



HARNESSING FRONTIER TECHNOLOGIES TO ENHANCE CUSTOMS SURVEILLANCE AND MONITORING ON BONDED ZONE FACILITY IN INDONESIA

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ABSTRACT

Perkembangan pesat teknologi frontier menawarkan potensi besar untuk meningkatkan sistem pengawasan dan pemantauan bea cukai, terutama di fasilitas zona bebas. Oleh karena itu, pemanfaatan teknologi frontier juga membawa dampak sampingan yang mengganggu dan masalah signifikan selama operasional. Artikel ini akan membahas kelebihan dan kekurangan penerapan teknologi mutakhir seperti Internet of Things (IoT), Kecerdasan Buatan (AI), drone, dan robot dalam operasional bea cukai di Indonesia, dengan membandingkannya dengan praktik di negara-negara anggota WCO. Artikel ini memberikan rekomendasi untuk praktik di zona bebas Indonesia yang menghadapi tantangan seperti ketidakefisienan, kerentanan terhadap ancaman keamanan, dan kurangnya transparansi. Dengan meninjau literatur tentang pengawasan bea cukai, sistem pemantauan, dan peran zona bebas, artikel ini mengeksplorasi pemanfaatan IoT untuk pengumpulan data dan pemantauan real-time, AI untuk analitik prediktif dan deteksi anomali, serta drone dan robot untuk pengawasan yang lebih fleksibel. Teknologi ini diharapkan dapat mendukung pengambilan keputusan Otoritas Bea Cukai secara lebih efektif. Melalui analisis mendalam terhadap praktik yang ada, terutama dalam penerapannya di sistem zona bebas Indonesia, studi ini akan merancang kerangka kerja untuk mengintegrasikan teknologi-teknologi ini. Artikel ini juga menyajikan studi kasus tentang pemanfaatan yang sukses di negara-negara anggota WCO lain, yang menunjukkan prospek evolusioner dari teknologi-teknologi ini. Diskusi juga mengulas manfaat pemanfaatan teknologi frontier, yang mencakup peningkatan efisiensi, akurasi, keamanan, transparansi, dan efektivitas biaya. Kesimpulannya, penerapan teknologi frontier dapat secara signifikan meningkatkan praktik pengawasan dan pemantauan bea cukai saat ini di fasilitas zona bebas Indonesia, yang akan mengarah pada peningkatan efisiensi dan keamanan dalam perdagangan dan logistik.

Rapid advancement of frontier technologies offers significant potential for enhancing customs surveillance and monitoring systems, especially within bonded zone facilities. Therefore, Utilization of Frontier Technologies also bring another disruptive side-effect and significant issues during the operation. This paper will examine the pros and cons of applying new cutting-edge technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), drones, and robot on customs operations in Indonesia, benchmarking from another WCO countries. This paper will also provide several recommendations to Indonesian bonded zones practices, which currently face challenges such as inefficiencies, security vulnerabilities, and a lack of transparency. This paper employs comprehensive review of existing literature on customs surveillance, monitoring systems, and the significant role of bonded zones in Indonesia. Subsequently, explores how IoT is able to use real-time data collection and monitoring, AI able to enhance predictive analytics and anomaly detection, drones and robots are able to offer versatile surveillance capabilities, hence all the frontier technologies are able to improve decision-making processes taken by Customs Authorities. Through profound analysis of current practices, particularly on implementing into Indonesian bonded zones systems, this study will outline a framework for integrating these technologies. It also presents case studies of successful utilization in another WCO countries, demonstrating the evolutionary prospect of these technologies. The discussion also examines the benefits of harnessing frontier technologies, encompassing improved efficiency, accuracy, security, transparency, and cost-effectiveness. In conclusion, applying frontier technologies can greatly enhance the current practices of customs surveillance and monitoring in bonded zone facilities in Indonesia, leading to better efficiency and security in trade and logistics.

1. INTRODUCTION

1.1. Background of Study

In the current worldwide and free trade economy, many expertise in economy realized that global trade take significant role in the economic growth.

Customs, as part of Border Agency are holding the key to international supply chains. As the fiscal agency of financial interests, protection and improvement of international trade, protection of society, etc., Customs clearance considered as pivotal factor in international trade, particularly on logistics process. Country competitiveness Index depend on how customs service efficiency and effectiveness taking part. Efficient customs operations, including customs surveillance and monitoring, are crucial for facilitating international trade, ensuring compliance on each country regulatory, and safeguarding national interest. (Zamora-Torres et al., 2013).

Indonesia located at the intersection of the Pacific Ocean, the Malacca Straits and the Indian Ocean. Over half of all international shipping goes through Indonesian waters. With its strategic geographical proximity and burgeoning trade volumes, heavily relies on bonded zones to streamline its logistics and trade operations. The country's bonded zones are critical hubs for manufacturing, warehousing, and transshipment, playing a vital role in the national economy. In short, Bonded Zone is an area where dutiable goods are allowed to be stored, processed or manufactured without payment of duties. In addition, the goods in question are also exempted from Value Added Tax (VAT) and another additional tax, particularly as an inputs as raw materials, intermediate inputs, and capital goods used to produce goods for export. As of 2012 there were 1350 bonded zone in Indonesia (Damuri, et al., 2015).

Table 1 – Number of Bonded Zone in Indonesia dan Tax Generated by Bonded Zone Facilities

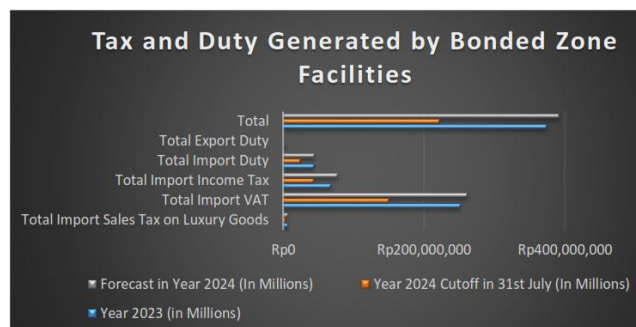


Bonded Zone Facility 2023 /2024

	2023	2024 (31st July)	2024 (Forecast)
Number of Bonded Zone in Indonesia	344	262	262
Total Import Sales Tax on Luxury Goods (In Billions)	Rp7.289	Rp3.754	Rp7.000
Total Import VAT (In Billions)	Rp252.361	Rp150.257	Rp262.000
Total Import Income Tax (In Billions)	Rp67.975	Rp43.550	Rp78.000
Total Import Duty (In Billions)	Rp44.140	Rp24.736	Rp45.000
Total Export Duty (In Billions)	Rp2.833	Rp69	Rp220
Total (In Billions)	Rp374.601	Rp222.369	Rp392.220

Source: Directorate of Customs and Excise Information and Technology and compiled by Author

Table 2 – Graphic of Tax and Duty Generated by Bonded Zone Facilities



Source: Directorate of Customs and Excise Information and Technology and compiled by Author

By data, Bonded Zone Facilities indeed generates great numbers of tax. In 2023 itself, Bonded Zone generates almost 374 trillion only from Tax and Customs Duty. It doesn't count the multiplier economic effect of Bonded Zone, which is contributed on national employment, regional inflation and national growth economic. In 2024, Bonded zone is predicted to generate almost 400 trillion from its Tax and Customs Duty (even though there is shortfall in Export Duty due the declining price of Crude Palm Oil) and will contribute on 1-2% to national income.

The advancement of future technologies i.e. Frontier Technologies allowing the ease of public operations in government services. As the name itself, Frontier technology is life-changing technological breakthroughs that are changing how humans work, communication, creativity, and everyday life. The current market for frontier technologies is predicted to foster until \$9.5 trillion by 2030 (UNCTAD, 2023). Frontier technologies fundamentally transform how humans make, create, and develop business. Frontier technology likely assist current practices to build better and more decent infrastructure projects and create better and sustainable future along with efficient usage of natural resources (Coursera, 2024).

Currently Customs surveillance and monitoring in Indonesia Bonded Zone traditionally rely on manual inspections, physical barriers, and paper-based documentation. These methods are labor-intensive, time-consuming, and prone to human error and fraud. Customs authorities often struggle with limited resources and increasing volumes of trade, leading to inefficiencies and vulnerabilities in the system (Keen, 2013). Utilizing Frontier Technologies on customs operation might be a great assist on Surveillance and Monitoring, allowing the ease of current customs operation in bonded zone, such as IoT, robot, AI and drones. Along with prominent monitoring and excellent surveillance, leveraging from Frontier Technologies, supposedly tax and customs duty generated from Bonded Zone will increase and contribute to national prosperity.

1.2. Problem Statement

To comprehensively explore the potential implementation of frontier technologies in enhancing customs surveillance and monitoring in bonded zone facilities in Indonesia, this study will address the following questions:

1. What are the current practices and challenges in customs surveillance and monitoring in Indonesian bonded zone facilities?
2. How can frontier technologies be integrated and benefitting into existing customs surveillance and monitoring practices?
3. What are the major challenges and how to overcome the challenges and ensure successful integration of frontier technologies in customs surveillance and monitoring?

1.3. Objectives

Based on the problem statements above, the main goal of this paper is to examine and provide a detailed suggestion on how frontier technologies are able to enhance customs surveillance and monitoring in bonded zone facilities in Indonesia. Hence, the study will focus on the following specific research objectives to achieve all of those targets, as follows:

1. Examines the current practices and challenges in customs surveillance and monitoring in Indonesian bonded zone facilities
2. Integrating frontier technologies holistically within customs systems and benefitting all of these technologies to enhance customs surveillance and monitoring practices.
3. Overcoming all of the major challenges and successfully integrate frontier technologies in customs surveillance and monitoring to achieve better customs operations.

By achieving all of these objectives, this study aims to provide a comprehensive framework for leveraging frontier technologies to enhance customs surveillance and monitoring in Indonesian bonded zone facilities. The findings and recommendations will offer valuable insights for policymakers, particularly Indonesian customs authorities, contributing to upgrade trade efficiency in Bonded Zone, amplify better security in current practices, and raise stakeholder regulatory compliance.

2. LITERATURE REVIEW AND HYPOTHESIS

2.1. Bonded Zone Facility in Indonesia

By definition, based on PP No. 85/2015 concerning revision of PP No. 32/2009 about Bonded Zone Area and PMK No. 131/PMK.04/2018, Bonded Zone is a building, place, or area for gathering imported goods and / or other goods originating from

other places under customs supervision area that fulfils certain requirements to be processed or combined before being exported or imported that is used with a specific purpose by obtaining a suspension of Import Duty. (Situmorang, 2020). Meanwhile, according to Widodo, A. and Arpangi (2020), Bonded Zone is one form of facilities provided by Government Authority (Directorate General of Customs and Excise) in the form of a fiscal policy which aims to provide the maximum benefit for national economic growth as well as the usual form of attracting investors for sake of international relations. There are 7 types of Bonded Zone, consist of Bonded Zone Centre, Bonded Zone Warehouse, Bonded Zone Area, Duty Free Bonded Zone, Bonded Zone Exhibition, Recycling Centre Bonded Zone Area, and Bonded Zone Auction.

Figure 1 - 7 types of Bonded Zone



Source: PMK No. 131/PMK.04/2018 and compiled by Author

Based on the functions and activities of the Bonded Zone above, compared with the theory of international trade, the purpose of the establishment of this Bonded Zone is ultimately to attract foreign investors, creating new employment, transfer of technology, boosting current economic growth, increase its national income by encourage export activities and subsequently raise its X (Exports) factor.

Figure 2 - Gross Domestic Product Formula

Macro-Economics 101 - National Income Formula

$$Y = C + I + G + (X - M)$$

Y = National Income (GDP)
C = Consumer Spending
I = Investment
G = Government Spending
X = Exports
M = Imports

Source: GDP is becoming an ever-worse measure of how we're doing – Adamsmith.org

2.2. Frontier Technologies

Frontier technology is the technology that clearly has the capability to reshape industry of communications and technology (ICT) by providing many breakthrough solutions to global challenges and most likely will displace existing processes in a future (World Economic Forum, 2023). Frontier technologies are appearing at the intersection of radical scientific innovation and real-world implementation. Artificial intelligence, Drones, and Robots, are the examples on how these technologies are changing human lives, subsequently change the way our generation communicate, innovate, create and do business (UNFCCC, 2022).

There were several existing Frontier Technologies that could be beneficial for Indonesia's Customs if applied, particularly on monitoring and surveilling on the Bonded Zone, such as:

Internet of Things (IoT)

IoT is a term used to describe a network of interconnected devices that collect and exchange data in real - time. In customs operations, IoT has the potential to monitor goods continuously through sensors and tracking devices, giving real-time data on location, temperature, and other important parameters (Atzori, Iera, & Morabito, 2010). This can have a significant impact on the visibility and control of goods in bonded zones, thereby reducing the risk of smuggling (Li, Da Xu, & Zhao, 2015).

Artificial Intelligence (AI)

AI encompasses various technologies that enable machines to perform tasks that usually be done by human intelligence, such as pattern recognition, decision-making, and predictive analytics (Russell & Norvig, 2016). In customs surveillance, AI can be used to analyse large volumes of data in very short time, detect anomalies more accurate, and uncover potential risks very thoroughly. AI also can improve the accuracy of inspections and reduce officer workload, leading to more efficient and effective monitoring (Gonzalez- Beltran et al., 2015).

Drones and Robots

Drones, or robots offer versatile surveillance capabilities which can be used to monitor wide-ranging and very far reached areas in bonded zones. It can provide real-time video feeds, capture high-resolution images, and perform automated customs inspections, enhancing the overall security and monitoring efficiency (Colomina & Molina, 2014).

Drones can also be used for rapid response in case of security breaches or emergencies (Kumar & Kumar, 2018).

The integration of these technologies can lead to significant benefits, including increased operational efficiency, improved accuracy and reliability, enhanced security and fraud prevention, greater transparency, and long-term cost savings (World Economic Forum, 2018). However, the adoption of frontier technologies also presents challenges, such as technological integration issues, regulatory and legal obstacles, financial constraints, and the need for training and capacity building (OECD, 2019). Addressing these challenges requires a comprehensive strategy that includes technological solutions, regulatory updates, funding models, and training programs.

3. RESEARCH METHODOLOGY

The research design is a critical component of the methodology that outlines the overall plan and structure of this paper. In the context of this paper which entitled, "Harnessing Frontier Technologies to Enhance Customs Surveillance and Monitoring on Bonded Zone Facility in Indonesia", the research design is carefully crafted to facilitate a comprehensive investigation into the Surveillance and Monitoring systems of Indonesian and how we are able to improve its current practices by harnessing frontier technologies. It incorporates various research methods to achieve the study's objectives.

3.1. Research Methods and Data Validity

Descriptive Qualitative Methods

The research method used was a qualitative method and a descriptive approach. Creswell (2014) describes qualitative research as a method for investigating and comprehending the meaning that individuals or groups of people perceive to be derived from social/humanitarian problems. The study used more analysis than descriptive research. According to Silaen & Widiyono (2013) goal of descriptive research is to give a summary of the facts, nature, and relationships of every phenomenon, including the relationships between activities, attitudes, views, and processes that take place. as well as the influence of the phenomenon on determining the frequency distribution of symptoms or frequency. One symptom is associated with another. Observation, interviews, and documentation were the methods used to collect data.

Qualitative descriptive research involves researchers understanding the unique context of an individual's experience. In order to conduct this type of inquiry, it is necessary for the research processes to be flexible, inductive, and dynamic, without transforming the data beyond recognition of the phenomenon being investigated (Ormston et al., 2014; Sandelwoski 2010). Using descriptive qualitative

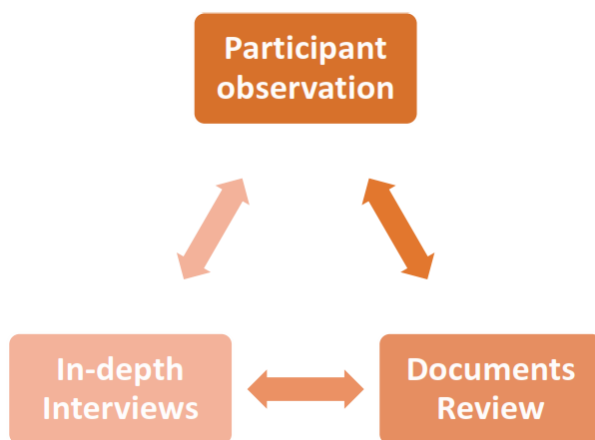
research in line with pragmatism (Neergaard et al., 2009), decisions are made about the research's conduct based on the study's aims, objectives, and context (Ormston et al., 2014). The pragmatic researcher doesn't object to any particular viewpoint on how to generate knowledge or methodology. Rather, they rely on the concepts or phenomena being investigated to guide decision-making during the research process, allowing them to choose the most appropriate methods to answer the research question (Bishop, 2015).

Case Studies by Employing Triangulation Methods

In-depth case studies are conducted to delve into specific instances of aligning the utilization of frontier technologies into current practices. Case studies, in this context, maintain the diligent analysis of a phenomenon under scrutiny, aiming to provide an in-depth understanding of the problem at hand. These case studies aim to extract detailed insights into the strategies, policies, and practices that have contributed to Monitoring and Surveillance in Bonded Zone Area as general. Additionally, contrast ing case studies in Indonesia are examined to identify challenges and areas for improvement. The case study method in this paper also employs a descriptive analysis to explain a problem, enabling a Specific examination thorough a singular case, involving detailed description, profound observation, and in-depth analysis (Bungin, 2011).

Employing Triangulation Methods also used to ensure the validity of data. According to Stake (1995), qualitative research requires data triangulation to test its validity. Still referring to Stake, triangulation is a way for research to emphasize the meaning and results of its findings, increasing good trust that the sources used are valid. In case studies, the most common pattern of triangulation is the combination of three main methods of data collection: participant observation, in-depth interviews, and documents review (Stake, 1995).

Figure 3 – Triangulation Methods



Source: Compiled by Author

3.2. Data Collection, Research Location, and Period of Time

This paper will select Bonded Zone Facilities on Soekarno-Hatta International Airport and Lhokseumawe as the sample location of this paper. The research will conduct based on time period between 2022 until 2024 and will interview officials that worked on Bonded Zone Facility on those Customs office at that time. According to Stake, informants can provide information based on observation (Stake, 1995, p. 67). This means that key informants and informants become interview sources in the research. Therefore, the selection of key informants or main informants was chosen based on the criteria of the case to be studied, as well as obtaining intensive information.

For this paper, authors also used purposive sampling and snowball sampling techniques to collect all related data. According to Sugiyono (2016), purposive sampling is a data source sampling technique with certain considerations (Rai & Thapa, 2015). The reason why using this technique is because not all samples have criteria that match the phenomenon under study. Snowball sampling is a technique of taking one source as a key informant who is in accordance with the research question then the researcher gets a recommendation for other sources (Parker, Scott, & Geddes, 2019). Later, the key informant will direct the researcher to other informants who are appropriate and have experiences relevant to the research being done. This technique is likened to a snowball rolling, getting bigger and bigger.

4. RESULTS AND FINDINGS

4.1. Current Practices of Customs Surveillance and Monitoring in Bonded Zone Facilities

Based on PER-02/BC/2019 concerning Monitoring inside Bonded Zone Centre, Indonesia's Customs are equipped with plenty of tools to monitor and supervised Bonded Zone. Three monitoring system, which are General Monitoring, Special Monitoring and Self-Independent Monitoring are regularly conducted to ensure the adherence of each factory inside Bonded Zone Facility. General monitoring of the TPB is a monitoring activity carried out by the relevant unit in DGCE, conjunction with the service and supervision activities of the companies receiving TPB facilities. General monitoring of TPB is conducted at least once a month or at least once every three months, for self-service TPB. General monitoring of TPB is conducted on the compliance of licensing requirements, unloading procedures, stockpiling, processing, recording and company activities related to customs and excise, such as IT Inventory, CCTV, Existence, Responsibility, Nature of Business and Audibility (ERNA). Special monitoring enable Authorities perform in-depth analysis allowing Enforcement and Investigation Team to easily monitor the movement of goods and activities inside it, and subsequently able to intercept the potential incurred crime activities. Post Audit, Rectification

Note, and Joint Analysis also engaged occasionally to ensure the compliance.

See Figure 4 in Appendix

In recent years, the utilization of technology to monitor and surveilling has begun to play a more significant role in customs operation. The optimization of Automated systems for document processing, electronic data interchange (EDI), and technologies like X-rays and scanners have been implemented to improve efficiency and accuracy (Hollister & Bradford, 2017). Also, the usage of E-Seal on transporting from seaport / airport toward Bonded Zone Area, are one of many tools from Directorate General of Customs and Excise did to enhance its current operation on supervision.

4.2. Problems in Bonded Zone Facility Due to Inadequacy of Current Monitoring and Surveillance System (Case Study of Bonded Zone Facilities in Soekarno-Hatta Airport and Lhokseumawe)

Many problems arose due to the inadequacy of current Customs system of monitoring and surveillance. According to Supreme Audit Agency (BPK), monitoring system inside Bonded Zone Facility is still insignificant. Investigation Report of BPK shows that IT Inventory system incapable of showing real time movement of the goods. Also, DGCE as Supervisor is lacking integrated database which linked and collect all of data from General Monitoring, Special Monitoring and Self-Independent Monitoring. As a consequence, all of those problems lead other related parties are unable to monitor the follow-up of the implementation of non-billing recommendations. In addition, there is a risk of inappropriate granting of TPB facility permit inaccurately (Kurniati, 2023). On the other hand, Minister of Industry, Agus Gumiwang Kartasasmita, alleged that bonded zones (KB) and bonded logistics centers (PLB) are the entry points for illegal imported goods into Indonesia. This was conveyed by Agus Gumiwang, who had started conducting inspections to a number of PLBs led by the Directorate General of Resilience, Territory and International Industrial Access (KPAII). The Minister of Industry said that import control in Indonesia faces many challenges ranging from the large number of imported products entering without SNI inspection at the customs area (border), due to weak supervision in bonded zones (Karina, 2023).

Weak Monitoring and surveillance also damaged the local textile industry, which is many textile factories are inside Bonded Zone Area. Association of Indonesian Fiber and Filament Manufacturers (APSyFI), acknowledge that Predatory Pricing Phenomenon frequently happened due to illegal import toward Bonded Zone. In its notes, APSyFI said that illegal or unrecorded textile imports in Indonesia reached 320,000 tons in 2022, an increase of 12.28% compared to the previous year of 285,000 tons. The

320,000 tons of illegal textile imports is equivalent to 16,000 containers per year or 1,333 containers per month. The losses generated by this illegal textile import practice reached IDR 32.48 trillion. The government also has the potential to lose revenue in the form of taxes amounting to IDR 19 trillion (Andi, 2023).

Based on the Interview from key informants, the utilization of current technology on customs services are often piecemeal and lack integration, limiting their overall impact. Especially, with the rapid development of today's technology. Several key informants also said, based on their own experienced, IT inventory system which always use to monitor the flow of the goods did not work very well. It was often encountering error and unable to show real-time condition, which is conflicted against the numbers of goods inside the bonded zone. CCTV also sometimes did not work 24 hours, and the recordings can only be stored maximum 7 days, causing enforcement team is unable to keep an eye on the movement of goods closely enough. These problems affected the entire monitoring and surveilling activities heavily, particularly in Lhokseumawe Bonded Zone, where the bonded one is located very far from the office. Inhouse system from DGCE, Ceisa 4.0, also sometimes encounter errors, causing the monitoring and surveillance getting more complicated. General monitoring, which is conducted monthly also still carried out manually, and the report also did not connect to inhouse system at all, causing relevant parties which want to collect all the data in order to proceed to other services are unable to retrieve the data properly. All of these current practices, causing the current monitoring and surveillance does not meet the requirements and unable to reach maximum output which is allowing the opportunity for any unscrupulous to commit smuggling or other crime.

Few of key informants also found out that one company located in Soekarno-Hatta Bonded Zone did commit smuggling and violates the provisions of the law by releasing out the unpaid goods unauthorized from customs officials. This led to that company being fined 75 million rupiah for its illegal activity. Inside Lhokseumawe bonded zone was also examined that several companies commit unintentionally crime by unloading goods that are not in accordance with the manifest submitted. Even with the current technology and tools constraint, officials were still able to find out the various kinds of smuggling inside bonded zone. Many key informants believed, utilizing the latest, and more advanced technologies, can lead to uncover more crime and raise the compliance of companies inside the bonded zone.

4.3. Integrating and Benefiting on Harnessing Frontier Technologies in Customs Surveillance and Monitoring

Many literature review and key informants believes that harnessing frontier technologies might be able to enhance its current system and cover all the

loopholes of the systems. Particularly on Lhokseumawe, which there is a problem occurring due to its lack of customs officials and the distance between bonded zone and the office is quite far. Utilizing robots and drone might offer unique leverage for customs surveillance and monitoring, particularly in very far-reached or difficult-to-access bonded zones. Drones can provide real-time aerial surveillance of bonded zones, allowing customs officials to monitor large areas quickly and efficiently. Bio-Robots (Boston's SPOT, a dog-like robots) are very useful on observing non-stop 24 hours without any breaks. This is particularly useful for detecting unauthorized activities, such as smuggling or unauthorized access, that may not be visible from ground-level surveillance cameras or in night condition (Kumar & Kumar, 2018). In the event of a smuggling or suspicious activity, drones and robots can be deployed rapidly to assess the situation and provide real-time video footage to customs officials. This enables a faster and more informed response, potentially preventing further escalation or loss (Watts, Ambrosia, & Hinkley, 2012). Drones and robots also can be used to mapping exact location of bonded zones, including warehouses, storage areas, and perimeter fences. This is valuable for issuing Bonded Zone Permit purposes, as well as for conducting regular inspections of infrastructure without disrupting operations (Colomina & Molina, 2014). Robots equipped with specialized equipment is also able to handling specific / dangerous goods which is needs special handling measurement. This is particularly important for Office which is lack of officers (most likely in Remote office) to monitor its under supervision's Bonded Zone. (Balamurugan et al., 2016).

Figure 5 – Boston Dynamics quadruped robot SPOT



Source: IoT World Today

<https://www.iotworldtoday.com/robotics/boston-dynamics-spot-the-design-behind-the-robot-dog>

IoT has the potential to enhance current customs surveillance and monitoring by providing real-time visibility into the movement and status of goods within bonded zones. Some specific applications encompass, Real-time Tracking and Monitoring which is connected to E-seal. IoT-enabled sensors which is attached to E-seal, locked into containers, pallets, or

boxes to track their precise location, condition, and movement throughout the process. This allows customs authorities to monitor the flow of goods in real-time, ensuring that they remain contact within designated bonded zones and are not diverted or tampered with (Li, Da Xu, & Zhao, 2015).

IoT embedded devices are also able to automate the collection and reporting of data related to customs compliance, such as the duration of goods in bonded zones, adherence to regulatory requirements, throughout IT Inventory System. This reduces the need for manual inspection, improving efficiency and accuracy (Perera, Zaslavsky, Christen, & Georgakopoulos, 2014). Another advantage of utilizing IoT is, the customs official is able to enhance their enforcement system by integrate directly with access control in Monitoring Room, surveillance cameras, and further the warehouse alarm systems. For instance, if a container or warehouse is opened without authorization, the system can immediately alert customs officials and activate security measures. This reduces the risk of smuggling and theft (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012).

Meanwhile, AI has the potential to significantly enhance customs surveillance and monitoring by analysing historical data and real-time information to identify patterns and trends that indicate potential risks, such as smuggling or fraud. By predicting these risks, customs officials can prioritize inspections and allocate resources more effectively, improving the overall efficiency of customs operations (Gonzalez-Beltran et al., 2015). AI-powered into IT Inventory systems can automate the inspection process by analysing images, videos, and other data collected by sensors, cameras, and drones. This will reduce the reliance on manual inspections, such as Monthly Monitoring on goods inside warehouses in Bonded Zone and improves accuracy (Li, Dai, & Liu, 2017). AI also can be used to automate the processing of customs documents, and subsequently helping the officials by encompassing on the classification of goods, filtering the red or green channel or assisting Enforcement officials to decide whether it is sufficient enough to issue NHI (Intelligent Note) on certain imported / exported goods or documents.

4.4. Exemplification of Utilizing Frontier Technologies from Other WCO's Customs Countries

Singapore

Singapore has successfully implemented various frontier technologies in its customs operations. The country's National Trade Platform integrates blockchain, IoT, and AI to provide a seamless and secure trade ecosystem. This platform has improved efficiency, transparency, and compliance, making Singapore a global leader in customs innovation (Tan, 2019). Singapore also successful on implementing AI on their job interview vacancy, allowing more efficient

and streamline process. During Covid-19 pandemic, Singapore also able to utilize SPOT robots (dog-like robots) to monitor people in public who did not wear a mask, and subsequently reminding them (Luk & Preston, 2021).

Netherlands

The Netherlands has adopted the TradeLens platform, which uses Internet of Things technology to streamline customs procedures and enhance supply chain visibility. This initiative has resulted in faster processing times, reduced paperwork, and increased trust among stakeholders (IBM, 2020).

South Korea

South Korea's Customs Service has deployed AI-powered systems for risk assessment and anomaly detection. These systems analyse historical data and real-time information to identify high-risk shipments, enabling more targeted inspections and improving overall security (Kim & Lee, 2018). South Korean Customs also successful on generating 5D image on their X-ray scanning process, by maximizing IoT and AI, resulting on more accurate physical examination and shortening the customs clearance process in overall.

4.5. Overcoming Challenge on Implementing Frontier Technologies on Indonesia Customs Systems

The utilization of drones and robots, along with integration of AI and IoT into customs operations also presents several challenges. Overcoming all the challenges will present a great advancement of customs monitoring and surveillance. All the issues as follows:

1. **Data Quality, Availability and Security:** AI and IoT systems rely on large volumes of high-quality data to function effectively. It also requires a lot of large storage and server to save of all the data. Inaccurate, or insufficient data can lead to incorrect predictions and decisions. Ensuring the availability and integrity of data is critical for the successful implementation of AI (Russell & Norvig, 2016). The vast amount of data generated by IoT and AI devices also raises concerns about data security and privacy. Lately, Indonesia's Government was under fire following string of cyber breaches, done by notorious hacker, Bjorka (Baharudin, 2024). Even though the breaches are able to be handled properly, the issue raise the concern about protection of national security data. Ensuring the data is being protected from unauthorized access and cyberattacks is very critical. Backing up the data regularly, hiring 3rd party security companies, and encouraging every IT officer in each of ministries with profound security

training will address this issue (Weber, 2010).

2. **Complexity and Cost:** Developing, deploying, and maintaining AI and IoT systems are to be surely complex and very costly. Customs authorities may require significant investment in infrastructure, training, and ongoing support to fully benefitting of utilization of AI (Gonzalez-Beltran et al., 2015). Meanwhile, the initial cost of buying drones, robots and developing its infrastructure, including sensors, connectivity, and data processing systems, can be high. Additionally, maintaining and upgrading these systems requires ongoing investment (Li, Da Xu, & Zhao, 2015). The use of drones is also subject to strict regulations, including restrictions on where and when they can be flown. Customs authorities must ensure that drone operations comply with national and international aviation laws (Clarke, 2014). Establishing long-term planning of this program, subsequently allocating this budget on APBN specifically, will address the issue. While the procurement runs, conducting distinct training on special officer which is assignment specifically on this section will also enabling the smooth transition over and resulting better integration.

5. CONCLUSIONS

5.1. Conclusion

1. Current practices of customs surveillance and monitoring employs several tools, and also utilize system and technology to monitor and supervise the operations inside the bonded zone. Despite of that, these advancements are often incapable and lacking the integration. IT Inventory system is incapable to show the real time movement of the goods, monitoring report still carried out manually and did not link to DGCE Inhouse system, making relevant parties facing difficulty to collect all the data. Ceisa 4.0 is often encounter error, CCTV sometimes did not work 24 hours, and the recordings can only be stored maximum 7 days. As a consequence, all of those problems causing the enforcement team is unable to keep an eye on the movement of goods closely enough, and other related parties are unable to monitor the follow-up. Inadequacy of current customs operations allowing one company in Soekarno-Hatta Bonded Zone committed a crime and being fined 75 million rupiah for its illegal activity, meanwhile several companies in Lhokseumawe Bonded Zone commit unintentionally crime by unloading goods that are not in accordance with the manifest submitted. Weak monitoring and surveillance also damaged textile and manufacture industry, which many of them are located inside Bonded Zone Facility.

2. Hence, the implementation of frontier technologies such as the Internet of Things (IoT), drones, robots, and Artificial Intelligence (AI) offers protruding potential for enhancing current customs surveillance and monitoring within bonded zone facilities in Indonesia. Bonded Zone hold as a key factor of Indonesia economic performance, generating its 1-2% national income and taking role on its economic growth by affecting to several economic sector. Frontier technologies enable significantly improve operational efficiency, security, and increase compliance through real-time tracking by optimizing E-seal. IoT system connected in monitoring room allows customs authorities to monitor the flow of goods in real-time, while IoT embedded devices are also able to automate the collection and reporting of data related to customs compliance, reducing the likelihood of smuggling, and regulatory violations. Drones and robots provide unique leverage for customs surveillance in difficult-to-access bonded zones and able to provide real-time observing non-stop 24/7 hours without any breaks. Drones and robots also able to execute bonded zones mapping accurately, inspecting regularly, and able to handling specific / dangerous goods which is needs special handling measurement. Meanwhile, AI can be used to automate the process of customs documents, helping enforcement officials to issue NHI (Intelligent Note) on certain condition. IT inventory AI-powered is able to automate the inspection process and subsequently self-monthly monitored, reducing workload which is very helpful for office which shortage of officials due minus growth policy in Ministry of Finance, allocate resources more effectively, and subsequently improving the overall efficiency.
3. However, the successful integration of these technologies requires addressing several challenges, including data quality, availability, and security, also Complexity and Cost issue which lingering in Indonesia budgeting allocation. Ensuring that data generated by IoT devices and AI systems is secure and protected from cyber threats is paramount. Moreover, the adoption of these technologies necessitates significant investment in infrastructure, profound training of customs officials, and ongoing support.

In conclusion, while the adoption of frontier technologies in customs operations presents challenges, the benefits far outweigh the potential drawbacks. By leveraging IoT, drones, robots, and AI, Indonesia is able to modernize its customs performance as a whole unit, enhancing the efficiency, security, and subsequently empowered its

current practicing of its surveillance and monitoring systems on bonded zone facilities.

5.2. Policy Recommendation

To fully harness the potential of frontier technologies in customs surveillance and monitoring, the following policy recommendations are proposed:

1. Invest Thoroughly in Frontier Technologies Infrastructure and Capacity Building:

Significant investment is needed to upgrade the technological infrastructure of bonded zone facilities, including the installation of IoT devices, drone and robots' deployment systems, and AI-powered analytics platforms. Proposing thoroughly on Annual budgeting of a State Budget (APBN) will help DGCE to allocate its budget more accurately particularly in procurement and long-term investment on those technologies. The government should also invest in capacity building for customs officials, providing profound training and maximizing remaining human resources to help them effectively use and manage these technologies. This includes specialized training on data analysis, cybersecurity, and the operation of drones, robots, and IoT systems.

2. Enhance Data Security and Privacy Protections and Revision Current Act of Bonded Zone Facility:

Ensuring robust data security and privacy protections of these technologies is very crucial. The integration of these technologies will generate vast amounts of sensitive data, including real-time tracking information, surveillance footage, and analytics derived from AI systems. This data must be secured against unauthorized access, hacker, and cyber threats, while ensuring that the privacy rights of individuals and businesses are also respected. Implement stringent data security protocols to protect the vast amounts of data generated by IoT devices and AI systems from cyber threats must be done before implementing these technologies. This includes encryption, access controls, and regular security audits. Updating existing regulations and revision act of Bonded Zone Facility to accommodate the utilization of robots, drones, AI, and IoT in customs operations. This includes establishing clear guidelines for the use of drones in surveillance, the processing of data by AI systems, and the deployment of IoT devices within bonded zones. Emulating national regulations along with other WCO's Countries standards also necessarily needed to ensure that Indonesia's customs operations remain compliant with global practices. This will facilitate smoother cross-border trade and enhance international cooperation in customs enforcement.

By adopting these policy recommendations, Indonesia can create a more efficient, secure, and transparent, subsequently empowered its customs

surveillance and monitoring system within its bonded zone facilities. This will not only enhance the country's competitiveness in global trade but also contribute to the broader goals of economic growth and national security interest.

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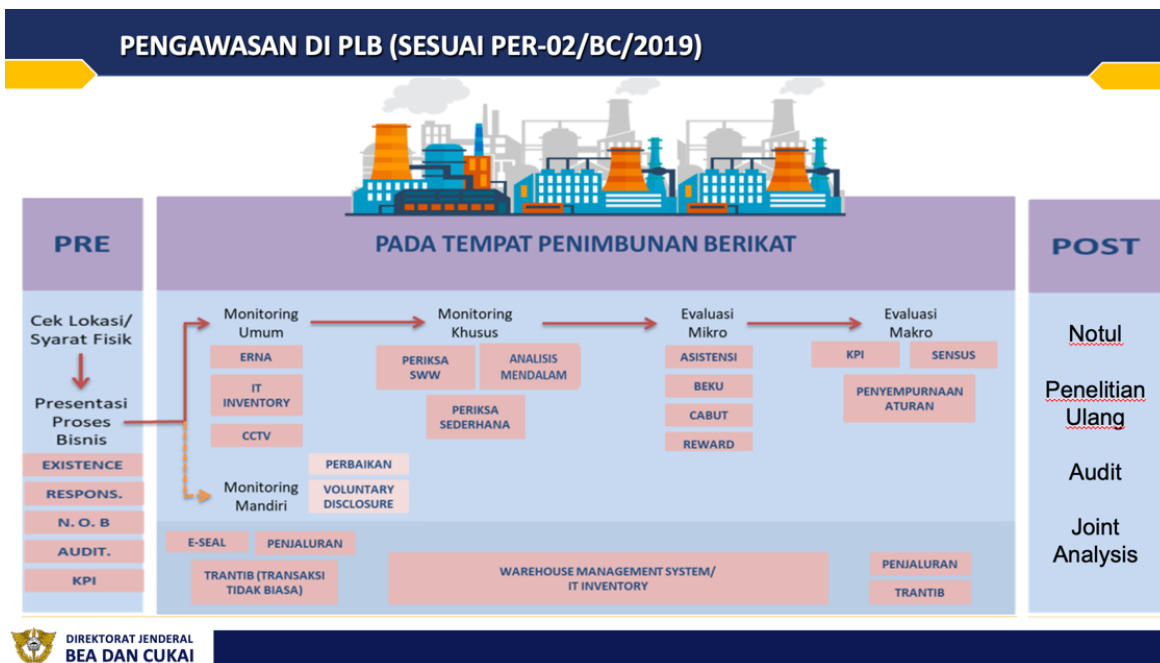
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APPENDIX I

Figure 4 – Monitoring on Bonded Zone Centre based on PER-02/BC/2019



Source: PER-02/BC/2019 and compiled by Author - 2021

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