



# An Examination of Vietnam and Space

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## ABSTRACT

Vietnam is slowly expanding its presence in space and to better understand where Vietnam is going in the future, a thorough examination that incorporates several factors must be completed. This article examines Vietnam's history in space, its space strategy, the organizational structure of its space program, how Vietnam is expanding its presence in space, and how Vietnam plans to use space for national security purposes. The article also reviews Vietnam's cooperation with other space nations where they are substantially benefiting from programs aimed at advancing the capabilities of emerging space nations. The article ends with potential areas that Vietnam and the United States can cooperate to advance both states capabilities in space while at the same time limiting Chinese influence in Vietnam.

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## 1. Introduction

The number of nations investing in space has greatly increased during the 21st century as the availability and commercialization of space assets has reduced costs and improved access to space. One nation that has more recently invested in space is Vietnam. Vietnam sees space as an important issue in international relations and military affairs, as well as an important investment opportunity because of the domestic benefits that space capabilities can provide [1]. The purpose of this article is to examine Vietnam's history and space strategy, their space organizations, their current and future space architecture, and their strategy and options to use space for national security purposes. The article will conclude by examining areas of cooperation between the United States and Vietnam that will benefit both nations.

## 2. Vietnamese space history and developing a space strategy

Vietnam's history with space began with the Soviet Union's Interkosmos program, an international effort between the Soviet Union and other socialist countries, which served as a high-profile propaganda exercise that allowed the Soviet Union to carry a "guest" cosmonaut-researcher into space [2]. Vietnam and the Soviet Union signed a cooperation agreement on 17 May 1979, which made Vietnam the ninth member of the Interkosmos program. On

23 July 1980, Pham Tuan became the first Vietnamese citizen to fly in space [3]. Following the spaceflight, Vietnam used satellite data provided by the United Nations Development Program for sustainable development purposes [4].

In 1986, Vietnam launched political and economic reforms that transformed Vietnam's economy into one of the fastest growing in the world since 1990 [5]. With this growth, Vietnam began to explore its options involving space. The government decided that a telecommunications satellite, VINASAT-1, would be the best space asset for Vietnam as it would improve telecommunications throughout Vietnam. VINASAT-1 was initiated in 1995, and the Vietnamese government approved the prefeasibility study in 1998. The satellite was approved by the government of Vietnam in 2002 and placed under the responsibility of the Vietnamese Posts and Telecommunications group, which is responsible for Vietnamese telecommunications networks [6].

In June 2002, Prime Minister Phan Van Khai asked the Vietnam Academy of Science and Technology (VAST) to collaborate with the Ministry of Science and Technology and all other relevant ministries to create a strategy for research and applications of space technologies [7]. This was the first major push for Vietnam to become a domestically capable space nation. In June 2006, in response to the Prime Minister's request, Vietnam introduced its first national space strategy: the "Strategy for Research and Application of Space Technology of Vietnam until 2020" [8]. The strategy outlines 6 objectives:

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- (i) To form the national policy and legal framework for research, application, and international cooperation on space technology and human resource policies;
- (ii) to build the initial infrastructure for space technology;
- (iii) to plan and carry out a national science-technology program on space technology;
- (iv) to master the manufacture technology of ground stations and small satellite technology;
- (v) to manufacture and launch small Earth observation satellites; and
- (vi) to apply the space science and technology [9].

Vietnam could not achieve this strategy alone and required cooperation with countries with advanced spacefaring capabilities to develop the technologies necessary to achieve its objectives and emerge as a modern space nation.

In 2006, the VAST and the Japan Aerospace Exploration Agency (JAXA) signed a cooperation agreement in 4 major fields:

- (i) Remote sensing and the application of remote sensing;
- (ii) development and application of small satellites;
- (iii) common research toward Japan's Module on the International Space Station (ISS); and
- (iv) improve VAST's capacity in the field of research and application of space technology [10].

To advance its domestic space industry infrastructure and its development of space systems, Vietnam implemented the Vietnam Space Center Project in 2012. This project is in cooperation with Japan and has 3 main goals:

- (i) Build the space center technical infrastructure;
- (ii) build and launch 2 Earth observation satellites with the assistance of Japan; and
- (iii) develop the capacity for training Vietnamese space scientists and space engineers [11].

The Space Center is located in Hoa Lac Hi-tech Park and opened 2018 [12]. The other 2 goals from the Space Center Project are expected to be completed by 2020. The Vietnam Space Center facilitates Vietnamese engineers to learn from an established space nation and develop the critical infrastructure and domestic workforce necessary to become a successful spacefaring nation, while building closer ties to a regional power that could further develop Vietnamese space technologies.

### 3. Vietnamese space organizational structure

The implementation of the "Strategy for Research and Application of Space Technology of Vietnam" until 2020 gave the nation a foundation and a path to begin developing its organizational structure for a space strategy. Space systems and operations were placed under VAST as Vietnam's leading scientific and technological agency. VAST conducts basic research on natural sciences and develops comprehensive high-standard technologies, including space and satellite components [13].

The Space Technology Institute (STI) and the Vietnam National Space Center (VNSC) each report to VAST as the 2 main space-focused governmental organizations in Vietnam [14]. STI is a national research institute that focuses on basic space science and technology. The research includes applications for remote sensing, geographic information systems, and global positioning system (GPS) for natural resources, environmental, and disaster management. STI also completes research and development on small Earth observation satellites [15]. STI's research intends to provide great

insight for Vietnam and the government's efforts to protect the environment and build a domestic workforce capable of developing small satellites.

VNSC, previously called the Vietnam National Satellite Center until July 2017, is a research center that is responsible for developing the Vietnam Space Center projects, which include research and development, technology applications, and the training of high-quality skilled workers who can develop space technologies that will improve the value of life for all Vietnamese people. VNSC is also responsible for developing and implementing international cooperation projects in space technologies [16]. VNSC is also responsible for controlling, operating, and managing Vietnam's Earth observation satellites as well as collecting, storing, processing, and developing satellite image applications [17].

The Vietnam Space Committee, established in 2010, operates outside of VAST and acts as a liaison to international organizations on space technologies. The Committee is also responsible for proposing programs, plans, and measures to implement the national strategy on research and application of space technology [18].

### 4. Vietnamese satellites and space data distributors

Vietnam, as with most other emerging space nations, is rightly seeking to leverage and import technologies already developed by countries with more advanced space capabilities. Through international cooperative agreements, this effort seeks to rapidly and affordably establish a modern foundation for the domestic space industry.

In addition to obvious tech transfer benefits, international cooperation also enables the development of Vietnamese aerospace engineers and scientists. Today, Vietnam lacks a large number of skilled workers in the high-tech sector [19]. To address this challenge, Vietnam relies on other nation states to teach its engineers the requisite technical knowledge that will become the foundation for creating indigenous space technologies in the future. For example, Vietnam is cooperating with JAXA to develop smallsat capabilities and train aerospace engineers. Vietnam is also using France's Official Development Assistance funds, which requires Vietnam to invest very little economically, while still obtaining an optical satellite and training of Vietnamese engineers. Because of these of international agreements, Vietnam has grown the country's space resources and emerged as a developing space nation. Vietnam's ability to work and set objectives with various nations has created a model for other emerging space nations to follow.

Currently, Vietnam has 2 operational commercial communications satellites in orbit, VINASAT-1 and VINASAT-2, both of which aim to improve Vietnam's communications network by providing radio, television broadcasting, and telecommunications services to Vietnam and its neighboring countries. Both satellites are operated by VNSC [20].

VINASAT-1 was originally planned to launch in 2005, but Vietnam faced registration problems with the International Telecommunications Union, which delayed the project and the launch of the spacecraft several times [21]. Obtaining the 132° east geostationary orbit position for VINASAT-1 was difficult because of 2 main concerns: Japan was using the slot for one of its satellites, and Vietnam faced radio frequency coordination problems with Japan and Tonga [22]. After the coordination and frequency problems were resolved in 2006, Vietnam issued a call for international bids to build and launch VINASAT-1 because it did not yet have the technical capability to construct its own satellite reliably [23]. Lockheed Martin won the contract in May 2006 to develop the satellite, and Arianespace won the contract to launch the spacecraft. On April 18, 2008, an Arianespace Ariane 5 launch vehicle launched VINASAT-1, which became Vietnam's first satellite [24].

The spacecraft was placed into 132° east geostationary orbit and entered operational service in June 2008 [25].

Following the success of VINASAT-1, in May 2010, Lockheed Martin won the right to build VINASAT-2, and it was launched on an Arianespace Ariane 5 launch vehicle on May 15, 2012 [26]. VINASAT-2 was placed into 131.8° east geostationary orbit and became operational on July 5, 2012 [27].

On May 7, 2013, Vietnam expanded the country's satellite capabilities beyond communications by having Arianespace launch their first Earth observation satellite, the Vietnam Natural Resources, Environment, and Disaster Monitoring Satellite (VNREDSat-1), on a Vega Rocket into a Sun-synchronous orbit [28]. VNREDSat-1 enables Vietnam to better monitor and study the effects of climate change, predict and take measures to mitigate natural disaster, and hopefully optimize the management of Vietnam's natural resources [29]. On May 9, 2013, the satellite successfully sent the first photos of Vietnam to a ground station based in Hanoi, which can connect with the satellite 3 or 4 times a day [30].

Funding for VNREDSat-1 came primarily from the French government's Official Development Assistance program, which contributed \$73.5 million and required Vietnam to contribute the remaining \$3.2 million [31]. The contract included academic training for 15 Vietnamese engineers and technology transfer through on-the-job training [32]. VNREDSat-1, built by France's Astrium, weighs 120 kg, has a 2.5 m-resolution imager in panchromatic bands, and 10-m resolution in multispectral bands [33].

Vietnam's first indigenously developed spacecraft were 2 cubesats designed for deployment from ISS. The first, the F-1 CubeSat, was built by the Financing and Promoting Technology University in Hanoi and launched to the ISS on a Japanese H-II Transfer Vehicle (HTV) resupply craft on July 21, 2012. The spacecraft was deployed from the small satellite launcher onboard ISS on October 4, 2012 [34]. The F-1 CubeSat needed to meet 3 criteria to be considered a success: survive the space environment for at least 1 month, measure temperature and magnetic data, and take low-resolution photos of Earth [35]. Unfortunately, the F-1 CubeSat was a mission failure because it was unable to contact the ground station.

The second Vietnamese cubesat, Pico Dragon, was carried to the ISS by the Japanese HTV-4 cargo spacecraft, on August 4, 2013, and deployed from the ISS on November 19, 2013 [36]. Pico Dragon was designed and built by the VNSC. Its mission was to photograph Earth, collect environmental data, and communicate and exchange data with the ground station [37]. On November 20, 2013, the first signals from Pico Dragon were received by ground stations around the world, including the VNSC ground station [38]. Pico Dragon was considered a success, and it eventually re-entered Earth's atmosphere on February 28, 2014 [39].

The emphasis on smallsat technologies in the national strategy allows Vietnam to develop less technically advanced and more cost-effective indigenous spacecraft than starting with large, complex space systems. The costs to develop, launch, and operate cubesats are typically a fraction of that of large satellites, providing ample opportunity for rapid technology development without significant financial risk.

The National Centre for Hydro-Meteorological Forecasting (NCHMF) is a government organization tasked with issuing forecasting/warning information for weather, climate, hydrology, water resource, and marine weather and provide hydro-meteorology services. NCHMF uses both storm radar installations along with satellite imagery to create forecasting products. NCHMF receives weather satellite imagery primarily from the Japanese Multifunctional Transport Satellite, the United States National Oceanic and

Atmospheric Administration polar orbiting satellites, Geostationary Operational Environment Satellites, and the Chinese Feng Yung-2 satellites [40].

Vietnam is also involved in a new satellite data sharing system named Vietnam Data Cube. The data sharing system is a satellite imagery database for Vietnamese Earth observation satellite data [41]. The goal of Data Cube is to provide free, open, and exploitable tools for community development [42]. The Data Cube system aims at connecting, training, and familiarizing Vietnamese citizens with space information for agriculture and capacity development.

## 5. Vietnam's future in space

Vietnam has several spacecraft planned for the future, including a launch of its next Earth observation satellite, VNREDSat-1b, which was scheduled for launch in 2017 but has been delayed for an unknown period of time [43]. Vietnam is teaming with Spacebel of Belgium to develop the satellite, and the agreement includes a training program with the University of Liège, which will train Vietnamese engineers in charge of satellite data reception and analysis [44]. The contract is valued at about €63 million, and the satellite will weigh approximately 100 kg, have an operational life of 5 years, and have similar capabilities to VNREDSat-1, with a 2.5 m-resolution imager in panchromatic bands and 10-m resolution in multispectral bands [45].

Vietnam has also agreed to purchase 2 Japanese radar imaging satellites; the first was built in Japan and is scheduled to launch in 2018, and the second is being built in Vietnam and set to launch in 2020 [46]. The 2 satellites, JV-LOTUSat-1 and JV-LOTUSat-2, are based off the Japanese ASNARO 2 satellite [47]. The satellites will monitor damages from flooding and other disasters in day or night [48]. They will also provide substantial assistance in surveying Vietnam's forests, which suffered massive deforestation from both the Vietnam War and logging between 1976 and 1990 [49]. The satellites' radar imaging capabilities will be particularly useful because of the vast forest area in Vietnam and can assist in monitoring the efforts that the Vietnamese government has taken to replant 5 million hectares of land and monitor the ban on logging in certain forests [50].

## 6. Using space for national security purposes

Although Vietnam has not developed or publicly announced the development of satellites designated for national security purposes, one cannot disregard the inherent dual-use nature of space systems.

Using scientific-purposed satellites for national security matters could be the next step for Vietnam, as the Ministry of National Defense 2009 White Paper states that

“Building the scientific and technological potential of the all-people's national defense is closely linked with the development of science and technology of the country. Despite difficulties, the scientific and technological potential of the country is being intensified step by step, thus contributing more effectively to economic development and consolidation of national defense-security” [51].

As Vietnam seeks to improve its domestic space industry, it is clear that the technologies necessary for capturing earth observation data and the skills necessary for analyzing this data for civilian purposes are the same for national security purposes, such as reviewing troop and naval movements and terrain modifications. Vietnam can use that knowledge to independently develop future

satellites for national security purposes instead of relying on foreign vendors.

Current optical satellites could be used for various national security means, including tracking large-scale changes and maritime movements occurring in the South China Sea or monitoring artificial island development in the region. To ensure that Vietnam is able to detect and track construction activity and air traffic going to and from the islands, 1-m resolution satellite imagery is probably most useful [52]. While the resolution limit for Vietnamese satellites is not at a 1-m resolution today, the images may still be helpful for monitoring maritime activities.

The development of radar imaging satellites, such as JV-LOTUSat-1 and JV-LOTUSat-2, will potentially expand Vietnamese remote sensing capabilities from civil space to the national security realm. These radar imaging satellites will monitor damages from flooding, other disasters, and survey forest and farmland, but they can also provide an opportunity for Vietnam to use them for national security purposes. Radar imaging has the distinct advantage over optical satellites because it is not limited by the time of day, weather, or camouflage [53]. Vietnam can use radar imaging to monitor the country's borders that, at certain locations, contain heavy forestation [54]. Radar imagery can also play a crucial role in the South China Sea conflict as it can help identify friend and foe and provide substantial opportunities for penetrating and perpetrating deception [55].

In January 2016, India and Vietnam entered into an agreement, which allows India to establish a satellite tracking and imaging center in Ho Chi Minh City, in exchange for access to imagery from Indian Earth observation satellites that cover the region [56]. This is the first foreign tracking station in Vietnam, and while Vietnam will use the imagery for civil purposes, the imagery will also be used for national security purposes. Access to India's Earth observation satellites will increase Vietnam's ability to monitor Chinese activities in the region, particularly the South China Sea. Instead of relying only on domestic capabilities that have minimal revisit rates because of a limited number of Earth observation satellites, Vietnam can access a greater amount of imagery data, with a greater amount of revisit rates [57].

Working with foreign nations also lends credence to the Vietnamese Defense White Paper, through which Vietnam tries to expand international cooperation to absorb advanced defense technologies for Vietnamese use [58]. Vietnam is using a combination of these foreign and domestic satellites to develop military support programs [59].

## 7. United States and Vietnam cooperation

Competition exists between large space powers, such as the United States and China, to work with emerging space nations to gain greater soft power influence with those states and expand their own space capability. Large space powers have several avenues to explore to work with emerging space nations, such as creating bi-lateral cooperation agreements, share information collected by satellites, or co-develop satellites. China's cooperation is becoming more extensive as they grow their space program. For example, China has worked with Venezuela to develop the Venezuela Remote Sensing Satellite, which China manufactured, but more than 100 Venezuelan engineers participated in the design and assembly of the satellite in China [60]. Although it is difficult for the United States to co-develop satellites because of International Traffic in Arms Regulations (ITAR), NASA still works with emerging space nations to co-develop satellites [61]. For instance, NASA previously worked with Argentina on the Aquarius/Satélite de Aplicaciones Científicas (SAC)-D mission, which operated from 2011 to 2015. NASA provided the Aquarius instrument, and

Argentina's space agency, Comisión Nacional de Actividades Espaciales, provided the SAC-D spacecraft an optical camera, and various sensors developed by various Argentine institutions [62].

China is using its Belt and Road Initiative (BRI) to make Eurasia (dominated by China) an economic and trading area to rival the transatlantic (dominated by the United States). The BRI is expanding China's influence in the region as they have spent roughly \$150 billion a year in 68 nations that signed up for the initiative [63]. In terms of space within the BRI, China created the Space Information Corridor, which offers space information services to BRI states, including position, navigation, and timing, Earth observation, communications and broadcasting, and other types of satellite-related development. States that sign up for the Space Information Corridor can become dependent on China for space services, which will increase China's ability to influence those BRI states. China would control vital space capabilities that create economic growth within states that agree to the BRI [64].

The United States must be cognizant of China's expansion and the potential loss of United States soft power influence in the region because of the BRI and Space Information Corridor. The United States can attract emerging states with its space policies in foreign cooperation to entice emerging space nations to work with the United States instead of China. If the United States were to work with these nations on space exploration and information exchange, it could retain or gain influence in the Asia-Pacific region. This is important to consider as the United States is rebalancing its military and diplomatic efforts toward the Asia-Pacific because of the region's growing security and economic infrastructures [65]. With this rebalance, the United States is developing closer ties with Asia-Pacific countries to limit the rise of China influence and maintain the freedom of navigation in the South China Sea. Vietnam is one nation that the United States can build closer ties with to increase United States soft power influence in the Asia-Pacific. The United States has only a few areas of cooperation with Vietnam, and space is an excellent area for growing cooperation between the 2 nations.

Relations between the United States and Vietnam have greatly improved from a once contentious relationship to a promising one. The United States placed a trade embargo on Northern Vietnam in 1964 and then extended the embargo to cover all of Vietnam following the fall of South Vietnam on April 30, 1975 [66]. The trade embargo eventually ended in 1994 when Congress passed the Foreign Relations Authorization Act, which expressed support for normalizing relations with Vietnam [67]. Following the normalizing of relations, the 2 nations signed a bilateral trade agreement in July 2000, which resulted in dramatic growth of trade and United States investment in Vietnam [68].

The growing presence and military threat of China in the region is pushing Vietnam to develop even closer ties with the United States to help maintain stability in the region. Vietnam and the United States began deepening defense ties when President Obama initiated the pivot to Asia [69]. In 2010, Secretary Clinton called for a strategic partnership between the United States and Vietnam, and in 2011, the 2 countries signed a memorandum of understanding on defense cooperation [70].

Closer ties with Vietnam will increase the United States influence in the region by achieving goals that are beneficial to both countries, such as promoting economic growth, enhancing Vietnam's maritime capabilities, and developing deeper defense ties in the Asia-Pacific region [71]. The United States will have opportunities to develop closer relations with Vietnam as many Vietnamese policymakers seek to counter Chinese ambitions in the region and preserve Vietnam's territorial and other interest by encouraging United States presence in the region [72]. For example, in October 2016, Vietnam announced its support of United States intervention in the Asia-Pacific if it brings peace, stability, and prosperity [73].

However, the United States needs to be mindful that Vietnam must manage this relationship delicately as it depends on both the United States and the Chinese for economic growth and employment opportunities.

To bring the United States and Vietnam closer together, while also increasing technological capabilities and economic prosperity, the United States and Vietnam must explore new areas to cooperate. One technological area that the 2 nations can turn toward to increase cooperation is in the space domain. Increased cooperation in space and space-based information sharing can help the United States counter Chinese influence with the Space Information Corridor in Vietnam. The United States and Vietnam are working toward creating a *Framework Agreement between the Government of the United States of America and the Government of the Socialist of the Republic of Vietnam on the Cooperation in the peaceful uses of the outer space* [74]. This agreement is a start to further Vietnam's ability to develop space technologies and conduct more research on small satellites that can benefit both the United States and Vietnam.

The United States has a long successful history of cooperating with emerging space nations to develop fundamental space capabilities [75]. With Vietnam's interest in expanding their domestic space capabilities, the United States can work with Vietnam to co-develop a satellite to help Vietnam further develop the fundamentals of satellite manufacturing capabilities while also gaining valuable space information. For instance, NASA is currently working with the Indian Space Research Organization (ISRO) on the NASA-ISRO Synthetic Aperture Radar mission, where NASA will provide the mission's L-band synthetic aperture radar (SAR), the high rate communications subsystem, GPS receivers, a solid state receiver, and a payload data subsystem. ISRO is providing the spacecraft bus, the S-band SAR, and is responsible for the launch of the system [76]. This cooperation can serve as a model for future United States and Vietnamese space cooperation.

The most obvious area of technical cooperation is in remote sensing. The United States can explore several different remote sensing options, such as light detection and ranging, which provides great precision in measuring heights of structures or terrain in comparison to ground surfaces, SAR for producing high resolution images, or electro-optical options that allows for characterization and identification of targets, that the 2 nations can work together to develop and use. Vietnam could develop a small satellite bus, similar to JV-LOTUSat-2, and the United States can contribute the main sensor for the spacecraft and provide launch services. The United States must be cognizant of ITAR restrictions and gain exceptions if there are any difficulties.

The United States can also offer to launch a Vietnamese spacecraft free of cost. This is another method the United States can use to gain more influence within Vietnam as long as there is an exchange/barter for access to the information produced by the Vietnamese satellite. Since Vietnam is interested in various remote sensing satellites, it will encourage them to develop small satellites, and the information provided can contribute to monitoring the South China Sea which would be of interest for both nations.

The exchange of space-based information can also be another area where the 2 nations can work together. The United States also has several spacecraft, such as Landsat and the Surface Water and Ocean Topography satellite, that can contribute Vietnam's goals of monitoring deforestation and climate change. The sharing of information can establish trust and be beneficial to both nations.

The United States Department of Commerce (DoC) is responsible for creating a civil space traffic management system, which will include a space situational awareness (SSA) network [77]. When building the network, DoC will need to create the foundational elements of a SSA system, as well as a set of standards and best practices for satellite operators. The United States can encourage

Vietnamese satellite operators to be fully involved in this process as it will provide them with a great opportunity to be involved in the creation of a civil United States SSA system, while also learning best practices for operating spacecraft from established satellite operators. Should Vietnam be included in the SSA process, it can also learn about the different space debris issues facing each Vietnamese spacecraft in the different orbits and altitudes in which they operate. These valuable experiences for Vietnam can help them be a more effective, efficient, and responsible space actor. Working with Vietnam on a civil SSA system can help create international interests and inputs for the DoC's SSA system. This opportunity can also be an attractive soft power policy that interests Vietnam on working with the United States more throughout the development of Vietnamese spacecraft.

Cooperation with Vietnam in space creates opportunities for the United States as well. The previously mentioned areas of cooperation can bring the 2 nations closer together and help create various levels of trust. These areas of cooperation can also help counteract China's Space Information Corridor. When creating the agreements, the United States can receive raw information from the Vietnamese spacecraft, which can be used for civil and national security purposes. Vietnamese spacecraft can monitor Chinese activity in the South China Sea and can help better inform the U.S. strategy in the region.

The United States can also look to hosting a payload on a Vietnamese satellite. In a conflict between the United States and China, China may look to expand the conflict into space and target United States spacecraft because space gives the United States an asymmetrical warfighting advantage. If the United States could rely on Vietnamese spacecraft information or a hosted payload on a Vietnamese spacecraft, the United States could potentially avoid having spacecraft targeted during antisatellite attacks as China may be reluctant to target another nation's spacecraft. If not targeted, the United States could continue to collect useful information during a potential conflict. It is worth noting that Vietnamese spacecraft hosting a United States payload or a spacecraft that provides the United States information may also be targeted by the Chinese, which could drag Vietnam into the conflict.

While the United States and Vietnam are growing closer, there are 2 main barriers that must be mentioned. First, ITAR will always remain an obstacle as it can prevent most space technologies that are used to develop spacecraft from being exported to Vietnam. If the United States truly wants to work with Vietnam and have the United States be the nation that Vietnam always turns to, the United States can waive some ITAR restricted items to help further the cooperation between the 2 states, such as allowing foreign exchange students to participate in smallsat development at universities in the United States.

Secondly, while cooperation is important, the United States must not rely on Vietnam to provide any critical national security space capabilities even as the relationship between the 2 nations grows because Vietnam could potentially limit or disable such systems in the event of a regional conflict between the United States and China [78]. In a worst-case scenario, Vietnam could provide the Chinese with information from the hosted payload. Vietnam could also distort the information to create confusion for the United States. The United States always has to weigh these risks with any new emerging space nation in a region of interest.

Space offers a unique opportunity for the United States to develop strong ties with new allies in an important region. The United States is trying to cooperate with more states to address major competitors in areas of interest to the United States. Space brings prestige that is of interest to all nations. As the world's leading spacefaring nation, the United States should exploit that prestige to gain new allies in areas of interest.

## 8. Conclusion

Becoming an emerging space nation is a difficult task to accomplish, but Vietnam created a strategy that should lead the country to success in space. This article reviewed Vietnam's history and space strategy, their space organizations, their current and future space architecture, their strategy and options to use space for national security purposes, and areas of cooperation between the United States and Vietnam. Vietnam is on the right track for developing its space capabilities to support its development and economic growth goals. Vietnam's ability to acquire and develop satellites for low costs and training for its engineers will assist in Vietnam's ability to develop future indigenous satellites as well as gaining great experience with cooperating with more developed space powers. If Vietnam is interested in developing a large indigenous satellite, it must not only continue to work with other space nations to further refine its basic spacecraft development knowledge and capabilities but also gain access to space information that may not otherwise be available. The United States and Vietnam can obtain more space-based information by cooperating together and co-developing spacecraft using the NASA-ISRO model. Observations of the South China Sea would be of interest to both nations and could be a starting point for areas of interest for cooperation. As Vietnam further develops its space capabilities, the cooperation with the United States can be beneficial to both nations as it can establish the foundation for future space cooperation as well as data sharing. Going forward, Vietnam will continue to improve its overall space capabilities and has an opportunity to work with the United States to further its development.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.spacepol.2018.07.002>.

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