The Journal of Instrumentation, Automation & Systems
Vol.11, No.1

Mapping The Prospect of Nano-Satellite Applications in Indonesia

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Abstract—The study on nanosatellite applications in Indonesia aims to understand the potential benefits and limitations of CubeSats in the country. The study highlights the potential of CubeSats to provide reliable and affordable connectivity in remote and rural areas, contributing to bridging the digital divide and improving access to essential services such as healthcare and education. The study also finds that CubeSats have the ability to provide valuable data on Indonesia's natural resources, environment, and other areas of interest, thereby supporting decision-making and promoting sustainable development. However, the limited capacity for data processing and analysis still presents a challenge. The study emphasizes the significance of comprehensive and effective policies for CubeSats in Indonesia to balance economic development and technological progress with security and privacy concerns. It also highlights the importance of capacity building initiatives, such as education and training programs, for the successful implementation of CubeSats in the country.

Keywords— nanosatellite, cubesat, communication, IoT.

DOI: 10.21535/rrfk3358

I. Introduction

INDONESIA has embraced the use of micro and nanosatellites, for various applications in telecommunications, earth observation, remote sensing, and environmental monitoring. These small and cost-effective satellites have proven to be a valuable tool for the country, especially in providing connectivity in remote regions, collecting data on natural resources, improving resource management, and monitoring the environment. CubeSats have a significant impact on Indonesia's economic, social, and environmental development, providing important information for policy making and decision making. In telecommunications, CubeSats help provide reliable and affordable connectivity to underserved communities. In earth observation, they gather data on the country's natural resources and monitor the environment for natural disasters. CubeSats are also used in remote sensing to gather data on agriculture, forestry, and fisheries, which leads to improved resource management and increased food security. The fast deployment and low cost of CubeSats make them an attractive option for Indonesia, where access to space technology is limited.

In addition, CubeSats also play a role in environmental monitoring. They are used to monitor air and water quality, which can provide valuable information for addressing environmental issues and promoting sustainable development. The use of CubeSats in Indonesia is still in its early stages, but the potential benefits are significant. As the country continues to develop its space technology capabilities, it is expected that the use of CubeSats will become even more widespread, providing more comprehensive coverage and even greater impact. The future of CubeSats in Indonesia is bright, and their applications are poised to play an increasingly important role in the country's development. Overall, the use of CubeSats in Indonesia highlights the importance of space technology in shaping the future and addressing the challenges of the modern world.

II. Literature Study

Nanosatellites are small, low-cost satellites that are becoming increasingly popular for space research and exploration. Developing countries have shown interest in nanosatellites for their potential to provide affordable access to space technology. This literature survey explores the use of nanosatellites for developing countries based on the following references.

Martínez (2012) describes the hands-on experiences of the Escuela Técnica Superior de Ingenieros de Telecomunicación (ETSIT) at the Universidad Politécnica de Madrid (UPM) in developing and launching nanosatellites. The paper highlights the importance of these hands-on activities in teaching and training students in space technology, and the potential for developing countries to engage in similar activities to build capacity in space engineering.

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This paper was submitted on March 2nd, 2024; revised on March 30th, 2024, and accepted on April 3rd, 2024.

Rhaman et al. (2015) propose a modular architecture for nanosatellites, which they suggest can enable developing countries to build their own satellite systems without requiring a large initial investment. The paper discusses the potential benefits of modular architecture, including the ability to add or remove modules as required and to reuse components in future satellite systems.

Roman-Gonzalez and Vargas-Cuentas (2016) present the INCA program, a nanosatellite development project at the Universidad de Ciencias y Humanidades (UCH) in Peru. The project involves collaboration with other institutions in Peru and the United States, and the paper discusses the challenges and opportunities of developing a nanosatellite in a developing country context.

González et al. (2016) present a case study on the design of nanosatellite ground monitoring and control software, highlighting the importance of software design in the development and operation of nanosatellites. The paper discusses the challenges of designing software for nanosatellites, including the need for robustness and the ability to handle large amounts of data.

Gonzalez et al. (2018) describe the SUCHAI project, which developed the first Chilean nanosatellite. The paper discusses the challenges faced by the project team and the lessons learned during the development and launch of the nanosatellite. The paper highlights the importance of collaboration between universities and industry in the development of nanosatellites.

Puma-Guzman and Soliz (2021) present a case study on the launch management of a nanosatellite for Bolivia. The paper discusses the challenges of managing the launch of a nanosatellite, including issues related to regulatory compliance and communication with launch service providers. The paper also highlights the importance of collaboration between different stakeholders in the development and launch of nanosatellites.

The use of nanosatellites for developing countries presents both opportunities and challenges. The literature survey highlights the potential for developing countries to build capacity in space engineering through hands-on activities and collaboration between universities and industry. The use of modular architecture and the importance of software design are also discussed. However, challenges such as regulatory compliance and communication with launch service providers remain important considerations for developing countries.

III. Problem Definition

The use of nanosatellites, also known as CubeSats, in Indonesia presents several problems that need to be addressed. These problems arise from the limited infrastructure and resources for space technology in the country, which limit the full potential of CubeSats for various applications. One of the main problems is the lack of reliable and affordable connectivity in rural areas and remote regions. CubeSats have the potential to provide this connectivity, but the limited resources and infrastructure in Indonesia make it difficult to fully utilize their capabilities.

Another problem is the limited capacity for data collection and processing. CubeSats can gather a significant amount of data on the country's natural resources, the environment, and other areas of interest, but there is a need for more advanced data processing and analysis capabilities to fully utilize this data. This includes a need for more sophisticated algorithms and technologies for data analysis, as well as an increase in computational power and storage capacity.

There is also a need for more comprehensive and effective policies for the use of CubeSats in Indonesia. This includes policies for regulating the deployment and operation of CubeSats, as well as policies for promoting investment and collaboration in the field of space technology. These policies need to be developed and implemented in a way that balances the need for economic development and technological progress with concerns for security and privacy.

Overall, the use of CubeSats in Indonesia presents several problems that need to be addressed, including the lack of reliable and affordable connectivity, limited capacity for data collection and processing, and a need for comprehensive and effective policies. These problems need to be addressed in a comprehensive and coordinated manner to fully realize the potential of CubeSats in Indonesia.

IV. Study Approach

The study of nanosatellite applications in Indonesia requires a comprehensive and interdisciplinary methodology to address the challenges and realize the potential of CubeSats. This methodology should consider various factors, including technological, economic, social, and environmental considerations.

One approach is to carry out a needs assessment to identify the areas in which CubeSats can have the greatest impact. This can involve consultation with stakeholders, including government agencies, industry groups, and local communities. The needs assessment should consider the availability of infrastructure and resources, as well as the potential benefits and challenges of CubeSats in each area.

Another important aspect of the methodology is the development and implementation of appropriate policies for CubeSats. This includes the development of regulations for the deployment and operation of CubeSats, as well as policies for promoting investment and collaboration in the field of space technology. The policies should balance the need for economic development and technological progress with concerns for security and privacy.

The methodology should also include a focus on research and development in the field of CubeSats. This includes the development of new technologies for data collection and processing, as well as the optimization of existing technologies. This research should be focused on addressing the challenges of CubeSats in Indonesia, such as limited connectivity and data processing capacity.

Finally, the methodology should include a focus on education and capacity building. This includes the training of individuals and organizations in the use of CubeSats, as well as the development of educational programs that promote the understanding and use of CubeSats in Indonesia.

Overall, a comprehensive and interdisciplinary methodology is needed to study nanosatellite applications in Indonesia. This methodology should consider the needs assessment, policy development, research and development, and education and capacity building. By addressing these factors, it will be possible to fully realize the potential of CubeSats in Indonesia and promote their use in the country.

V. Highlight of Study Results

The study on nanosatellite applications in Indonesia is a crucial step in understanding the potential benefits and limitations of CubeSats in the country. The study provides valuable insights into the opportunities that CubeSats offer across various sectors, including telecommunications, environmental monitoring, and resource management.

One of the key results of the study is that CubeSats can provide reliable and affordable connectivity in remote and rural areas, contributing to bridging the digital divide and improving access to essential services such as healthcare and education. In many rural areas, traditional connectivity methods are expensive, unreliable, and often unavailable. CubeSats offer an innovative solution to this problem by providing low-cost and reliable connectivity to these areas.

Another key result of the study is that CubeSats have the ability to provide valuable data on Indonesia's natural resources, environment, and other areas of interest, thereby supporting decision-making and promoting sustainable development. CubeSats equipped with sensors and cameras can collect data on various aspects of the environment and natural resources, providing valuable insights into the current state of the country's ecosystem. This data can be used to make informed decisions on issues such as deforestation, climate change, and resource management.

However, the study also highlights the limitations of CubeSats, particularly the limited capacity for data processing and analysis. The ability to collect vast amounts of data is limited by the capacity of the current systems and infrastructure to process and analyze this data. This challenge needs to be addressed to fully realize the potential of CubeSats in Indonesia.

The study also highlights the significance of having comprehensive and effective policies in place for CubeSats in Indonesia. These policies will help balance economic development and technological progress with security and privacy concerns. As CubeSats collect and transmit vast amounts of data, it is important to ensure that the data collected is secure and protected from unauthorized access. Policies should be in place to ensure that CubeSats are used responsibly and sustainably.

Finally, the study highlights the importance of capacity building initiatives for the successful implementation of CubeSats in Indonesia. Education and training programs for individuals and organizations are necessary to ensure that CubeSats are effectively utilized in the country. This will help to ensure that the full potential of CubeSats is realized and that they are used to their fullest potential to benefit the country.

We view that the study on nanosatellite applications in Indonesia demonstrates the potential of CubeSats to bring numerous benefits to various sectors in the country. However, the study also highlights the need for appropriate infrastructure, effective policies, and capacity building initiatives to fully realize this potential.

Applications of nanosatellites in Indonesia cover, but are not limited to, the following areas:

A. Weather Prediction and Meteorological Services

The use of nanosatellites for weather and meteorological services provides a cost-effective and flexible alternative to traditional weather prediction systems. Nanosatellites can be deployed in large numbers, providing increased coverage of the Earth's surface and allowing for more comprehensive data collection. Additionally, they can be rapidly developed and deployed, making them ideal for addressing changing weather and climate needs.

One of the key applications of nanosatellites in weather and meteorological services is the measurement of temperature, atmospheric pressure, and humidity. These data can provide insights into atmospheric conditions, which can be used to forecast weather patterns and events. Another important application of nanosatellites in weather prediction is the observation of cloud patterns and precipitation. This information can be used to better understand the formation and movement of clouds, which play a critical role in weather patterns.

Nanosatellites can also be equipped with specialized sensors that can measure atmospheric properties such as wind speed and direction, solar radiation, and precipitation. These data can provide a better understanding of weather patterns, including severe weather events such as hurricanes, tornadoes, and thunderstorms.

In recent years, there have been several initiatives to launch nanosatellite constellations for weather and meteorological services. These constellations consist of multiple nanosatellites working together to gather data from different regions of the Earth. The data gathered from these constellations can be used to improve weather forecasting models and provide more accurate predictions.

Overall, the use of nanosatellites in weather and meteorological services offers a cost-effective and flexible solution for improving our understanding of weather patterns and providing more accurate predictions. By leveraging the latest advances in nanosatellite technology, weather and meteorological services can provide valuable information to a wide range of stakeholders, including governments, businesses, and the general public.

B. Disaster Management and Mitigation

Nanosatellites are often used in constellations for disaster mitigation and management because of their affordability, versatility, and rapid deployment capabilities. A constellation is a group of satellites that work together to provide a desired coverage or service. Nanosatellite constellations provide high-resolution and near real-time data, making them ideal for monitoring and responding to natural disasters such as hurricanes, earthquakes, and forest fires. The combination of multiple nanosatellites in a constellation can offer a wide coverage area and frequent revisit times, providing critical information to disaster response teams, as well as for recovery and reconstruction efforts.

For example, nanosatellites equipped with high-resolution cameras and other sensors can be used to map the extent of a disaster, monitor its progression, and assess the impact on infrastructure, communities, and the environment. The data collected by nanosatellites can also be used to create detailed damage assessments, identify potential hazards, and plan evacuation routes and disaster relief efforts.

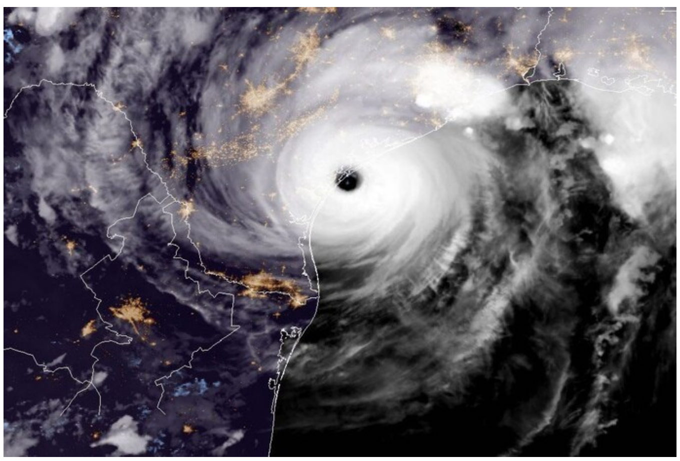

Figure 1 NOAA's GOES-East satellite captures Hurricane Harvey on Aug. 25, 2017, on the mid-Texas coast. (NASA/NOAA GOES Project/Getty Images)[2]

One example of a nanosatellite constellation used for disaster management is the Planet Dove constellation, which consists of more than 100 small satellites that capture high-resolution imagery of the Earth's surface. This constellation provides daily global coverage and has been used to respond to a variety of natural disasters, including hurricanes, earthquakes, and volcanic eruptions.

We conclude that the use of nanosatellite constellations for disaster mitigation and management offers a cost-effective and efficient solution for providing critical information to disaster response teams and facilitating recovery and reconstruction efforts.

C. Smart Agriculture

Smart agriculture refers to the use of advanced technologies, including nanosatellites, to improve the efficiency, productivity, and sustainability of agricultural operations. The use of nanosatellites in smart agriculture can provide valuable information such as crop yield predictions, crop health assessments, and soil moisture content.

Nanosatellites equipped with sensors can be used to collect data on crop health and soil moisture levels from remote locations. This data can be used to make more informed decisions about irrigation and fertilization, leading to more efficient and effective use of resources. Additionally, the data collected by nanosatellites can be used to predict crop yields, helping farmers to plan for the future and minimize waste.

Another use of nanosatellites in smart agriculture is for precision agriculture. Precision agriculture involves the use of GPS and other geospatial technologies to precisely map and monitor crop fields, allowing farmers to precisely target inputs such as fertilizers and pesticides. Nanosatellites can be used to collect high-resolution imagery of crops, which can be used to monitor crop health, detect stress, and identify areas that require attention.

We view that the use of nanosatellites in smart agriculture can provide valuable information and support for decision-making, leading to improved efficiency, productivity, and sustainability in agricultural operations.

D. Marine Resource Mapping and Sustainable Fishery

The use of nanosatellites for archipelagic nations like Indonesia can have a significant impact on their ability to map marine resources and promote sustainable fishing practices. Nanosatellites can provide high-resolution images and data from the coastal areas and offshore fishing grounds. This information can be used to monitor and track changes in ocean conditions and assess the impact of fishing activities on the marine ecosystem. The data gathered by nanosatellites can also help in identifying potential fishing grounds and detecting illegal fishing practices.

In Indonesia, the coastal and offshore fishing industries are an important source of food and livelihood for the local communities. However, overfishing, pollution, and climate change are major challenges that threaten the sustainability of these industries. By using nanosatellites, the government and the fishing industry can have access to the information they need to make informed decisions about fishing practices and marine conservation efforts.

In recent years, the use of nanosatellites for maritime surveillance has become increasingly popular. There have been several successful missions and demonstrations, such as the TanDEM-X and TerraSAR-X missions, which have shown the potential for nanosatellites to be used for marine resource mapping.

We view that the use of nanosatellites for marine resource mapping and sustainable fishery can provide critical information and support for the sustainable development of the coastal and offshore fishing industries in archipelagic nations like Indonesia.

E. Interference Monitoring

Nanosatellite constellation is a network of multiple small satellites that work together to provide coverage over a large geographic area. The use of nanosatellites in a constellation configuration can bring several advantages to the field of interference monitoring.

First, the deployment of multiple nanosatellites allows for a more dense coverage of the monitored area. This increased coverage allows for a more detailed analysis of the radio frequency (RF) environment and the identification of interfering signals. This can help improve the accuracy of the interference monitoring process and reduce false alarms.

Second, the use of nanosatellites with advanced payloads and onboard processing capabilities allows for real-time monitoring and analysis of RF signals. This capability can enable more effective and efficient mitigation of interfering signals. The onboard processing can also be used to perform complex signal analysis, such as direction finding, to quickly locate the source of the interference.

Third, the ability to rapidly deploy nanosatellites in response to changing circumstances or new requirements can help ensure that the interference monitoring system remains up to date and effective. The ability to quickly add new satellites to the constellation can also help to extend the coverage area, improving the ability to detect interfering signals in remote areas.

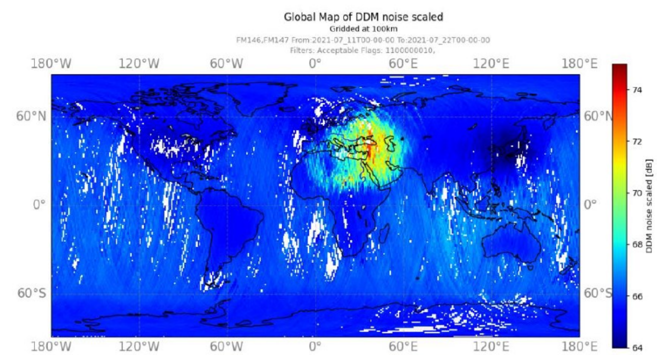

Figure 2 Example of GNSS noise interference detection [9]

Overall, the use of nanosatellite constellation for interference monitoring offers several advantages compared to traditional mobile monitoring methods. These advantages include increased coverage, real-time monitoring, advanced processing capabilities, and the ability to quickly respond to changing requirements.

F. Asset Tracking

Nanosatellites can be used for asset tracking, including aircrafts, ships, and land vehicles, as they are small, low-cost, and have the capability to provide real-time data communication. The use of nanosatellites can provide better coverage and more frequent data transmission than traditional satellite systems, which can be especially useful in remote or underdeveloped areas. These satellites can be equipped with GPS and other navigation sensors to track the location of the assets and provide real-time information about their movements.

In the case of aircraft tracking, nanosatellites can provide more accurate and up-to-date information about flight paths, altitude, and speed. This information can be used to improve air traffic management, reduce the risk of collisions, and improve the overall safety of air travel.

In the maritime industry, nanosatellites can be used to monitor ships, improve navigation safety, and track the movements of vessels for purposes of border security and law enforcement. By providing real-time data about ship location, speed, and direction, nanosatellites can assist in preventing maritime accidents and improve the efficiency of shipping operations.

For land vehicles, nanosatellites can be used to track the movements of vehicles in real-time, allowing fleet operators to optimize routes and improve delivery times. This information can also be used to improve safety and reduce the risk of theft or unauthorized use.

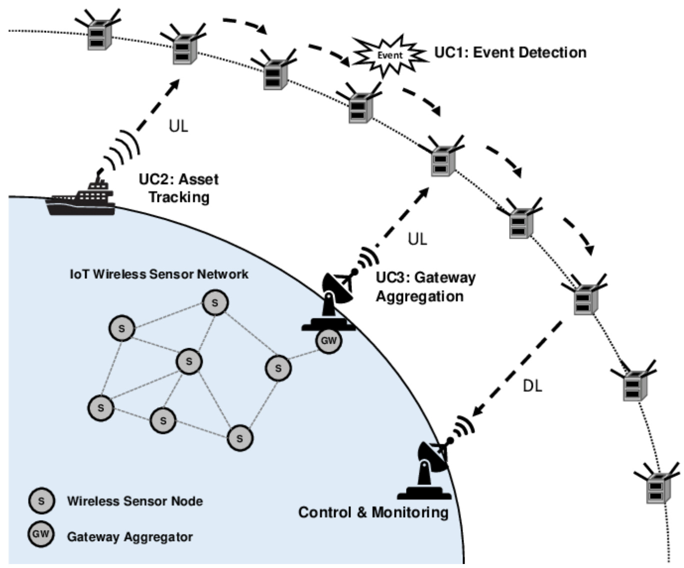

Figure 3 Nanosatellite constellation for assets tracking [3]

We conclude, the use of nanosatellites for asset tracking can bring many benefits, including improved safety, increased efficiency, and cost savings. The potential applications of this technology are diverse and include industries such as aviation, shipping, and transportation.

G. Mining Industry

The use of nanosatellites in the mining industries is growing as a promising technology for monitoring and optimizing various aspects of the mining operations. Nanosatellites can provide real-time remote sensing data and high-resolution imaging of mining sites, which can be used to monitor the progress of excavation and extractions, as well as to assess the environmental impact of the operations. This information can be used to identify areas of high mineral concentrations, track changes in the landscape over time, and detect the presence of contaminants such as heavy metals and other pollutants in the soil and water.

In addition to monitoring the environment, nanosatellites can also be used to track the movement of mining equipment and vehicles, as well as to monitor the safety and well-being of workers on-site. For example, nanosatellites equipped with GPS and other location-tracking technologies can be used to monitor the movement of trucks and other vehicles as they transport materials to and from the mining site. This information can be used to optimize the transportation routes and schedules, reducing fuel consumption and costs while also increasing safety and efficiency.

Another potential application of nanosatellites in the mining industry is in the field of mineral exploration. Nanosatellites equipped with remote sensing and imaging technologies can be used to scan large areas of land for mineral deposits, helping to identify new resources and reduce the time and cost associated with traditional exploration methods.

Overall, the use of nanosatellites in the mining industry is a rapidly growing field that offers significant potential for improving the efficiency and sustainability of mining operations, while also reducing the environmental impact of these activities.

H. IoT Mission

The use of nanosatellites for IoT (Internet of Things) missions involves leveraging the capabilities of these small, low-cost satellites to support IoT applications and networks. The main objective is to provide global coverage, connectivity, and accessibility to remote or hard-to-reach areas, such as rural areas, developing countries, or disaster-stricken regions.

Some possible uses of nanosatellites for IoT missions include:

- Data collection: Nanosatellites can be used to collect data from various IoT devices, such as sensors and cameras, which are deployed on the ground or in the air. The data collected can be used to monitor the environment, track assets, and gather intelligence for various applications.
- Communication: Nanosatellites can serve as communication hubs for IoT devices, providing wireless connectivity and data transfer services. This enables remote or offline devices to communicate with the rest of the world.
- Networking: Nanosatellites can also be used to create a network of IoT devices, allowing them to communicate with each other and share data in real-time.
- Disaster response: In the case of natural disasters, nanosatellites can be used to provide rapid and reliable communication and data transfer services to first responders and rescue teams.

Overall, the use of nanosatellites for IoT missions offers numerous benefits, such as lower cost, faster deployment, and more flexible and scalable solutions, compared to traditional satellite technologies. As a result, nanosatellites are increasingly being used for various IoT applications and services, particularly in remote and underserved areas.

I. Environmental Protection and Forestry

Nanosatellites can play an important role in environmental protection and forestry management by providing high-resolution, real-time data that can help monitor changes to land and ecosystems. One of the key applications of nanosatellites in these fields is remote sensing, which involves using satellites to capture images and gather data about the Earth's surface.

One of the main areas of interest for nanosatellites in environmental protection and forestry is the monitoring of forests and their carbon stocks. Satellites equipped with sensors can measure the height, area, and biomass of trees, which can be used to calculate carbon stocks and assess the health of forests. This information can be used to identify areas where conservation efforts are needed, monitor changes in forest cover, and track the progress of reforestation projects.

Nanosatellites can also be used to monitor changes to the landscape and detect environmental hazards such as fires, oil spills, and deforestation. In addition, they can be used to monitor air and water quality, track wildlife populations, and study the impact of climate change on ecosystems.

Another application of nanosatellites in environmental protection and forestry is mapping and geographic information systems (GIS). Nanosatellites can provide high-resolution images and maps of land and water resources, which can be used to identify and manage areas of conservation importance, study the impact of human activities on the environment, and monitor changes to land use patterns.

Overall, the use of nanosatellites in environmental protection and forestry is a valuable tool that can help conserve natural resources, protect the environment, and ensure sustainable development. With their cost-effectiveness and ability to provide real-time data, nanosatellites have the potential to play a significant role in these fields in the years to come.

J. Navigation Platform

Nanosatellites can provide a navigation platform for ride-sharing businesses by offering high-precision positioning and real-time data communication capabilities. The small size and low cost of nanosatellites make them suitable for integration into existing ride-sharing systems, providing reliable and cost-effective navigation and communication solutions. By leveraging the capabilities of nanosatellites, ride-sharing companies can improve their operational efficiency, enhance the safety and reliability of their services, and gain a competitive advantage in the market.

Additionally, nanosatellites can provide real-time traffic information, weather updates, and other valuable data that can help ride-sharing companies make informed decisions and optimize their services. By leveraging the latest advances in nanosatellite technologies, ride-sharing companies can improve their operations and achieve their goals more efficiently and effectively.

K. Potential Use of AI

One area where AI can be utilized is in the automatic detection and classification of objects or events of interest in nanosatellite imagery. Traditional methods often rely on manual analysis, which can be time-consuming and subjective. AI algorithms, such as deep learning models, can be trained on large datasets to automatically identify specific features or anomalies in the images. This can aid in tasks such as monitoring environmental changes, identifying potential disaster zones, or detecting illegal activities.

AI can also assist in optimizing data transmission and storage on nanosatellites. Due to their limited resources, nanosatellites face challenges in managing the large volumes of data they collect. AI algorithms can be used to compress and prioritize data based on its relevance and significance, enabling efficient utilization of limited onboard storage and bandwidth. This ensures that valuable data is not lost or delayed due to resource limitations.

Furthermore, AI can be employed to improve data analysis and decision-making on board nanosatellites. By implementing machine learning algorithms, nanosatellites can autonomously process and interpret data in real-time, making critical decisions without relying on constant communication with ground stations. This capability is especially valuable in time-sensitive applications such as disaster response or remote sensing.

In addition, AI can enhance the predictive capabilities of nanosatellite missions. By analyzing historical data, AI models can identify patterns and trends that provide insights into future events. This can be applied to various applications, including weather forecasting, climate modeling, and space debris tracking. By leveraging AI algorithms, nanosatellites can contribute to early warning systems and support proactive decision-making.

VI. Discussion

The study on nanosatellite applications in Indonesia provides insights into the potential benefits that CubeSats can bring to the country. The results of the study demonstrate that CubeSats have the ability to offer reliable and affordable connectivity in rural and remote regions, thereby closing the digital divide and increasing access to essential services such as healthcare and education.

One of the key observations of the study is that CubeSats can provide valuable data on Indonesia's natural resources, environment, and other areas of interest, which can support informed decision-making and promote sustainable development. However, the challenge of limited capacity for data processing and analysis still persists, which must be addressed to fully leverage the benefits of CubeSats.

The study also highlights the importance of comprehensive and effective policies for CubeSats in Indonesia. Such policies are necessary to balance the goals of economic growth and technological advancement with considerations for security and privacy. By developing and implementing these policies, it will be possible to ensure the responsible and sustainable deployment of CubeSats in the country.

Furthermore, the study finds that capacity building initiatives are crucial for the successful implementation of CubeSats in Indonesia. This includes education and training programs for individuals and organizations to enhance the effective utilization of CubeSats in the country.

In summary, the study on nanosatellite applications in Indonesia highlights the potential benefits that CubeSats can bring to the country. However, to fully realize this potential, it is important to develop appropriate infrastructure and resources, implement effective policies, and invest in capacity building initiatives. These actions will help ensure that CubeSats are used in a responsible and sustainable manner, and contribute to the overall development of Indonesia.

VII. Conclusion

In conclusion, the study on nanosatellite applications in Indonesia provides valuable insights into the potential benefits and limitations of CubeSats. Results show that CubeSats can offer reliable and affordable connectivity in remote and rural areas, which can help bridge the digital divide and improve access to essential services such as healthcare and education.

The study also highlights the challenge of limited capacity for data processing and analysis, which needs to be addressed to fully utilize the potential of CubeSats in Indonesia. Additionally, comprehensive and effective policies for CubeSats in the country are necessary to balance economic growth and technological advancement with security and privacy considerations.

Capacity building initiatives, such as education and training programs, are also crucial for the successful integration of CubeSats in Indonesia. These initiatives can enhance the effective utilization of CubeSats in the country and support the responsible and sustainable deployment of CubeSats.

In summary, the study on nanosatellite applications in Indonesia suggests that CubeSats have the potential to bring numerous benefits to Indonesia, but appropriate infrastructure and resources, effective policies, and capacity building initiatives are necessary to tap into this potential and ensure responsible and sustainable deployment.

References

[1] Gonzalez, Carlos, et al. “Lessons learned from building the first Chilean nanosatellite: The SUCHAI project.” (2018).

[2] Freedman, Andrew, “Weather company using tiny satellites inks deals with NASA, top European agencies to improve forecasts”, The Washington Post, June 16, 2020

[3] González, Freddy Alexander Díaz, Pablo Roberto Pinzón Cabrera, and Claudio Marcel Hernández Calderón. “Design of a nanosatellite ground monitoring and control software–a case study.” Journal of Aerospace Technology and Management 8 (2016): 211-231.

[4] Hernández Marcano, Néstor & Jacobsen, Rune. (2019). On the Delay Advantages of a Network Coded Transport Layer in IoT Nanosatellite Constellations. 10.1109/ICC.2019.8761254.

[5] Martínez, Ramón. “ETSIT-UPM experiences in hands-on nanosatellite activities.” Proceedings of the 2012 IEEE Global Engineering Education Conference (EDUCON). IEEE, 2012.

[6] Puma-Guzman, Rosalyn, and Jorge Soliz. “Launch Management of a Nanosatellite for Bolivia.” Space Fostering Latin American Societies: Developing the Latin American Continent Through Space, Part 2. Cham: Springer International Publishing, 2021. 87-103.

[7] Rhaman, Md Khalilur, et al. “Exploring Modular Architecture for Nano Satellite and Opportunity for Developing Countries.” IOP Conference Series: Earth and Environmental Science. Vol. 23. No. 1. IOP Publishing, 2015.

[8] Roman-Gonzalez, Avid, and Natalia Indira Vargas-Cuentas. “INCA program for developing a nanosatellite at the UCH.” 67th International Astronautical Congress-IAC 2016. 2016.

[9] Weekes, O. “Spectrum Monitoring and Geo-location Space Service Overview, Spire, Nov 4, 2022.