Netherlands Enterprise Agency

# Overview of Space Developments in Taiwan

By the Netherlands Innovation Network at the Netherlands Office Taipei
Will Ting - August 2021

# Preface

Dear reader,

This report presents the outcome of a study on space developments in Taiwan, performed by Will Ting, on behalf of the Netherlands Innovation Network in Taiwan. It aims to inform Dutch stakeholders, including companies, knowledge institutes and governments with ambitions in the field of international innovation and cooperation, about relevant space policies, technologies and projects, and stimulate knowledge intensive collaboration between the Netherlands and Taiwan.

The Netherlands Innovation Network (Innovatie Attaché Netwerk in Dutch) stimulates international cooperation between companies, research institutes and public authorities in the fields of innovation, technology and science. The network's activities help implement the international knowledge and innovation agenda of the Dutch government. We address national and global challenges, aiming to further develop key enabling technologies through international cooperation and a worldwide network of offices.

We started our study in the field of Space in April 2021. Despite the Covid-19 pandemic, we managed to gain insights via desktop research and refined the report through online interviews with space experts in Taiwan. A special thanks go to the Ministry of Science and Technology in Taiwan, Industrial Development Bureau in Taiwan, Taiwan National Space Organization, Netherlands Space Office, Industrial Technology Research Institute, Netherlands Organisation for Applied Research, Taiwan Space Union, Tronfuture and Tensor Tech for their valuable contributions!

We also wish to thank Will Ting, for his dedication to write this report. We hope this report will offer valuable insights to bring the bilateral cooperation between the Netherlands and Taiwan further. Your thoughts and comments on this report are welcome.

We wish you a great read!

Anouk van der Steen - Counsellor for Innovation, Technology and Science in Taiwan
Chih-Kai Yang - Sr. Officer for Innovation, Technology and Science in Taiwan

Taipei, November 2021

# List of abbreviations

| | |
|---|---|
| ADS-B | Automatic Dependent Surveillance–Broadcast |
| AIP | Advanced Ionosphere Probe |
| AIS | Automatic Identification System |
| B5G | Beyond 5G Communication Satellite Project |
| BOST | Board of Science and Technology, Executive Yuan, Taiwan |
| DoIT | Department of Industrial Technology |
| ESA | European Space Agency |
| ESTEC | European Space Research and Technology Centre |
| GNSS | Global Navigation Satellite System |
| GNSS-R | Global Navigation Satellite System-Reflectometry |
| IAC | International Astronautical Congress |
| iCASE | International Conference on Astronautics and Space Exploration |
| ICT | Information and Communications Technology |
| IDB | Industrial Development Bureau |
| LEO | Low Earth Orbits |
| MoEA | Ministry of Economic Affairs |
| MoST | Ministry of Science and Technology |
| NOAA | National Oceanic and Atmospheric Administration |
| NSO | Netherlands Space Office |
| NSPO | Taiwan National Space Organization |
| SBIC | Space Business Innovation Centre |

# Summary

Both Taiwan and the Netherlands are developing their space industry, with strengths in different areas. A better understanding of the global trends in space and current developments in Taiwan and the Netherlands are helpful to identify potential collaboration opportunities that can benefit both.

Taiwan is one of the few places in the world that has its own satellites and is running its space programs for more than 30 years now. Executed via three phases, its current space development program aims to flourish the space industry and related supply chains. Since 2019, Taiwan has extended the scope of space activities beyond academic oriented science research, managed by the Ministry of Science and Technology (MoST), to include the development of the space industry that is managed by the Ministry of Economic Affairs (MoEA). One example of such inter-ministerial collaboration is on the joint development of Low Earth Orbit communication satellite technologies and applications.

The Netherlands has a long history in space development and is an important member of the European Space Agency (ESA). The Netherlands has advanced technology available, and is particularly strong in specific areas, such as earth observation instruments, solar array, laser satellite communications, high-precision optics, small satellites, structures (f.e. igniters) and a variety of downstream applications amongst others.

This report is performed by the Netherlands Office Taipei. It explores the space industry and government policies of Taiwan. While writing the report and in contact with various experts, we learned Taiwan and the Netherlands have gained complementary knowledge and technologies related to space. Various potential collaboration themes are identified, such as laser communication, optical payloads and data applications.

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# Introduction



In the early days, space technology was mainly used for military competition between nations. Governments controlled most of the resources as well as its development process. In the last decades, a shift occurred from military demand to commercial purposes. Increasing demand for telecommunication and data services are the main causes, as well as commercial space travel. As a result, more and more private companies put investments into space activities while governments are making relevant policies to promote space industries. With more attention from various parties, the development of new technologies accelerated, and a continuous growth is expected.

Morgan Stanley estimated that the global space industry could grow its revenue to more than €851.6 billion in 2040 (see Figure 1). In their estimation, the main driver is providing consumers with faster and more convenient internet access. The expected demand is reflected by an increasing number of low earth orbit (LEO) satellites since 2017.

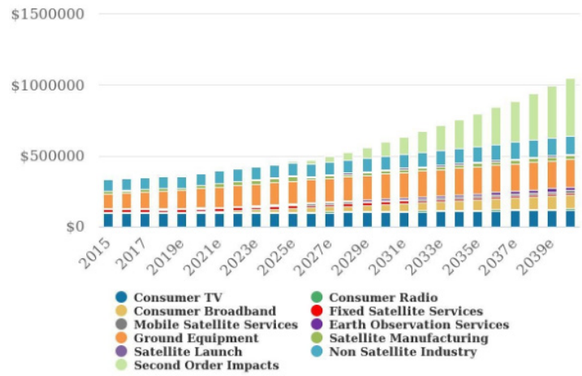


***Figure 1. The Global Space Economy (USD$)***

Source: Haver Analytics, Morgan Stanley Research forecasts

The space industry can be divided into satellite and non-satellite topics. The satellite industry includes topics such as 1) ground segments, providing the support for satellite operations; 2) the manufacturing of satellites; 3) the launching industry and 4) satellite services used in telecommunication and remote sensing. While the number of satellites increases, so does its data volume. A wide range of applications evolves following the data collected by satellites.

According to the "State of the Satellite Industry Report" by Satellite Industry Association (SIA) , the total revenue of the global space economy is €315.3 billion (US$371 billion) in which satellite-related topics took up nearly 73% (€230.3 billion; US$271 billion). Ground equipment and satellite services contribute over 93% of the satellite revenues, as shown in Figure 2.

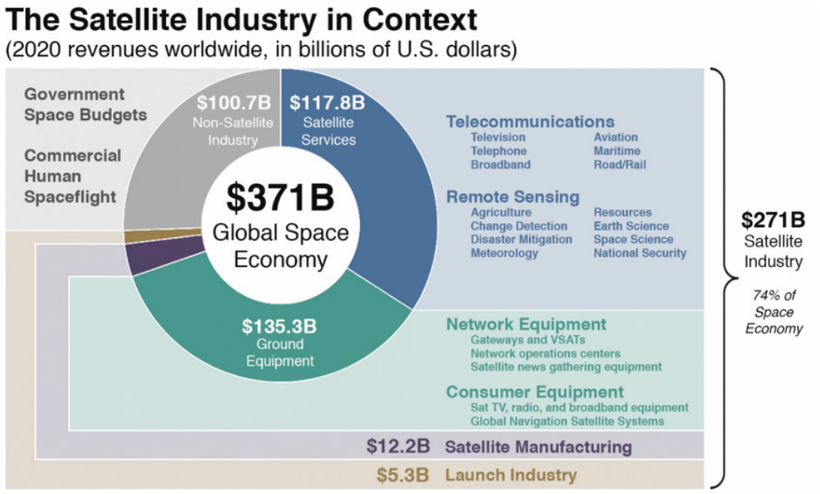


***Figure 2. The Satellite Industry in Context***

Source: Satellite Industry Association, State of the Satellite Industry Report, 2021

Non-satellite topics, covers the conventional government space budgets and the fast emerging commercial human space flights. On 17 January 2021 we witnessed the first trip by Richard Branson with Virgin Orbit, followed by Jeff Bezos with Blue Origin on July 20, 2021. This highlights new opportunities and involves new investments.



Following these global insights, various high-tech-focused regions listed space technology as one of the main topics for the future. Also Taiwan is actively pursuing further developments in the space industry and believes that its strong position in high-tech can be a competitive advantage.

## Goals of the Report

This report describes the space industry in Taiwan and aims to identify potential collaboration between the Netherlands and Taiwan. It covers governmental space policies, national programs, regulations, and industry developments.

The goals of this report are:

- Explore the space industry in Taiwan
- Identify new possibilities for collaborations between Taiwan and the Netherlands

The report consists of three chapters. Chapter one and two provide a closer look at the space industry developments in Taiwan and the Netherlands respectively. Chapter three continues with an analysis of strengths and weaknesses.

# 1

# Taiwan's Space Policy, National Program, Regulations and Industry Ecosystem



## 1.1 Taiwan Space Policy

Taiwan is determined to become an important R&D and manufacturing hub for satellite components, ground segments and related system equipment, as stressed by President Tsai.

In 2019, 'Beyond 5G Low Earth Orbit (LEO) Satellites' was discussed in the Board of Science and Technology, Executive Yuan (BOST) in Taiwan. The main goal is to drive the development of the industry by pushing Taiwanese companies to become a supplier for lower earth orbit satellite modules, components, subsystems and systems, while also making broadband communication services available in remote places, high mountains and islands around Taiwan. Taiwan wishes to build a verification and testing platform to better understand the demand for space communication products.

Unlike other official space programs led by research institutes, the 'Beyond 5G' project emphasizes the development of related industries. Therefore the Ministry of Economy Affairs (MOEA) plays a key role in this project. The Industrial Development Bureau (IDB) and the Department of Industrial Technology (DoIT) from MOEA are assigned to promote the space industry. You can find the responsible unit per task in Figure 3.


***Figure 3. Tasks and Responsible Units of Taiwan Beyond 5G Communication Satellite Project***

The timeline of this project is scheduled in two phases. With a budget of 4 billion NTD, an experimental satellite will be launched (by 2025) in the first phase. In the second phase, six communication satellites are planned to be launched (in 2027, 2029, and 2030).

By developing low earth orbit satellites, Taiwan aims to introduce existing industries (Taiwan is particularly strong in the ICT industry) to the production of satellite components and space communication systems - and create a new market.

By 2020, the Taiwan government announced the *Program for Promoting Six Core Strategic Industries (2021-2024)*, including national defense and aerospace industries. According to this program of Executive Yuan, there are three main development strategies:

1. **Communication and remote-sensing satellite key components:** support production of domestic satellites as the mean to create the opportunity to obtaining flight heritage which will accelerate development of key satellite component, building up domestic supply chain and entering international market.

2. **Small satellite:** countries such as the US, Japan and Korea are leading in the development of small (under 500 kg) satellite. Taiwan has the technology and experience in building small satellite and hoping to enter the international small satellite market through establishment of the local satellite supply chain and the launch of the FORMOSAT-8 and Beyond 5G communication satellites.

3. **Communication satellites ground equipment:** the recent rapid development of low earth orbit (LEO) satellite, particularly the Starlink project of the US company Space X, has brought attention to the massive business potential of LEO satellite communication equipment. Taiwan is one of the global leading players in semiconductor, precision machinery ICT industry and already supplying equipment to LEO operators. The goal is to become a key player in the international market.

## 1.2 National Space Programs

Taiwan is now in the third phrase of the Long-Term National Space Technology Development Plan

**Phase 1** (1991-2006, 15 years): Taiwan's government budgeted €602 million for this program. The goal was to establish a firm foundation for the development of national space technology through the development of space organizations, technology and talents. This program successfully constructed and launched 8 satellites for the FORMOSAT-1, -2, and 3 projects. FORMOSAT-1 (launched in 1999) was Taiwan's first satellite and was specifically for conducting science experiments.; FORMOSAT-2 (launched in 2004) was the first remote-sensing satellite owned by Taiwan; FORMOSAT-3 (launched in 2006) was an international collaboration project between Taiwan (NSPO) and the US (University Corporation for Atmospheric Research). The project consists of a LEO constellation of six microsatellites to collect atmospheric remote sensing data for operational weather prediction, climate, ionospheric (space weather monitoring), and geodesy research.



**Phase 2** (2004-2018, 15 years): This program aimed to further stimulate academic research and development of domestic space sector through the FORMASAT 5 & 7 projects. The FORMOSAT-5 (launched in 2017) is the first satellite that was designed, produced, assembled and tested domestically. Since 2018, the high resolution satellite image has become commercially available mostly for research purpose but also supported more than 15 countries in the disaster rescue missions. FORMOSAT-7 (launched in 2019) is the follow-on program of FORMOSAT -3 and the biggest US-Taiwan space technology collaboration so far. The United States team (includes National Oceanic and Atmospheric Administration, the United States Air Force, The University Corporation for Atmospheric Research) is responsible for satellite launches, payloads, and deployment of global ground receiving stations; the team in Taiwan is responsible for the design and integration of mission systems, the development of 6 spacecrafts, and constellation of mission operations. Data processing and application technology development are developed by the two parties in cooperation.

**Table 1. Launched FORMOSAT (Taiwan) Satellites**

| Satellite Project Name | Main function | Timeline | Milestone |
|---|---|---|---|
| FORMOSAT-1 | Scientific experiment | 1999/01/28~ 2004/06/17 | The first satellite was owned by Taiwan. |
| FORMOSAT-2 | Remote-sensing and science | 2004/05/21~ 2016/08/19 | The first remote-sensing satellite was owned by Taiwan. With 2m black/white image resolution. |
| FORMOSAT-3 | Weather observation | 2006/04/14~now | First constellation observing system that comprised six micro-satellites |
| FORMOSAT-5 (successor of FORMOSAT-2) | Remote-sensing and science | 2017/08/25~now | First fully self-build satellite. With 2m color image resolution. |
| FORMOSAT-7 (successor of FORMOSAT-3) | Weather observation | 2019/06/25~now | The biggest cooperation program by Taiwan (NSPO) with the National Oceanic and Atmospheric Administration in the U.S. |

Source: compiled for this report

During the first two Space Programs, Taiwan constructed a research platform and the ability to develop new technologies. Furthermore, it provided the opportunity for more than 40 manufacturers to enter the space industry supply chain, it cultivated startups and pushed for talent in the space activity field.

**Phase 3** (2019-2028, 10 years): The program aims to promote the development of the space industry in Taiwan. The planned budget is around €765 million.

The goal is to launch one satellite per year, carrying high-tech equipment for homeland security and environmental monitoring. This helps domestic companies to get flight heritage and speed up the development of Taiwan's space industry. This third phase consists of four parts: weather research, remote-sensing, cube satellite, and deep-space exploration. All are described in more detail below.



1. Weather Research

   For weather research, the third program continues the mission of FORMOSAT-7. Furthermore, there will be a self-developed weather satellite: TRITON (Wind-Hunter Satellite). TRITON will carry the Global Navigation Satellite System-Reflectometry (GNSS-R) developed by NSPO and gathers data on the low earth orbit from the reflection of the surface. The data will be used for typhoon intensity predictions (Taiwan is often affected by typhoons), soil properties, ocean-atmosphere interchange, and environmental research.

2. Remote-Sensing

   For remote-sensing, there will be three kinds of satellites deployed serving various purposes.
   - High-resolution remote sensing constellation comprised of six satellites with a 1-meter resolution. This is the main mission of FORMOSAT-8.
   - Ultra-high resolution smart optics remote sensing satellites with <0.35-meter resolution, which have an AI seeker and Short-Wave Infrared (SWIR) system. The AI seeker can help the satellites to capture more accurate photos while the SWIR system utilizes spectral transmittance differences to monitor the air pollution source.
   - Synthetic aperture radars (SAR) Satellites to track changes in topography through electromagnetic waves.

3. Cube Satellite

   There are three Cube Satellite projects: IDEASSat (Ionospheric Dynamics Explorer and Attitude Subsystem Satellite, 3U), NutSat (2U), and YUSAT(1.5U), and Taiwan is planning to have more in the coming year.

- IDEASSAT: The science payload is the Compact Ionosphere Probe (CIP), an all-in-one in-situ plasma sensor developed at National Central University (NCU), based on heritage from the Advanced Ionosphere Probe (AIP) aboard FORMOSAT-5.

- NutSat: The payload is the ADS-B (Automatic Dependent Surveil) receiver. The technology and devices of ADS-B have been used on commercial airplanes for many years. Using satellites to track airplanes benefits the safety of the flights.

- YUSAT: there are two communication payloads, namely Automatic Identification System (AIS) receiver and Automatic Packet Reporting System (APRS) receiver. The AIS receiver can receive AIS data packets from vessels globally. The AIS data packets will be stored onboard and then dumped to ground stations via UHF radio frequency. This technology improves maritime navigation safety. The APRS receiver can receive APRS messages from cars for traffic monitoring and from ground sensor devices for large area environmental monitoring.

The large number of CubeSats deployed provides more opportunities for the verification of CubeSat components and instruments, therefore the project also encourages researchers and scholars to come up with more applications of CubeSats.

4. Deep-Space Exploration

For outer space, the initial plan is to put a satellite in the moon's orbit. The goal is to develop outer space communication and Trans-lunar injection technology. Once the technology is ready, research on the moon's environment such as the moon's surface and solar wind is planned.

Taiwan's moon orbit satellite plans also allow for international collaboration, seeking outer space communication and navigation resources to be shared in research results. At the same time, setting such an ambitious task aims to attract more talent devoted to the space technology field in Taiwan. In Table 2, the projects within the Third Long Term Space Technology Development Program are listed.



**Table 2. Taiwan Third Long Term Space Development Program**

| Project. | Number of Sat. | Content |
|---|---|---|
| SWIR Remote Sensing Satellites (FORMOSAT-8) | 6 | • 1 m resolution- SWIR(Short Wave InfraRed)<br>• Coastal/AerosolAerosol(433-453 nm), red edge(690-730 nm)<br>• LiDAR(1064 nm) |
| Ultra-high Resolution Smart Optics Remote Sensing Satellites | 2 | • 0.35 m resolution |
| SAR (Synthetic-aperture radar) Satellites | 2 | • SAR (9.6 GHz)<br>• FORMO-SAR by Tron Future |

Source: Compiled for this report

## 1.3 Taiwan Space Development Act

With an emerging demand for rocket launching in Taiwan, the government realized the immediate need for national space legislation. This idea was accelerated by an incident in April 2020, when a private company built a launching base on a rental farmland but came into conflict with aboriginals. After this incident, the Ministry of Science and Technology (MOST) submitted the draft "Space Development Act" in March 2021. The act was officially promulgated on16 June 2021.

The "Space Development Act"[1] contains six chapters, including general principle, Basic principles of Space Development, Space activities and Space industries, Handling of Space Accidents, penal provisions, and supplementary provisions. The purpose of the act is not only to regulate relevant activities but also to carry out national space policies and programs.

The main principle is based on international conventions, related regulation, environmental protection, sustainability practices, and promotion of space science. The law defines the areas of space activities, launchers, spacecraft, the industry, space accidents and launching locations. The supervisory authority of the "Space Development Act" is the Minister of Science and Technology, while the competent authority of each activity is laid down in the regulation accordingly.

## 1.4 Stakeholders

This part will describe the relevant government bodies, research institutes, industry and associations in more detail.

**Government (Ministries)**

The Ministry of Science and Technology (MOST) is the competent authority for space activities and initiates Taiwan's Space Programs.

The Ministry of Economic Affairs (MOEA) is also involved in space, and more focused on the industry side. MOEA financially contributes to vitalize the space industry and related supply chains, executed by the Department of Industrial Technology (DoIT) and Industrial Development Bureau (IDB). The main focus for MOEA is the Beyond 5G communication satellite project. This project is implemented through investments in IDB's Taiwan Industry Innovation platform Program (TIIP), supporting the development of low earth orbit satellites.

**Research institutes**

The key research institutes involved in development of space technology include

- **The National Space Organization (NSPO):** the main governmental research institution in space technology, set up under MOST. It was founded in 1991 to implement the first National Space Development Plan. Currently, NSPO is carrying out the 3rd phase of the National Space Development Plan and is leading most of the space projects in Taiwan.

- **the Industrial Technology Research Institute (ITRI):** ITRI is among the top applied technology research institute in the world with more than 6,000 employees. Its mission is to drive industrial development, create economic value, and enhance social well-being through technology R&D. Founded in 1973, it pioneered in IC development and started to nurture new tech ventures and deliver its R&D results to industries. ITRI is involved in developing Beyond 5G LEO satellites, payloads and other elements such as antennas and ground stations.

- **Academia Sinica:** the most preeminent academic institution in Taiwan founded in China in 1928 to promote and undertake scholarly research in the sciences and humanities. The institute of Astronomy and Astrophysics (ASIAA) is one of the 32 institutes and centers in Academia Sinica aspiring to be at the forefront of astronomical research theoretical and experimental astrophysics and instrumentation.

- **Universities:** Universities active in space related research include the National Cheng Kung University (NCKU), National Central University (NCU) and National Yang Ming Chiao Tung University (NYCU).

1 https://law.moj.gov.tw/ENG/LawClass/LawAllPara.aspx?pcode=H0160078

## Industry

Looking at the current turnover of the space industry in Taiwan, ground equipment devices take up €9.25 billion while satellite service involves around €1.98 billion. Most of the value comes from companies already active in other industries, extending their products and/or services to the space field.

The process of building satellites can be put into six main segments which are: component material, subsystem, system integration, launching service, satellite operation and satellite application. Taiwan's industry has leading positions in the component material sector, especially in microelectronics, microwave communication, solar battery and advanced material. A few private companies also take part in the subsystem, system integration, launching service and satellite operation. Product testing, as it needs a real space environment, is mainly done by NSPO.

As mentioned before, the ICT industry in Taiwan is very strong and there are many companies are already providers communication satellite ground equipment to the international LEO satellite projects. Microelectronics Technology, Tong Hsing, Gemtek, D-link, Pyras, Universal Microwave Technology, Transystem, InnoLux are a few examples of Taiwanese companies that have a high potential of making world-class high-quality space components. Meanwhile, there are various startups. Tron Future Tech is capable of building a Synthetic-aperture Radar (SAR) module, as well as providing solutions for communication. Tensor Tech focuses on satellite attitude control systems; while Gransystems, HelioX Cosmos and Odysseus are targeting launching services. Figure 4 provides an overview of the local companies in the satellite industry chain and the orange boxes indicate the gaps in the local supply chain.

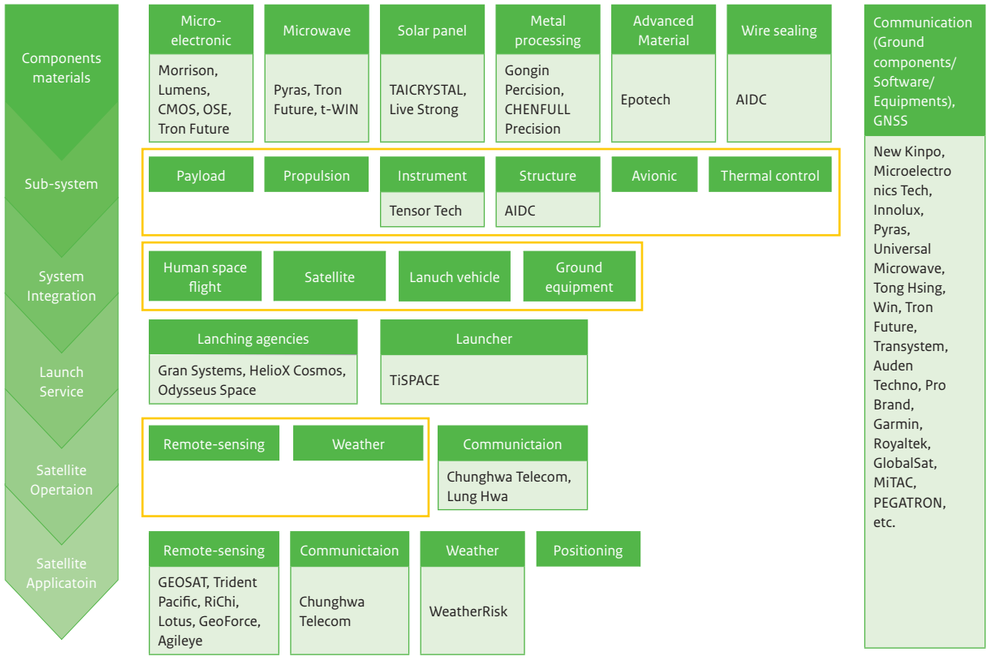


***Figure 4. Satellite Industry Chain in Taiwan***

## Associations

Since the industry shifts towards more business opportunities, associations play an increasingly important role as connectors and promoters in the space industry. There are two associations focusing on space at the moment:

1. **Taiwan Space Industry Development Association** (founded in 2019) aims to promote the development of the space industry. Their main tasks are to research the development strategies and provide suggestions on policies; host domestic and international space industry conferences such as International Conference on Astronautics and Space Exploration (iCASE), the annual iCASE for 2021 is on November 16 - 18; and commission training and research requests from other units. The association collects its funds from 46 Taiwanese companies/institution members. The association, together with its members, provides a strong network and is a valuable entry to get in touch with space-related companies and units in Taiwan. This association serves both the public and private sectors and the chairperson is the Director of NSPO.

2. **Taiwan Space Union (TSU)** aims to connect space academic communities. Its goal is to act as a think tank and to stimulate more dialogue between academic and businesses. It hosts Taiwan Satellite Science Workshop annually since 2019.

# 2

# The Netherlands' Space Ecosystem



The Netherlands develops space technology via its own National Space Policy, aside from its participation in European space collaborations such as ESA's projects.

The **National Space Policy** identifies the following themes of space innovation: energy & sustainability, agriculture & food & water, health, and safety & security. The main objectives of the policy are:

- Supporting high-quality scientific research in the field of astronomy, earth-oriented space research, and planetary research
- Contribute to the development of healthy space industry, including saleable products and services related to space
- Using satellite data for new applications and services that are useful in our society, as well as contributions to developments elsewhere, especially in developing countries and emerging markets
- Maintaining and strengthening the ESA location in Noordwijk (ESTEC), as well as further intensifying the collaboration between ESTEC, the Dutch knowledge institutions, and the Dutch business community.

There are various **state agencies** that provide funding to implement the national policy. The Ministry of Economic Affairs and Climate Policy is the main state actor for space, coordinating the policy. The Ministry of Infrastructure and Environments mainly works on policies related to satellite data and its implementation. Whereas the Ministry of Foreign Affairs joins specific projects related to space. They f.e. kicked off the G4AW program, managing the risk in global food production and food security using data applications.

The **Netherlands Space Office (NSO)** is the space agency of the Dutch government. It helps the implementation of governmental assignments and advises on space policy. NSO also plays a coordinating role between governments, institutes, universities, and companies. Collaboration is constructed via public-private partnerships. As a result, the Netherlands has an increasing number of companies related to space, communication, transportation, big data, and artificial intelligence.



**The Netherlands Organization for Applied Scientific Research (TNO)** and the **Royal Netherlands Aerospace Center (NLR)** set up space research and development programs, sometimes together with institutes related to the Dutch Research Council NWO (i.e. SRON, Universities).

Furthermore, the Netherlands actively participates in the **EU's Horizon program** and has strong connections with the EU in terms of space technologies. **The NL Space Campus Noordwijk** (set up in 2020), serves as the knowledge center of the European Space Research and Technology Centre (ESTEC, ESA) and the EU Galileo Reference Centre (GRC). The Campus has become an important hub for the international industry, which gives the Netherlands a geographic advantage in talent fostering and economic activities. Lastly, the **Space Business Incubation Centre** in the Netherlands (SBIC, ESA) hosts an incubation program for innovations, startups, and scale-ups.

Aside above mentioned focus of policies, state agencies and public interest, the Dutch space industry showcases many technologies and applications in both up- and downstream. There are various active sector organisations (such as SpaceNed and Nevasco) and "NLSpace" is used to jointly promote the industry.

More detailed information about the space industry in the Netherlands is available via the following websites:
www.spacened.nl
nevasco-group.nl
www.nlspace.nl/en/home
www.nlspacecampus.eu

# 3

# International Collaboration, Challenges, and Opportunities



## 3.1 International Collaboration

In the past thirty years, Taiwan had various international collaborations. Especially successful is the GNSS-R weather monitor program with the U.S. which is set in Taiwan's FORMOSAT-3 plan. Taiwan used its constellation to monitor the changes of the weather through data variation of radio waves from GNSS satellites. The success of FORMOSAT-3 was the stepping stone for the FORMOSAT-7 project receiving more involvement and resources from the National Oceanic and Atmospheric Administration (NOAA, U.S.), an increased number of satellites, and upgraded electronic wave receivers.

Following the latest Space Program, Taiwan set the goal to have more such international collaborations in the future.

## 3.2 The Challenges

Taiwan faces challenges in three areas:

1. The general public is not familiar with space industries, resulting in a relatively small amount of (private) investments. Investors are often conservative when putting their money into space-related companies or new projects. At the moment only two startups are building space application products in Taiwan. As mentioned earlier in the report, Taiwan does include the promotion of private companies in the space industry - yet this is only in its recent program. Structural systems and strategies are yet to be built in order to establish a flourishing private industry. The second challenge relates to that.

2. Taiwan's space industry still heavily relies on the government. This results in a lack of launching equipment and the ability to test and verify space activities.

3. Due to a complex geopolitical position (mainly its relation to Mainland China), it is more difficult for Taiwan to collaborate with international space organizations. China has proved its strength in space (with the successes of the Tiangong Space Station and Zhurong Rover starting exploration on Mars) and is considered an important player in the space industry. International organizations are often hesitant to collaborate with Taiwan out of fear of ruining their (potential) collaborations with China. This directly impacts the access to radio frequencies, while also limiting knowledge sharing.



## 3.3 Opportunities for International Collaboration between the Netherlands and Taiwan

The Netherlands and Taiwan have a long history of collaboration in industries such as high tech, energy, water, amongst others. However, no collaborations in the space industry are known to us.

Taiwan has developed technologies and applications in the space industry for 30 years now. With its own supply chain, Taiwan manufactured numerous satellites and proved its abilities in system integration. Overall Taiwan is good at utilizing supply chain advantages, manufacturing (mass production), and optimizing costs. The Netherlands on the other hand gained a lot of experience by participating in ESA for a long time. Furthermore, it established a private sector in the space industry via its industrial park (Space Campus in Noordwijk). Overall the Netherlands has more frontier technologies and is active in some targeted areas of the industrial chain.

Taiwan and the Netherlands have gained complementary knowledge and technologies related to space. They could learn from each other's strategies - and try to implement each other's successes (while preventing the failures). More specific collaboration opportunities identified during this report are:

1. **Laser Communication**
   Following Taiwan's industry background and main focus on ICT, telecommunication is Taiwan's strategic position in the global space supply chain. In the upcoming years, Low Earth Orbit (LEO) communication satellites are the main focus for Taiwan, targeting 5G and beyond. This is not only scientific research, but also to promote relevant industries. As mentioned in chapter one, Taiwan is planning to launch six mission satellites and one experimental satellite in the B5G LEO communication satellites project. Laser communication plays an important role in communicating with terrestrial stations and inter-satellite communication. With the technique of producing the satellite's ground equipment and various components, Taiwan also wants to gain the technology of optical communication components.

   On the other side, the Netherlands has state-of-art technology in this area. For example, TNO's TOMCAT (Terabit Optical Communication Adaptive Terminal) presents advanced technology as adaptive optics can stabilize the connection. Because laser communication is affected by the turbulence in the atmosphere, adaptive optics is an important sub-system for the ground terminals.

   Combining the strengths from both sides, Taiwan and the Netherlands could play a complementary role in developing satellite communication devices.

2. **Optical Payloads**
   Earth observation is the major task in Taiwan Third Space Development Program. According to the plan, there will be six satellites that need optical payloads. The Netherlands has advanced technologies related to optical payload. High precision optical instruments could be a possible topic for collaboration between the Netherlands and Taiwan.

3. **Satellite Data Application (for agriculture and rainfall predictions)**
   According to Taiwan's latest space project, Taiwan will launch synthetic aperture radar (SAR) satellites that can provide images in different spectrums. Compared to earlier satellites, these satellites capture more detailed and clear land photos. The demand for such landscape photos has increased in recent years, mainly due to the visible results of climate change and its practical use in agriculture. The photos will be used in research and strategies related to for example disaster response and optimizing agriculture activities.

   NSPO in Taiwan brought up the Taiwan Data Cube (TWDC) program which offers space data for application in different fields such as agriculture and environment protection. As more and more satellites are launched into space, it can collect data with various resolutions in a multi-period. By sharing data with different countries, the value of these space geodata can be maximized to benefit solving current mutual environmental problems.

   In the Netherlands, NSO and the Ministry of Foreign Affairs host a program called Geodata For Agriculture And Water (G4AW). This program aims to support agriculture and water management via Geodata. Timely data can help food producers to make decisions with confidence. The Netherlands has many private companies and associations that are devoted to the applications of space data in smart cities and traffic, such as dotSpace foundation. Their satellite data application experience can be a great starting point for best-practice exchange with Taiwan.

   Another application for data usage can be applied to rainfall predictions.



# Looking Ahead

Taiwan's space industry has a good foundation with their own satellites, a strong position related to ICT and many products and services suitable for the supply chain in the space industry. The Netherlands on the other hand has a complete space industry ecosystem and has better conditions to attract talents in space. To make collaboration happen, it requires the complementation of technical capabilities, long-term interaction and trust, and more importantly, a clear understanding of the direction and positioning of each other's space industry. We hope this report will be helpful to start collaboration.

Ideally experts from the Netherlands and Taiwan have the opportunity to meet (online/ offline) to further discuss their interests, possible during the following events:

- **International Astronautical Congress (IAC)**:
  IAC is the world's premier space event. The global space community, it's major players, leaders will all join the meeting together. It also provides a platform to network with global space industry leaders across government, industry and academia.

- **International Conference on Astronautics and Space Exploration (iCASE)**:
  The iCASE is an annually conference organized by Taiwan's National Space Organization (NSPO) incorporates with Taiwan Space Industry Development Association (TSIDA). It covers space technology development, value-added applications and services, deep space exploration and science innovation, space law and policy governance, space industry opportunities, and education.

Aside, the Netherlands Innovation Network would be happy to facilitate (online) events and activities to stimulate the knowledge intensive collaboration between the Netherlands and Taiwan.

# Reference

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