

The focuses of the Space Technology Development Session was emphasized on the technical issues of 1) Space Research-Industry Development in Taiwan; and 2) the current and the future perspectives on Taiwan's CubeSat Technologies and industrialization.

Prof. Jiun-Jih Miau, Department of Aeronautics and Astronautics, National Cheng Kung University (NCKU) suggests the perspective to promote Taiwan's space industry **Toward the Space Clusters Development Model in Taiwan:** He noted the space industry is a high entry-level business which is always in favor of the proven technology via space flight. Therefore, it is essential to consider how to transform and advance the technology of Taiwan to the level of space qualified. To gain a critical mass to make the space industry grow in Taiwan,

there are issues of concern in terms of resources and technology readiness. The concept of forming space clusters is aimed to respond to these concerns. Functionally speaking, the space clusters would be able to attract the investment from public and private sectors, as well as to advance the technology to the level space qualified. The space clusters consist of members from academia, public research institutions and private sectors of different specialties, who are liable for the success of the space business. In this talk, the function of a research university, such as NCKU, in this regard was particularly addressed.

Prof. Jyh-Ching Juang, Department of Electrical Engineering, NCKU presented his project of **Lean Satellites and NCKU Space** which is a satellite developed by adopting a non-traditional, risk-tolerant development and management approach with the aim of providing value to the customer at affordable cost and permissible development time. Ever since 2011, an international community has been discussing various aspects of lean satellites, leading to the publication of ISO-19683 "Space systems - Design qualification and acceptance tests of small spacecraft and units" in 2017 and the publication of IAA study group 4.18 report "Definition and Requirements of Small Satellites Seeking Low-Cost and Fast-Delivery". The proliferation of lean satellites is changing the landscape of the space sector. The presentation elaborated the significance of lean satellites and the benefits of adopting lean-satellite approach in space research and education activities.

Prof. Alfred Bing-Chih Chen, Institute of Space and Plasma Sciences, NCKU presented **the development of the space plasma and optics instruments in NCKU about** which is the heritage and current progress of the space plasma and optics instruments in NCKU. The development of the space plasma instruments was initiated from the Taiwan sounding rocket mission 10, including a Langmuir probe, a retarded potential analyzer and a neutral particle analyzer. After that, TeNeP, Solar EUV probe and floating Langmuir Probe as well as Ion Drift Meter were developed and fabricated for the need of the different CubeSat or sounding rocket missions. Optical instruments were mainly inherited from ISUAL, the scientific payload of the FORMOSAT-2 satellite. Several miniaturized cameras for earth or lightning/transient luminous events observations were developed. An on-going star tracker was also presented in this talk.

Assistant Prof. Yueh-Heng Li, Department of Aeronautics and Astronautics, National Cheng Kung University presented the **Development of Miniature Electric Propulsion System in Taiwan:** The application of CubeSat spans from atmospheric probe, to relay communication, to end up the deep space exploration. The requirement of propulsion system in CubeSat moves from simple attitude control, Hoffmann transfer, and deep space navigation. The required thrust is decreasing, but required specific impulse is increasing in order to meet the propulsion requirement. However, pulsed plasma thruster (PPT) and vacuum cathode arc thruster (VCA) are the promising candidates for the electric propulsion

of CubeSat. The discharge process and plasma formation of PPT and VCA are strongly related to discharge chamber configuration, ignition fashion, and propellant sort. Integrating the past experience on engaging researches related to plasma-stabilized flame and electrical propulsion, and technical supports as well as equipment from Aerospace Science and Technology Research Center (NCKU), Plasma and Space Science Center (NCKU) and Institute of Space Systems (University of Stuttgart, Germany) can accelerate the accomplishment of the indigenous electric propulsion prototype system.

The session ends with a lab tour at the NCKU Kuei-Ren Campus, guided by **Prof. Yei-Chin Chao, Department of Aeronautics and Astronautics**.

IV. Taiwan Space Industrial Forum

The panel session invites a number of local and foreign space technology related companies in order to identify the current industrial landscape and the future potentials for Taiwan's space industrialization development.

Giuseppe Izzo, Managing Director of ST Microelectronics Taiwan Vice President of Asia Pacific Region presents: Space presented a panoramic view of the global commercial activities taking place in space from tourism to satellite launching which are creating **New Frontiers, New Business Opportunities**. He noted the likely patterns that ST Microelectronics can offer to the space applications sector and its commercial activities. At the end, he shared his views on the commercial aspect of the European Galileo Program.

Jordan Vannitsen, ODYSSEUS Space presents **A start-up view on the future of Space in Taiwan:** ODYSSEUS was funded in early 2016 and is recruiting Taiwanese and International team members with professional backgrounds from academia, industry and space agency. The team has many years of professional experience working on space missions both locally and abroad. As a young, cosmopolitan and innovative start-up, with a local and global view, ODYSSEUS introduces the NewSpace philosophy of developing faster, better and cheaper space missions. As a worldwide leader in several key technologies, Taiwan's own Space capabilities will be presented. Ideas about how Taiwan could reach the global NewSpace market will be proposed. Finally, the talk will conclude with ODYSSEUS view on the future of Space in Taiwan.

Jack Chen, General Manager of LiscoTech presents his company viewpoint about the **Empower the Space Cluster Technology in Taiwan.** LiscoTech was noted with successful reference in satellite. By seeing the trend for Big Data and the potential for cubic satellite, LiscoTech integrates its strong R&D experience to design dedicated on-board computer suitable in demanding space environment. Besides indicating the opportunities and

challenges, LiscoTech prepares its mid-term development to 1) extended products for space technology; 2) MPEG image compression IP and motion detection IP for space remote sensing applications.

Kuang-Han Ke, Gran Systems Co., Ltd., & MZone MakerSpace shows a project of **"Taiwan Space Business Incubation Center"** carried by the company to establish a Business Incubation Center (BIC) for space related start-up companies. The Gran System has some experiences with the student CubeSat project of the National Taiwan University and other universities near Taipei. From the private sector aspect, the noted that the business incubation will be faster from the industry than from the university, provided that resources would be available. It is further stated that Taiwan's "new space" industry needs the funding from Taiwanese government. Universities therefore can contribute its vital function role to lead the advanced technological development. Finally, the interaction of push-pull-and-supporting exercise aiming for a public-private or private-public partnership.

Teng-Ying Tai, MoGaMe Mobile Entertainment Co., Ltd presented the company's experience on the project of **Global AIS/APRS TRACKING SYSTEM FOR MARINE AND LAND SAFETY APPLICATIONS: YUSAT-1 CUBESAT** (aka, YUSAT-1) mission. He offered an overview about the YUSAT mission, one of three CubeSat projects funded by Taiwan's Space Industry Development Initiative – microsatellite/small-satellite development program proposed by National Space Program (NSPO), Taiwan. YUSAT-1 is a 1.5U cubic satellite equipped with an Automatic Identification System (AIS) and an Automatic Packet Reporting System (APRS) payload instrument for marine and land navigation safety and position reporting application. AIS information supplements marine radar and has been widely used for international merchant vessels since 2001. The vessels and shore stations obtain the dynamic and static data from AIS, which is the primary method of collision avoidance for marine transport. APRS is an amateur radio-based system for real-time digital communications of information of immediate value in the local area. The AIS/APRS data can include object Global Positioning System (GPS) coordinates, speed, weather station telemetry, text messages; announcements, queries, unique identification, and other needed telemetry. The YUSAT-1 mission will serve as a technology demonstration of AIS to provide a solution for AIS radio blind coverage area for Taiwan's authority surveillance. The YUSAT-1 mission will also provide APRS services when it is in the operation mode to the covered area by immediately forwarding and storing its packet information. APRS will help vehicle to transmit and receive all kinds of message.

Nick L. Yen, Trident Pacific Inc. presented **Taiwan First Commercial SAR Constellation Satellite Mission** which is the first commercial SAR (Synthetic Aperture Radar) constellation satellites in Taiwan by the international collaboration investments and the space technology. So far, the optical satellite images have been prevailing to dominate the earth observation

for over 57 years since the first photo of Earth from a weather satellite, taken by the TIROS-1 satellite on April 1, 1960. However, the optical images of earth is blocked by the cloud formations at the average of 66% above the earth surface, and no optical images can be taken at 50% of the time when the earth surface is in the shadow. SAR earth observation imaging is superior to the optical method primarily for its data acquisition by the means of RF signals that has characteristics of sunlight independency and cloud penetration. Trident Pacific's vision is to become the Taiwan first commercial satellite company in utilizing the innovative SAR-Synthetic Aperture Radar technology; enhancing the domestic aerospace technical capability; promoting the satellite SAR image applications; sharing the SAR image market opportunity in Asian Pacific Regions; and promoting Taiwan stepping into the international commercial aerospace arena. The first dual satellite system with the U.S. partner, Trident Space, will be launched near the end of 2019 and operating between 2020 and 2023. The 6 to 8 satellite constellation will be implemented during 2021 and 2023 to assure the continuation of the SAR constellation mission and increase the cluster satellite revisit frequency and the service range of SAR data application.

V. Round Tables:

After the one and half days international symposium, the international experts and the local participants of the NCKU Space 2017 jointly drew a number of remarks in form of policy and strategic recommendations for the future development of Taiwan's space capabilities building and space industrial development.

Round table I: Taiwan' space Industrialization

1. Taiwan's unique situation in the international astropolitics

The efforts of the over two primary decades on Taiwan's space technological development and capabilities building were noticed hindered by the country's particular statehood situation in international politics, likewise in the regional geo-astropolitics. Taiwanese and international attendees of the symposium commonly recognized there will be hardly any significant breakthrough in the near future regarding such difficult political burdens. Yet, the participants unanimously shared the same viewpoint and encourage Taiwan should grow its economic strength by developing space industrial products and services to serve and improve peoples' daily in order to overcome the international and national astropolitical hurdles.

2. Continuous governmental supports are indispensable:

The international experts of the NCKU Space 2017 unanimously recognized the fact that none of any country's government in the world will totally free their hands from their national space technology and industrial development. For the national security and interest causes, and social economic benefits, all spacefaring nations, emerging powers and

spacefaring countries' governments remain as the owner, user and clients of their own supported space industry. Hence, national government and its public services entities are the key to guarantee a steady development and growth of their national space technological research, applications and extensive economic activities. With the astropolitical hurdles, steady governmental policy and finance supports are absolutely indispensable to sustainably grow Taiwan's national space strength building. It is also a matter of Taiwan's national competitiveness of the future generations are at sake vis-à-vis the other regional competitors' harsh challenges.

3. Develop Taiwan's space tech niche toward the global market through the SME

Driven by the proactive and breakthrough force of small and medium size enterprises (SME), SME has been reviewed and recognized in the developing and industrialization path of many liberal spacefaring countries. This SME-led industrial and business development model for space sector was noted considerably applicable by the international experts to the case of Taiwan's future space industrial development and space economic activities growth. It was recommended that Taiwan's government, space technological research community, and private sectors should be aware and needed to make a good use of such strength and developing modality. More efforts in incubating start-up and spin-off companies that develop space capability building and applications were recommended during the NCKU Space 2017.

4. A University-driven Space Industry / Space Economy Development Model

Due to Taiwan's international astropolitical situation, universities and scientific research institutes enjoy its neutral stance and the optimal position to initiate, grow and sustainably maintain a **U**niversity-**P**ublic Services/**U**niversity-**P**rivate sector/**U**niversity-**P**eople friendly space capabilities and strength develop ecosystem. Such neutral and nutritional ecosystem is supposed to gather all domestic and international partners to jointly develop and grow Taiwan's space industry by interconnecting Taiwan and its regional space application networks and markets, finally position Taiwan's space technological niche and commercial strength in the global space economy. Such cooperative modality was recommended to be implemented in the future event.

5. Taiwan space industry development matters to global space governance.

Although nowadays Taiwan possesses and operates its own space assets and enjoys numerous space tech application services, Taiwan, as a non-UN nation has been excluded from the equal right to have free access to the public goods of satellite orbital slots and satellite frequency spectrum attributed by the UN Specialized Agency-International Communication Union (ITU). The country is also lacking of the chance to fulfill the duty as a part of the global space community that should participate the space safety missions, e.g. space debris mitigation and space awareness capabilities building. Such broadened space

security issues effectively concern Taiwan's satellite constellation, its operation and its extended applications for its people's daily lives. Therefore, Taiwan's and international space community need to be greater aware about the relevance between Taiwan's space capability building and global governance on space activities.

Round Table II: Toward the NCKU II, 2018?

The international experts and the local participants of the NCKU Space 2017 made numerous suggestions for any future NCKU Space or similar initiatives are recommended to continue 1) refining its targeted missions; 2) consolidating the technology and education capacity; 3) assuring the financial resources; 4) exploring the international partnership. It is also vital that the future similar initiatives to carry on the committed missions on 1) continuing the legacy of Taiwan's space capabilities development; 2) studying smart and coordinated national space policies for Taiwan's future space capabilities and utilities development; 3) promoting international cooperation to enhance Taiwan's space technological and economic development among the domestic stakeholders and international partners. The participants also concluded that any future NCKU Space like initiatives will receive the utmost encouragement and full support from all the local and international participants.